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GEOMAGNETIC BULLETIN 27

Magnetic Results 1997

LERWICK, ESKDALEMUIR AND HARTLAND OBSERVATORIES

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1. INTRODUCTION

This bulletin is a report of the measurements made between the 1st January and the 31st December 1997 at the UK geomagnetic observatories operated by the British Geological Survey (BGS) at Lerwick, Eskdalemuir and Hartland.

The three observatory sites are described, with notes of any changes made during the year. The major instrumental change that took place was the replacement of the Automatic Remote Geomagnetic Observatory System (ARGOS), which had operated at each observatory since the 1st January 1987, with the Geomagnetic Automatic Unmanned Sampling System (GAUSS) (Turbitt *et al.*, 1999). This new system, which was developed by BGS staff, was first installed in 1996 and became the definitive operating system for the three UK observatories from the 1st January 1997. A description of the GAUSS instruments is given and the method of collecting the data from each observatory, the quality control procedures and the method of reducing the data to absolute values are also outlined.

The presentation of the data in this bulletin is principally in graphical form, with complete sets of daily magnetograms derived from one-minute values, and plots of hourly and daily mean values for each observatory. The data are available in digital form on request (details are given in Section 7).

2. DESCRIPTIONS OF THE OBSERVATORIES

The locations of the UK geomagnetic observatories are shown on the map in Figure 1 and the co-ordinates of each are given in the table below.

Observatory		**Lerwick**	**Eskdalemuir**	**Hartland**
Geographic	**Latitude**	60°08′N	55°19′N	51°00′N
	Longitude	358°49′E	356°48′E	355°31′E
Geomagnetic	**Latitude**	62°01′N	57°53′N	54°00′N
	Longitude	89°27′E	84°06′E	80°26′E
Height above mean sea level		85 m	245 m	95 m

Geomagnetic co-ordinates given are relative to a geomagnetic pole position of 79°23′N, 71°34′W, computed from the seventh generation International Geomagnetic Reference Field (Barton, 1997) at epoch 1997.5.

The history of the current UK geomagnetic observatories, and of other observatories that have operated in the British Isles, is described by Robinson (1982).

2.1 Lerwick (Shetland, Scotland)

Lerwick Observatory is situated on a ridge of high ground about 2.5 km to the SW of the port of Lerwick. The surrounding countryside is moorland comprising peat bog, heather and rocky outcrops. The observatory is operated by the Meteorological Office as a meteorological station carrying out routine synoptic observations and upper-air measurements. Other work includes detection of thunderstorms, measurement of solar radiation, ozone and atmospheric pollution levels, and chemical sampling. BGS uses Lerwick as a seismological station, recording data from a local three-component seismometer set and, via radio link, from the Shetland seismic array. Lerwick was established as a meteorological site in 1919 and geomagnetic measurements began in 1922. Responsibility for the magnetic observations passed from the Meteorological Office to BGS in 1968. No members of BGS staff are stationed at Lerwick.

Figure 2 is a site diagram of Lerwick Observatory. During 1997, no major changes were made at the site. Routine maintenance work was carried out on the observatory buildings.

2.2 Eskdalemuir (Dumfries & Galloway, Scotland)

Eskdalemuir Observatory is situated in the Southern Uplands of Scotland. It is on a rising shoulder of open moorland in the upper part of the valley of the river White Esk. It is surrounded by young conifer forests with hills rising to nearly 700 m to the NW. The observatory is 100 km from Edinburgh and 25 km from the towns of Langholm and Lockerbie.

Eskdalemuir is a synoptic meteorological station involved in measurement of solar radiation, levels of atmospheric pollution, and in chemical sampling. The observatory operates a US standard seismograph and an International Deployment Accelerometer Program long-period sensor. BGS has a three-component seismometer set installed at the observatory and records data from four remote sites transmitted to the observatory by radio link. The observatory opened in 1908. It was built because of disruption to geomagnetic measurements at Kew Observatory (London) following the advent of electric tramcars at the beginning of the 20th century. BGS took over responsibility for magnetic observations from the Meteorological Office in 1968. There are two members of BGS staff stationed at the observatory. Mr W E Scott and Mrs M Scott were responsible for the general maintenance of the observatory during 1997.

Figure 3 is a site diagram of Eskdalemuir observatory. No major changes were made at the observatory during 1997. Routine building maintenance was carried out on the observatory buildings.

2.3 Hartland (Devon, England)

Hartland Observatory is situated on the NW boundary of Hartland village. The site is the southern half of a large meadow, which slopes steeply northward into a wooded valley. The sea (Bristol Channel) is about 3 km to both the north and west of Hartland. BGS operates a three-component seismometer set and a LF microphone at the observatory, and data from seismic outstations are transmitted to the observatory by radio link.

The observatory was purpose-built for magnetic work, and continuous operations began in 1957, the International Geophysical Year (IGY). Hartland is the successor to Abinger and

Greenwich observatories. The moves from Greenwich to Abinger and then to Hartland were made necessary as electrification of the railways progressed, making accurate geomagnetic measurements impossible in SE England. BGS took over control of Hartland Observatory, from the Royal Greenwich Observatory, in 1968. The observatory also houses an archive of material consisting of records of geomagnetic measurements and observatory yearbooks from all over the world. The only member of BGS staff stationed at Hartland is the caretaker, Mr C R Pringle.

Figure 4 is a site diagram of Hartland observatory. Routine maintenance was carried out on all the observatory buildings during 1997.

3. INSTRUMENTATION

3.1 Absolute observations

At each observatory absolute measurements are made in a single absolute hut (see the site diagrams). Since 1 January 1990, absolute values of all geomagnetic elements are referred to a single standard pillar at each of the observatories. For continuity with previous records the differences between the new and old standards are quoted in the tables of annual mean values in the sense (new standard - old standard) for all elements of the geomagnetic field. Thus, annual mean values prior to 1990.5 can be referred to the new standard by adding the site difference to the old standard values. A detailed account of the change in absolute measurement reference is given by Kerridge and Clark (1991).

The instruments used at each observatory are given below.

	Fluxgate-Theodolite (Inventory Number)	**Absolute Proton Vector Magnetometer (PVM)**
Lerwick	ELSEC 810 (LER32)	ELSEC 8801 Proton precession magnetometer mounted in ELSEC 5920 coils
Eskdalemuir	Bartington MAG 01H (ESK43)	ELSEC 8801 Proton precession magnetometer mounted in ELSEC 5920 coils
Hartland	ELSEC 810 (HAD16)	ELSEC 8801 Proton precession magnetometer mounted in ELSEC 5920 coils

In an ideal fluxgate-theodolite, the magnetic axis of the sensor core would be parallel to the optical axis of the telescope. However, this situation is impossible to achieve and small alignment errors called collimation errors are the result. These are systematic errors associated with each individual instrument and should remain roughly constant. With the telescope horizontal, δ is the collimation error about the vertical axis and ε is the collimation error about the horizontal axis, both expressed as angles. A third error, measured in nT, is the zero-field offset. This represents the output if the instrument was placed in a zero field and is due to permanent magnetisation of the core or to features of the electronics. The collimation and zero-field offset values calculated throughout the year are plotted to check that they remain reasonably constant. Departures from a long-term mean value may be caused by mechanical or electronic changes to the fluxgate-theodolite or by errors in recording the measurements.

3.2 GAUSS

The essential components of GAUSS are: a triaxial linear-core fluxgate magnetometer (model FGE) manufactured by the Danish Meteorological Institute (DMI); an Overhauser Effect proton precession magnetometer (GEOMAG, SM90R), with its sensor mounted at the centre of a set of dual axis Helmholtz coils; and a Global Positioning Satellite (GPS) receiver (Garmin GPS36). These instruments all operate under the control of two IBM compatible Personal Computers (PC1 and PC2). A block diagram of the GAUSS system is given in Figure 5.

Each GAUSS system is supported by a 500 VA Merlin-Gerin SX500 Uninterruptable Power supply (UPS), this equipment has internal batteries capable of powering the system for one hour in the event of a mains failure. Each observatory also has a stand-by diesel generator designed to start automatically, within one minute of loss of mains power. In normal operation the UPS is only required to maintain mains power to the GAUSS system until the generator takes over.

3.2.1 Fluxgate Variometer Measurements

The fluxgate sensors are orientated to measure the variations in the horizontal (H) and vertical (Z) components of the magnetic field. The third is orientated perpendicular to these and measures variations that are proportional to the changes in declination (D). The fluxgate magnetometers, operating as variometers, provide an analogue output of ±10 Volts, which corresponds to a magnetic field change of ±5000 nT. Mounted orthogonally to one another, the sensors are in a single 20 cm cube marble block, which is located on a pier in a temperature-controlled variometer chamber. At Eskdalemuir this marble block is supported in a gimballed, mounting which provides magnetometer tilt correction. This automatic compensation is not carried out at Lerwick or Hartland. The temperature in the variometer chamber is controlled by a separate temperature sensor, which activates heaters when required. A full description of the DMI fluxgate magnetometers is given in a DMI technical report (1997).

The rate at which the outputs from the three fluxgate sensors are sampled is one per second. These one-second values are then passed through a 61-point cosine filter to generate one-minute values of H, D and Z variations centred on the beginning of the minute.

3.2.2 PVM Variometer Measurements

The proton vector magnetometer (PVM) apparatus has been designed to measure absolute values of total intensity (F) as well as variations in D and Inclination (I). The apparatus used to make PVM measurements consists of a proton precession magnetometer (PPM) sensor mounted at the centre of two orthogonal sets of Helmholtz coils in a delta D/delta I ($\delta D/\delta I$) configuration. Currents are passed through the coils creating bias fields, the magnitude of which are measured in combination with the earth's magnetic field. The coils are orientated initially so that one set provides a bias field approximately perpendicular to the geomagnetic field vector in the horizontal plane (δD), and the other provides a bias field approximately perpendicular to the geomagnetic field vector in the magnetic meridian (δI). If the resultant magnetic field is measured after applying the bias fields then vector algebra can be used to calculate the change in declination (δD) and the change in inclination (δI). These changes are relative to baseline values of declination and inclination (D_0 and I_0) determined by the directions of the magnetic axes of the coils. The values of D_0 and I_0 can be determined by comparing the PVM measurements with absolute observations. This technique is described in full by Alldredge (1960).

The proton magnetometer and associated coils are sited in non-magnetic huts, which are within 50 m of the GAUSS control electronics. A magnetic field measurement is made every eight seconds, following a sampling sequence of: *i.* without a bias field (F_1); *ii.* with a current flowing in the δI coils to create a bias field positive in the direction of I (I+); *iii.* with a current flowing in the opposite direction from that of *ii.* (I–); *iv.* without a bias field (F_2); *v.* with a current flowing in the δD coils to create a bias field positive in the direction of D (D+); *vi.* with a current flowing in the opposite direction from that of *v.* (D–); and *vii.* without a bias field (F_3). The complete cycle of measurements takes 56 seconds. Using the results from the vector measurements quasi-absolute one-minute values of D and I are derived as well as absolute one-minute mean values of F.

Full PVM absolute observations would require a sequence of measurements to be made with the coils rotated into positions enabling errors due to imperfect alignment of the magnetic axes to be eliminated. The Helmholtz coils used at the UK observatories cannot be rotated, so the measurement is not error-free. If the mechanical stability of the coil system is good, and the pier on which it is mounted does not tilt, then the error should be (practically) constant. Comparisons of PVM results with measurements made by the fluxgate magnetometers have shown that this is not the case. Drifting can be observed in the PVM values, which means that they have not been used as a means for interpolating between absolute observations as originally designed. Instead, these measurements have been useful as an extra quality control check for the individual absolute observations and, if used over short term periods only, as an extra backup system for the one-minute variometer data.

3.2.3 Data Collection, Control and Communications

In routine operations the analogue outputs from the three channels of the fluxgate magnetometer and the two temperature sensors are sampled every second by a 20-bit analogue to digital converter (ADC). The temperature sensors measure the temperature in the variometer chamber and the hut housing the PVM apparatus. The control of this operation along with switching bias currents to the Helmholtz coils and sampling of the proton magnetometer is done by the embedded PC2. This PC has its operating system and all control and data collection software stored in erasable programmable read only memory (EPROM). Its operation is dedicated to sampling the fluxgate and proton magnetometers and transferring these data through serial communications to PC1, which computes the one-minute values, handles the data storage and provides provides operating status codes.

In designing GAUSS one of the main constraints was that all data input and sensor control functions should be carried out through standard serial or parallel PC ports (COM1, COM2 or LPT1). No specialised interface cards have been used in its design. This feature will allow, in the event of a system failure, the replacement of either PC1 or PC2 with any IBM compatible PC fitted with the correct number of standard ports.

PC1 controls all data collection, filtering and error checking operations along with the transmission of data from the observatory back to Edinburgh for analysis, dissemination to users and archiving. All system timing operations are controlled by the PC1 software clock, which is synchronised to GPS time using the time and position information received through the Garmin GPS receiver. Time information is received and decoded every second by the

GPS receiver and relayed serially through the COM2 port on PC1 to update or correct the PC1 processor clock. This timing information is also relayed serially, from PC1 to PC2, and used to control all data collection operations. Using this method of time synchronisation the sample timing and time stamping of the recorded data is maintained to an accuracy of ±100 ms.

The data are stored in files on the disk drive on PC1. Each file contains one day of time-stamped one-minute values of *H*, *D* and *Z* variations from the fluxgate magnetometer, two sets of temperature measurements and five PVM measurements in the sequence *I*+, *I*-, *D*+, *D*- and *F*. These files are maintained for 40 days on PC1, after which they are overwritten.

Communication between GAUSS and Edinburgh is maintained through a Multitech modem operating at speeds of up to 9600 baud with the data relayed through the public switched telephone network (PSTN). GAUSS is normally interrogated automatically at several selected times by the data collection processor in Edinburgh, but facilities have been included to allow manual operator control of several functions. These permit the operator to extract any current data which have not been retrieved by an automatic call-up, retrieve historical data (up to 40 days old), replace GAUSS operating software or make adjustments to system configuration parameters (e.g. adjust fluxgate/ADC scaling factors).

3.2.4 Technical Specifications Summary

The specifications quoted here are those given by the manufacturers of the equipment.

3.2.4.1 DMI Fluxgate Magnetometer

Sensitivity	0.2 nT
Dynamic Range	±5000 nT
Temperature coefficient	< 0.25 nT/°C

3.2.4.2 GEOMAG SM90R Overhauser Effect Proton Magnetometer

Resolution	0.01 nT
Accuracy	±0.1 nT
Measurement Range	10,000 - 90,000 nT

3.2.4.3 Garmin GPS receiver

Output code	NMEA standard coded messages
Output data rate	4800 baud
Output update rate	Once/second

3.2.4.4 Analogue to Digital Converter

Type	2 x Crystal CS5506
Resolution	20 bit (2^{20})
Number of channels	8
50Hz noise rejection	105 dB
Sampling rate	1 Hz (maximum 100/sec)
Scaling factor	approx. 100 counts/nT (This depends on the calibration values of the fluxgate)

3.2.4.5 System clock

PC1 Real Time Clock	without GPS corrections >1 second/day with GPS corrections applied every second within ±100 ms of GPS time.

3.3 Back-up Systems

At each observatory, an EDA FM 100B three-axis fluxgate magnetometer, completely independent of GAUSS, is maintained to provide back-up data in the event of a total GAUSS failure. The three fluxgate sensors are aligned with one along magnetic north to measure changes in *H*, one along magnetic east to measure changes in *D* and one vertically to measure changes in *Z*. The analogue outputs of the magnetometer are input to a 16-bit ADC and sampled every 10 seconds. A 7-point cosine filter is used to convert the 10-second samples to one-minute values, which are then recorded on a 3.5" DOS diskette by a GCAT embedded PC. The disk is changed every 14 days (or more frequently if required) and sent by post to BGS, Edinburgh for archiving. The dynamic ranges of the magnetometers are: ±2000 nT at Lerwick; and ±1000 nT at Eskdalemuir and Hartland. A block diagram of the back-up system is shown in Figure 6. At Eskdalemuir and Hartland, a facility is also included in the back-up system to transmit data to Edinburgh via the METEOSAT geostationary satellite. This link can be used to retrieve back-up data quickly in the event of the loss of GAUSS data.

3.4 Calibration of geomagnetic measurements

The physical measurements made by GAUSS are of the analogue voltage output from the fluxgate sensors and the precession frequency radiated by the polarised sample in the proton precession magnetometer.

For calibration purposes these measurements can be split into two separate processes:

Calibration of the fluxgate magnetometer and the ADC module;
Calibration of the proton magnetometer.

At all three observatories the same calibration procedures are followed and all the sensors and digitising equipment listed above are calibrated at 3-monthly intervals. All test equipment used in these calibrations is checked annually against National Physical Laboratory standards. A file containing the relevant certificates for all observatory test equipment is maintained at BGS, Edinburgh. The equipment used in these calibrations is a Fluke Type 45, 5½ digit, a digital voltmeter (DVM), a PYE 1000Ω, a 4-terminal manganin-wound resistor and an Off-Air 198 kHz radio receiver.

3.4.1 Calibration of the fluxgate magnetometers

The scale values of the fluxgate sensors are calibrated by the manufacturer at the DMI. A regular check of the scale value of each sensor is carried out by measuring the current through the 1000 Ω resistor connected in series with the feedback coil of each sensor and then using the coil constant, provided by the manufacturer, to calculate the scale value. The object of the calibration is to check any drift, or change in the manufacturer's supplied scale values.

3.4.2 Calibration of the ADC

This unit is calibrated by disconnecting the fluxgate and applying a +5 Volt, 0 Volt and a -5 Volt stabilised voltage source to each input of the ADC, respectively. This input voltage is measured using the calibrated DVM and the resultant digital counts are displayed on the PC1 monitor. The ADC conversion factor in Volts per count can then be calculated.

3.4.3 Calibration of the proton magnetometer

The proton magnetometer measures the frequency of emitted radiation from a sample of proton enriched fluid. This is related to the ambient magnetic field by the proton gyromagnetic ratio. The conversion from frequency to magnetic field value carried out by the proton magnetometer is checked by irradiating the sensor with a signal of various frequencies derived from a stable frequency source. The stable source used to provide these frequencies is a 198 kHz signal transmitted from Rugby. The long-term accuracy of this signal, quoted by NPL, is 1 part in 10^9; the short-term accuracy is 1 part in 10^{11}. All proton magnetometers operating at the UK magnetic observatories are calibrated using this method over a range of field values from 20,000 nT to 80,000 nT at three monthly intervals.

4. DATA PROCESSING

Data are retrieved to Edinburgh from the observatories by a dedicated IBM PS/2 PC. It can either be programmed to call the observatories automatically at predetermined times or it can be used to manually retrieve the data when required. The data are then transferred via a standard serial link to a Sun Workstation where they are stored in day files in raw binary format. The raw data are also stored on the data retrieval PC for 45 Days, after which time they are overwritten.

Data processing is carried out automatically on the Sun Workstation each day at 03:45 UT. The binary data files are first converted into ASCII, with the data sorted by Universal Time (UT). Subsequent data processing is carried out on these day files by a single FORTRAN program which uses subroutines to generate various data products and derivatives. Several quality control routines are also carried out to identify possible errors. The overall control of the automatic data processing jobs are carried out by UNIX C-Shell scripts, which are executed by the UNIX clock daemon command, *cron*. A flow chart covering the main stages in the data processing is shown in Figure 7.

The data products generated automatically each day are:

- *HDZ* fluxgate magnetograms;
- *HDZ* PVM magnetograms;
- A plot of absolute *F* measured by the PPM at all three observatories;
- A comparison plot between *F* computed from *H* and *Z* and the measured *F*;
- A list of any missing data;
- Formatted lists of one-minute values;
- Hourly mean values of each geomagnetic component;
- Hourly and daily ranges in each geomagnetic component;
- Daily mean values;
- K indices; and,
- Forecasts of geomagnetic activity for up to 27 days ahead.

The final check on the quality of the data is the responsibility of the operator in Edinburgh who examines the magnetograms and *F* comparison plots each day. Any erroneous values, undetected by the automatic quality control procedures, will be identified at this stage. If required, data from the backup system or the PVM measurements can be used to replace any erroneous values or fill any gaps in the GAUSS fluxgate data, after which the main data processing procedure is repeated.

At both Lerwick and Eskdalemuir observatories there were no periods during 1997 when the GAUSS and the back-up variometers and the GAUSS PVM measurements all failed simultaneously. Consequently, the time-series of one-minute values are complete throughout the year for these two observatories. At Hartland observatory during a period in October, there were three days when farm machinery, which was operating in the field adjacent to the observatory, affected all the magnetometer systems to various degrees. Following the data processing procedures, the outcome was a total of 265 missing one-minute values from the *Z* component time-series, covering four separate periods; the dates and times of which are listed below. The *H* and *D* time-series are complete for 1997 at Hartland.

Date	Start Time (UT)	*Z* one-minute values missing
21-10-97	13:40	51
21-10-97	15:15	26
22-10-97	14:00	46
25-10-97	09:20	142

The scientific and commercial demand for rapid access to UK observatory data has steadily increased over recent years, prompting the continued development of the automatic data processing procedures and quality control standards. The BGS local area network is connected to the Internet, which enables transfer to academic and commercial users world-wide by electronic mail. The Geomagnetism Information and Forecasting Service (GIFS) was created to provide "user-friendly" access to the data sets, and is available on the world-wide web (*http://www.nmh.ac.uk/gifs/on_line_gifs.html*). The data sets on GIFS derived from UK observatory data are updated daily.

At the end of each month, a monthly bulletin is issued for each observatory to present the magnetic results obtained during the month and record the quality control procedures undertaken to maintain the standard of these results. The magnetic results included in these bulletins are: magnetograms; hourly and daily mean plots; monthly mean values; lists of rapid variations; *K* and *aa* indices; and the forecasts of magnetic and solar activity. The quality control records included are: the results of absolute observations and the associated collimation errors; PVM-Fluxgate comparisons; plots of the baselines applied to the variometer measurements; and a diary giving details of any changes made during the month at the observatory. The baseline values allocated to the variometer data are reviewed each month and definitive monthly mean values are published 4 to 6 months in arrears.

At the end of each year the baseline values are finalised to give absolute values, the details of which are given in Section 5. The results obtained from these definitive absolute values are presented in Section 6.

5. CORRECTION OF DATA TO ABSOLUTE VALUES

The GAUSS fluxgate magnetometers only monitor accurately variations in the components of the geomagnetic field, they do not measure the absolute magnitudes of the components. Absolute measurements of the field are made typically once a week. As described in Section 3.1, *D* and *I* are determined using a fluxgate sensor mounted on a theodolite and *F* is measured using a proton precession magnetometer. The absolute observations are used in conjunction with the GAUSS variometer measurements to produce a continuous record of the absolute values of the geomagnetic field elements as if they had been measured at the observatory reference pillar.

The baselines allocated for each observatory for 1997 are shown in Figures 8-10. (The results for each observatory are discussed in more detail below.) The baselines are derived by comparing the fluxgate measurements with absolute measurements taken simultaneously. In each of the figures, the top panel shows the comparison between the absolute measurements and the fluxgate measurements for *H* (plotted in the sense absolute – fluxgate). The second panel shows the same for *D*, in which East is represented by positive values, and the next panel shows the same for *Z*. In these absolute – fluxgate comparison panels, the symbols represent the observed values and the full line shows the adopted baselines. The adopted baselines are derived from piecewise linear fits to the observed values computed using the method of least squares. In deriving the baselines the points immediately before the beginning and after the end of the year were used, but are not shown in the plots. This ensures that unrealistic discontinuities are not introduced at the year boundaries. Daily mean differences between the measured absolute *F* and the *F* computed from the baseline corrected *H* and *Z* values are plotted in the third panel from the bottom (plotted in the sense measured – derived). The bottom two panels show the daily mean temperature in the fluxgate chamber and the daily mean temperature in the hut housing the PVM apparatus, which follows changes in the outside temperature.

5.1 Lerwick

Absolute measurements were made by BGS staff during service visits to the observatory in March, June, September and December. The measurements between service visits were made by Meteorological Office staff. These are plotted as the observed baselines (with variometer subtracted) in Figure 8, with the clusters of measurements made within a few days indicating the dates of service visits.

The ranges of the allocated baselines during the year were 6 nT for *H*, 2.0 minutes of arc for *D* and 6 nT for *Z*. These ranges are smaller than in previous years. This indicates that the DMI fluxgate magnetometers are more stable than those used in the ARGOS systems.

Steps in the baselines were observed on the 26^{th} November after the system had been powered down to replace both the GPS system and PC2. The steps were 3.6 nT, 0.95 minutes of arc and 3.3 nT in *H*, *D* and *Z* respectively. The variometer data were permanently adjusted by these amounts up to the end of the day, thus moving the baseline change to 00:00 UT on the 27^{th} November.

The table below lists the root mean squared (*rms*) differences of the observed baseline corrections from the allocated values. The *rms* differences for 1994-96 are also listed. The number of observations made of each component in each year is given in brackets.

Year	H(nT)	D(min)	Z(nT)
1994	0.87 (21)	0.25 (21)	0.66 (21)
1995	0.97 (21)	0.35 (24)	0.85 (23)
1996	1.20 (49)	0.32 (48)	1.03 (47)
1997	0.60 (33)	0.17 (35)	0.44 (35)

5.2 Eskdalemuir

Absolute measurements were made by staff of the Meteorological Office at Eskdalemuir whenever it was possible to do so. These were supplemented by measurements made by BGS staff, which were on a regular basis up to the end of March providing a total of one observation per week. After March, these became less regular giving on average three observations per month. These are plotted as the observed baselines (with variometer subtracted) in Figure 9.

The ranges of the allocated baselines during the year were 5 nT for *H*, 1.1 minutes of arc for *D* and 1 nT for *Z*. These ranges are smaller than in previous years. This indicates that the DMI fluxgate magnetometers are more stable than those used in the ARGOS systems.

Small steps in the baselines were observed on the 4th December after the system had been powered down to replace both the GPS system and PC2. The steps were 1.0 nT, 0.06 minutes of arc and 0.9 nT in *H*, *D* and *Z* respectively. The variometer data were permanently adjusted by these amounts from the start of the day to the time of the step, thus moving the baseline change to 00:00 UT on the 4th December.

The table below lists the root mean squared (*rms*) differences of the observed baseline corrections from the allocated values. The *rms* differences for 1994-96 are also listed. The number of observations made of each component in each year is given in brackets.

Year	H(nT)	D(min)	Z(nT)
1994	1.56 (28)	0.45 (29)	0.92 (28)
1995	1.31 (44)	0.29 (42)	0.97 (45)
1996	1.05 (59)	0.38 (65)	0.98 (59)
1997	0.58 (41)	0.15 (42)	0.54 (41)

5.3 Hartland

Absolute measurements were made weekly by the caretaker at Hartland Observatory and by Edinburgh staff during service visits. These are plotted as the observed baselines (with variometer subtracted) in Figure 10.

The ranges of the allocated baselines during the year were 2 nT for *H*, 1.3 minutes of arc for *D* and 5 nT for *Z*. These ranges are smaller than in previous years. This indicates that the DMI fluxgate magnetometers are more stable than those used in the ARGOS systems. The above values do not however include the baseline steps, described below, which occurred at various times through the year.

Steps in the baselines were observed on the 20th January after the system had been powered down to replace PC2. The steps were 1.2 nT, 0.24 minutes of arc and 1.5 nT in *H*, *D* and *Z* respectively. These steps were almost reversed (–1.6 nT, –0.24 minutes of arc and –1.9 nT) on the 4th February when a replacement power supply was installed. Further steps in *H* and *Z* were observed on the 24th February when the voltage regulator of the fluxgate backing-off supply was replaced. These were –16.3 nT and –37.5 nT respectively. On each of the above occasions, the variometer data from the start of the year were adjusted by the relevant amount and baseline values recalculated, thus giving the allocated baselines shown in Figure 10.

Steps in the baselines were observed on the 19th September after the voltage reference to supply the bias current to the fluxgate magnetometer was replaced. The steps were 8.0 nT in *H*, –0.04 minutes of arc in *D* and –18.7 nT in *Z*. The variometer data were permanently adjusted by these amounts from the start of the day up to the time of the step, thus moving the baseline change to 00:00 UT on the 19th September. Further baseline steps were observed on the 13th October after a change was made to the DC supply to the fluxgate electronics. These were –66.4 nT, –11.76 minutes of arc and –128.0 nT in *H*, *D* and *Z* respectively. A further alteration was made on the 15th October resulting in an additional step of +1.02 minutes of arc in *D*. On both these occasions the variometer data were permanently adjusted by these amounts from the start of the day up to the time of the step, thus moving the baseline changes to 00:00 UT on the given dates. These steps do not appear on the plot of the allocated baselines in Figure 10 since the plotting software has been written to adjust the values to fit on the plotting panel.

The table below lists the *rms* differences of the observed zero-field corrections from the allocated values. The *rms* differences for 1994-96 are also listed. The number of observations of each element in each year is given in brackets.

Year	H(nT)	D(min)	Z(nT)
1994	1.20 (56)	0.25 (56)	0.70 (56)
1995	1.05 (44)	0.21 (46)	1.24 (43)
1996	1.06 (53)	0.20 (51)	0.80 (51)
1997	0.67 (46)	0.14 (43)	0.39 (46)

6. PRESENTATION OF RESULTS

The data are organised by observatory in the order Lerwick, Eskdalemuir and Hartland. The following sub-sections summarise the results presented for each observatory.

6.1 One-minute values

The GAUSS one-minute values of *H*, *D* and *Z* are centred at the beginning of the minute. These are plotted in daily magnetograms of *H*, *D* and *Z*. They are organised as 16 to a page, the data for days 1 to 16 of each month on one page, and the data for the remaining days of the month on the facing page. The *D* trace is plotted positive (east) upwards. The absolute level in each plot is indicated by the value shown to the left of the plots, in degrees for *D* and in nanoteslas for *H* and *Z*, which have been set to equal the relevant monthly mean values. The magnetogram scale values, shown to the right of the plots, are varied by multiples of two where necessary, and when changes are made this is indicated at the top of the magnetogram. This accounts for the occasional discontinuities in the traces at day boundaries.

6.2 Hourly mean values

Hourly mean values, centred on the UT half-hour, are computed from the one-minute values. They are not computed if there are more than six one-minute values missing. The hourly mean data are plotted at a constant scale in 27-day batches, according to the Bartels rotation number. These plots show a number of features of geomagnetic field variations including diurnal variation, and seasonal changes in its magnitude, and periods of geomagnetic disturbance. By plotting the data in 27-day batches, recurrent disturbances caused by active regions on the Sun, which persist for more than one solar rotation, are highlighted. Changes due to secular variation at the UK observatories over the course of a year are small compared to diurnal variations and disturbances. However, the gradual drift eastwards in *D* is discernible in the plots.

6.3 Daily mean, minimum and maximum values

Daily mean values and the daily maximum and minimum values are calculated from the one-minute values. Daily means are not computed if there are more than 144 one-minute values (2 hours and 24 minutes) missing. In the plots of daily mean values, secular variation is quite clear in *H*, *D*, *Z* and *F* as shorter period variations are attenuated by the averaging. The reference values shown on the left sides of the daily mean plots are the annual mean values. The black shading indicates when the daily mean was less than the annual mean; the white part indicates when the daily mean was greater. The plots of daily maximum and minimum values are also plotted. These are shaded black and white relative to the daily means.

6.4 Monthly mean values

Monthly mean values are calculated from the daily mean values. Monthly means are not computed if there are more than 3 missing daily values. At each stage of processing the mean values of the remaining geomagnetic elements are calculated from the corresponding mean values of *H*, *D* and *Z*. Annual mean values are also calculated from the daily mean values. If there are more than 36 missing daily values they are not computed. The monthly mean and annual mean values for all the geomagnetic elements are tabulated. Declination and inclination are expressed in degrees and decimal minutes of arc, the units of all the other elements are nanoteslas. Monthly and annual mean values are also calculated for the five international quiet days and the five international disturbed days in each month.

6.5 K indices

The *K* index summarises geomagnetic activity at an observatory by assigning a code, an integer from 0 to 9, to each 3-hour UT interval. The index values are determined from the ranges in *H* and *D* (scaled into nT), with allowance made for the regular diurnal variation. The method for computing *K* indices is described by Clark (1992). The *K* index has a Local Time and seasonal dependence associated with the geographic and geomagnetic co-ordinates of the observatory. The complete sets of *K* indices for each of the UK observatories are tabulated throughout the year.

A summary of the occurrence of each *K* index in 1997 is given below (there were no intervals of missing *K* indices at any of the three UK observatories).

	K Index									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
LER	993	950	609	244	83	23	12	5	1	0
ESK	735	931	687	394	139	29	5	0	0	0
HAD	499	1078	720	406	167	45	5	0	0	0

A number of 3-hour geomagnetic indices are computed by combining *K* indices from networks of observatories to characterise global activity levels and to eliminate Local Time and seasonal effects. *K* indices from each of the three UK observatories are used in deriving the planetary geomagnetic activity indices *Kp*, *Kn* and *Km*, sanctioned by the International Association of Geomagnetism and Aeronomy (IAGA). The *K* indices from Hartland and Canberra (approximately antipodal to Hartland) are used to produce the *aa* index, a further planetary activity index. Daily, monthly and annual mean values of the *aa* index have been computed in Edinburgh and are listed following the tables of *K* indices for Hartland. (Definitive values of the indices recognised by IAGA are published by the International Service for Geomagnetic Indices, St. Maur, France.) The derivation of the geomagnetic activity indices mentioned here is described in great detail by Mayaud (1980).

6.6 Rapid variations

The scaling of rapid variations is performed according to the guidelines given in the Provisional Atlas of Rapid Variations (IAGA, 1961). Occurrences of Solar Flare Effects (SFEs), Sudden Impulses (SIs) and Storm Sudden Commencements (SSCs) are given along with the time, amplitude and quality of the event.

6.7 Annual mean values

The annual mean values at each observatory since operations began are tabulated. Declination and inclination are expressed in degrees and decimal minutes of arc, the units of all the other elements are nanoteslas. Plots of the annual mean values of *H*; *D*, *Z* and *F* and of first differences of the annual means, representing secular variation at the observatories are presented. In the case of Hartland, annual mean values from Abinger observatory for 1925.5-56.5 have been included in the table. The plots for Hartland also include values from Abinger, taking into account the site differences between the two observatories determined during 1957 when both observatories operated simultaneously for a period of time.

7. DATA AVAILABILITY

One-minute mean values of geomagnetic elements at each of the UK observatories are available in digital form from 1983 onwards. Hourly mean values are available in digital form for Lerwick (1926-present), Eskdalemuir (1911-present), Abinger (1926-57) and Hartland (1957-present). *K* indices from the current UK observatories are available in digital form from 1954 onwards. In its role as the World Data Centre C1 for Geomagnetism, the Global Seismology and Geomagnetism Group also holds a selection of hourly mean values and annual mean values from observatories world-wide. Digital data can be transferred directly by electronic mail or *ftp* over the Internet. Up to date UK observatory hourly mean values, *K* indices and geomagnetic activity forecasts are also available on the group's world-wide-web pages. For more information contact:

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Global Seismology and Geomagnetism Group
British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
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☎:	+44 (0) 131 667 1000
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Telex:	727343 SEISED G
Email:	e.clarke@bgs.ac.uk
Internet:	http://www.nmh.ac.uk/

8. GEOMAGNETISM STAFF LIST 1997

In April 1997, the Geomagnetism Group merged with the Global Seismology Research Group to form the Global Seismology and Geomagnetism Group. The list below shows the members of staff who were involved in the geomagnetism programme.

Edinburgh

Group Manager (Grade 6)	Dr D J Kerridge
PSec	Mrs M Milne
Grade 7	Dr D R Barraclough
	Dr T D G Clark
	J C Riddick
SSO	Dr S Macmillan
	Dr A W P Thomson
HSO	E Clarke
	S M Flower
	T J Harris
	E M Reader *
SO	J G Carrigan
	C W Turbitt
ASO	J McDonald **
Casual	P Woodhall

Eskdalemuir

Craftsman	W E Scott
Cleaner	Mrs M Scott

Hartland

PGS E	C R Pringle

* After a career in BGS spanning 32 years, stationed both at Hartland observatory and in Edinburgh, Mr E. M. Reader retired at the end of March 1997.

** Mr J. McDonald died in service in September 1997. John had been a valuable member of the group in Edinburgh for 26 years. He is and will continue to be sadly missed.

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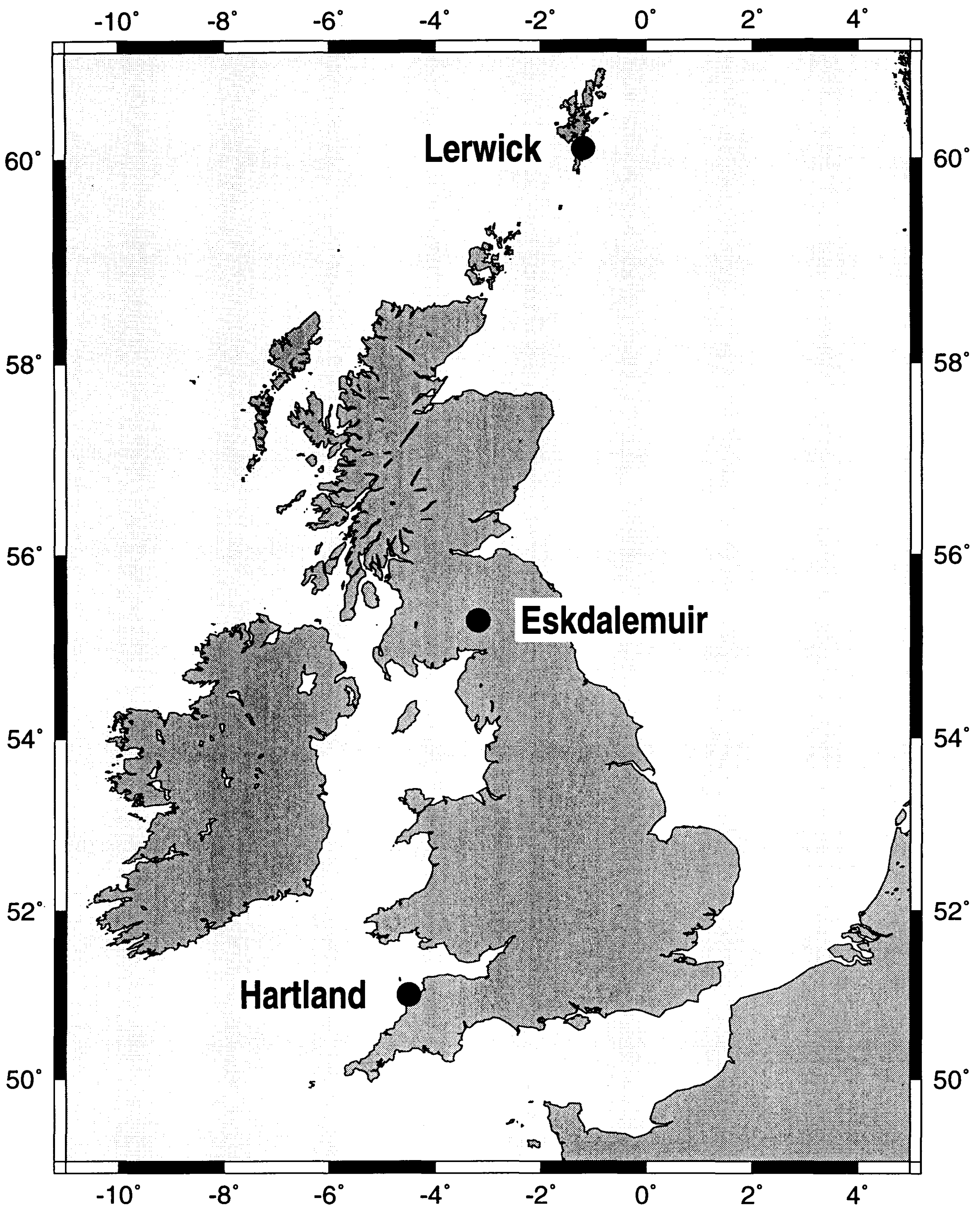
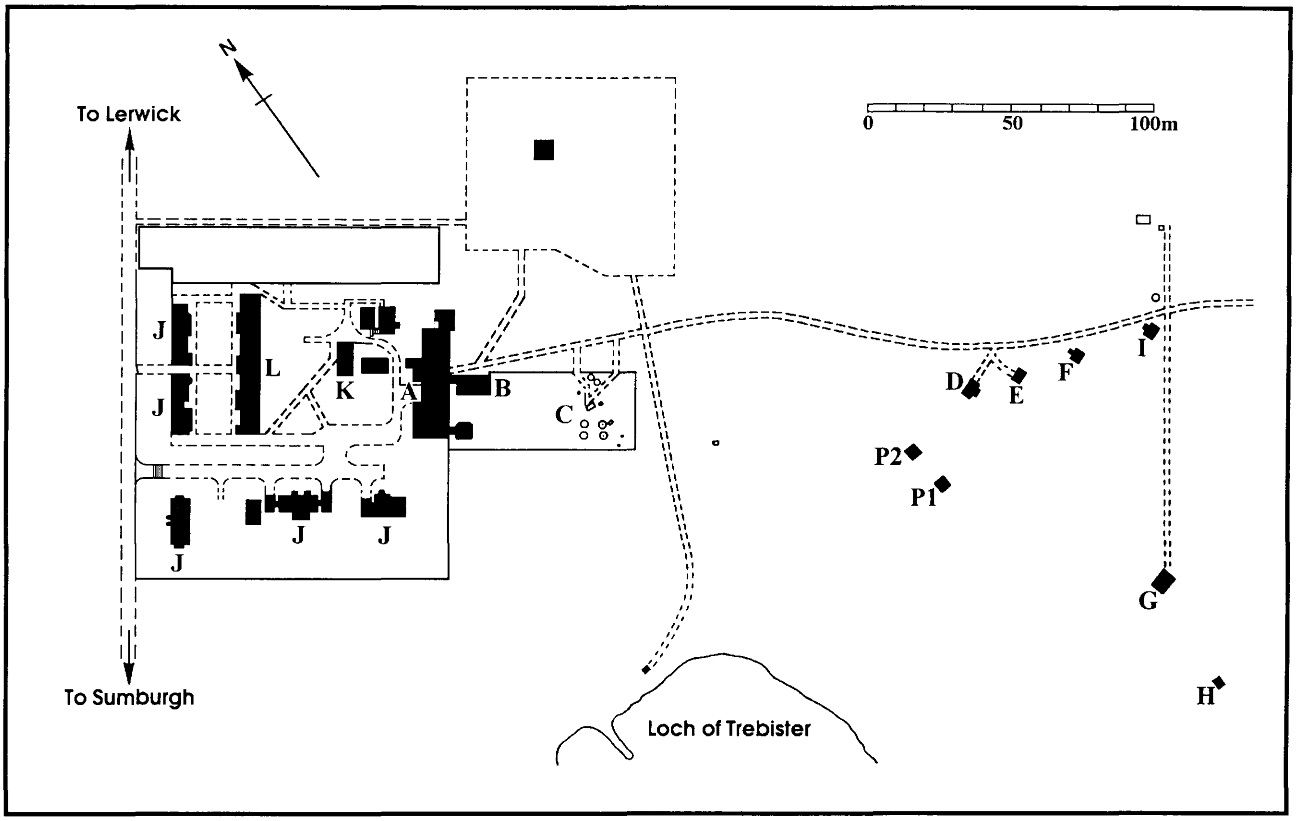


Figure 1. **Map showing the location of the three UK geomagnetic observatories**

Lerwick Observatory



Observatory Layout

A	Main observatory building
B	BGS office, seismic recorders
C	Meteorological instrument enclosure
D	Absolute hut
E	Instrument hut
F	Variometer house
G	West hut
H	Azimuth mark
I	Back-up fluxgate data logger & METEOSAT transmitter
J	Staff houses
K	Standby generator
L	Staff hostel
P1	Unused proton magnetometer
P2	GAUSS proton magnetometer & $\delta D/\delta I$ coils

Instrument Deployment

Absolute Hut
PVM (used only as PPM for F measurements)
D/I fluxgate theodolite

The fixed mark (azimuth 8° 38' 02" E of S) is viewed through a sliding panel in the hut door.

Instrument Hut
GAUSS logger
Uninterruptable power supply (UPS)

Variometer House
GAUSS fluxgate sensor (*HDZ*)
Back-up fluxgate sensors (*HDZ*)

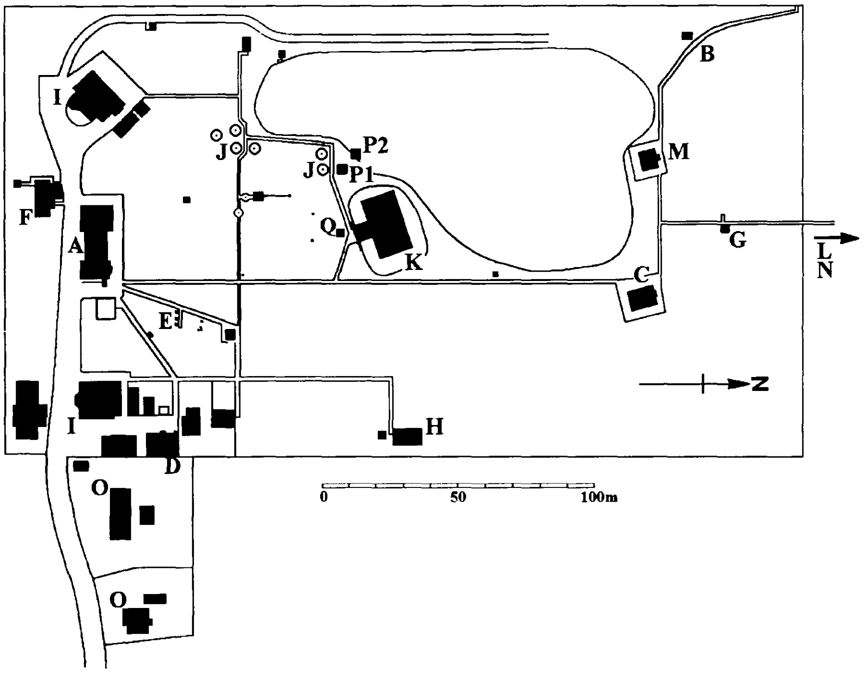
The variometer house is constructed from non-magnetic concrete and has internal dimensions of 4.9 by 3 meters. The roof is semi-circular in cross section. The temperature of the house is controlled to a diurnal range of ±1°C. The meridian at the time of construction is defined on the north and south walls.

West Hut
Remote fluxgate magnetometer transmitting via METEOSAT.

Previous descriptions
The observatory is described by Harper (1950) and Tyldesley (1971).

Figure 2. Lerwick observatory site diagram

Eskdalemuir Observatory



Observatory Layout

A	Main observatory building
B	Atmospheric pollution sampling
C	East absolute hut
D	Garage and standby generator
E	Meteorological instruments
F	Seismic laboratory, seismic recorders, offices, electronics laboratory
G	Hut G
H	Non-magnetic laboratory
I	Staff accommodation
J	Rain gauges
K	Underground variometer chamber
L	Seismic vault containing remote fluxgate (280 metres from boundary wall)
M	West absolute hut
N	Chemical sampling (Warren Spring Laboratory) (75 metres from boundary wall)
O	Private houses – formerly staff housing
P1	GAUSS proton magnetometer & $\delta D/\delta I$ coils
P2	Unused proton magnetometer
Q	METEOSAT transmitter

Instrument Deployment

Underground Variometer Chamber
GAUSS fluxgate sensor (*HDZ*)
Back-up fluxgate sensors (*HDZ*) transmitting to METEOSAT

The variometer chamber comprises two separate rooms inside a domed chamber covered with a thick layer of earth. The instruments are situated below ground level. The inside temperature is controlled to a diurnal range of ±0.5°C. The instrument room was created by extending the former porch back into the stairwell and entrance. Standby batteries are kept in a compartment under the floor. The entrance to the room is protected by an external porch.

Hut G
PVM electronics, digital clock and printer to record total field values during absolute observations.

East Absolute Hut
PVM (used only as PPM for F measurements)
D/I fluxgate theodolite
The fixed mark (azimuth 8° 12' 35" W of S) is viewed through a shutter on the south wall.

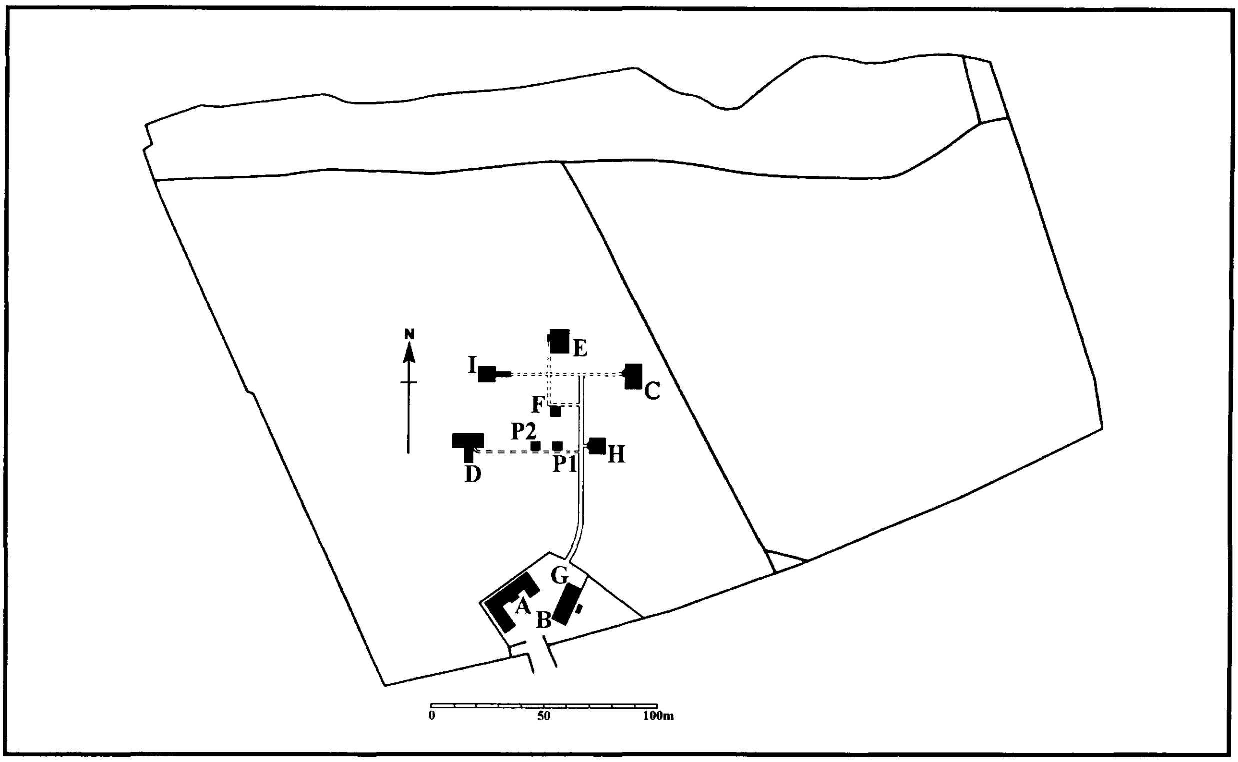
The Non-Magnetic Laboratory
The laboratory is used for instrument development and testing. It contains a sensor room with three piers and a larger room with a single pier.

West Absolute Hut
The hut contains three instrument piers. The fixed mark (azimuth 4° 36' 08" W of S) is viewed from the central pillar through a shutter on the south wall.

Previous descriptions
The observatory is described by Crichton (1950) and Blackwell (1958).

Figure 3. Eskdalemuir observatory site diagram

Hartland Observatory



Observatory Layout

A Main observatory building
B Caretakers house
C Absolute hut
D Non-magnetic laboratory
E Variometer house
F Instrument hut
G Garage
H Test hut 2
I Test hut 1
P1 Unused proton magnetometer
P2 Unused proton magnetometer & $\delta D/\delta I$ coils

Instrument Deployment

Absolute Hut
PVM (used only as PPM for F measurements)
D/I fluxgate theodolite
The fixed mark (azimuth 11° 27' 54" E of N) is viewed through a window in the north wall.

Variometer House
GAUSS fluxgate sensors (*HDZ*)
The variometer house comprises an entrance porch and a main room, which contains two separate internal rooms, each divided into three compartments. The temperature is controlled to a diurnal range of ±0.5°C. Two cable ducts connect the variometer house to the instrument hut.

The Non-Magnetic Laboratory
GAUSS proton magnetometer & $\delta D/\delta I$ coils (PVM)
Back-up fluxgate sensors (*HDZ*) transmitting to METEOSAT
Fluxgate system transmitting to the GOES satellite.

The laboratory was built in 1972 to provide accommodation for a rubidium-vapour magnetometer digital recording system. It comprises an instrument room and a sensor room with five instrument piers.

Instrument Hut
GAUSS logger
Standby batteries
Uninterruptable power supply (UPS)

Test Hut 1
Low field facility (LFF) comprising an orthogonal coil system of dimension ~2m and its power supply. The system consists of a pair of vertical-axis square coils and two pairs of horizontal-axis square coils for creating fields parallel and normal to the meridian.

Test Hut 2
Auxiliary measurement position. The fixed mark (azimuth 12° 52' 08" E of N) is viewed through a window in the north wall from the north-east theodolite position.

Previous descriptions
The observatory is discussed in Finch (1960) and Reader (1997).

Figure 4. Hartland observatory site diagram

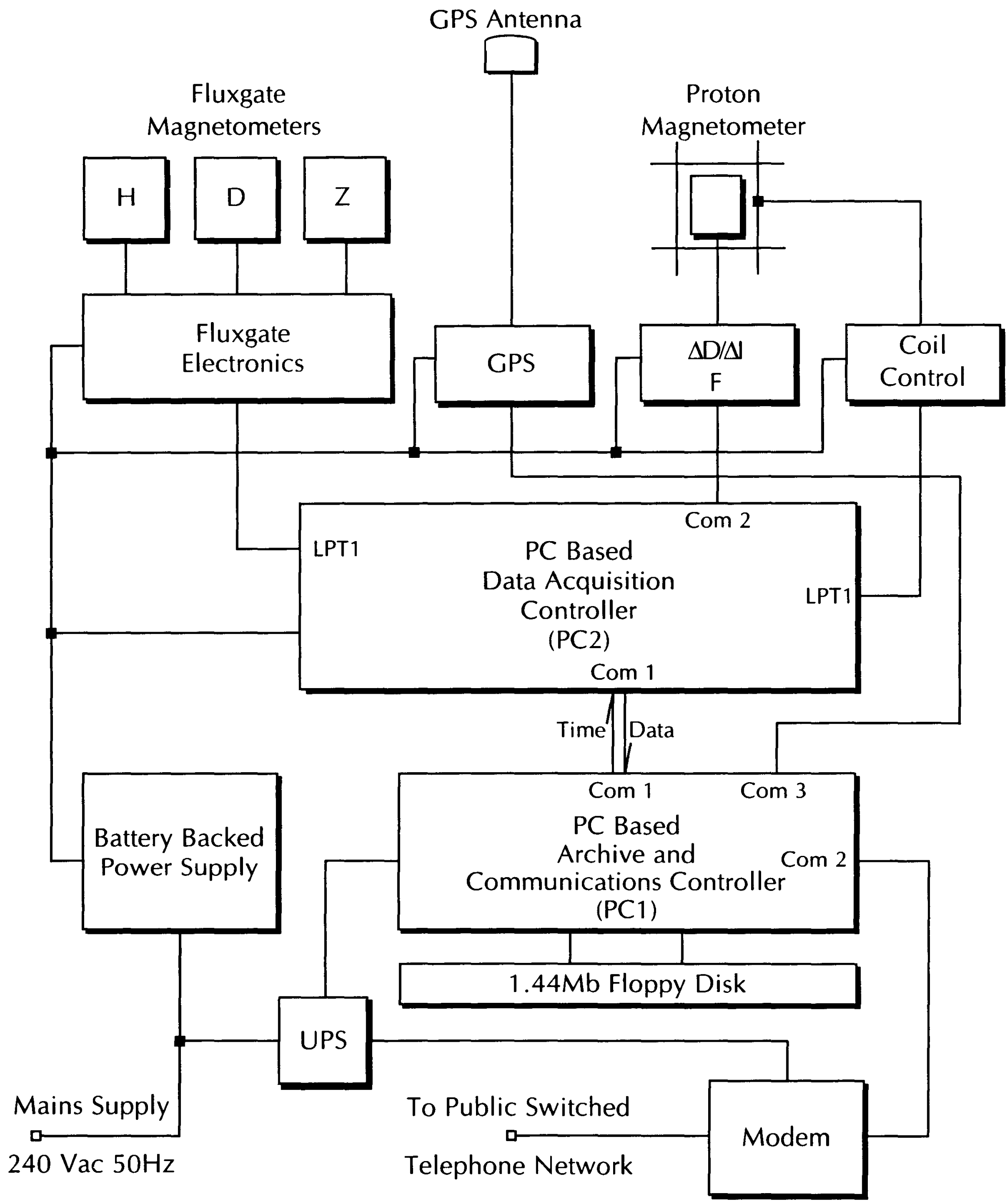


Figure 5. **Block diagram of the GAUSS system**

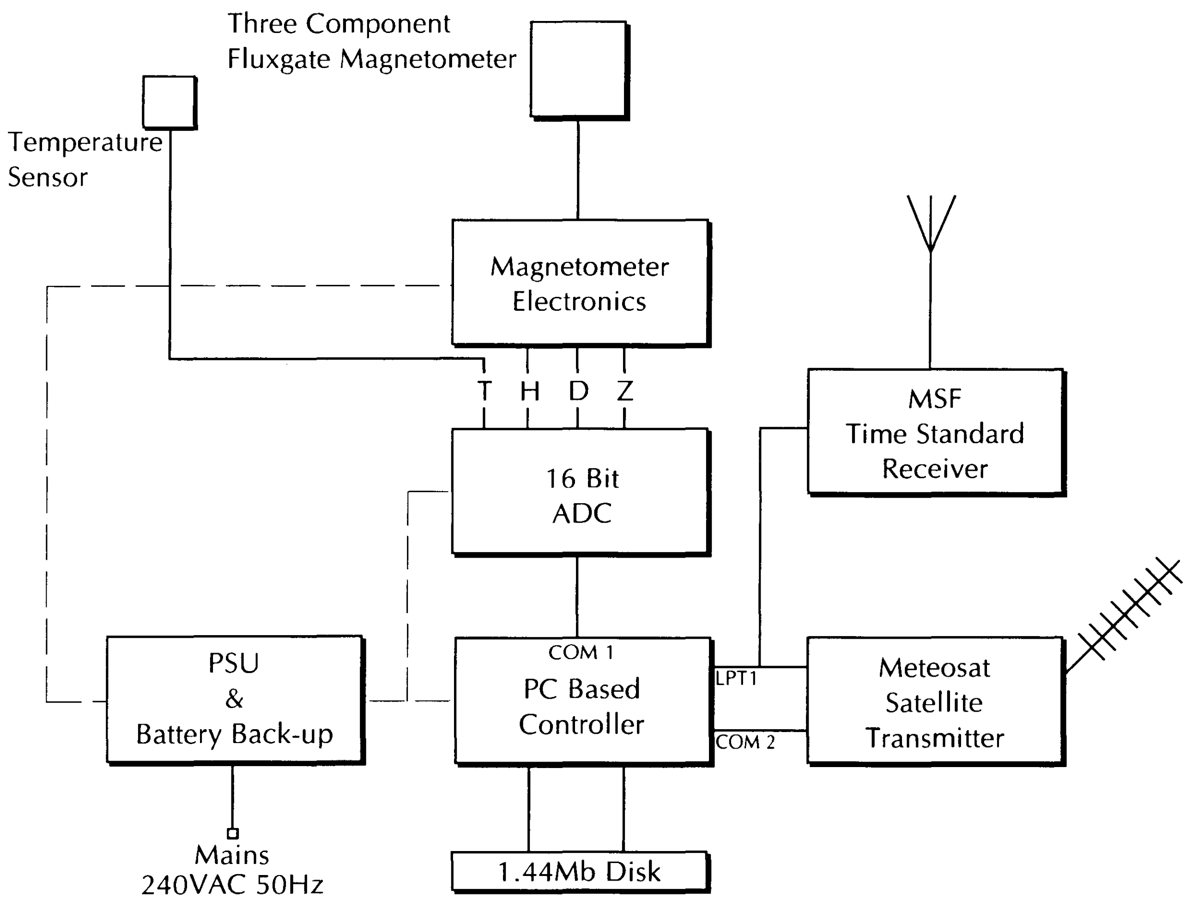


Figure 6. Block diagram of backup system

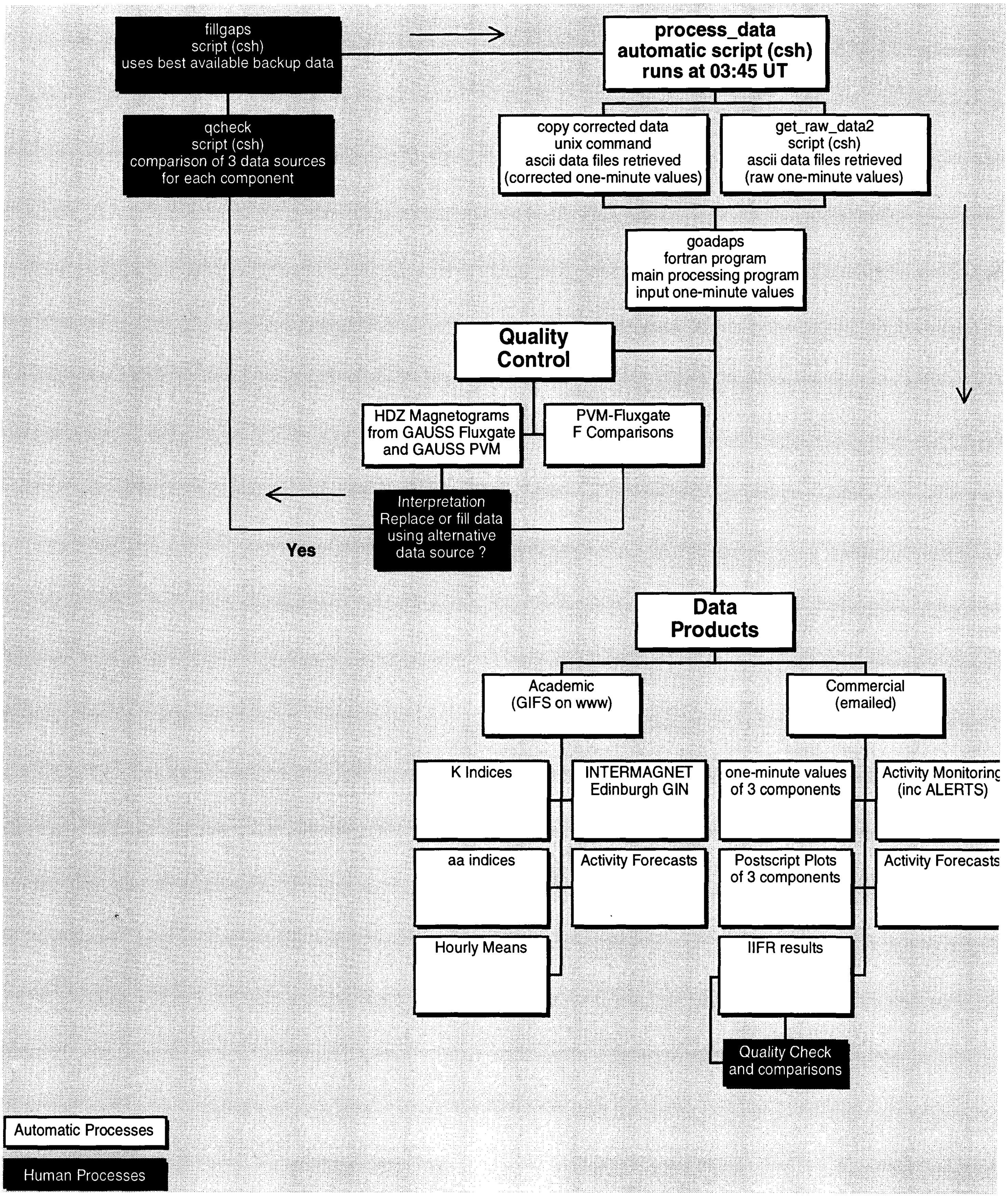


Figure 7. GAUSS data processing flow chart

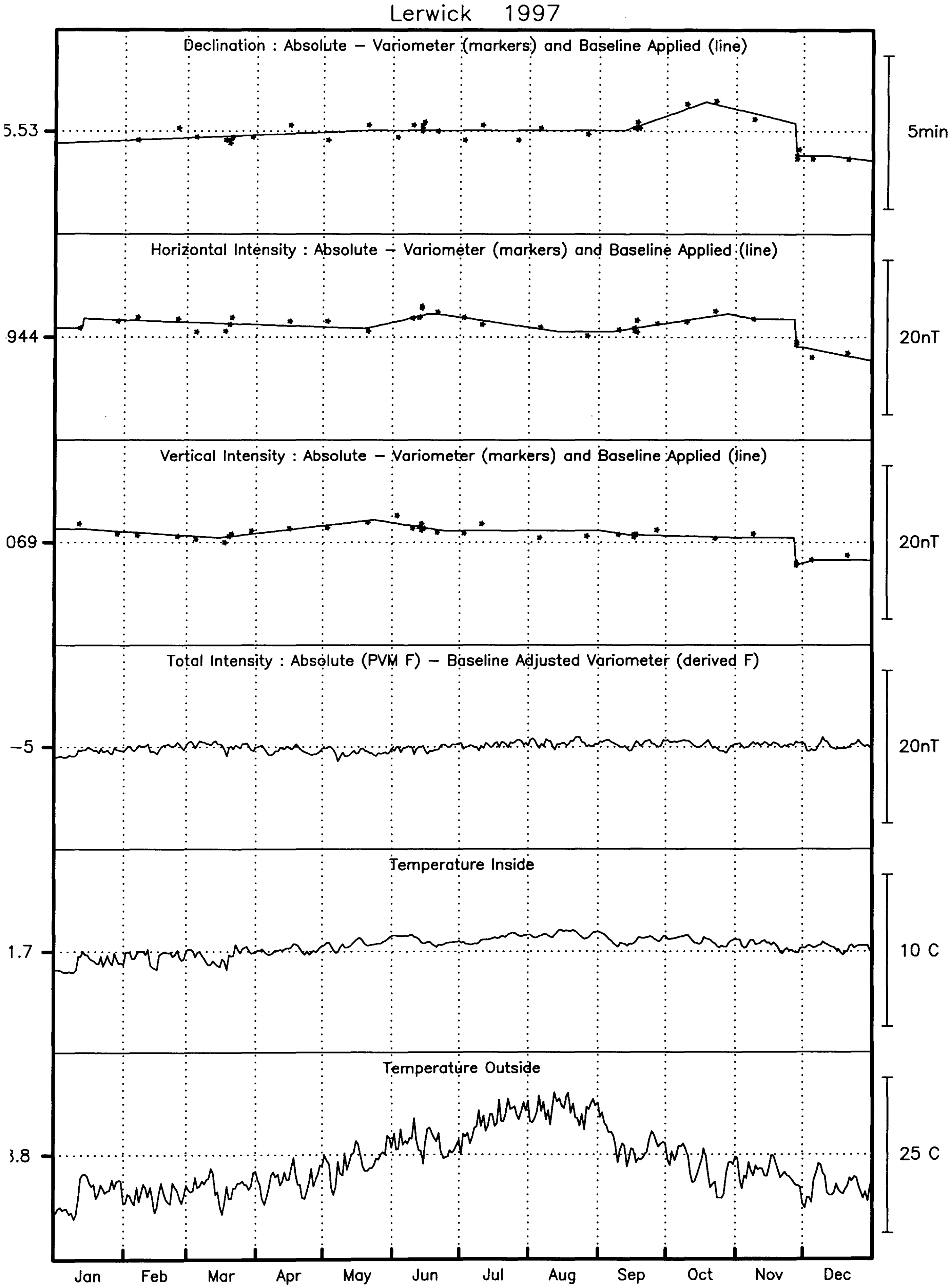


Figure 8. **Observed and allocated baselines at Lerwick**

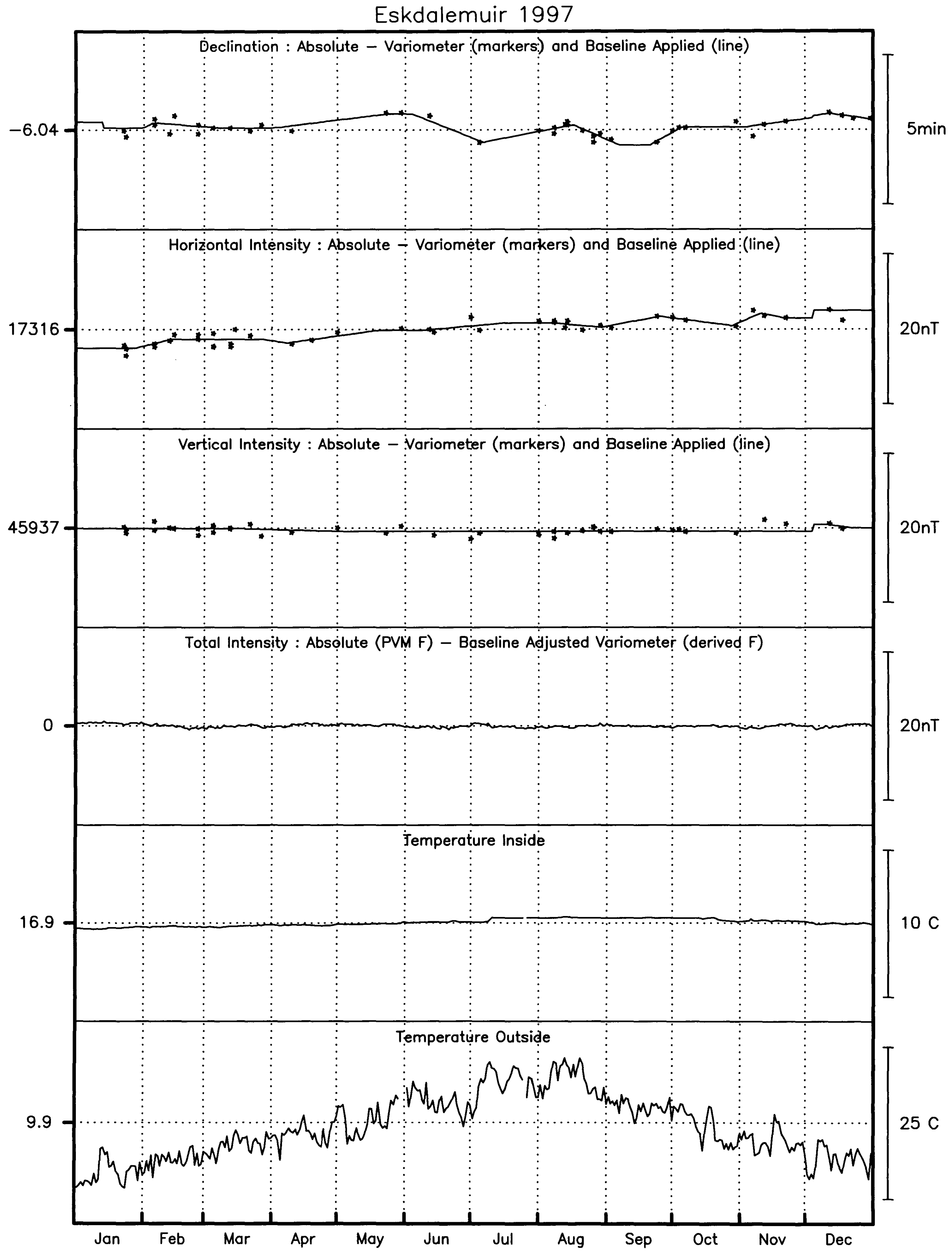


Figure 9. **Observed and allocated baselines at Eskdalemuir**

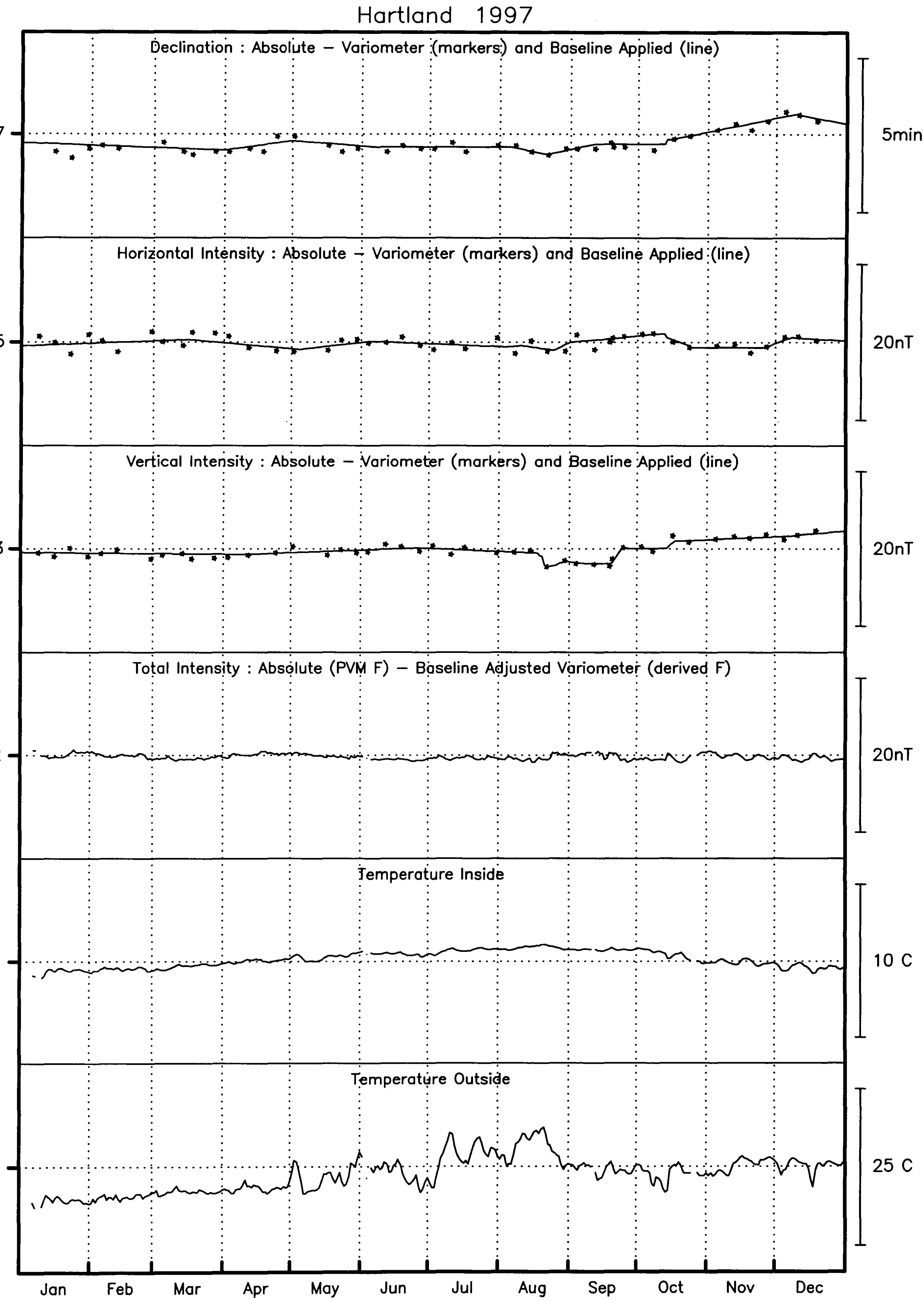
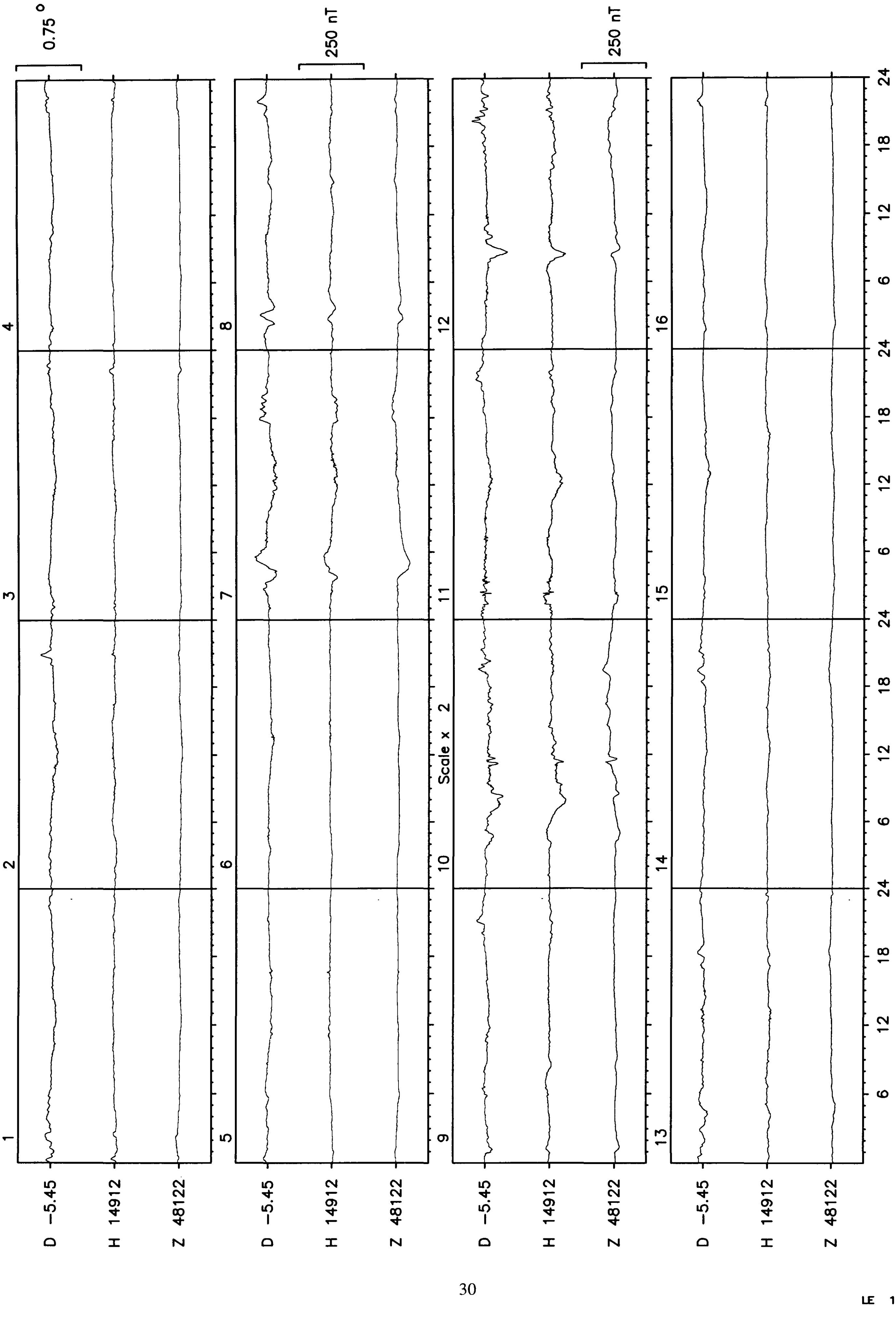


Figure 10. Observed and allocated baselines at Hartland

Lerwick 1997 Results

Lerwick January 1997



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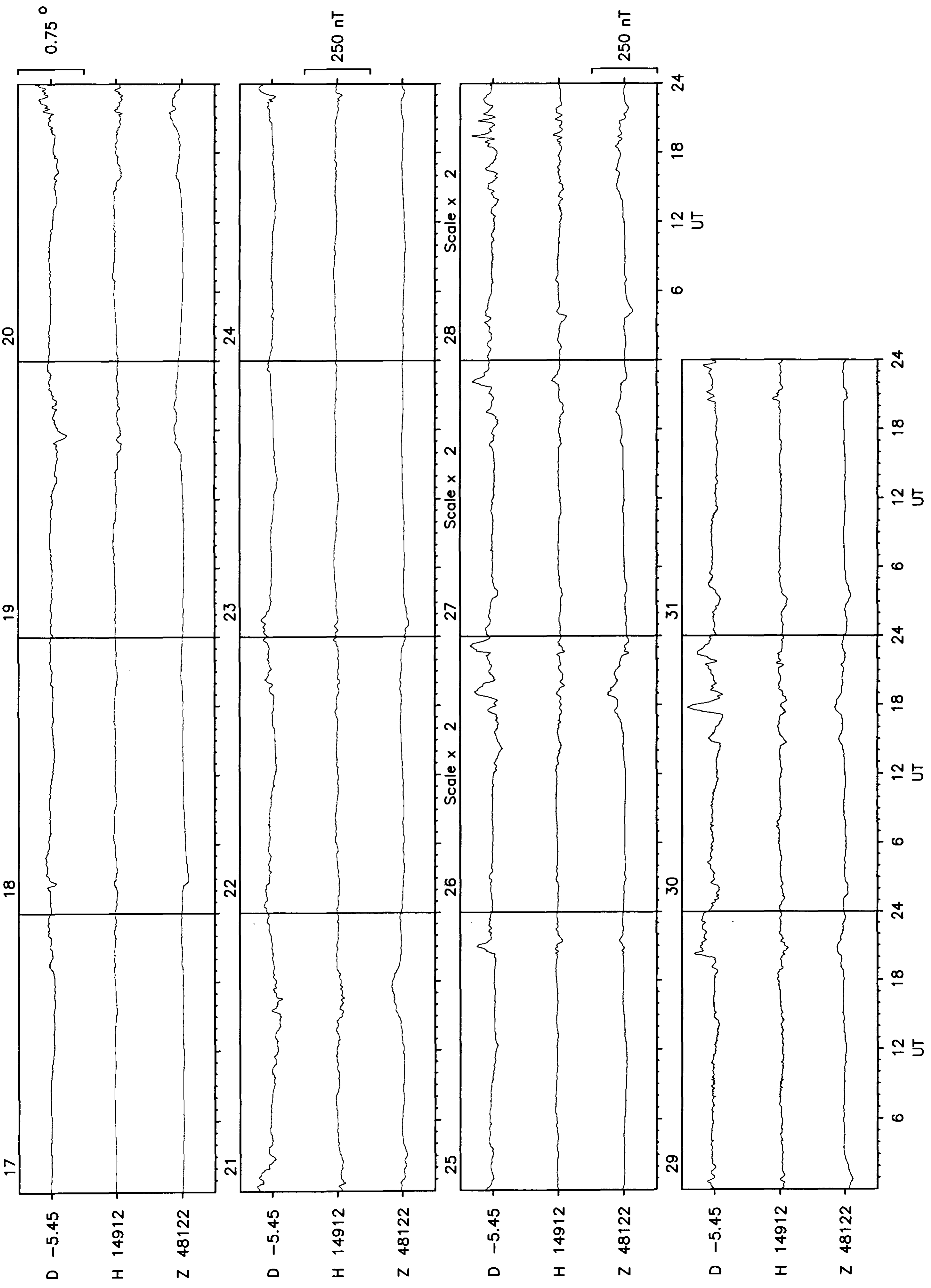

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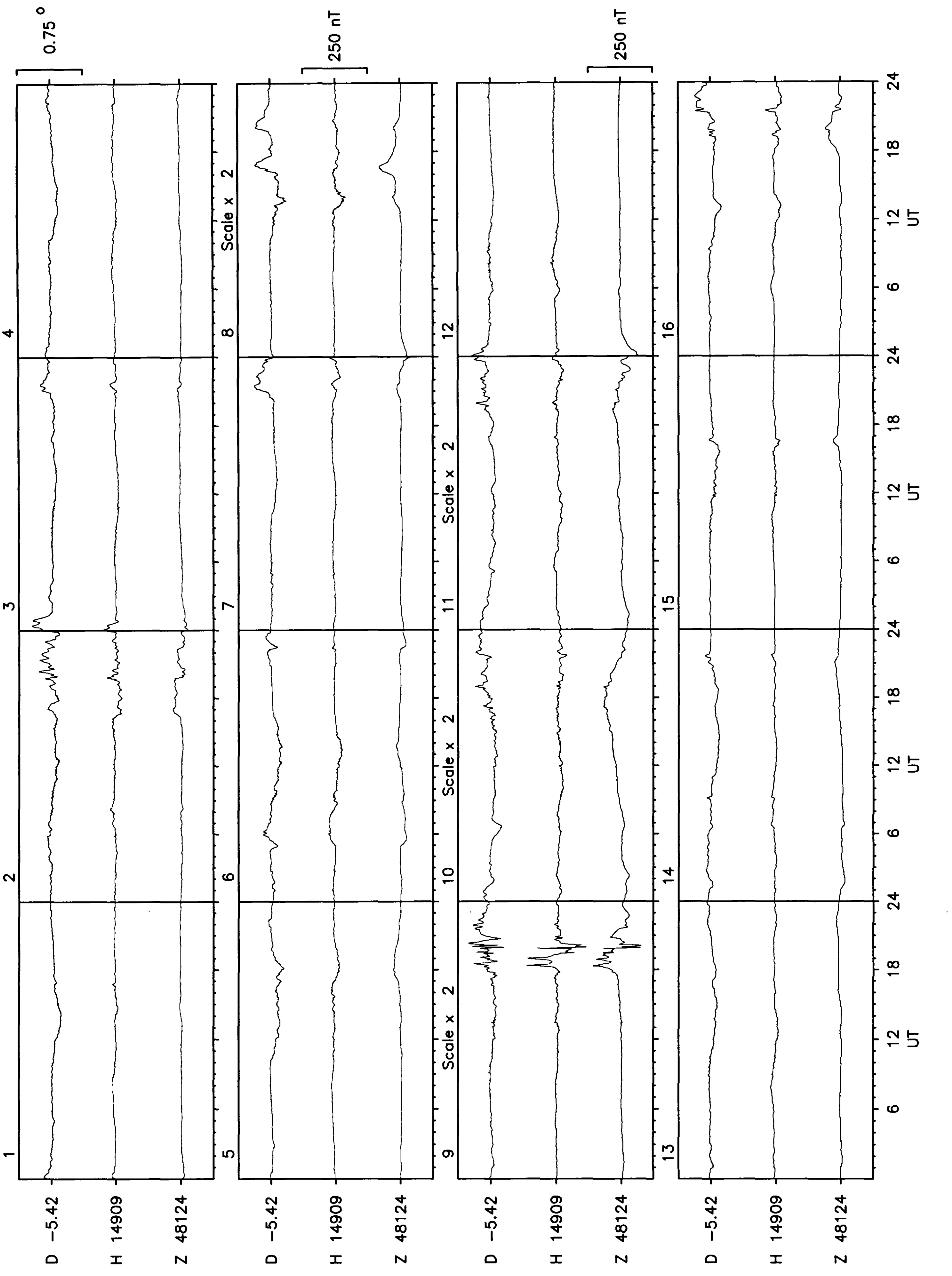

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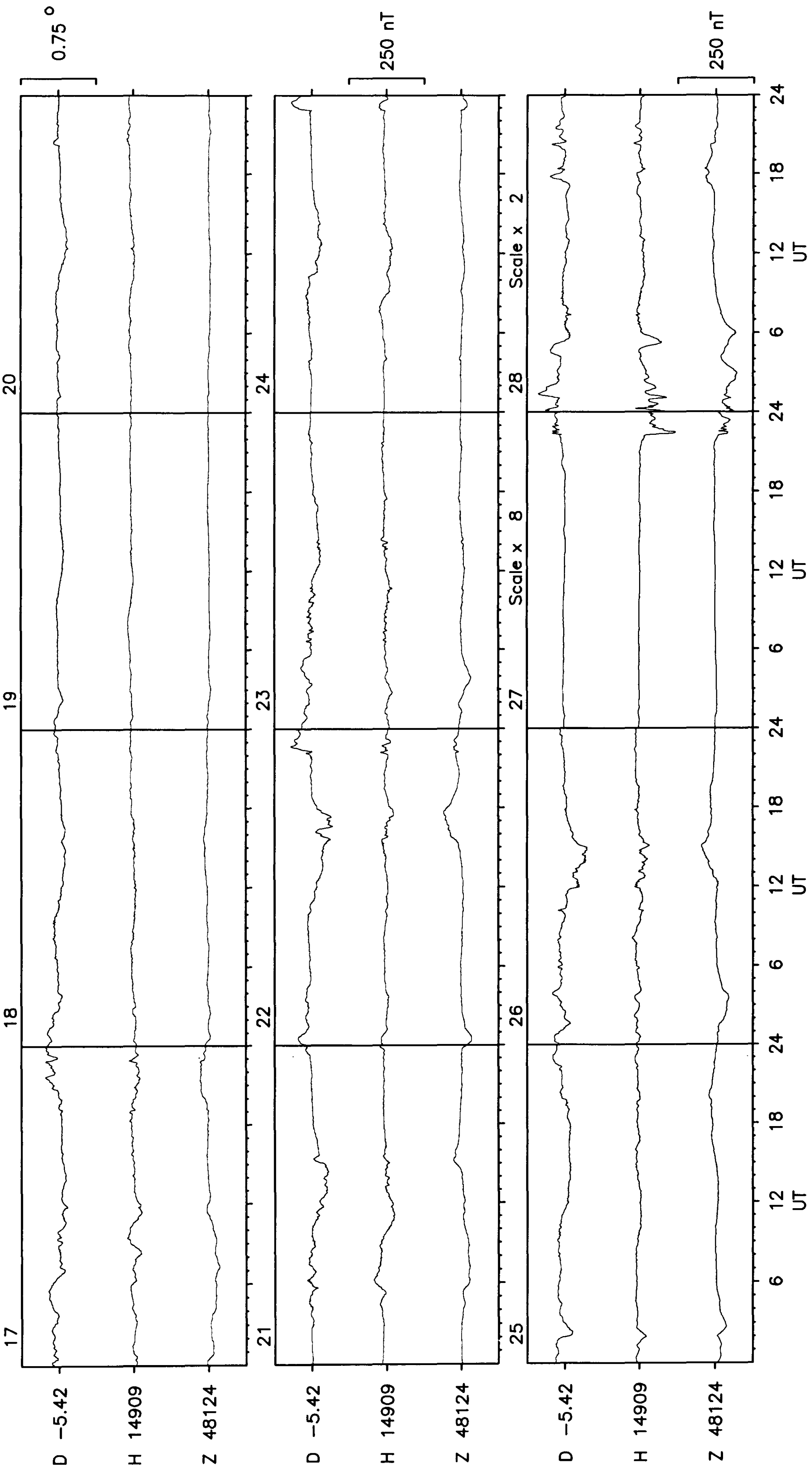

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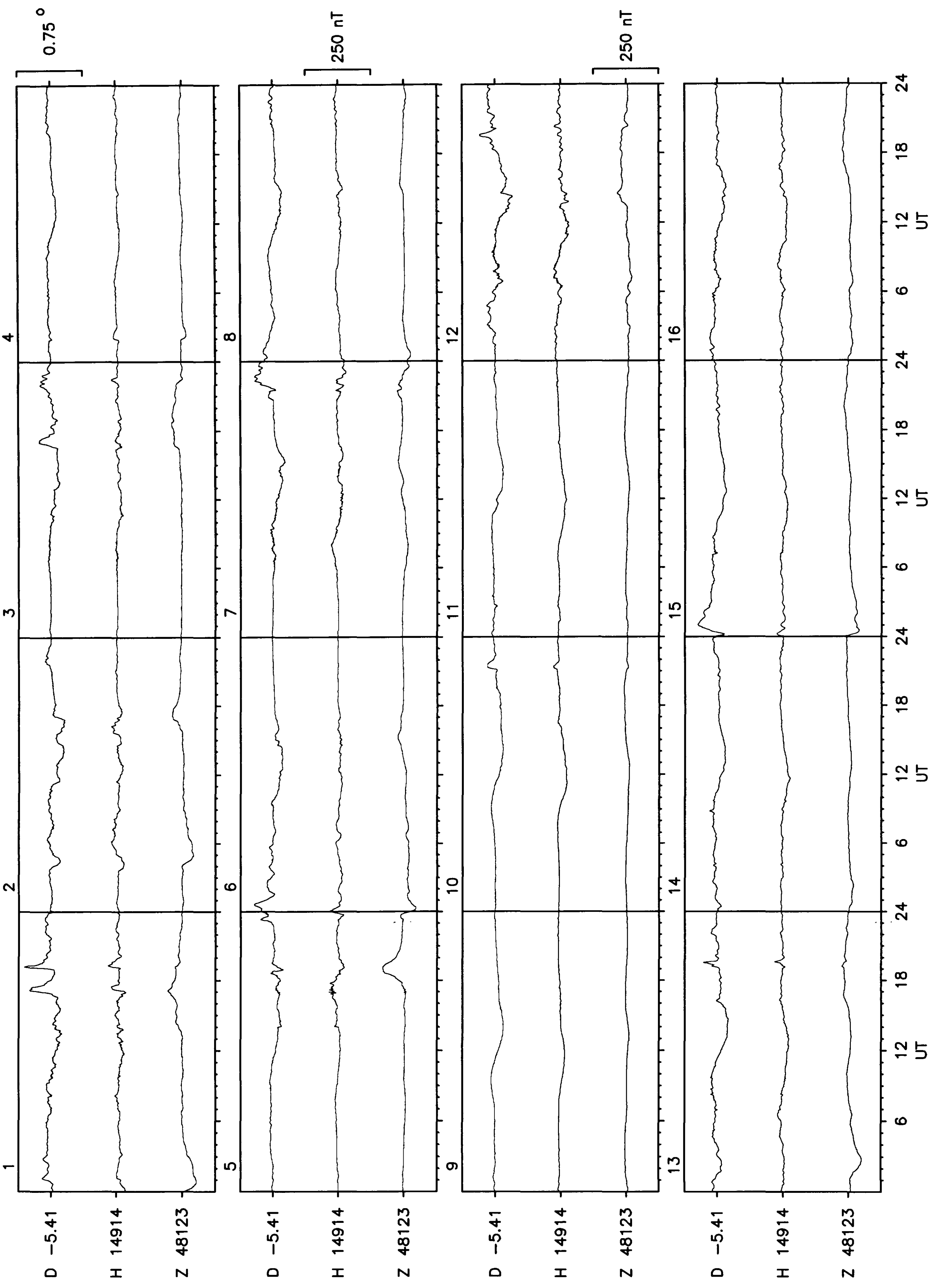

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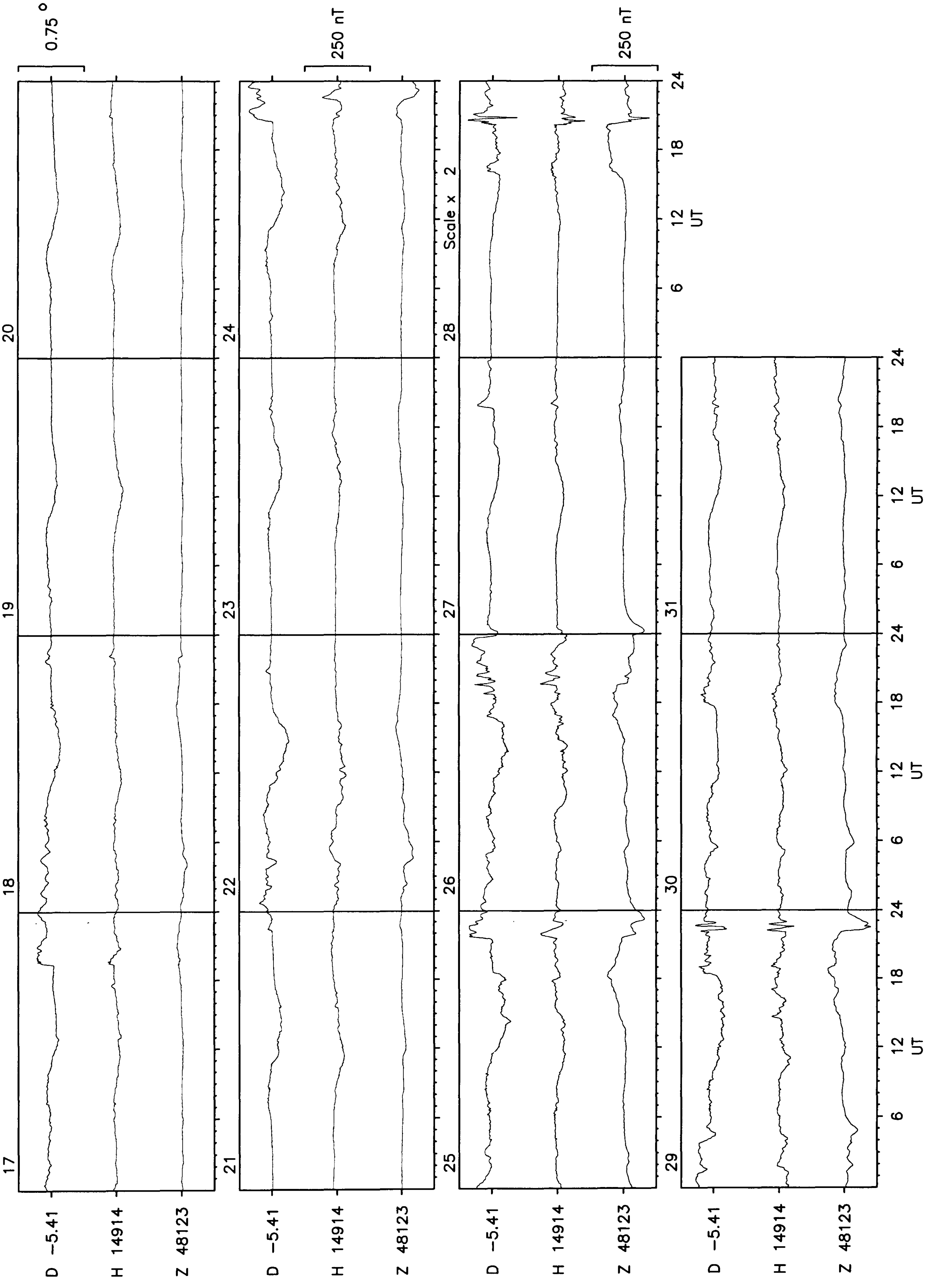

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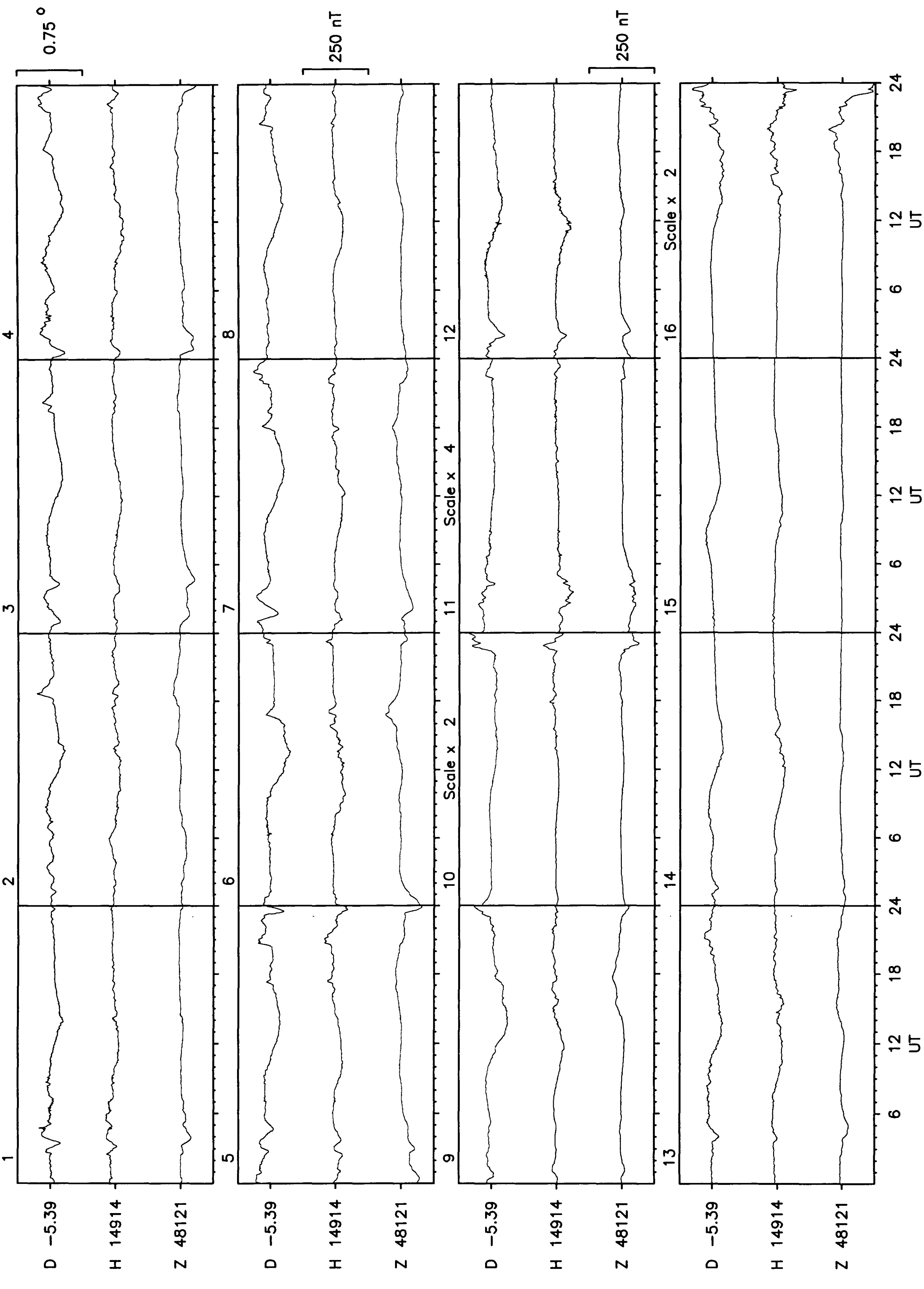

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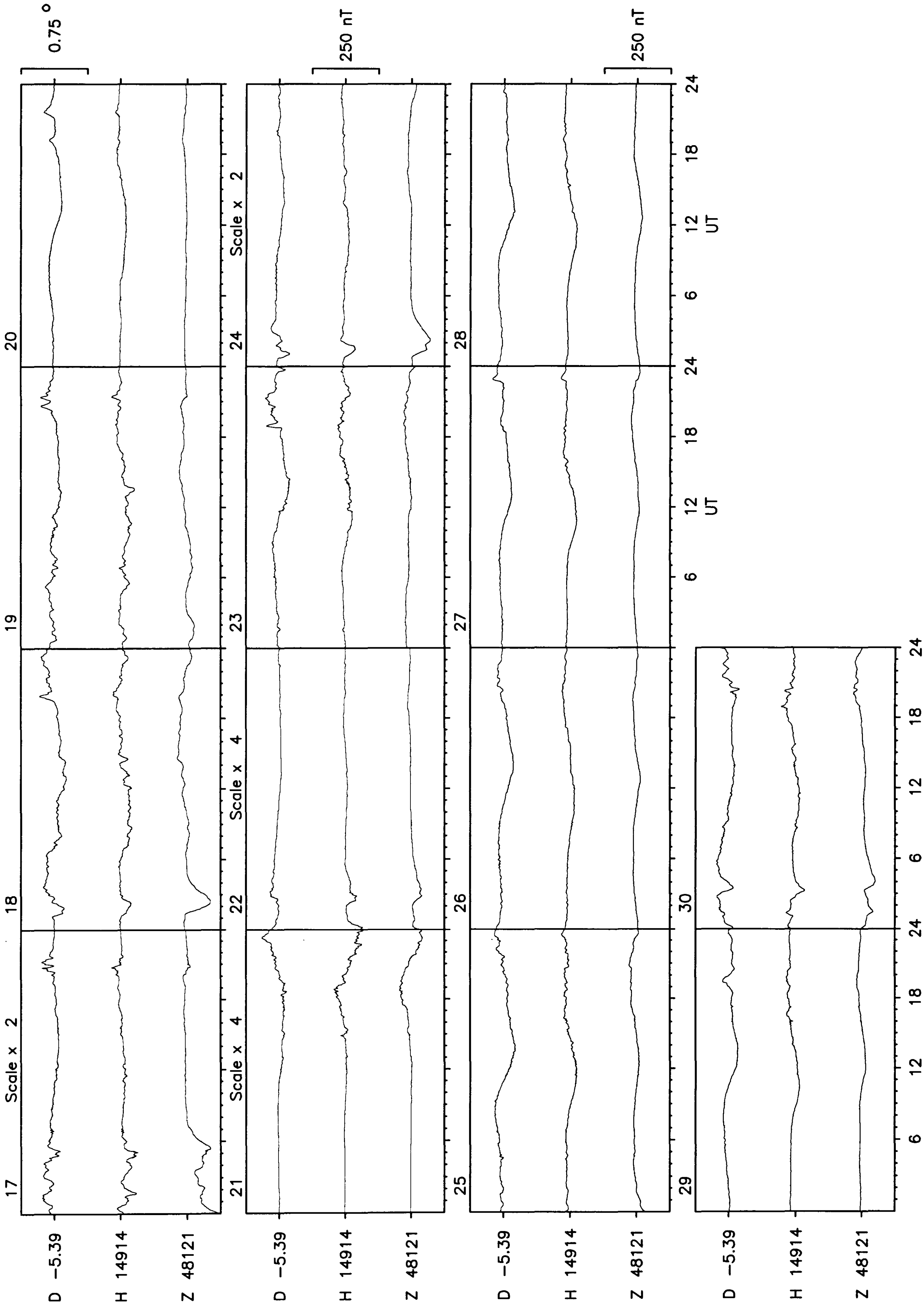

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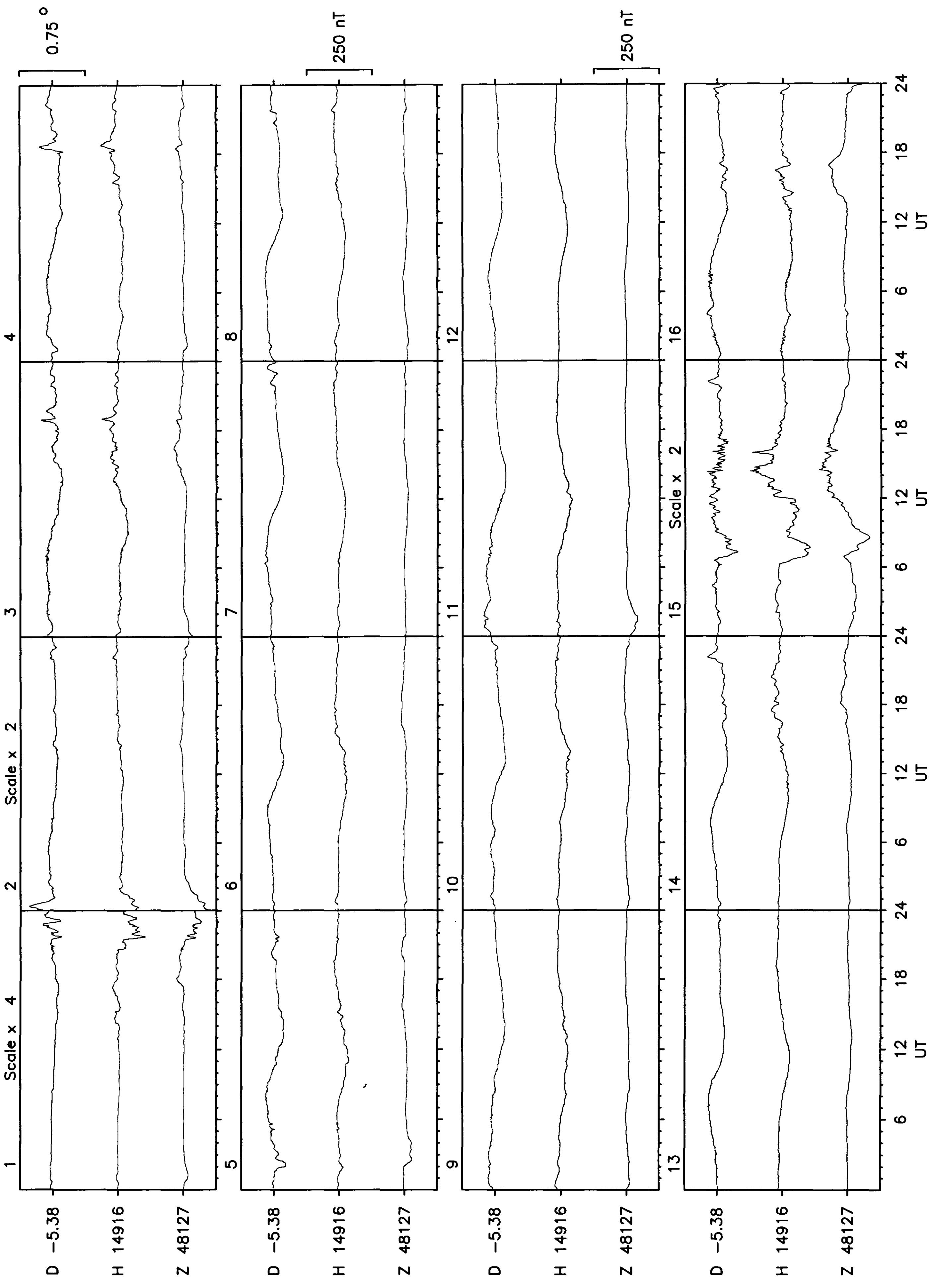
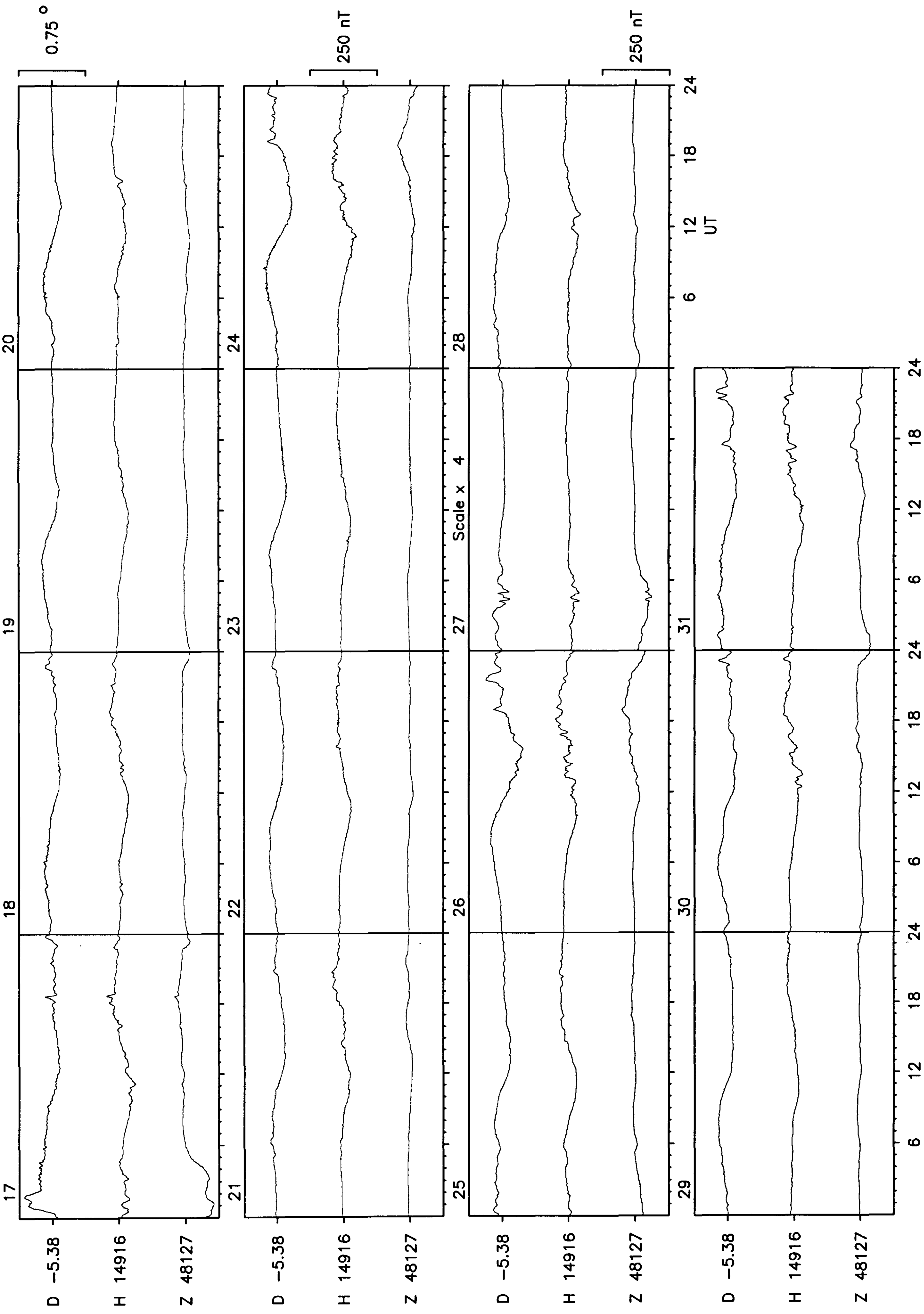


LE 5 97

Lerwick May 1997



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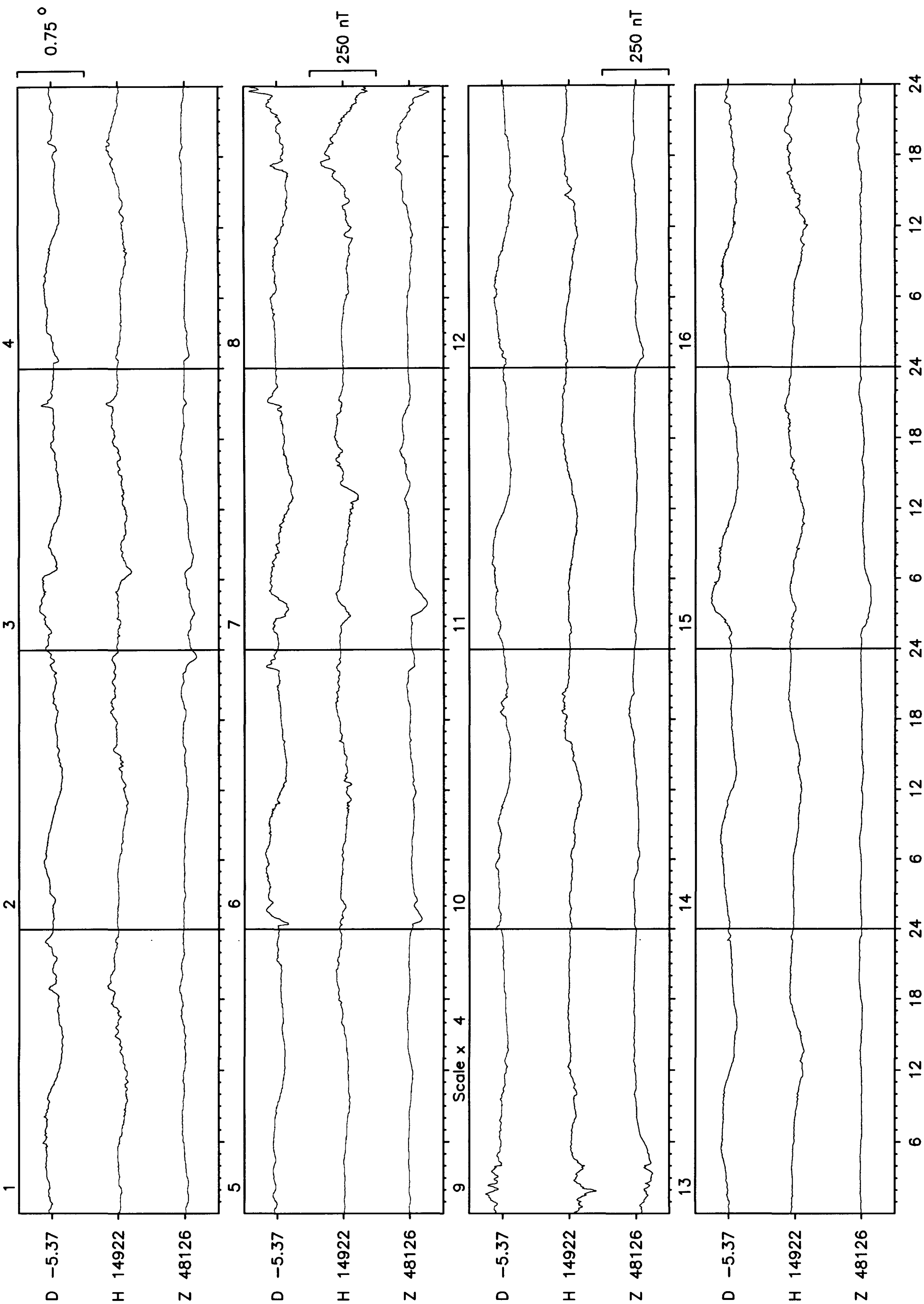

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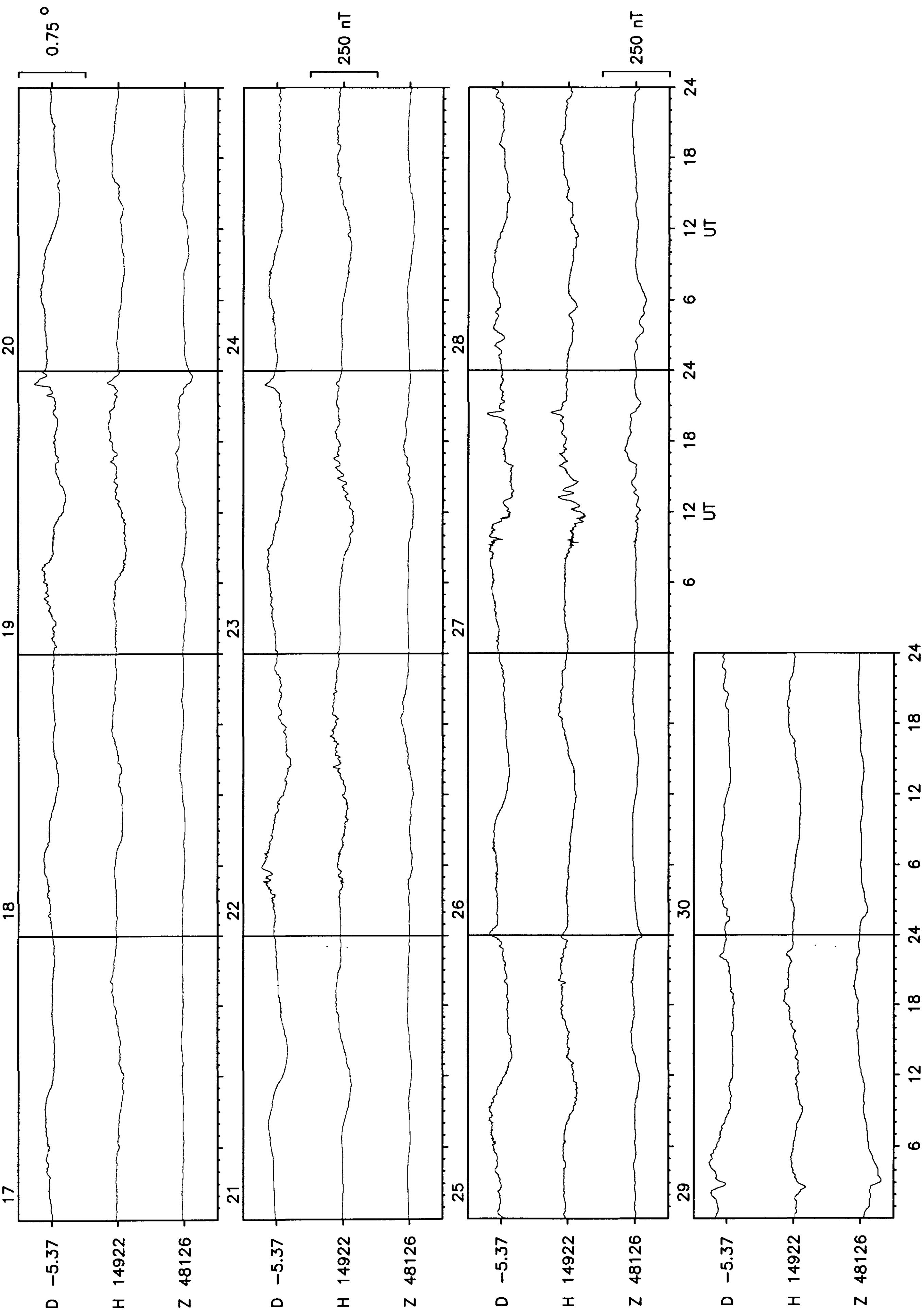

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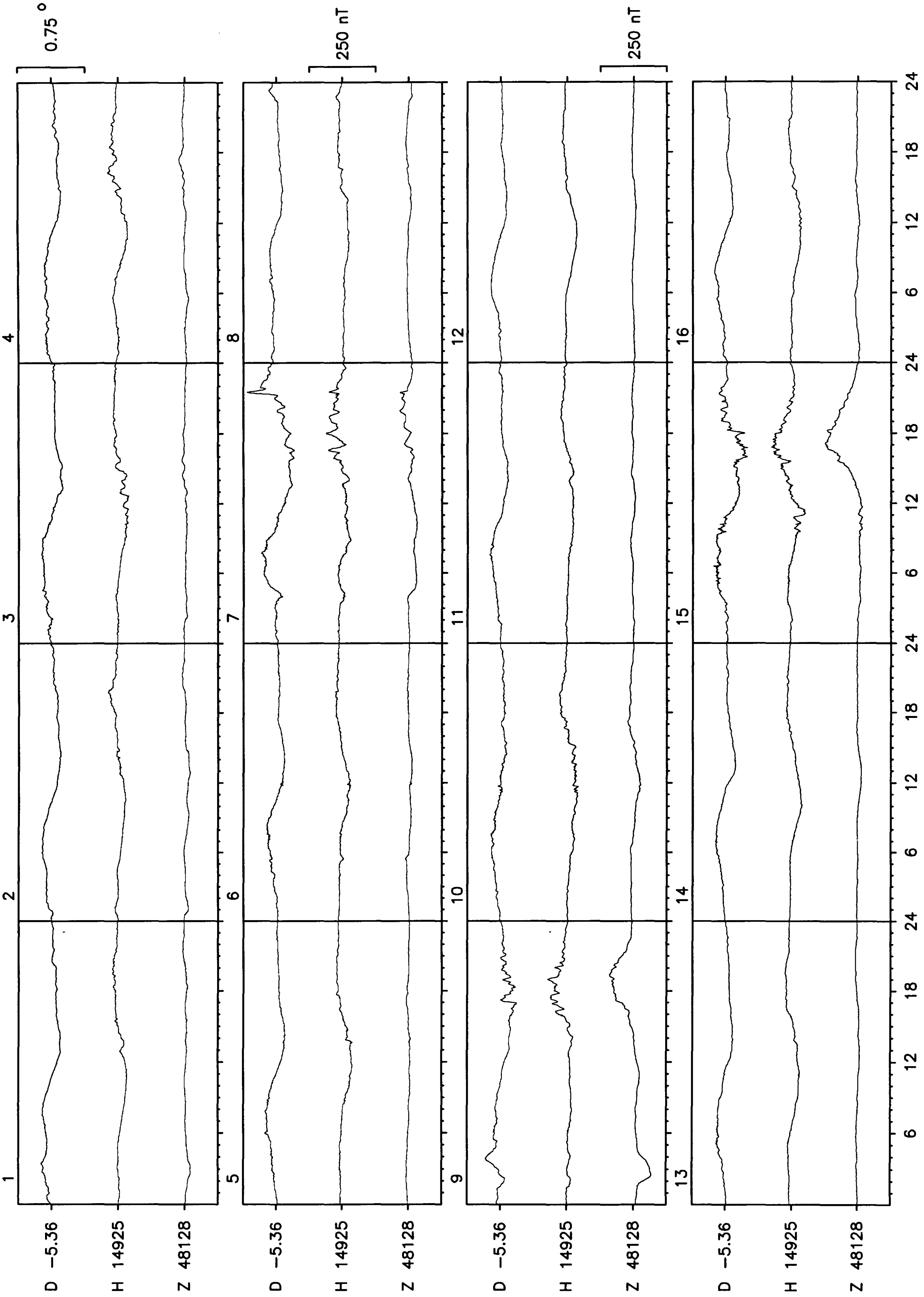

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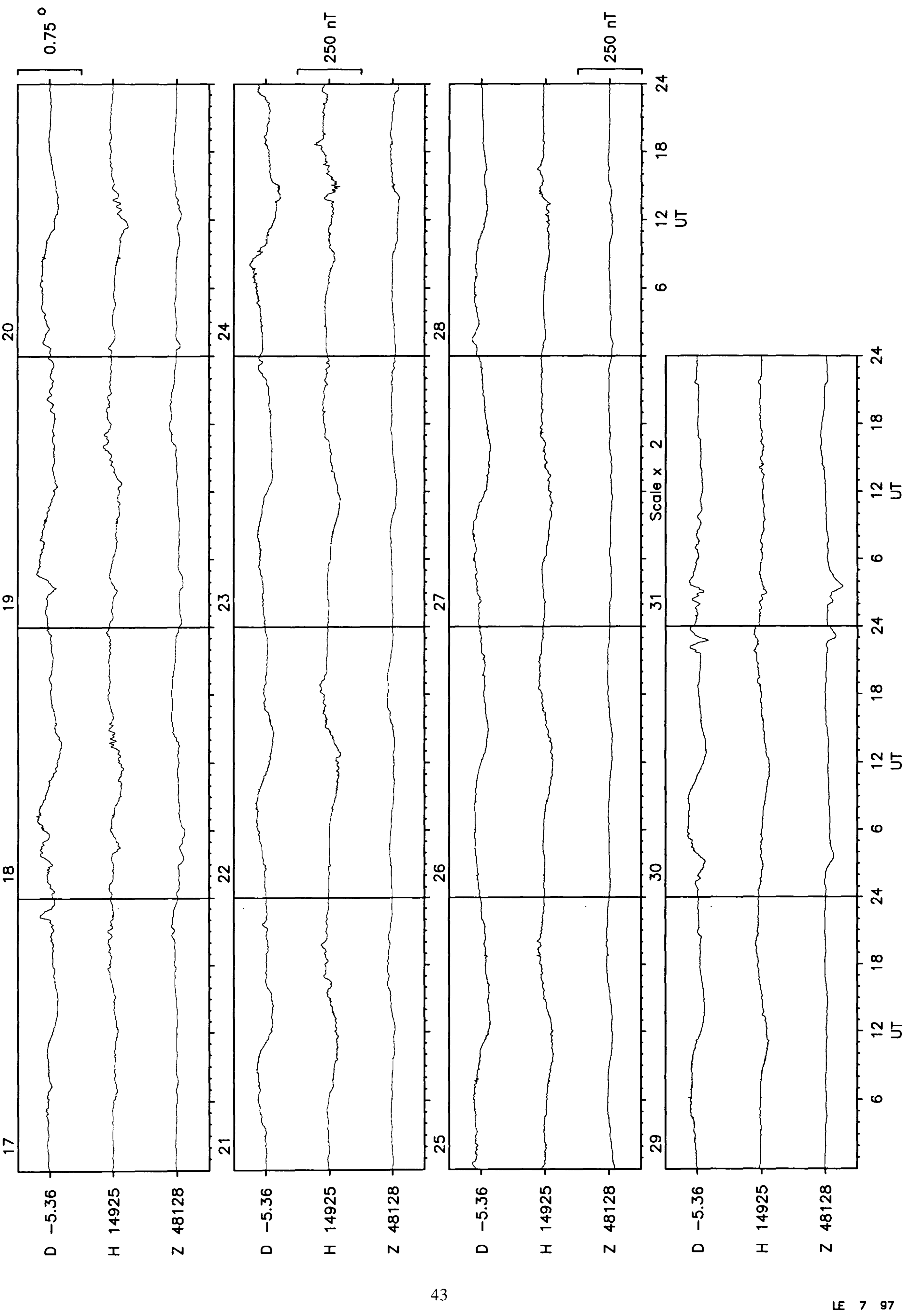

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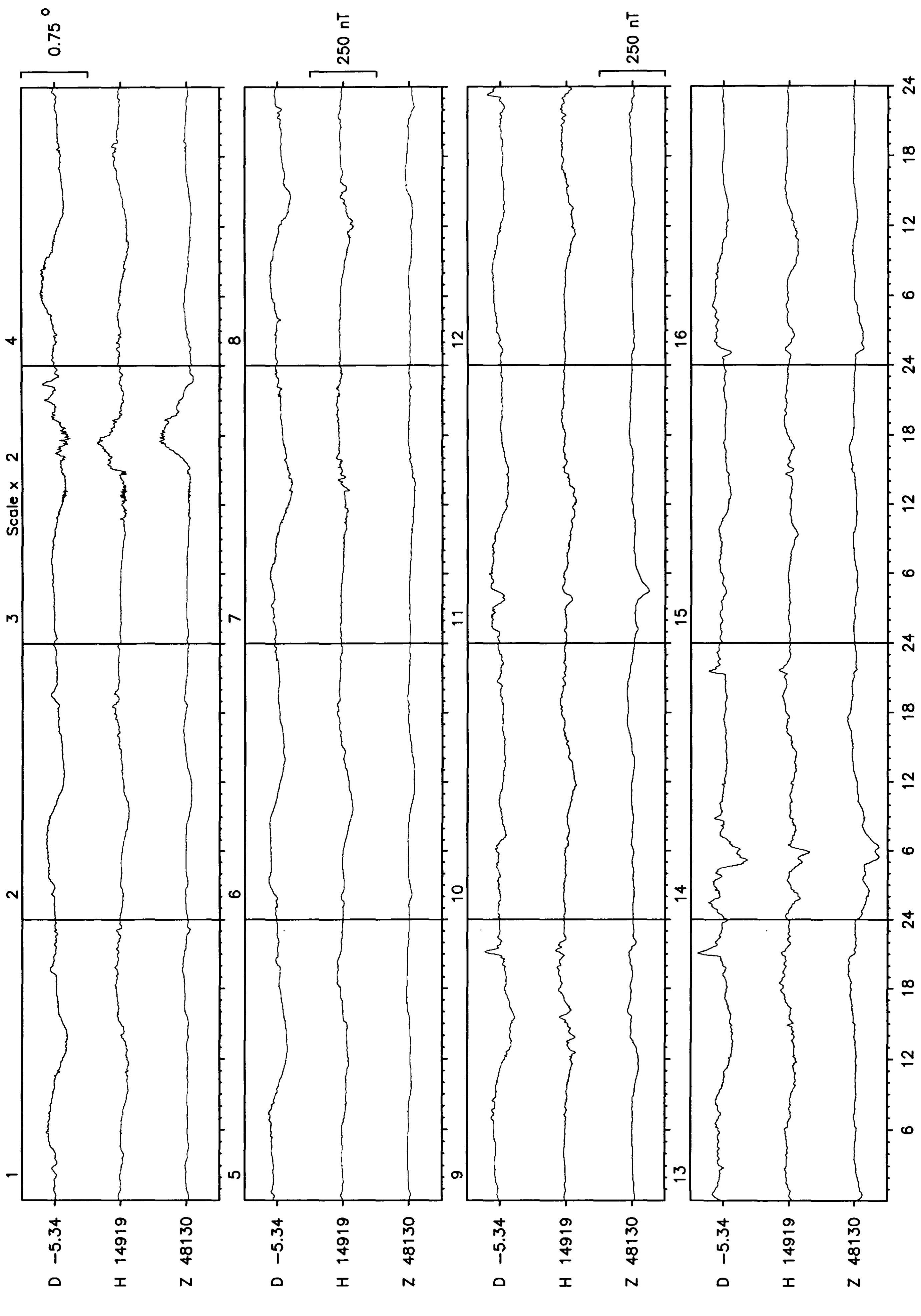

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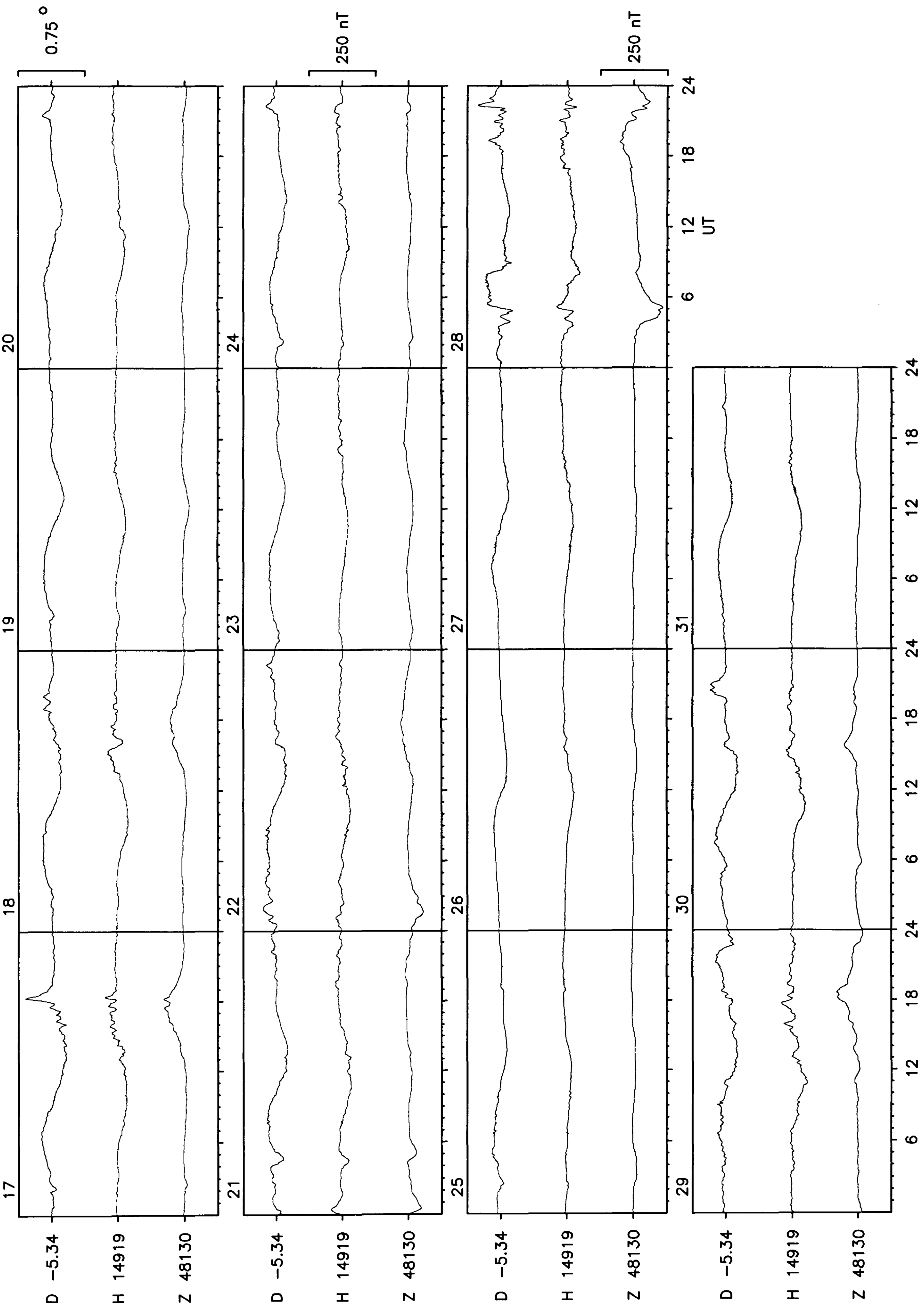

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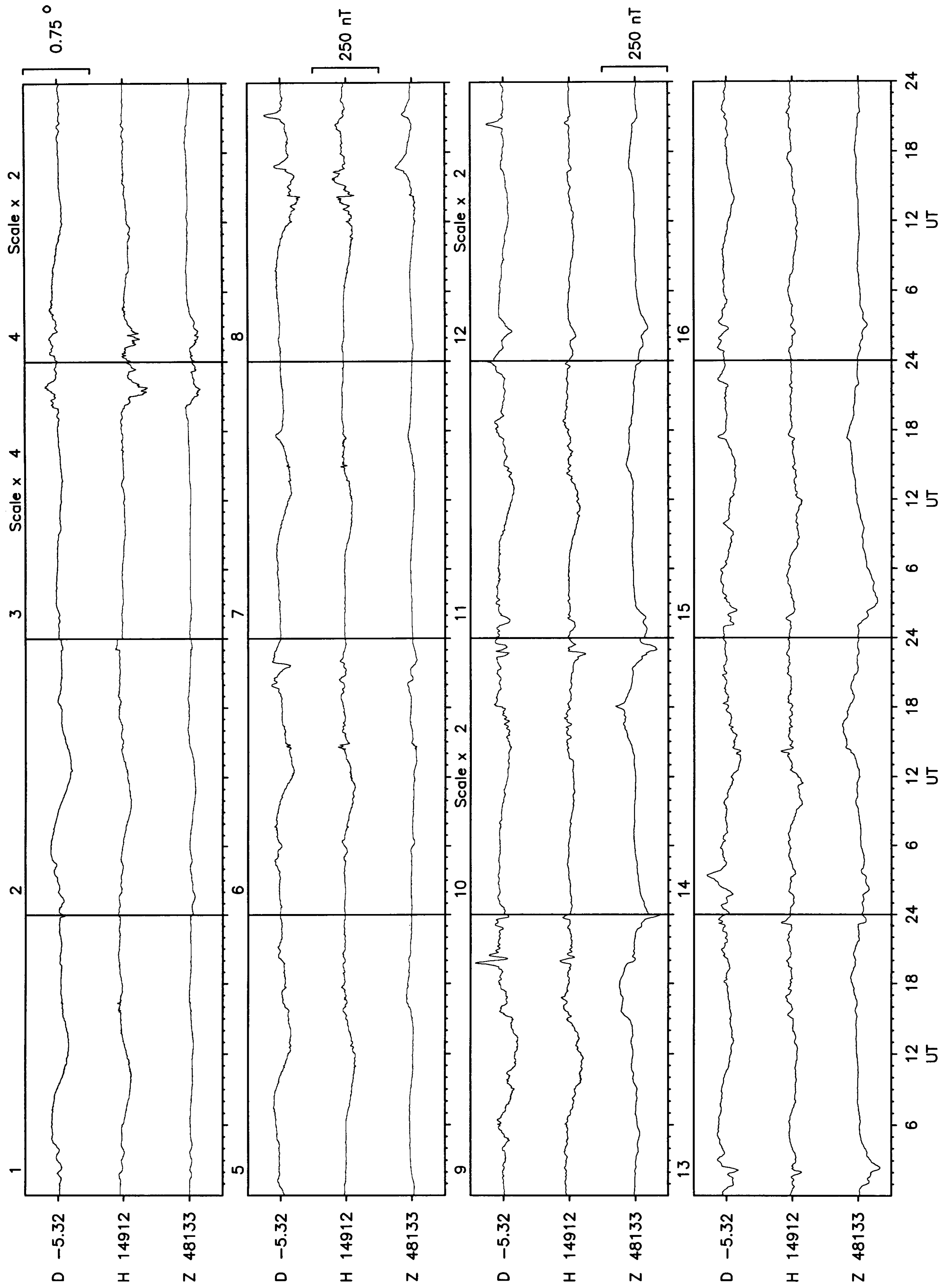

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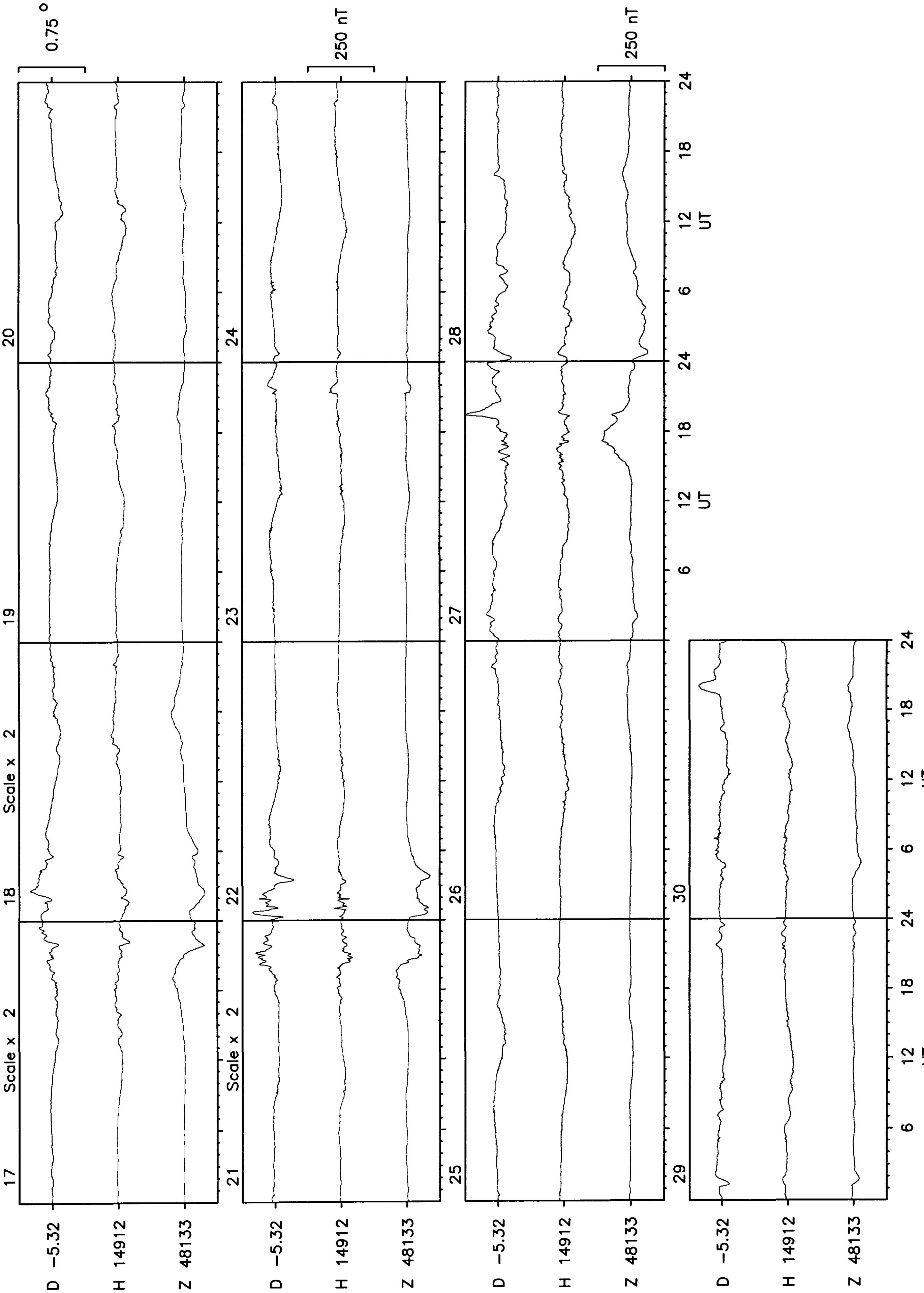

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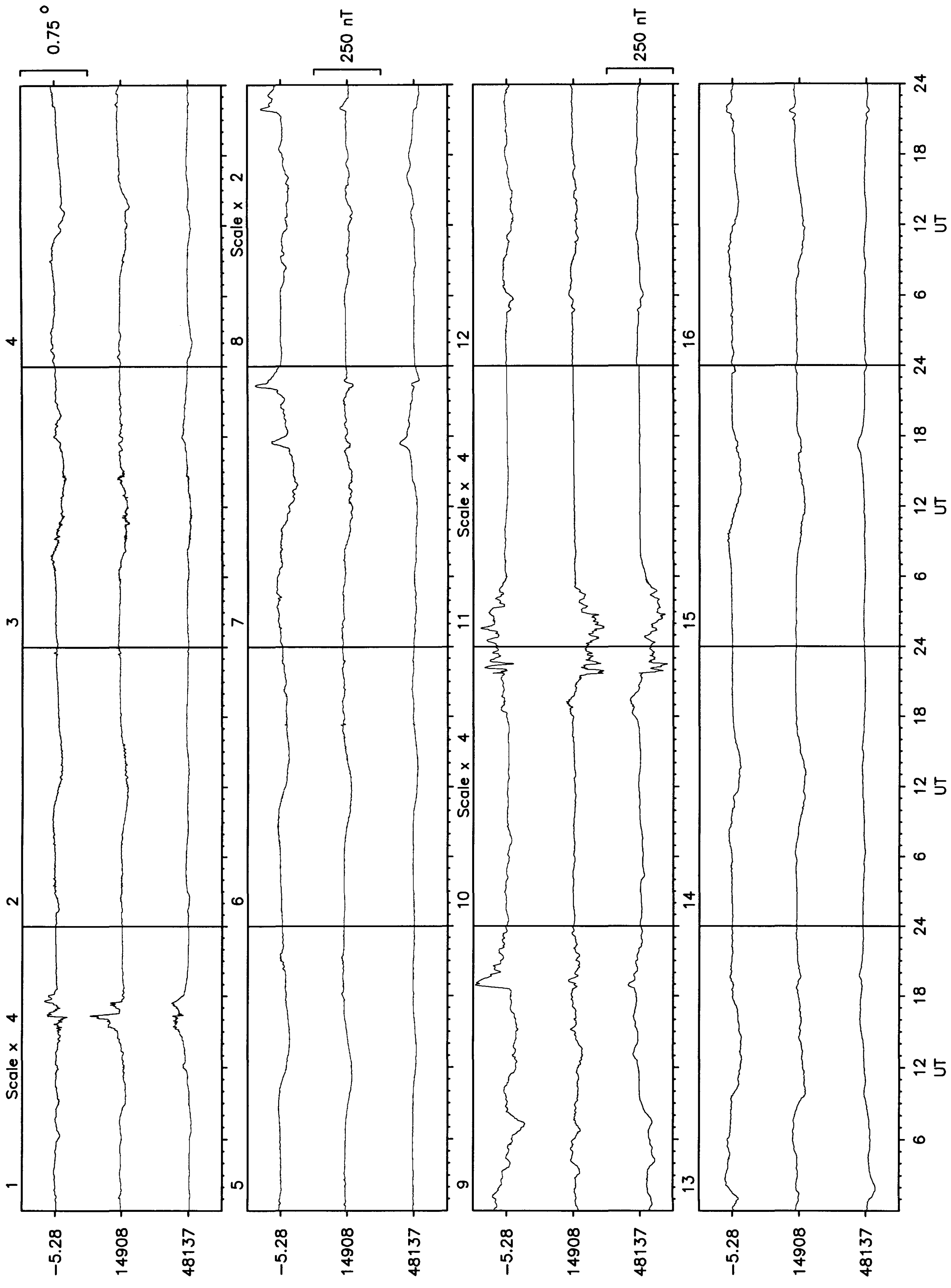
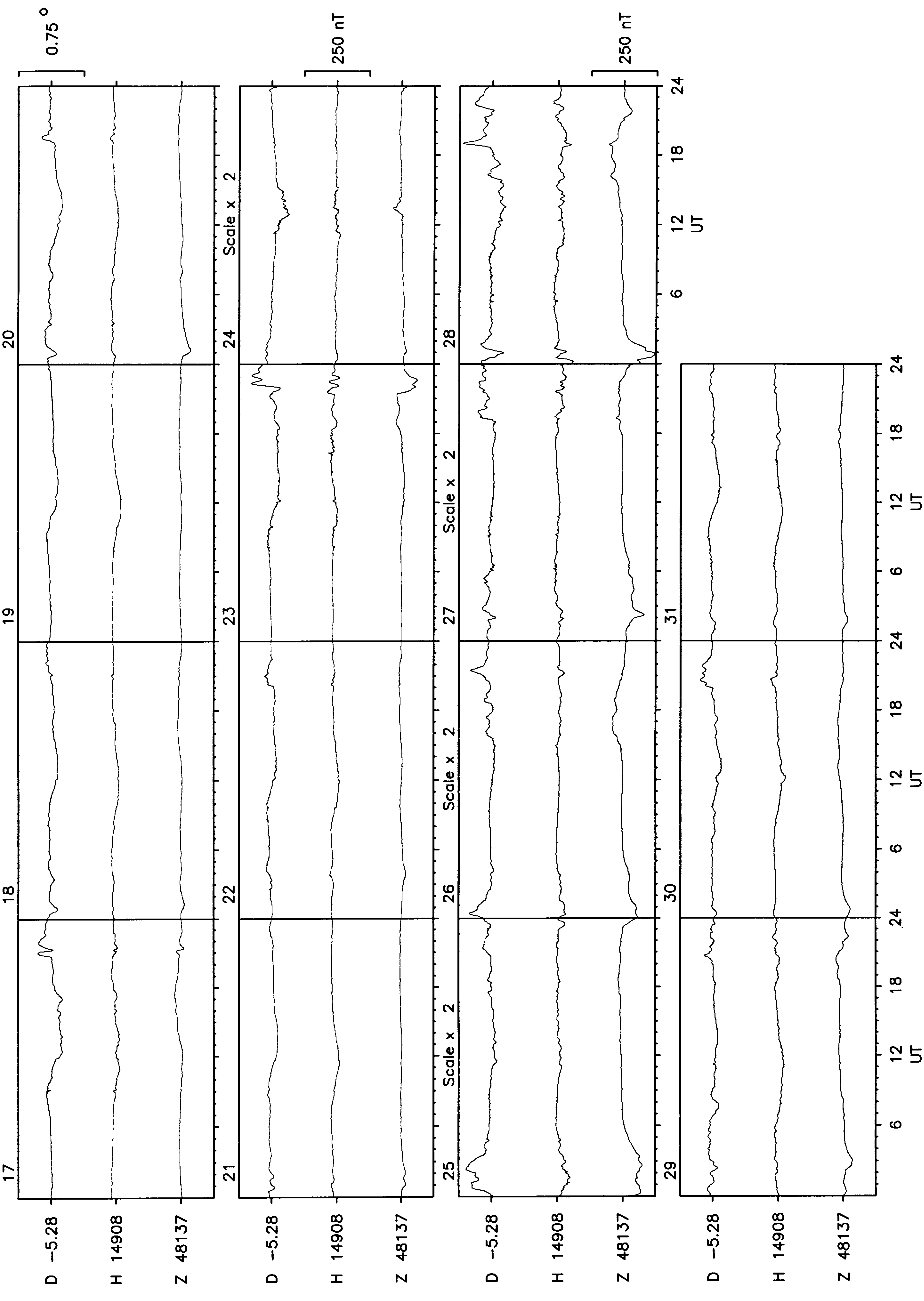
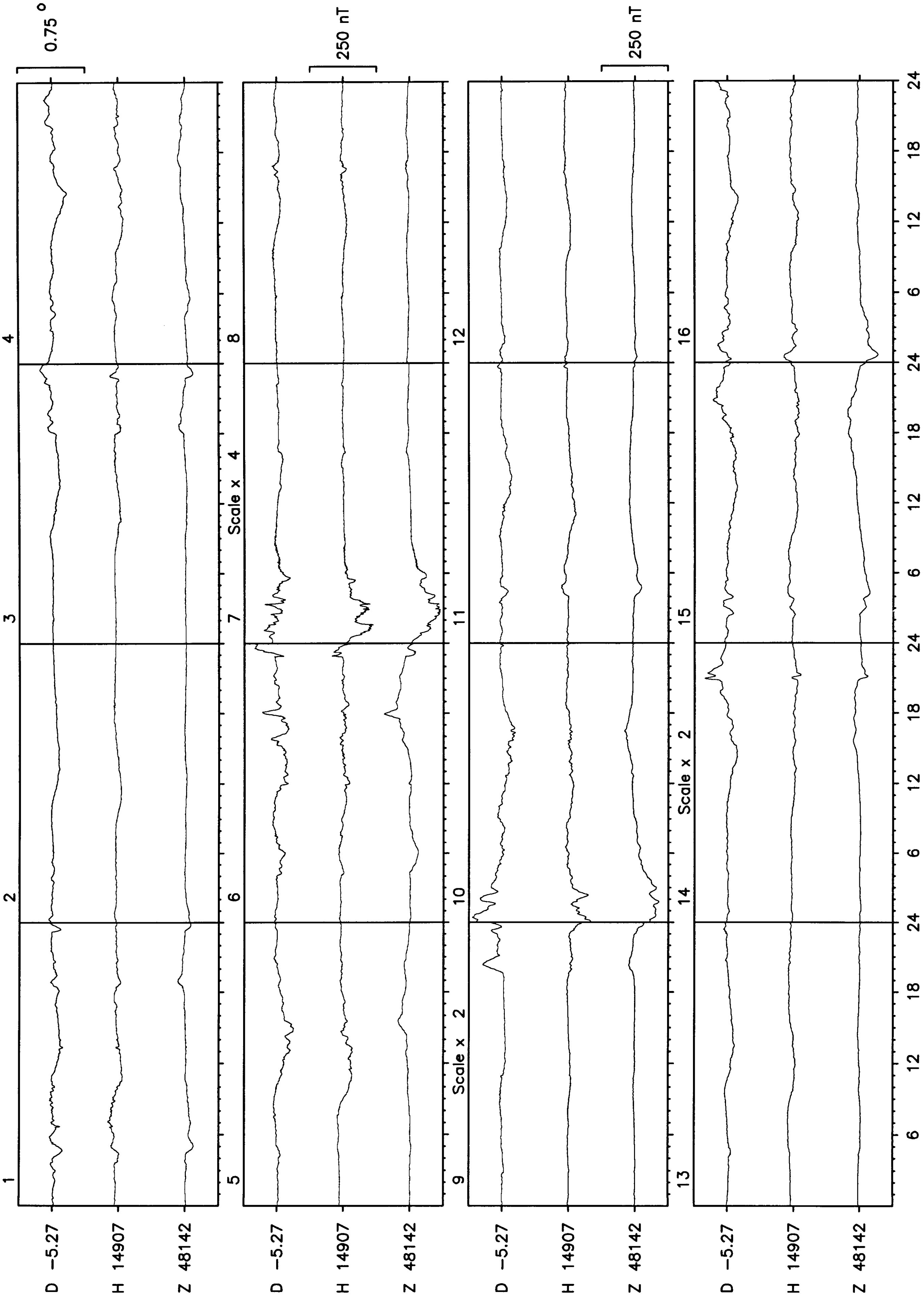


Lerwick October 1997

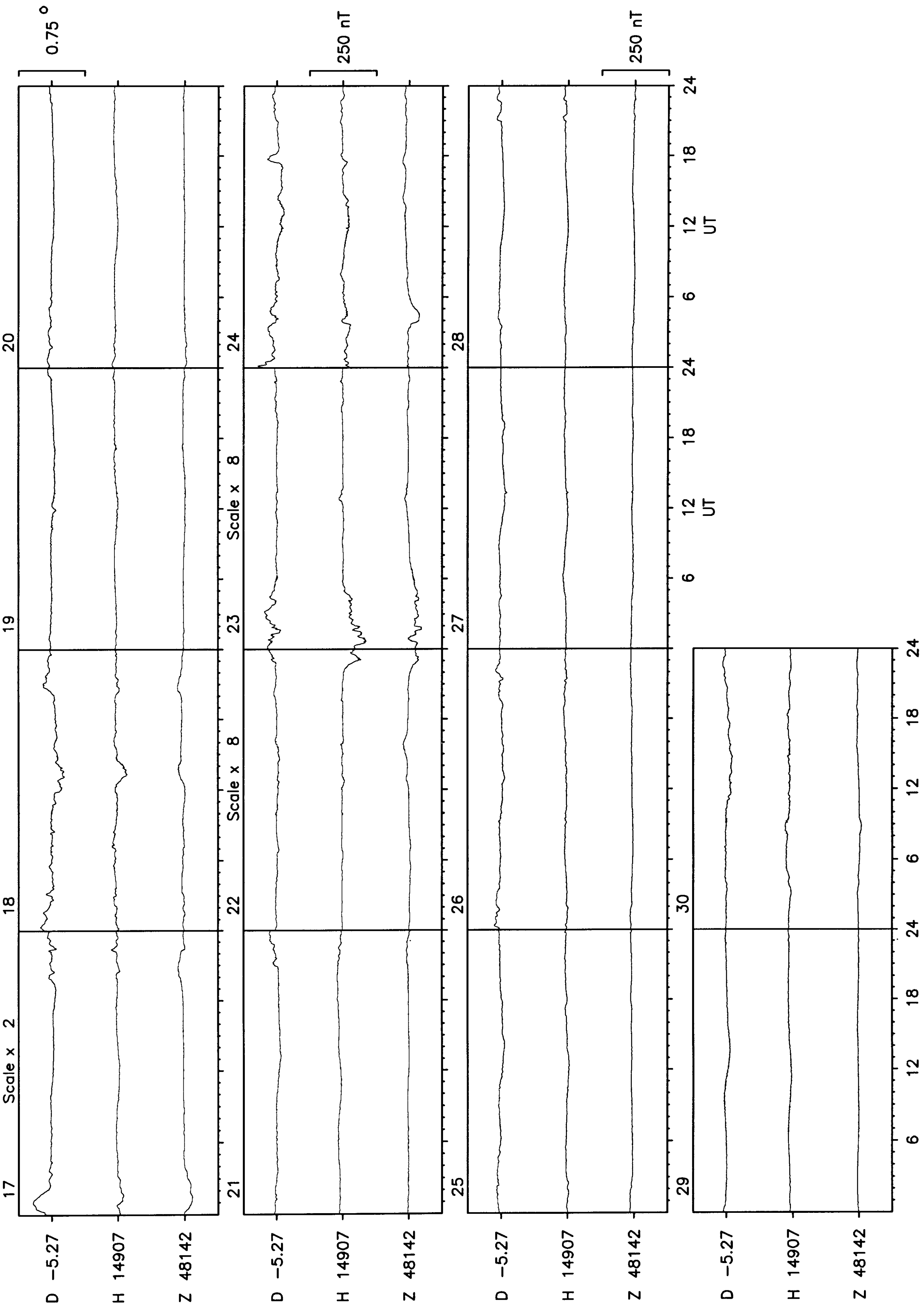


Lerwick November 1997

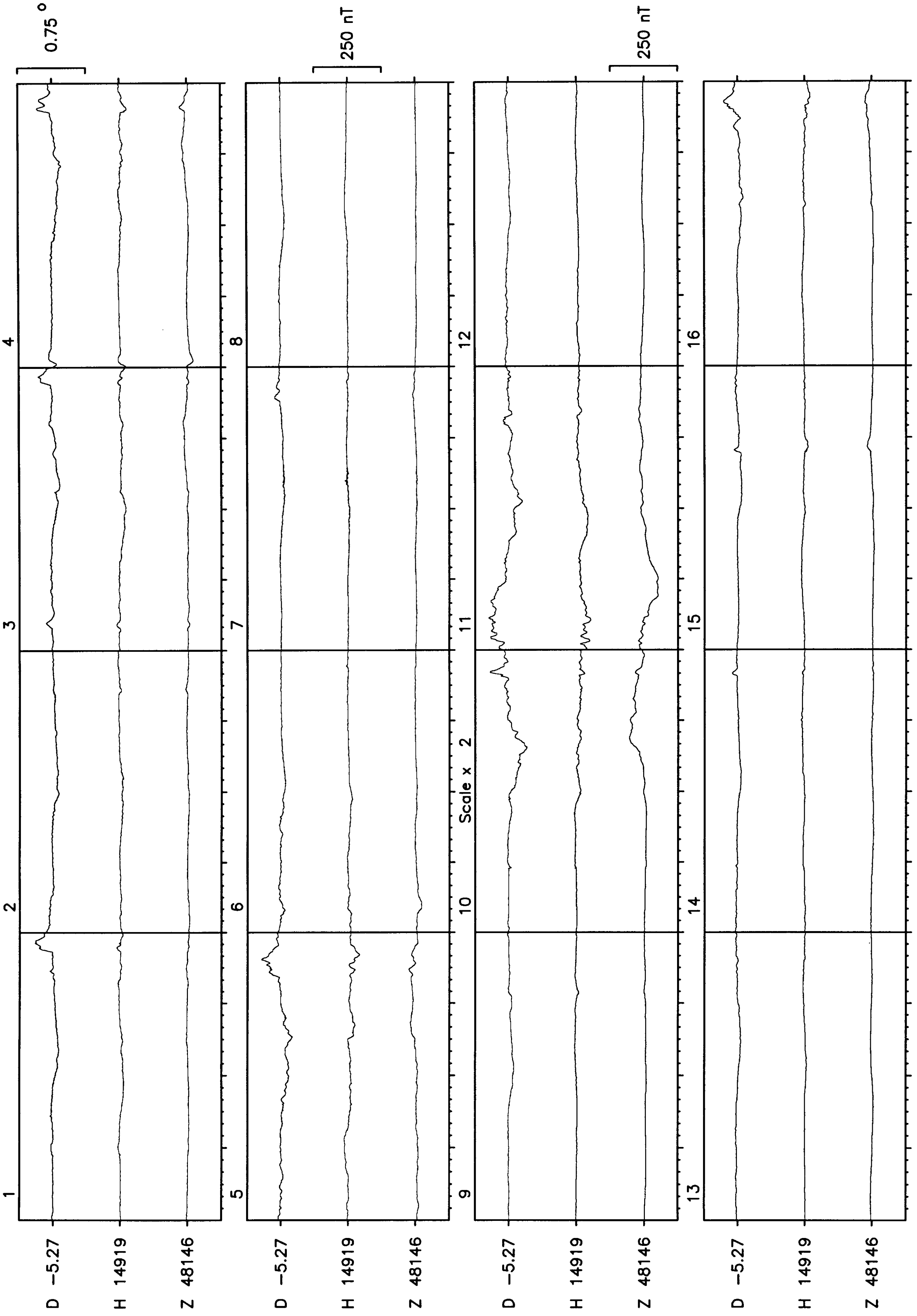


LE 11 97

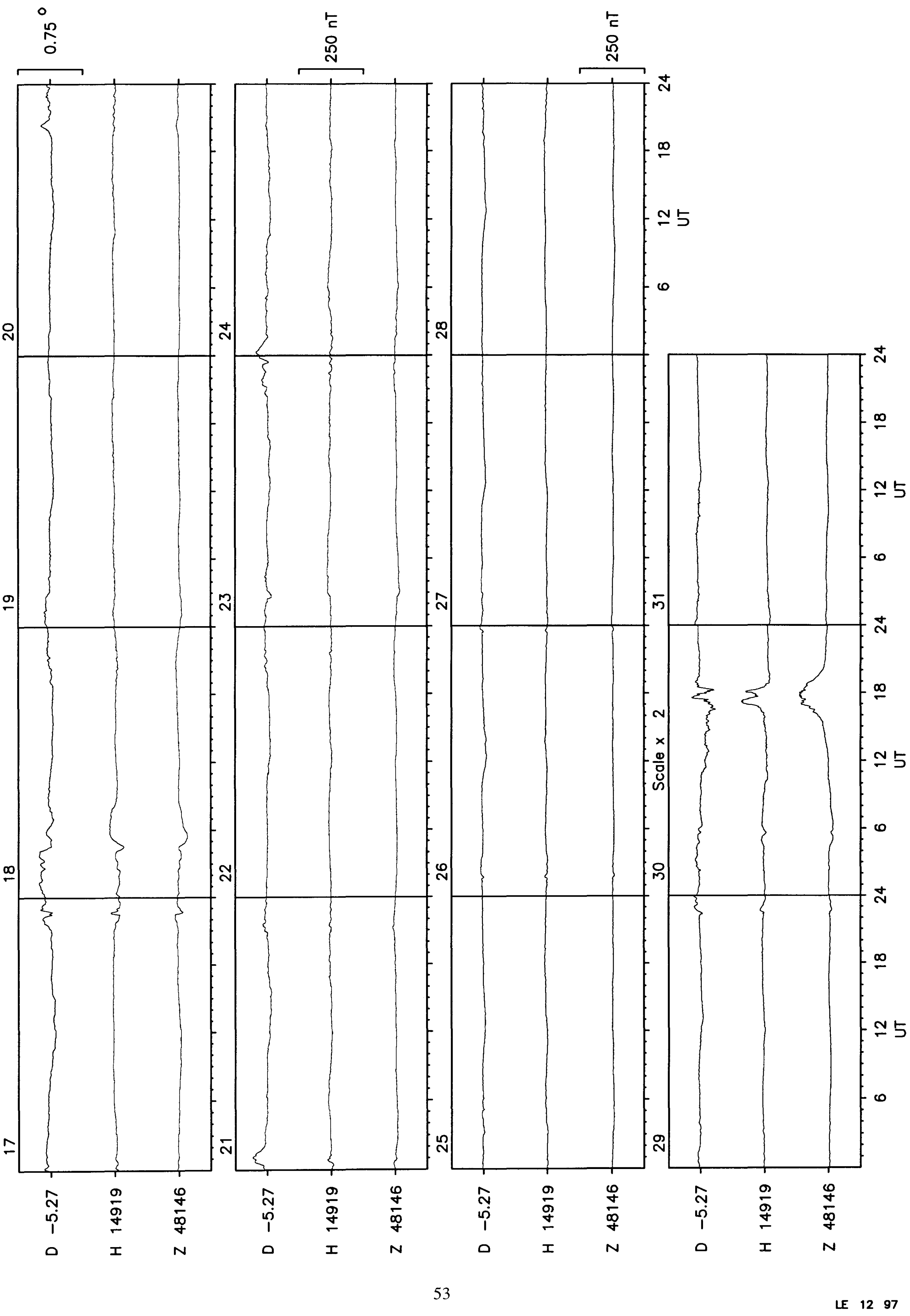
Lerwick November 1997



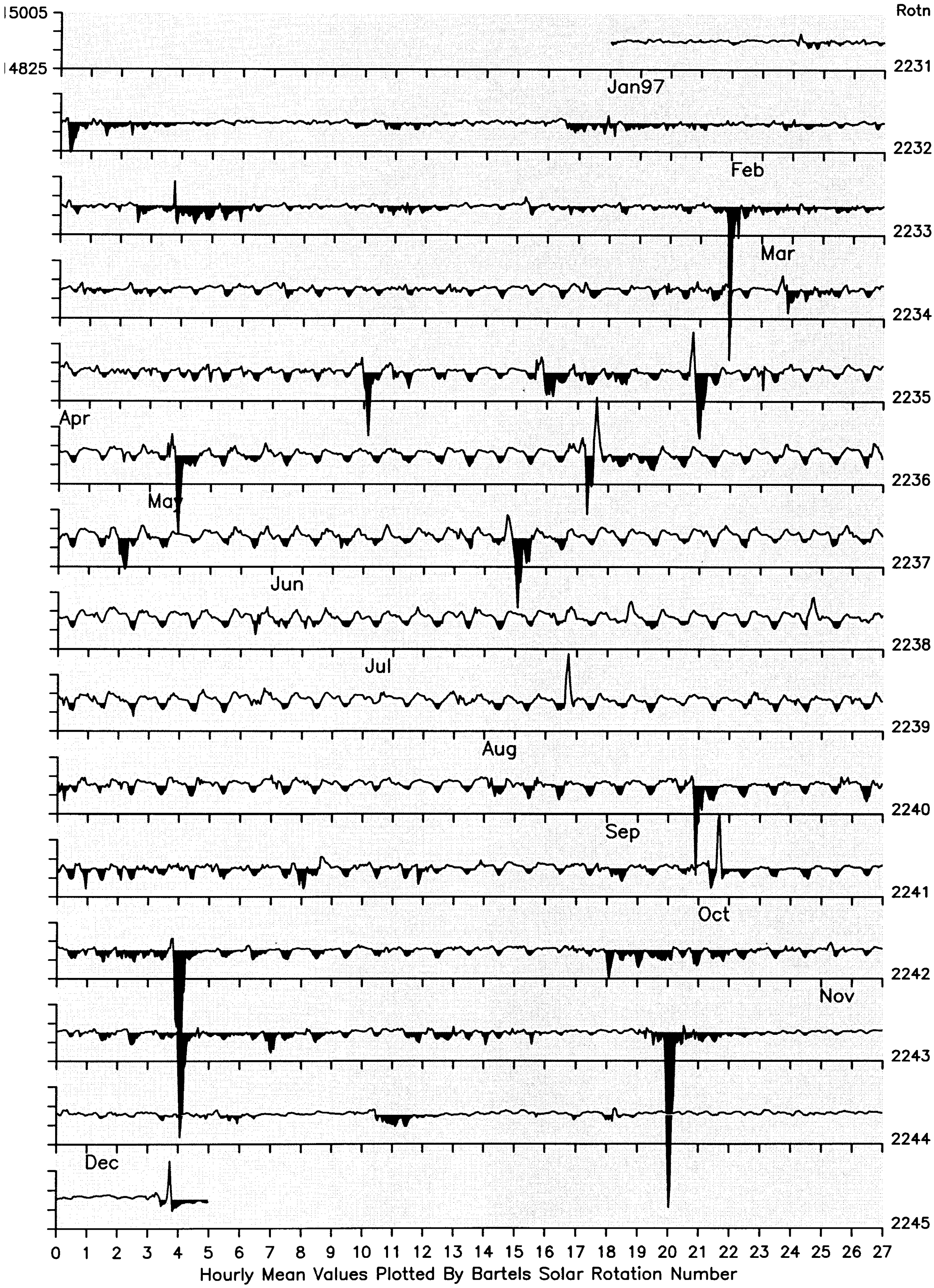
Lerwick December 1997



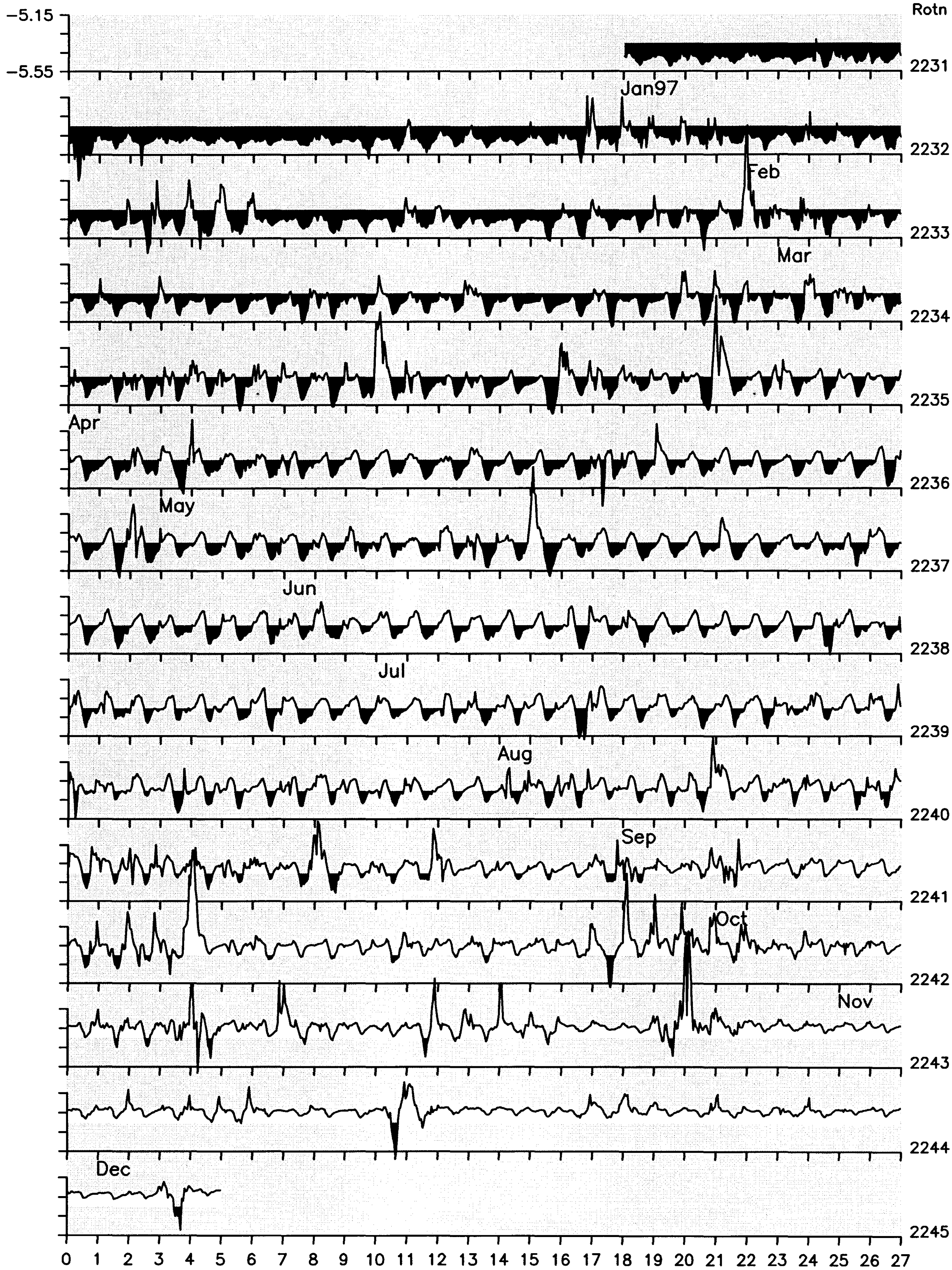
Lerwick December 1997



Lerwick Observatory: Horizontal Intensity (nT)

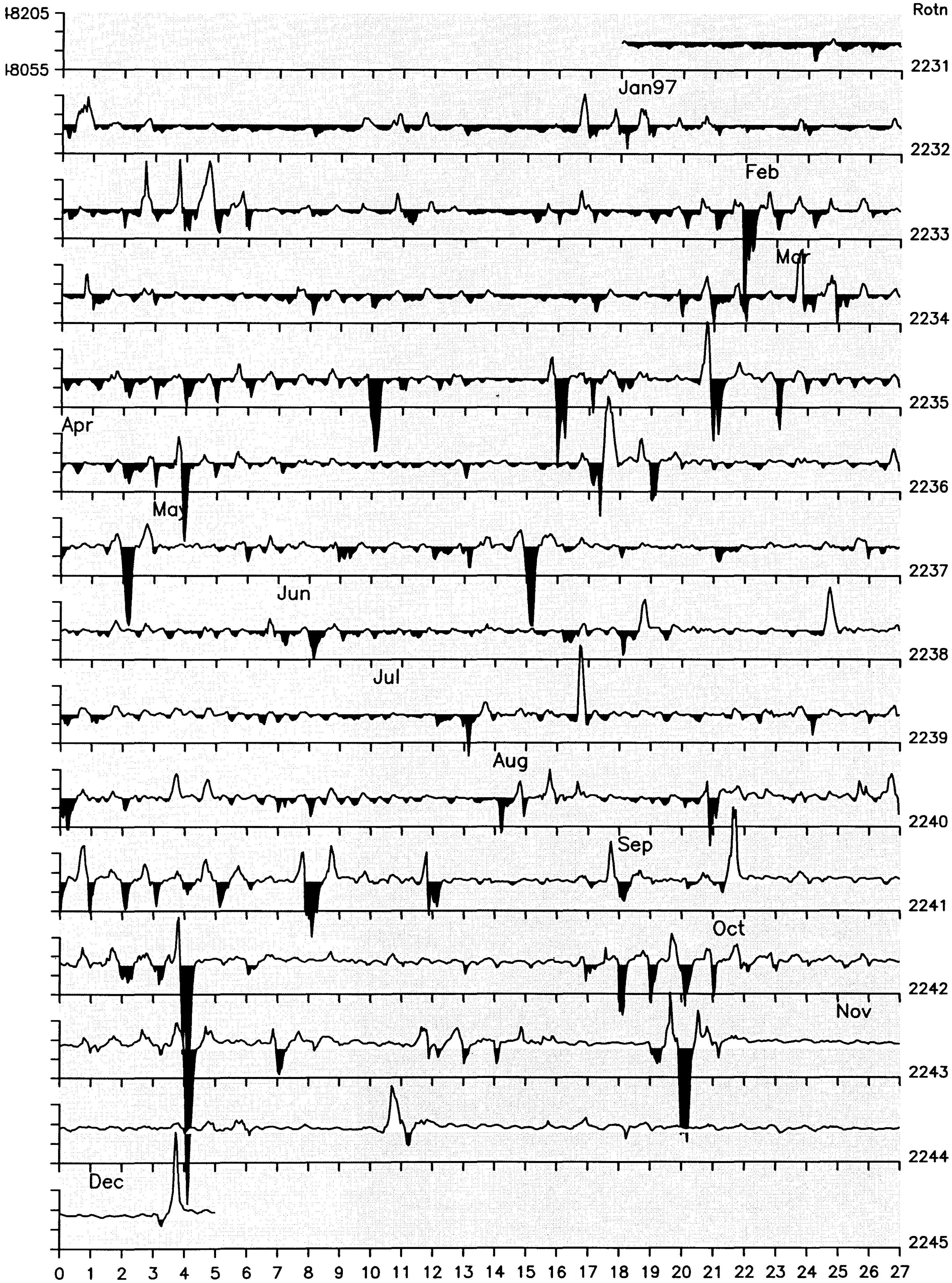


Lerwick Observatory: Declination (degrees)

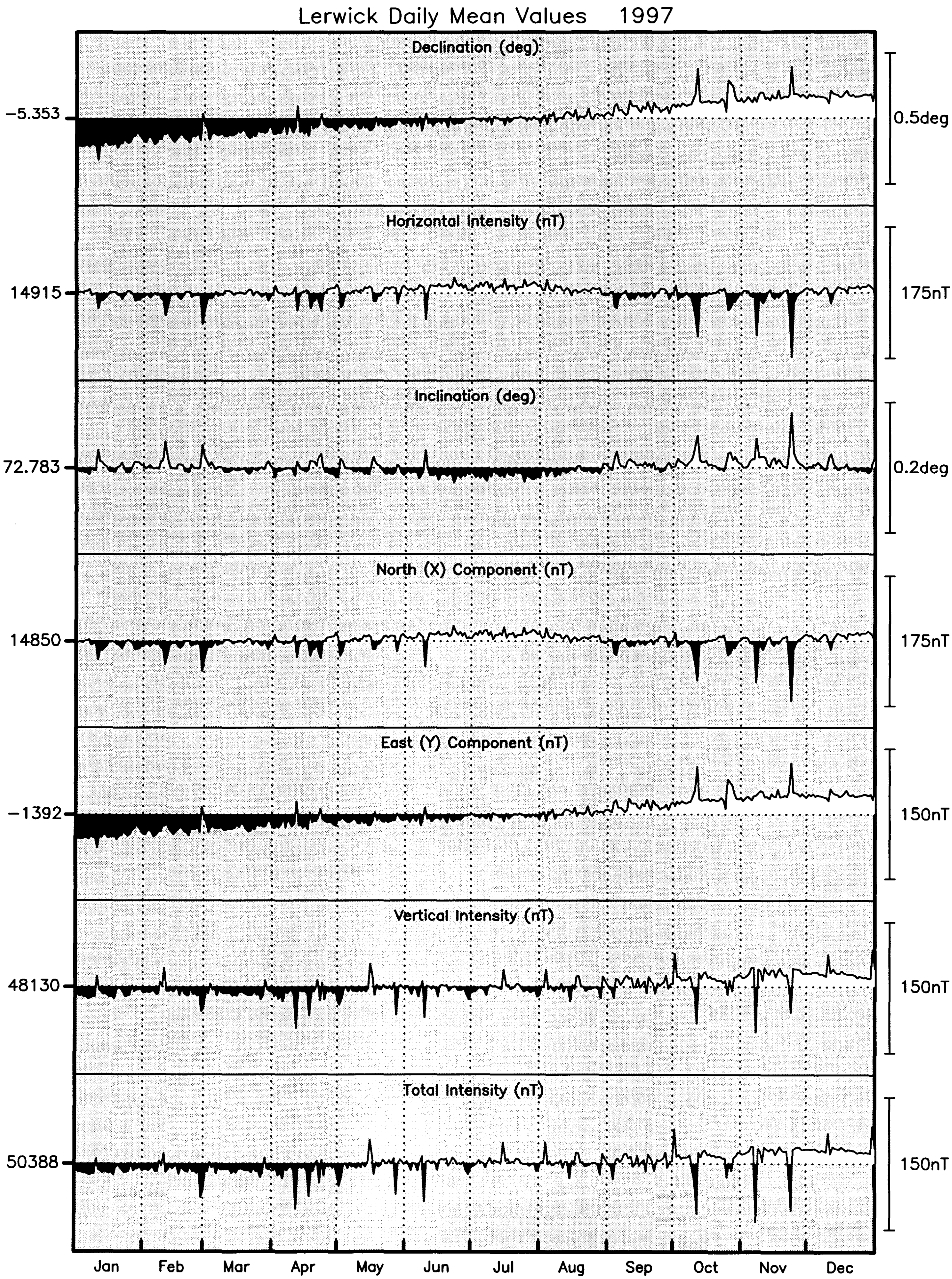


Hourly Mean Values Plotted By Bartels Solar Rotation Number

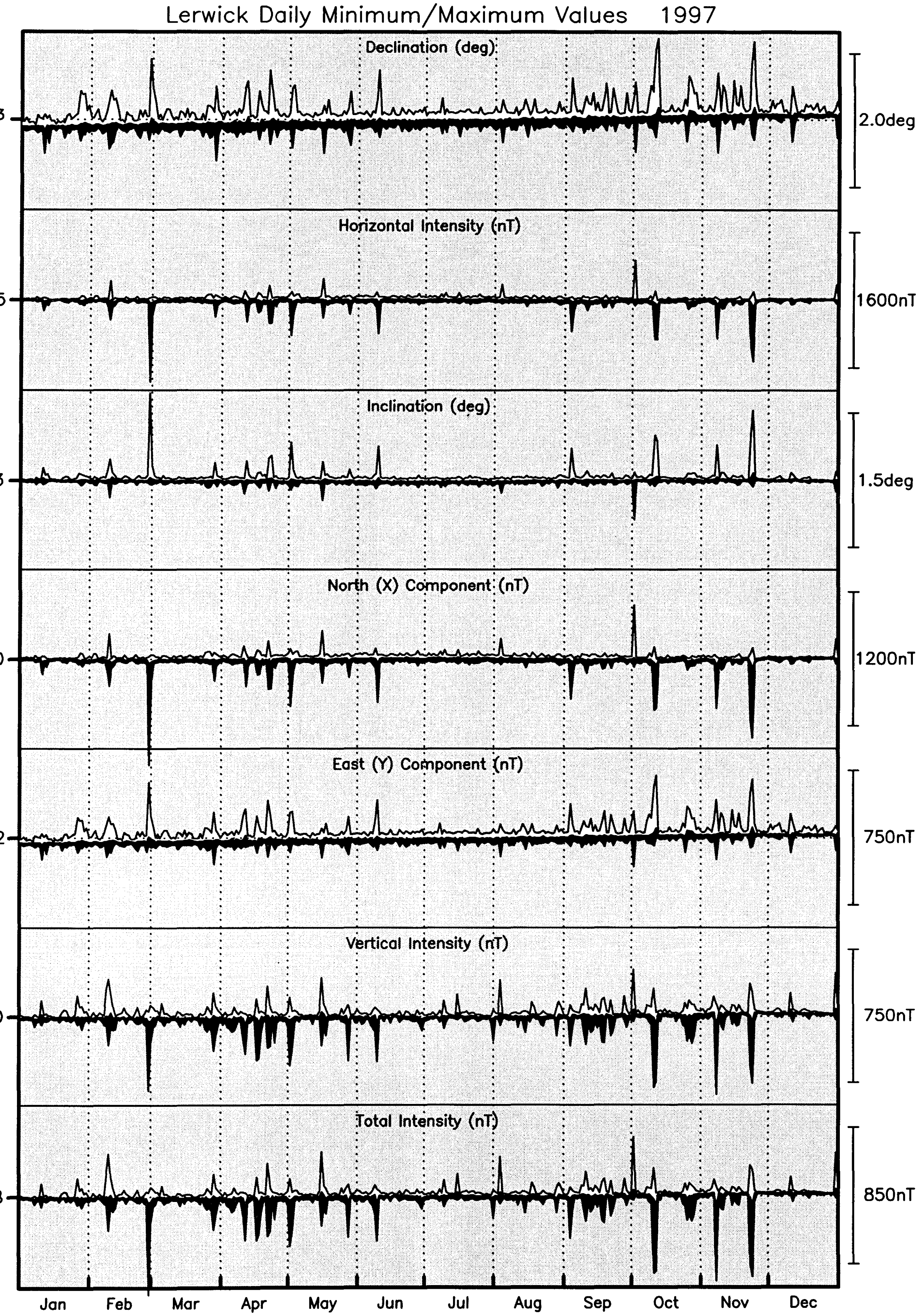
Lerwick Observatory: Vertical Intensity (nT)



Hourly Mean Values Plotted By Bartels Solar Rotation Number



Lerwick Daily Mean Values 1997
Declination (deg)
-5.353
0.5deg
Horizontal Intensity (nT)
14915
175nT
Inclination (deg)
72.783
0.2deg
North (X) Component (nT)
14850
175nT
East (Y) Component (nT)
-1392
150nT
Vertical Intensity (nT)
48130
150nT
Total Intensity (nT)
50388
150nT
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Lerwick Daily Minimum/Maximum Values 1997
Declination (deg)
.353
2.0deg
Horizontal Intensity (nT)
4915
1600nT
Inclination (deg)
.783
1.5deg
North (X) Component (nT)
850
1200nT
East (Y) Component (nT)
392
750nT
Vertical Intensity (nT)
130
750nT
Total Intensity (nT)
388
850nT
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Monthly Mean Values for Lerwick 1997

Month	D	H	I	X	Y	Z	F
Based on All Days							
January	-5° 26.8′	14912 nT	72° 47.0′	14845 nT	-1416 nT	48122 nT	50380 nT
February	-5° 25.3′	14909 nT	72° 47.2′	14842 nT	-1409 nT	48124 nT	50380 nT
March	-5° 24.6′	14914 nT	72° 46.9′	14847 nT	-1406 nT	48123 nT	50381 nT
April	-5° 23.2′	14914 nT	72° 46.8′	14848 nT	-1400 nT	48121 nT	50379 nT
May	-5° 22.7′	14916 nT	72° 46.8′	14851 nT	-1398 nT	48127 nT	50386 nT
June	-5° 22.0′	14922 nT	72° 46.4′	14857 nT	-1396 nT	48126 nT	50386 nT
July	-5° 21.4′	14925 nT	72° 46.2′	14860 nT	-1394 nT	48128 nT	50389 nT
August	-5° 20.6′	14919 nT	72° 46.7′	14854 nT	-1389 nT	48130 nT	50389 nT
September	-5° 19.0′	14912 nT	72° 47.2′	14848 nT	-1382 nT	48133 nT	50390 nT
October	-5° 16.9′	14908 nT	72° 47.5′	14845 nT	-1372 nT	48137 nT	50393 nT
November	-5° 16.1′	14907 nT	72° 47.7′	14844 nT	-1369 nT	48142 nT	50397 nT
December	-5° 16.1′	14919 nT	72° 47.0′	14856 nT	-1370 nT	48146 nT	50405 nT
Annual	**-5° 21.2′**	**14915 nT**	**72° 47.0′**	**14850 nT**	**-1392 nT**	**48130 nT**	**50388 nT**
International quiet day means							
January	-5° 27.4′	14917 nT	72° 46.5′	14850 nT	-1419 nT	48118 nT	50378 nT
February	-5° 25.9′	14915 nT	72° 46.8′	14848 nT	-1412 nT	48123 nT	50381 nT
March	-5° 25.3′	14918 nT	72° 46.6′	14851 nT	-1409 nT	48122 nT	50381 nT
April	-5° 23.5′	14922 nT	72° 46.3′	14856 nT	-1402 nT	48124 nT	50385 nT
May	-5° 22.8′	14920 nT	72° 46.6′	14854 nT	-1399 nT	48128 nT	50387 nT
June	-5° 22.3′	14923 nT	72° 46.4′	14858 nT	-1397 nT	48129 nT	50389 nT
July	-5° 21.3′	14924 nT	72° 46.3′	14859 nT	-1393 nT	48127 nT	50388 nT
August	-5° 20.5′	14919 nT	72° 46.7′	14854 nT	-1389 nT	48129 nT	50388 nT
September	-5° 19.6′	14917 nT	72° 46.9′	14853 nT	-1385 nT	48134 nT	50393 nT
October	-5° 17.5′	14915 nT	72° 47.2′	14851 nT	-1376 nT	48140 nT	50398 nT
November	-5° 16.4′	14918 nT	72° 47.0′	14855 nT	-1371 nT	48145 nT	50403 nT
December	-5° 16.2′	14922 nT	72° 46.7′	14859 nT	-1371 nT	48142 nT	50402 nT
Annual	**-5° 21.6′**	**14919 nT**	**72° 46.7′**	**14854 nT**	**-1393 nT**	**48130 nT**	**50389 nT**
International disturbed day means							
January	-5° 26.3′	14905 nT	72° 47.6′	14838 nT	-1413 nT	48130 nT	50385 nT
February	-5° 23.2′	14890 nT	72° 48.4′	14824 nT	-1398 nT	48123 nT	50374 nT
March	-5° 24.1′	14910 nT	72° 47.2′	14844 nT	-1404 nT	48126 nT	50382 nT
April	-5° 21.2′	14897 nT	72° 47.7′	14832 nT	-1390 nT	48111 nT	50365 nT
May	-5° 22.7′	14905 nT	72° 47.5′	14839 nT	-1397 nT	48124 nT	50380 nT
June	-5° 21.8′	14914 nT	72° 46.9′	14848 nT	-1394 nT	48122 nT	50380 nT
July	-5° 22.1′	14930 nT	72° 45.9′	14865 nT	-1397 nT	48129 nT	50391 nT
August	-5° 20.8′	14918 nT	72° 46.7′	14853 nT	-1390 nT	48130 nT	50389 nT
September	-5° 18.2′	14904 nT	72° 47.7′	14840 nT	-1378 nT	48132 nT	50387 nT
October	-5° 16.0′	14903 nT	72° 47.8′	14840 nT	-1368 nT	48134 nT	50389 nT
November	-5° 15.0′	14878 nT	72° 49.2′	14816 nT	-1362 nT	48122 nT	50370 nT
December	-5° 16.2′	14912 nT	72° 47.6′	14849 nT	-1370 nT	48156 nT	50412 nT
Annual	**-5° 20.6′**	**14905 nT**	**72° 47.5′**	**14841 nT**	**-1388 nT**	**48128 nT**	**50383 nT**

Lerwick Observatory K Indices 1997

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2100 0101	1000 1100	2111 2442	2321 2001	2110 3456	1111 1222	1100 2110	1101 1111	1100 0211	3243 4742	0221 1122	0000 1013
2	0101 1122	1111 1233	1322 2312	1221 2131	5211 2212	1101 2222	1000 1020	1100 0121	2100 1111	1100 1101	1000 0000	1001 1010
3	1000 0002	3000 0112	0011 1323	3310 0021	2111 2231	2221 1223	1111 2200	1013 3544	2212 3256	0012 2220	0000 0122	2000 1113
4	1001 0001	1001 0001	2000 1011	3221 2223	2100 1232	2101 1121	1110 2310	2111 0121	4322 1121	1011 2101	2111 2222	2000 1113
5	1100 0100	1000 1221	0000 2223	2311 0224	3101 1111	1000 0101	0100 2100	1010 0110	1000 1211	0000 0011	0111 2211	1111 2223
6	0000 1000	1321 2112	3221 1100	2111 2312	1000 1100	3111 2112	0111 1110	1100 1010	0211 3123	0000 0111	0222 2334	1000 0000
7	2311 2221	1000 0023	0011 2213	3310 2223	0010 0002	3311 3222	1221 2334	0111 2201	0000 2210	1111 1314	7642 2312	0000 1002
8	2300 1112	1001 4543	1100 2201	1010 1122	1100 1111	0112 2424	1010 2111	0102 2201	0002 3323	1122 3224	0000 1210	0000 0000
9	2011 0012	2111 2374	0000 0000	2100 2213	1110 1000	6534 3212	2210 2331	0011 2323	1222 2243	2231 2242	1111 1144	0000 0010
10	2344 3232	3232 2344	0000 0112	3000 2325	1110 2111	1110 1220	0012 2211	1121 1111	3111 3334	3231 2256	3111 1211	0102 3424
11	3212 2112	2222 2244	1000 1000	5631 3334	2111 1000	1100 0000	1000 2111	2211 2210	3111 2223	6531 0100	1201 1101	3211 2121
12	1032 1232	3220 0000	1221 2231	3112 2200	0000 0000	1001 2111	1100 1100	1001 1113	4211 2242	0221 1001	1000 0100	0000 0000
13	2210 1121	1000 1101	2110 1232	0211 2213	0000 0010	0000 1100	0100 1100	2111 2234	3210 1223	2101 1010	0000 0000	0000 0000
14	0000 1121	1011 0012	2011 0011	2110 2200	1000 1323	0000 1000	0000 0110	3431 1213	3312 3221	0001 1000	1110 2244	0000 0001
15	0000 1100	0001 1200	3020 1011	1000 0000	3354 6523	2210 1221	1223 2332	1111 2210	3222 1312	0000 1101	2210 1123	0000 0200
16	0000 0001	0111 2123	1121 1211	0000 3345	1210 3302	0012 2221	1100 1110	3111 1100	2210 1111	0000 0012	3101 2012	0000 1023
17	0000 0011	1223 1022	1110 1232	5422 2233	4202 1222	0100 1010	0010 1213	2100 2241	1100 2334	0001 1133	4200 1123	1000 0002
18	2100 0000	2100 0101	2210 1112	3121 2232	1110 2222	0010 2110	2222 2211	1110 2321	4421 2322	2100 0001	2211 3122	2310 0001
19	1000 1211	1000 0000	0100 1000	2222 3233	1000 1100	1121 2223	2311 2321	1100 0100	0000 1121	0001 1000	0001 0101	1000 0000
20	0010 1212	1000 1011	0000 0010	0000 0122	1120 1210	1000 1210	2112 2100	0001 1012	1110 2102	2110 1021	1000 0000	0000 0021
21	3111 2211	1222 2201	0001 1101	0001 4565	0010 1111	0000 0001	0111 1221	3311 2111	1111 0244	1000 0000	0000 0001	2000 0011
22	1100 0121	2100 1323	2312 2211	6411 1122	0000 0211	1211 2221	1011 2120	2111 2212	4310 1000	0100 0022	2233 4447	0000 0000
23	2000 0000	2212 2101	0000 1210	1001 1233	0000 1000	1011 2212	0101 1111	2000 0110	0000 1012	0011 1224	7633 4134	1100 0002
24	0000 0103	0111 2103	0101 1133	4211 2222	1112 2222	0001 1110	1122 3332	2001 2112	1010 0001	2112 3213	3211 2321	2000 0000
25	2100 0033	3101 1111	3111 2224	1101 1112	1110 1110	1111 2222	2011 1110	1110 1010	0000 1100	5422 2223	1000 0000	0000 0000
26	2201 3344	3213 3310	2221 2333	1000 0011	0001 2333	2100 0011	0000 1111	0000 0100	0001 1112	4200 2334	1000 0012	1000 0001
27	2211 1234	3211 2348	2000 1131	0000 0112	4541 2223	1013 4331	1101 1201	0010 1101	2111 1342	3322 1244	0000 0000	0000 0000
28	2321 3353	5532 2433	0011 2364	1000 1111	1102 2110	2211 2112	2101 2200	2332 1234	3321 1211	3111 2343	0100 0001	0000 0000
29	2111 1132		3312 2334	0000 0221	0000 0001	3311 1122	0111 1010	1122 2323	3111 1002	2121 0021	0000 0000	0000 0002
30	2211 2433		2212 2221	3311 1232	1000 2222	1000 0111	2200 1013	0221 2233	0221 1232	1011 2122	1111 1111	2212 2552
31	2201 0022		1100 1221		2101 2322		3422 2212	0000 1110		1010 1211		1000 0000

SIs and SSCs

Day	Month	UT		Type	Quality	H(nT)	D(min)	Z(nT)
8	2	06	29	SSC*	B	5.0	1.40	-2.0
8	2	09	52	SSC*	C	6.0	0.90	
9	2	13	21	SSC*	B	24.0	3.10	-11.0
5	3	13	56	SSC*	B	16.5	-3.20	-2.6
20	3	20	42	SI*	B	12.1	-0.80	-2.3
21	3	15	30	SI*	B	7.7	-1.10	
10	4	17	44	SSC*	B	35.8	-1.90	4.1
16	4	13	19	SSC*	A	17.9	-3.40	-2.3
21	4	13	00	SSC*	C	-28.4	3.60	8.3
1	5	12	42	SSC*	B	27.9	-2.68	-6.2
12	5	03	35	SSC*	C	6.2	1.25	
15	5	01	59	SSC	B	32.8	-3.75	-12.0
20	5	06	02	SSC*	C	-9.7	-1.91	-2.2/+2.3
25	5	14	35	SSC*	B	10.1	-0.64	-3.1
26	5	09	57	SSC*	B	-8.2	0.51	-1.6
26	5	15	51	SI*	C	-17.6	1.24	6.9
8	6	11	02	SSC*	C	20.1	-1.17	-5.0
19	6	00	31	SSC*	C	6.1	-2.14	
27	6	07	58	SSC*	B	6.3	-1.75	
15	7	03	11	SSC	C	5.3	-1.40	
15	7	10	10	SI*	C	-18.0	-3.98	10.1
29	7	06	08	SI	B	-5.0	2.32	
3	8	10	42	SSC	B	24.8	1.74	-10.4
28	8	15	51	SSC	B	29.9	-1.49/+1.71	-9.2
2	9	22	58	SSC*	B	16.5	-1.60	-7.0
3	9	16	22	SSC*	C	+13.1/-12.5	0.71	-6.0
21	9	15	40	SSC	C	-7.6	0.81	3.5
1	10	00	59	SSC	B	27.0	-3.38	-10.8
6	10	17	17	SSC	B	-17.8	1.11	-2.5
10	10	16	12	SSC	C	24.2	0.79	2.7
23	10	08	05	SSC*	B	-6.9	1.55	-1.9
24	10	11	15	SSC*	C	-3.8	4.16	-3.0
1	11	06	35	SSC*	B	-11.7	-3.33	-1.8
3	11	11	19	SI	C	4.9	-0.90	
6	11	11	52	SSC	B	-14.8	-3.98	8.6
6	11	22	48	SSC*	A	40.4	-6.55	-23.3
9	11	17	40	SSC*	B	6.5	0.39	-2.0
22	11	09	50	SSC*	A	-27.0	8.47	-8.6
10	12	05	25	SSC*	A	+10.5/-11.2	-4.50	3.0
30	12	02	09	SSC*	B	8.3	-2.86	3.3

Notes

A * indicates that the principal impulse was preceded by a smaller reversed impulse.

The quality of the event is classified as follows :

- A = very distinct
- B = fair, ordinary, but unmistakable
- C = doubtful

The amplitudes given are for the first chief movement of the event.

SFEs

Day	Month	Universal Time Start		Universal Time Maximum		Universal Time End		H(nT)	D(min)	Z(nT)
2	9	12	26	12	31	12	40	-3.6	-1.10	2.3
27	11	13	14	13	20	13	27	-6.2	-1.31	4.7

Notes

The amplitudes given are for the chief movement of the event.

Annual Values of Geomagnetic Elements

Lerwick

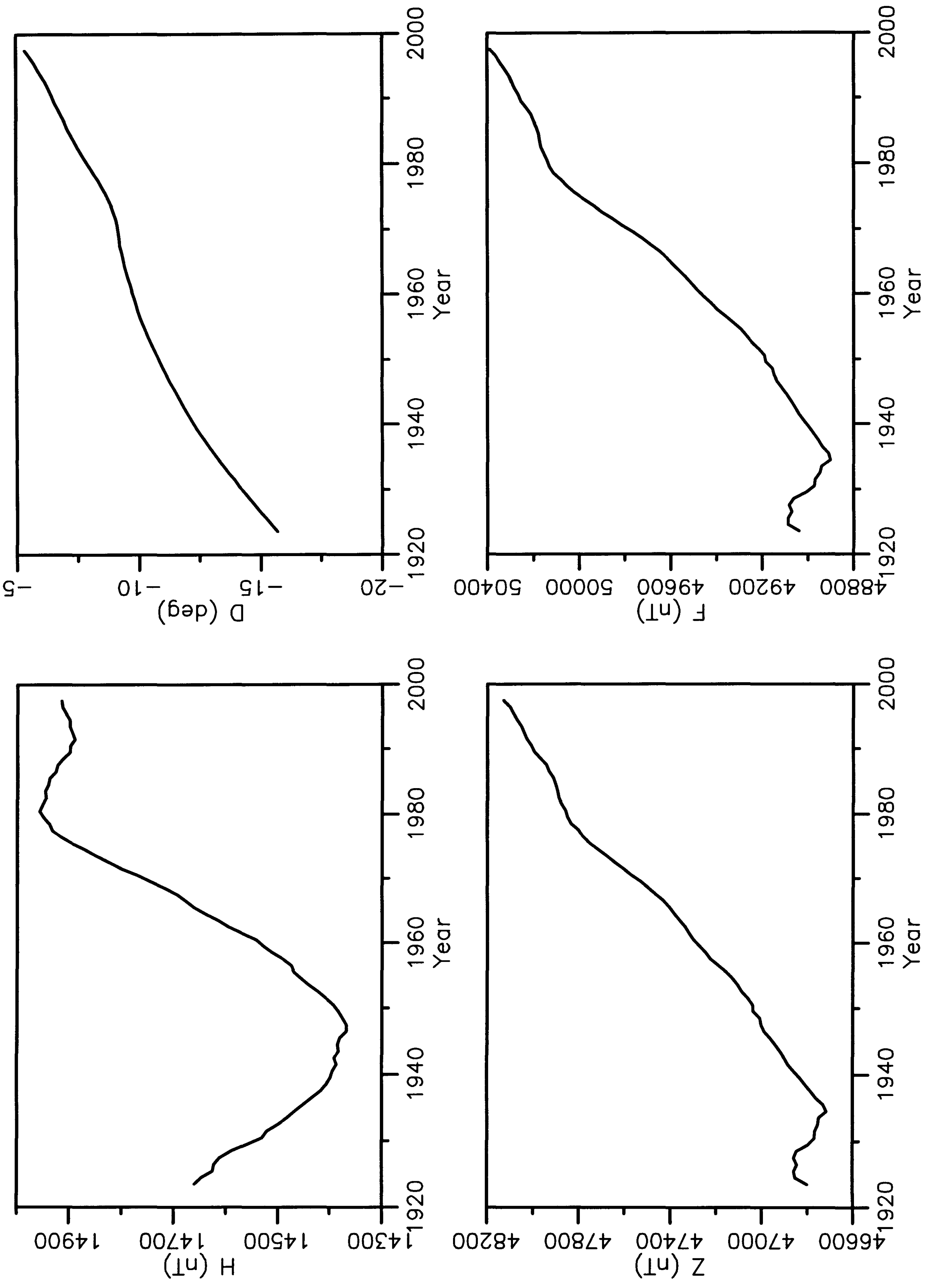
Year	D	H	I	X	Y	Z	F
1923.5	-15 40.3	14655	72 33.7	14111	-3959	46655	48902
1924.5	-15 26.5	14642	72 35.7	14113	-3899	46708	48950
1925.5	-15 13.5	14621	72 37.2	14108	-3840	46713	48948
1926.5	-14 58.6	14618	72 37.1	14121	-3778	46699	48933
1927.5	-14 45.7	14607	72 38.1	14125	-3722	46713	48944
1928.5	-14 32.9	14585	72 39.4	14117	-3664	46702	48926
1929.5	-14 19.4	14556	72 40.3	14104	-3601	46651	48869
1930.5	-14 7.0	14527	72 41.6	14088	-3543	46624	48835
1931.5	-13 55.4	14517	72 42.3	14090	-3493	46623	48830
1932.5	-13 41.9	14495	72 43.5	14083	-3433	46608	48809
1933.5	-13 29.8	14477	72 44.6	14077	-3379	46605	48802
Note 1	0 0.0	0	0 3.0	0	0	144	138
1934.5	-13 17.7	14462	72 48.0	14074	-3326	46716	48903
1935.5	-13 5.3	14445	72 49.4	14070	-3271	46730	48911
1936.5	-12 53.6	14428	72 51.2	14064	-3220	46763	48938
1937.5	-12 42.4	14411	72 52.8	14058	-3170	46785	48955
1938.5	-12 31.6	14401	72 54.0	14058	-3123	46809	48974
1939.5	-12 21.4	14394	72 54.9	14061	-3080	46833	48995
1940.5	-12 11.1	14389	72 55.8	14065	-3037	46860	49019
1941.5	-12 1.0	14382	72 56.8	14067	-2994	46884	49040
1942.5	-11 52.5	14386	72 56.8	14078	-2960	46899	49056
1943.5	-11 43.5	14378	72 57.8	14078	-2922	46919	49073
1944.5	-11 35.1	14380	72 58.1	14087	-2888	46940	49093
1945.5	-11 26.3	14376	72 58.8	14090	-2851	46963	49114
1946.5	-11 17.1	14363	73 0.2	14085	-2811	46989	49135
1947.5	-11 8.7	14363	73 0.5	14092	-2776	47002	49148
1948.5	-11 0.9	14371	73 0.1	14106	-2746	47009	49157
1949.5	-10 53.1	14378	73 0.2	14119	-2715	47037	49185
1950.5	-10 45.5	14388	72 59.5	14135	-2686	47039	49190
1951.5	-10 37.7	14402	72 59.1	14155	-2656	47061	49215
1952.5	-10 29.9	14417	72 58.6	14176	-2627	47087	49245
1953.5	-10 22.8	14435	72 57.8	14199	-2601	47106	49268
1954.5	-10 15.6	14450	72 57.3	14219	-2574	47129	49294
1955.5	-10 9.2	14464	72 56.9	14237	-2550	47156	49324
1956.5	-10 2.8	14469	72 57.3	14247	-2524	47191	49359
1957.5	-9 57.5	14486	72 56.8	14268	-2505	47225	49397
1958.5	-9 52.7	14507	72 55.8	14292	-2489	47246	49423
1959.5	-9 48.1	14523	72 55.3	14311	-2472	47271	49452
1960.5	-9 43.4	14538	72 54.9	14329	-2455	47299	49483
1961.5	-9 39.1	14565	72 53.5	14359	-2442	47318	49509
1962.5	-9 33.3	14591	72 52.1	14389	-2422	47336	49534
1963.5	-9 28.5	14610	72 51.3	14411	-2405	47359	49561
1964.5	-9 24.4	14634	72 50.2	14437	-2392	47382	49590
1965.5	-9 21.1	14656	72 49.2	14461	-2382	47403	49617
1966.5	-9 17.8	14672	72 48.7	14479	-2370	47431	49648
1967.5	-9 14.2	14688	72 48.3	14498	-2358	47464	49685
1968.5	-9 12.1	14712	72 47.4	14523	-2353	47496	49722
1969.5	-9 10.3	14740	72 46.2	14552	-2349	47531	49764
1970.5	-9 7.9	14766	72 45.4	14579	-2343	47573	49812
1971.5	-9 5.2	14796	72 44.1	14610	-2337	47607	49853
1972.5	-8 59.5	14820	72 43.3	14638	-2316	47646	49898
1973.5	-8 53.6	14844	72 42.4	14666	-2295	47680	49937
1974.5	-8 46.5	14866	72 41.8	14692	-2268	47719	49981
1975.5	-8 38.4	14890	72 40.9	14721	-2237	47753	50021
1976.5	-8 29.9	14911	72 40.1	14747	-2204	47780	50053
1977.5	-8 20.9	14927	72 39.5	14769	-2167	47803	50079
1978.5	-8 10.1	14933	72 39.8	14782	-2122	47835	50112
1979.5	-8 0.3	14944	72 39.3	14798	-2081	47850	50129
1980.5	-7 50.4	14952	72 39.0	14812	-2039	47858	50139
1981.5	-7 40.9	14946	72 39.7	14812	-1998	47875	50154
1982.5	-7 31.6	14940	72 40.4	14812	-1957	47890	50166
1983.5	-7 22.6	14942	72 40.4	14818	-1918	47895	50172
1984.5	-7 13.4	14936	72 40.9	14818	-1878	47902	50177
1985.5	-7 5.5	14933	72 41.3	14819	-1844	47913	50186
1986.5	-6 58.4	14921	72 42.5	14811	-1811	47931	50200

Year	D		H	I		X	Y	Z	F
1987.5	-6	50.3	14918	72	43.0	14812	-1776	47944	50211
1988.5	-6	42.2	14908	72	44.1	14806	-1740	47968	50231
1989.5	-6	34.1	14894	72	45.6	14796	-1704	47995	50253
Note 2	0	0.0	5	0	-0.5	5	-1	-8	-6
1990.5	-6	26.6	14898	72	45.4	14804	-1672	48001	50260
1991.5	-6	19.0	14890	72	46.4	14800	-1638	48021	50277
1992.5	-6	11.3	14894	72	46.3	14807	-1606	48033	50289
1993.5	-6	2.3	14899	72	46.2	14816	-1567	48044	50301
1994.5	-5	52.7	14899	72	46.6	14821	-1526	48063	50319
1995.5	-5	43.2	14907	72	46.5	14833	-1486	48080	50338
Note 3	0	0.0	0	0	0.5	0	0	8	6
1996.5	-5	32.6	14914	72	46.5	14844	-1441	48103	50362
1997.5	-5	21.2	14915	72	47.0	14850	-1392	48130	50388

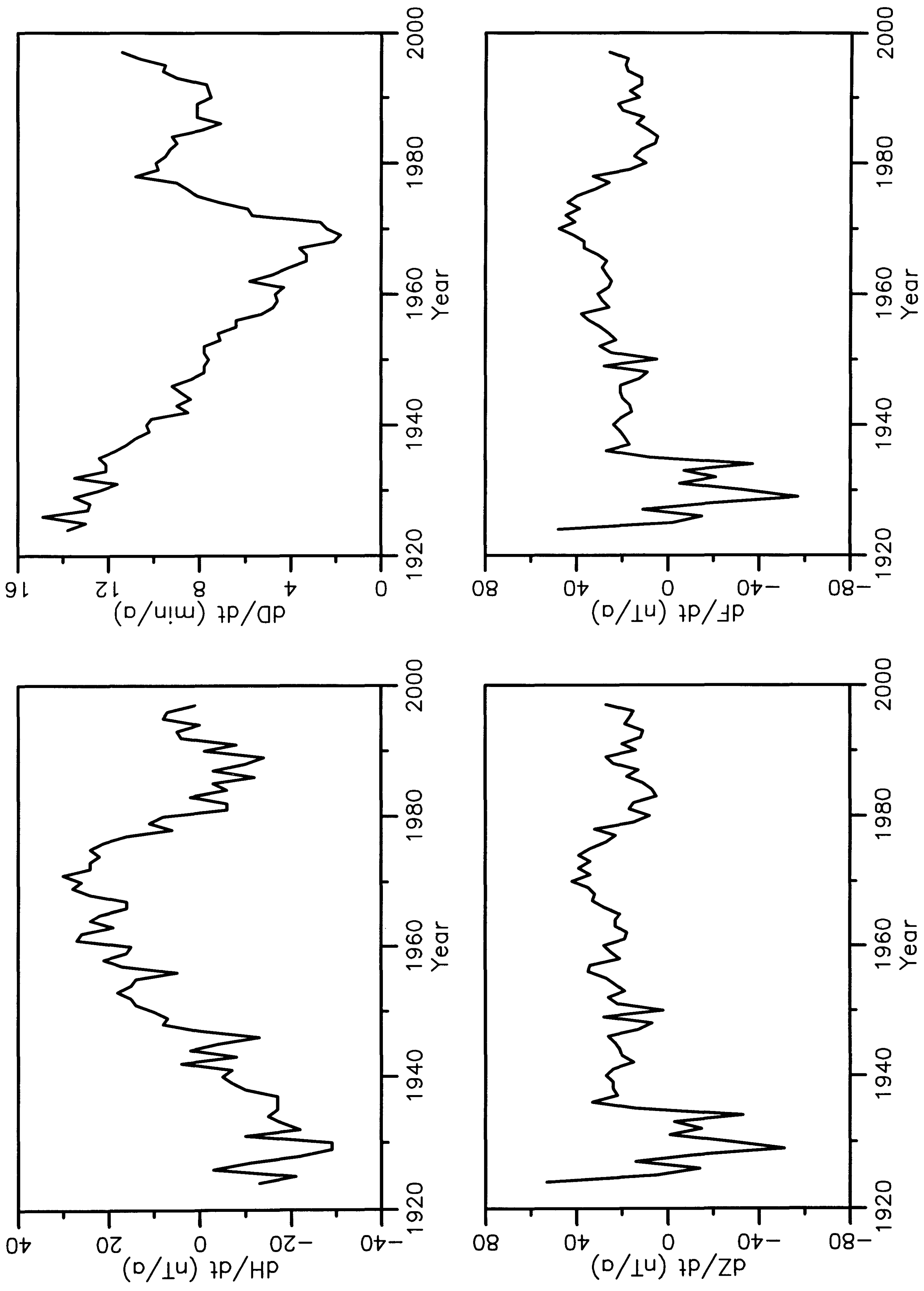
1 Site differences 1 Jan 1934 (new value - old value)
2 Site differences 1 Jan 1990 (new value - old value)
3 Site differences 1 Jan 1996 (new value - old value)

D and I are given in degrees and decimal minutes
All other elements are in nanoteslas

Annual Mean Values at Lerwick

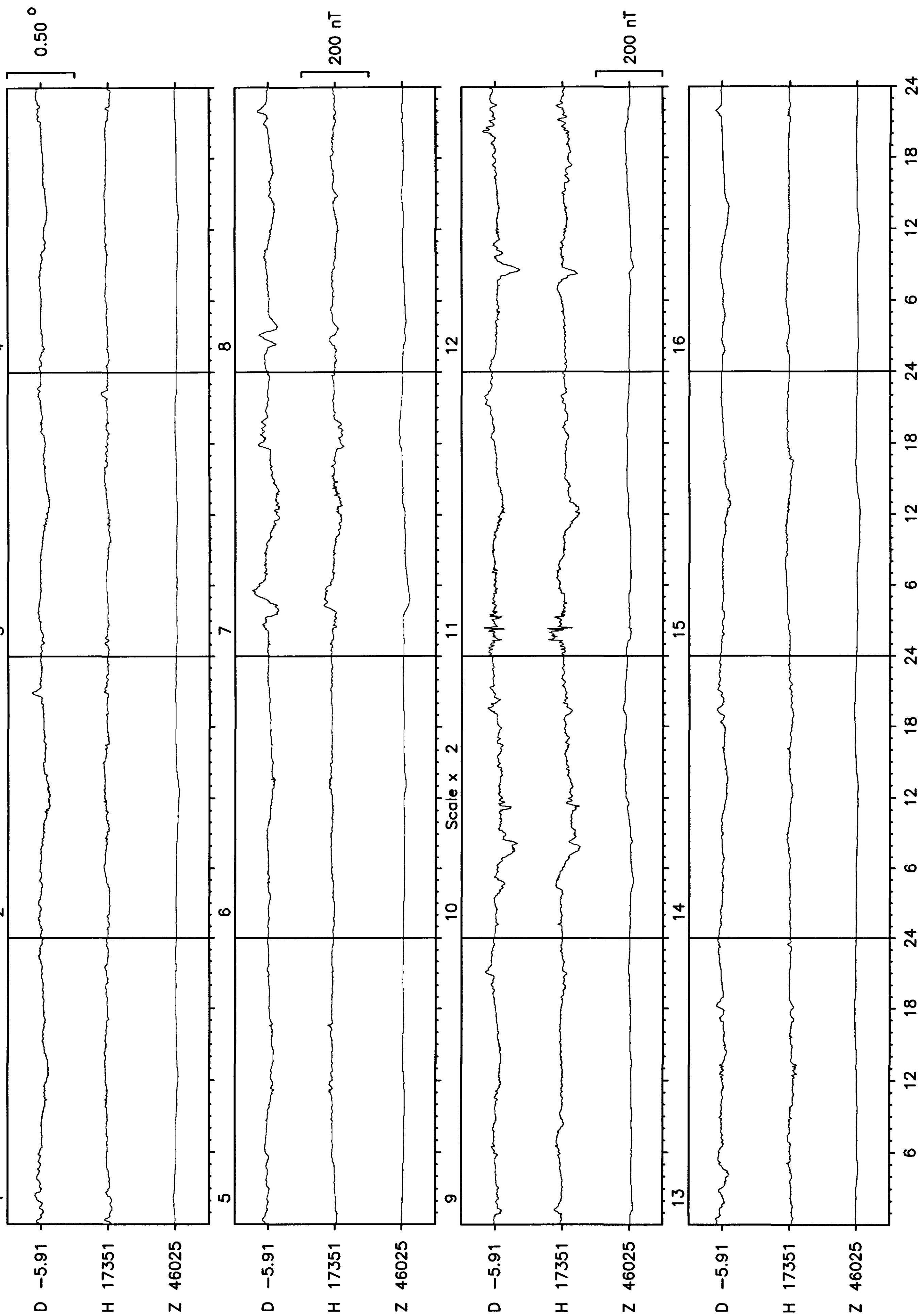


Rate of Change of Annual Mean Values at Lerwick

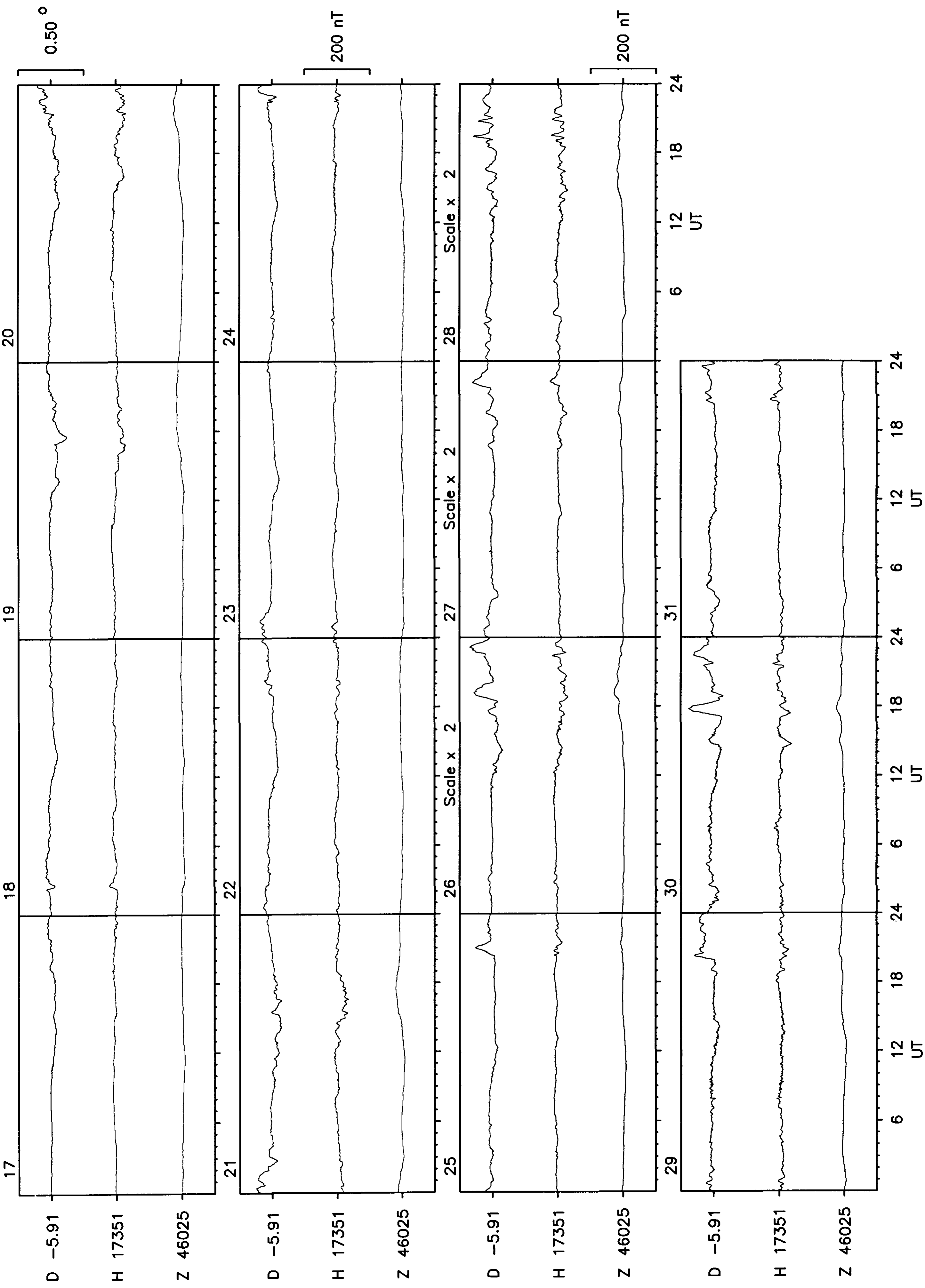


Eskdalemuir 1997 Results

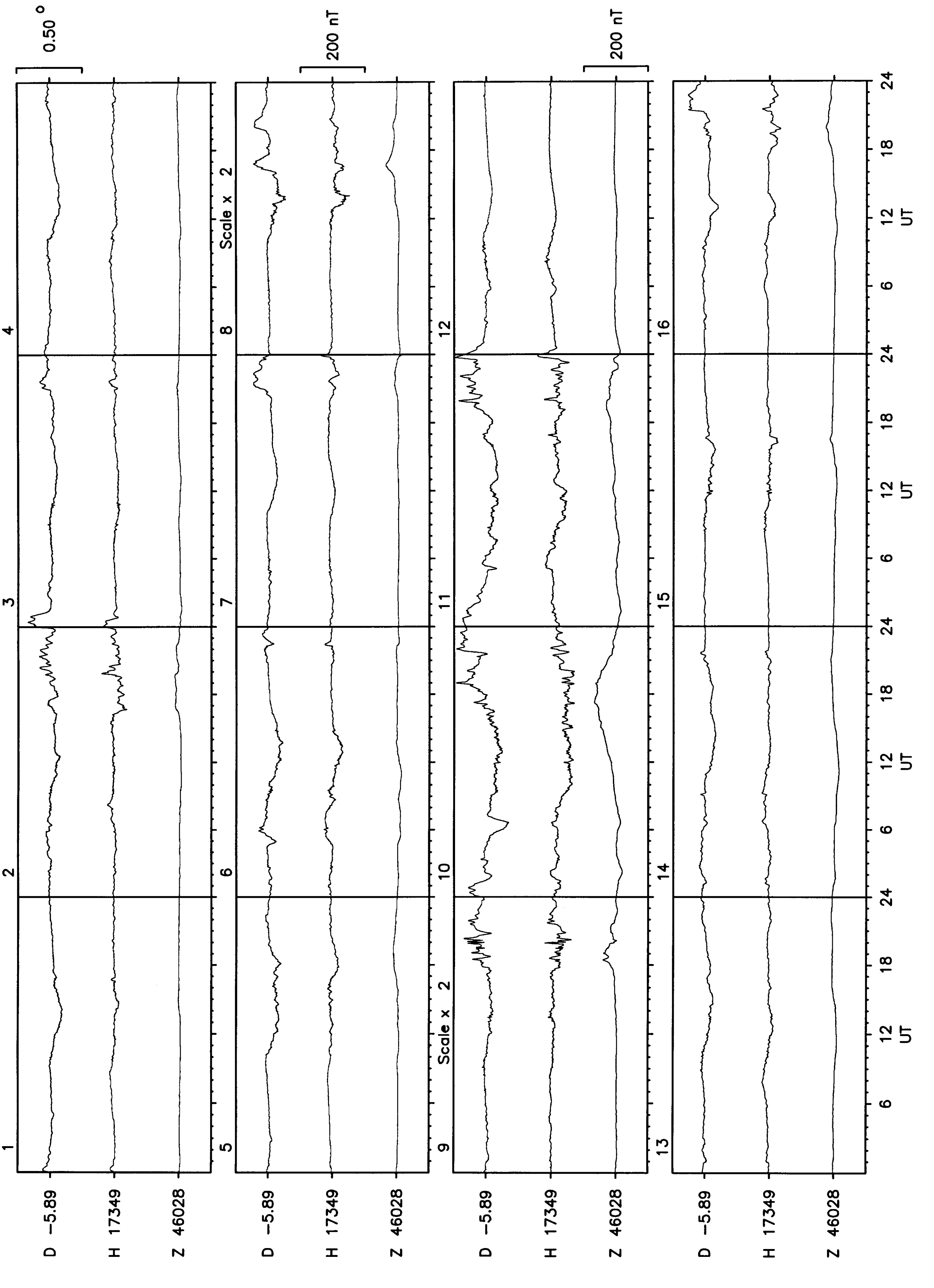
Eskdalemuir January 1997



Eskdalemuir January 1997

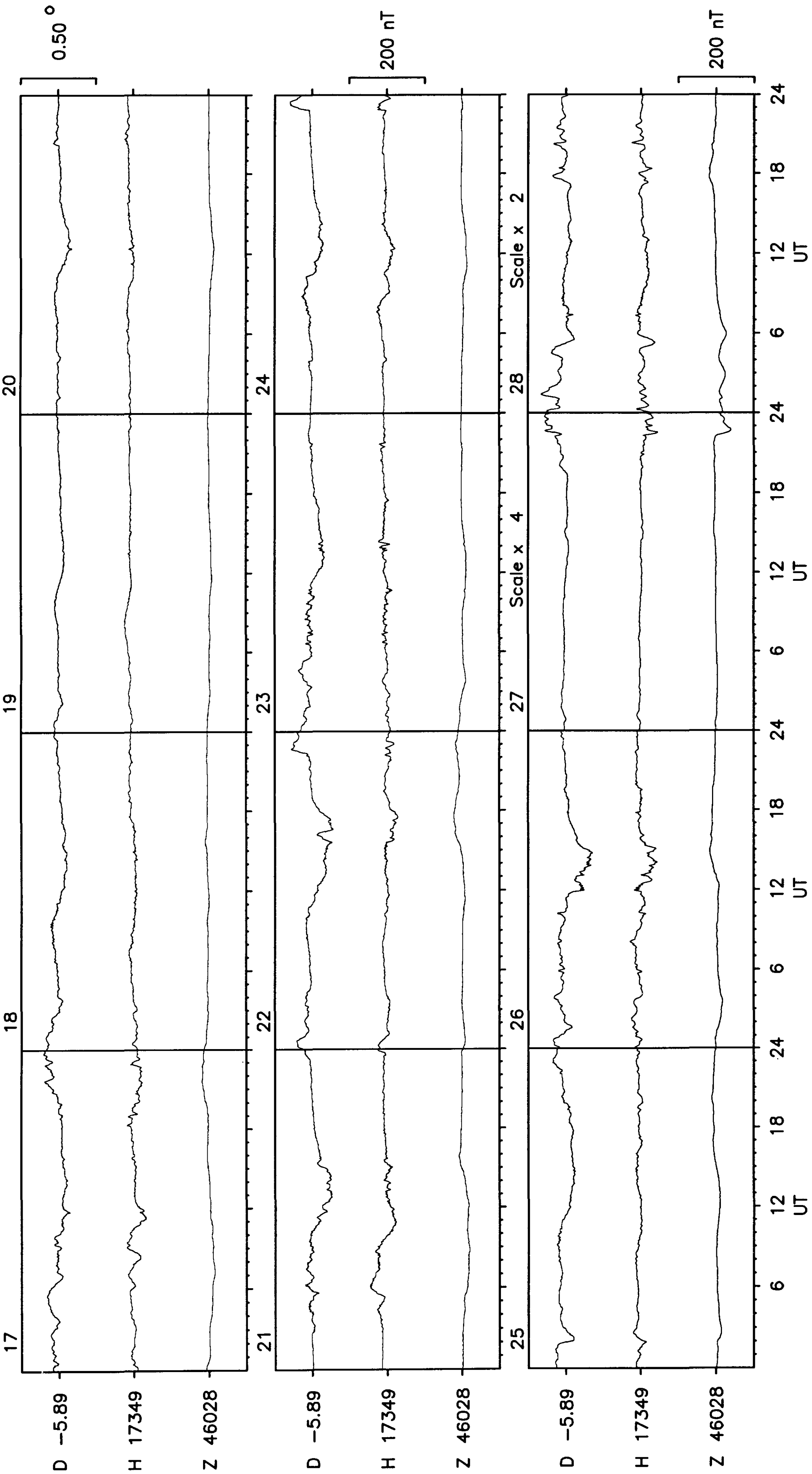


Eskdalemuir February 1997

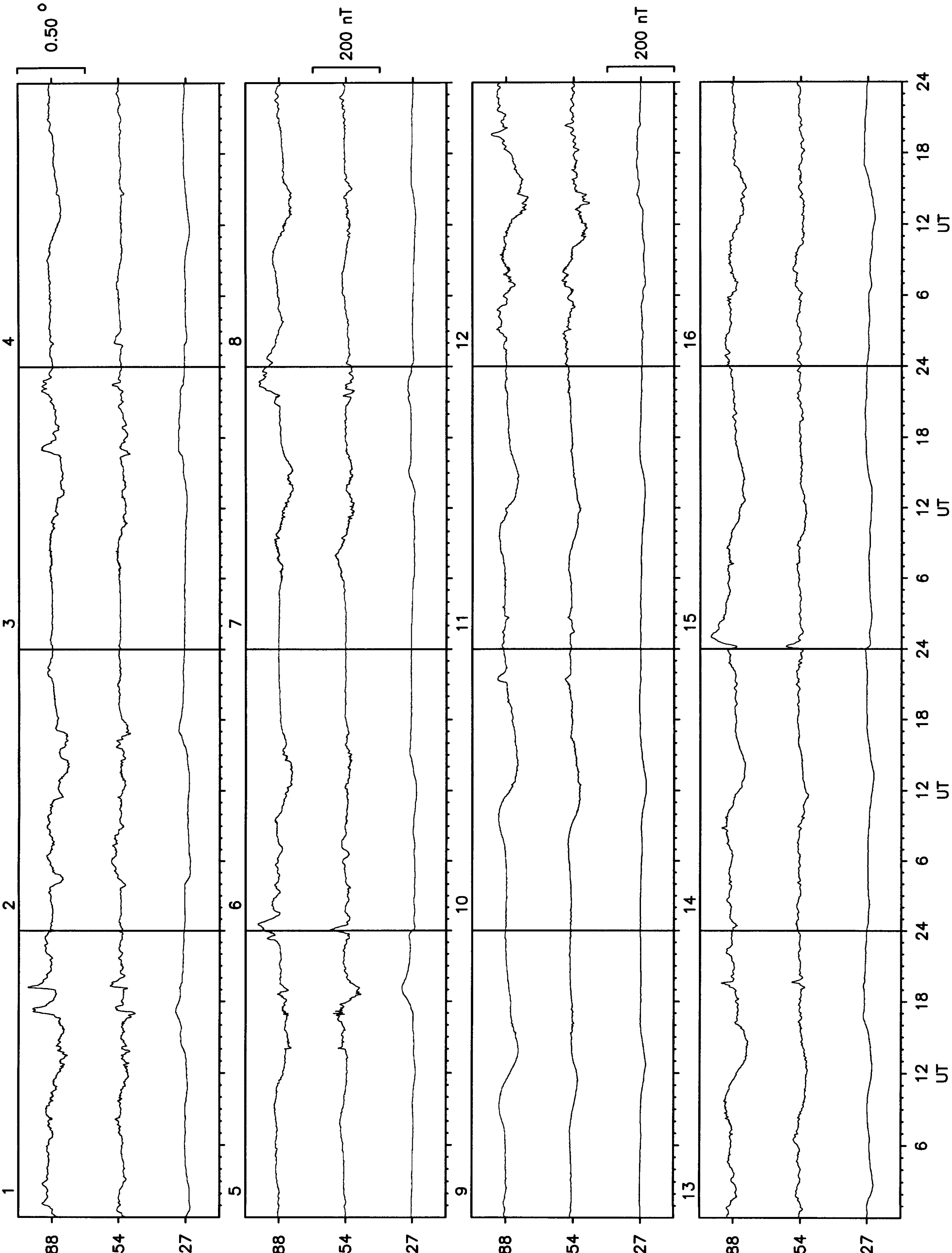


LE 2 97

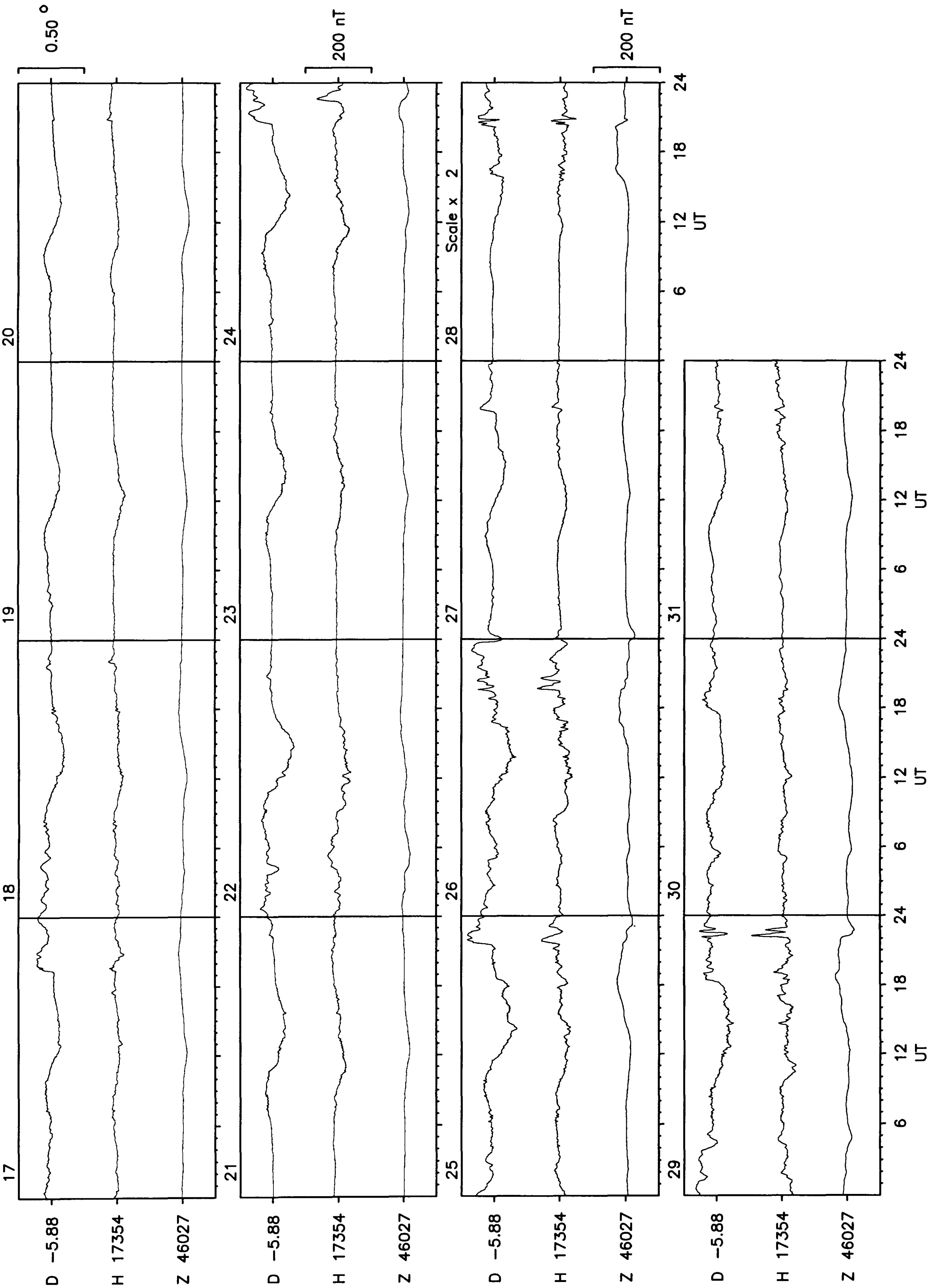
Eskdalemuir February 1997



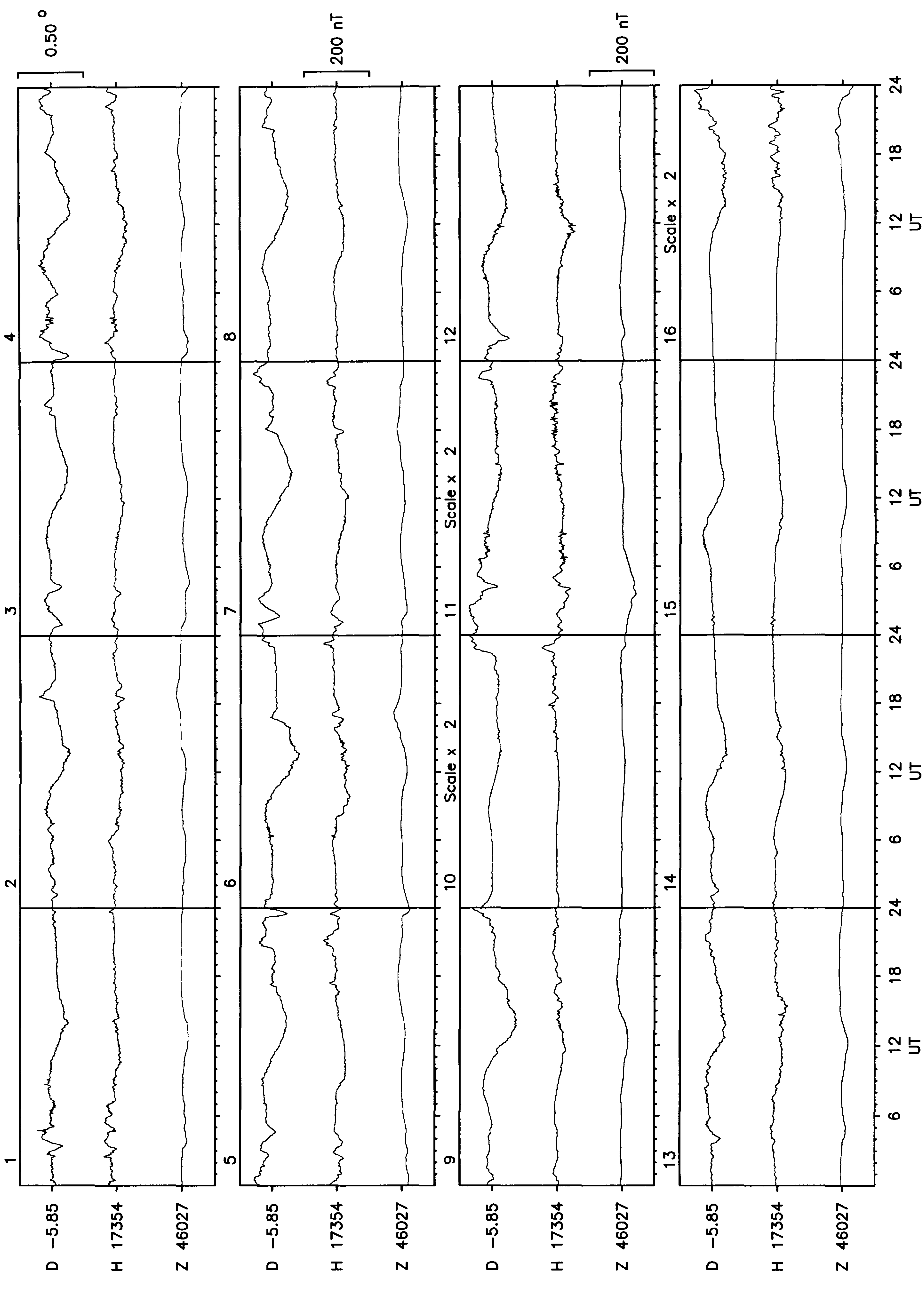
Eskdalemuir March 1997



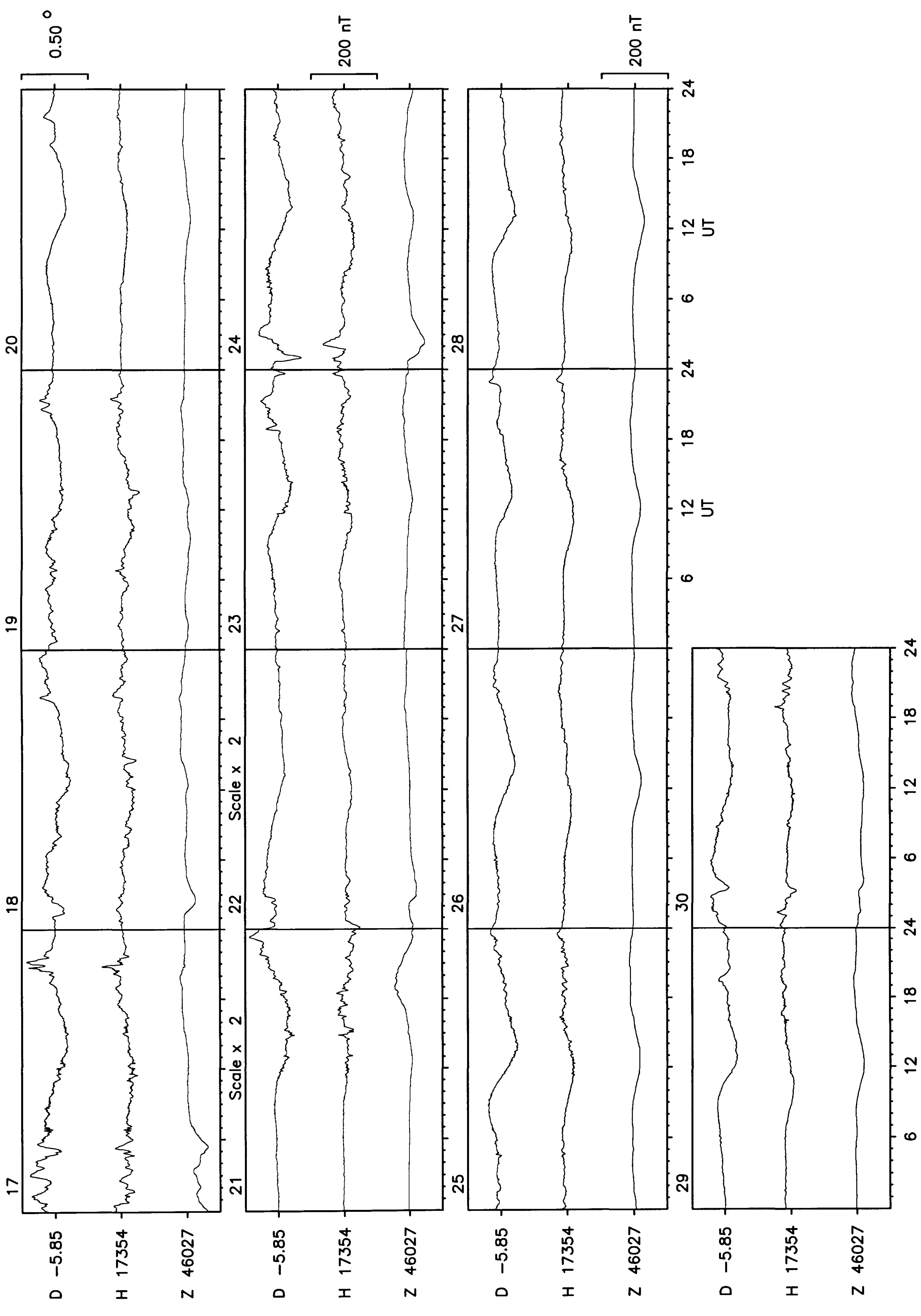
Eskdalemuir March 1997



Eskdalemuir April 1997

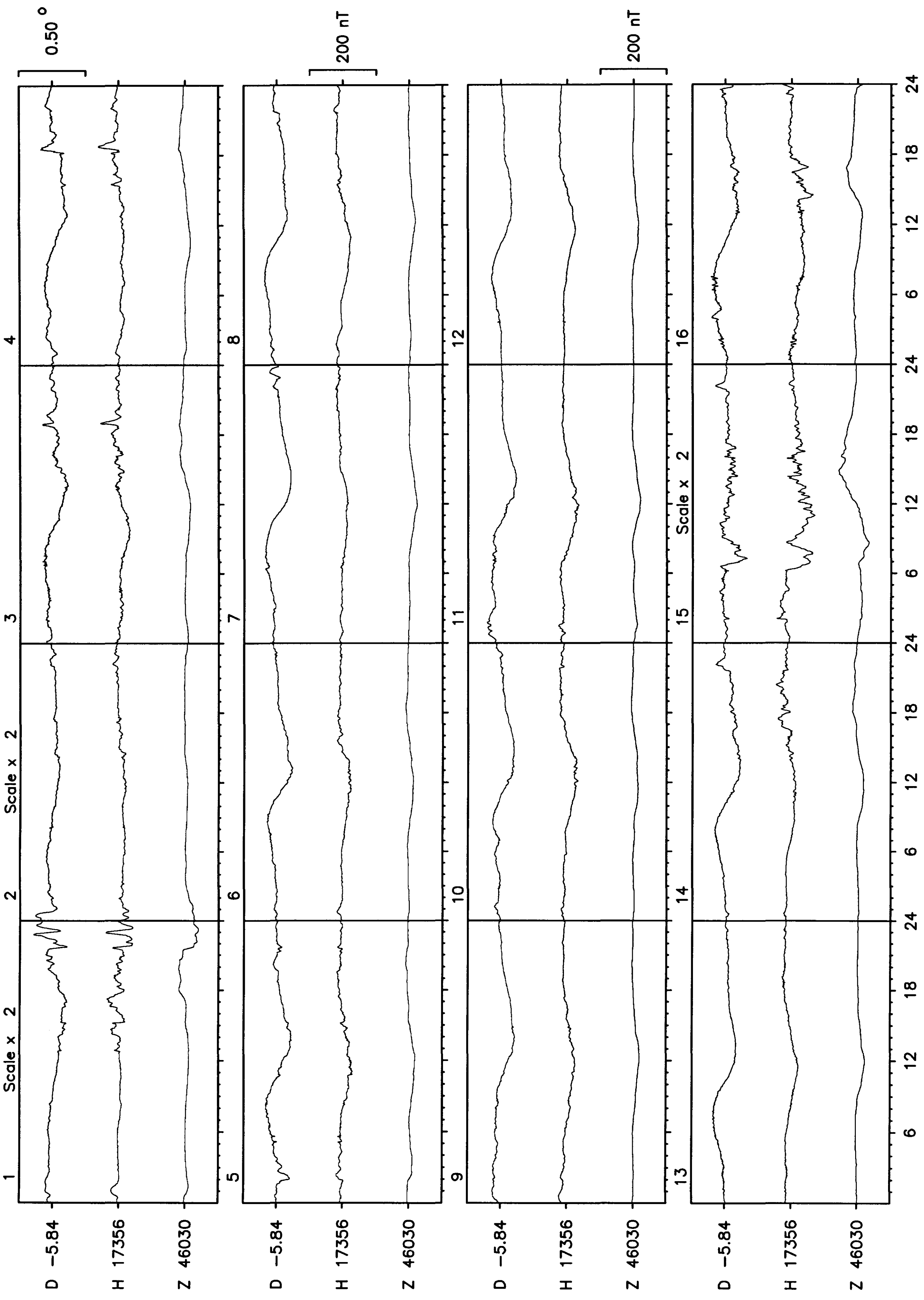


Eskdalemuir April 1997

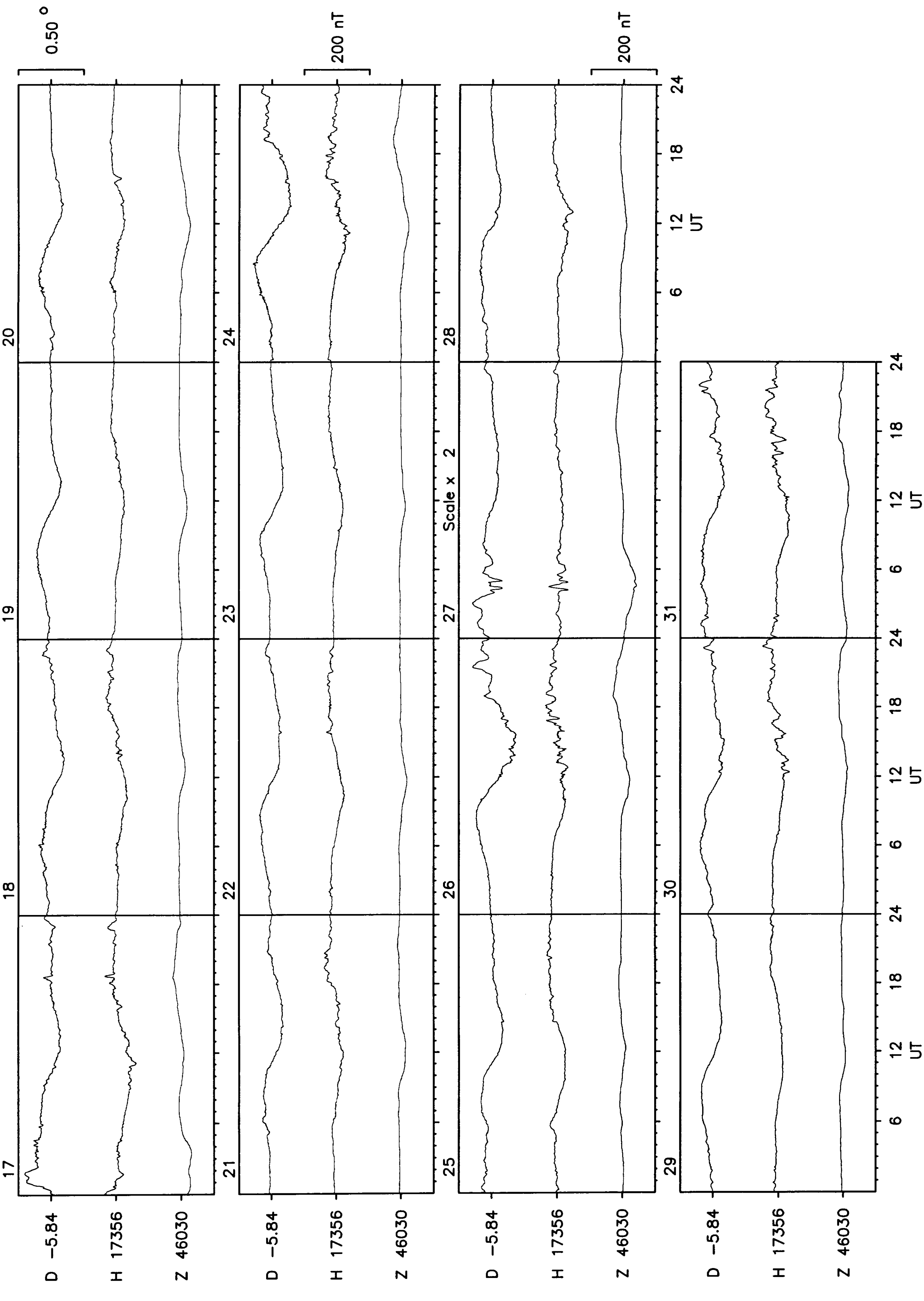


LE 4 97

Eskdalemuir May 1997

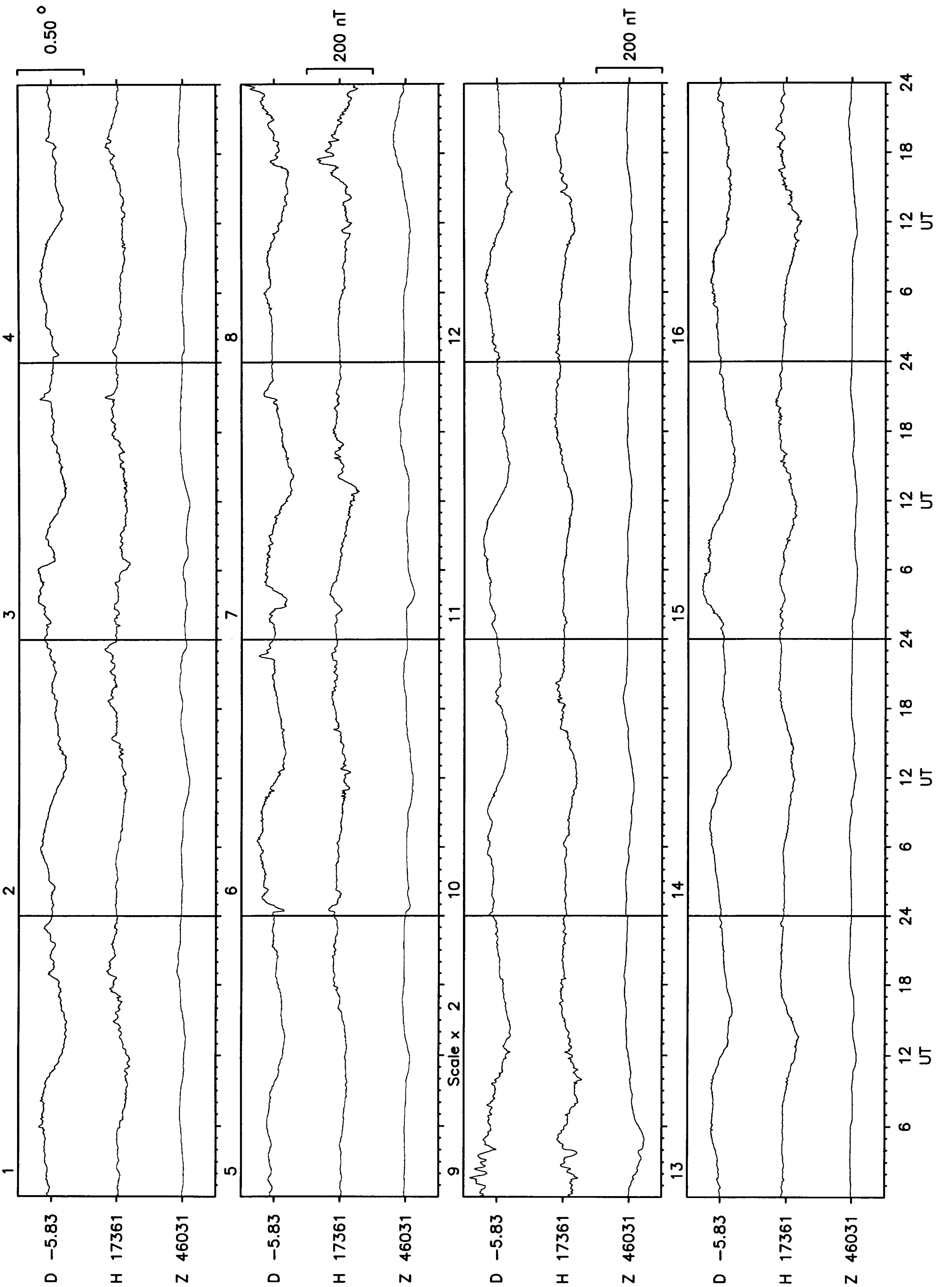


Eskdalemuir May 1997



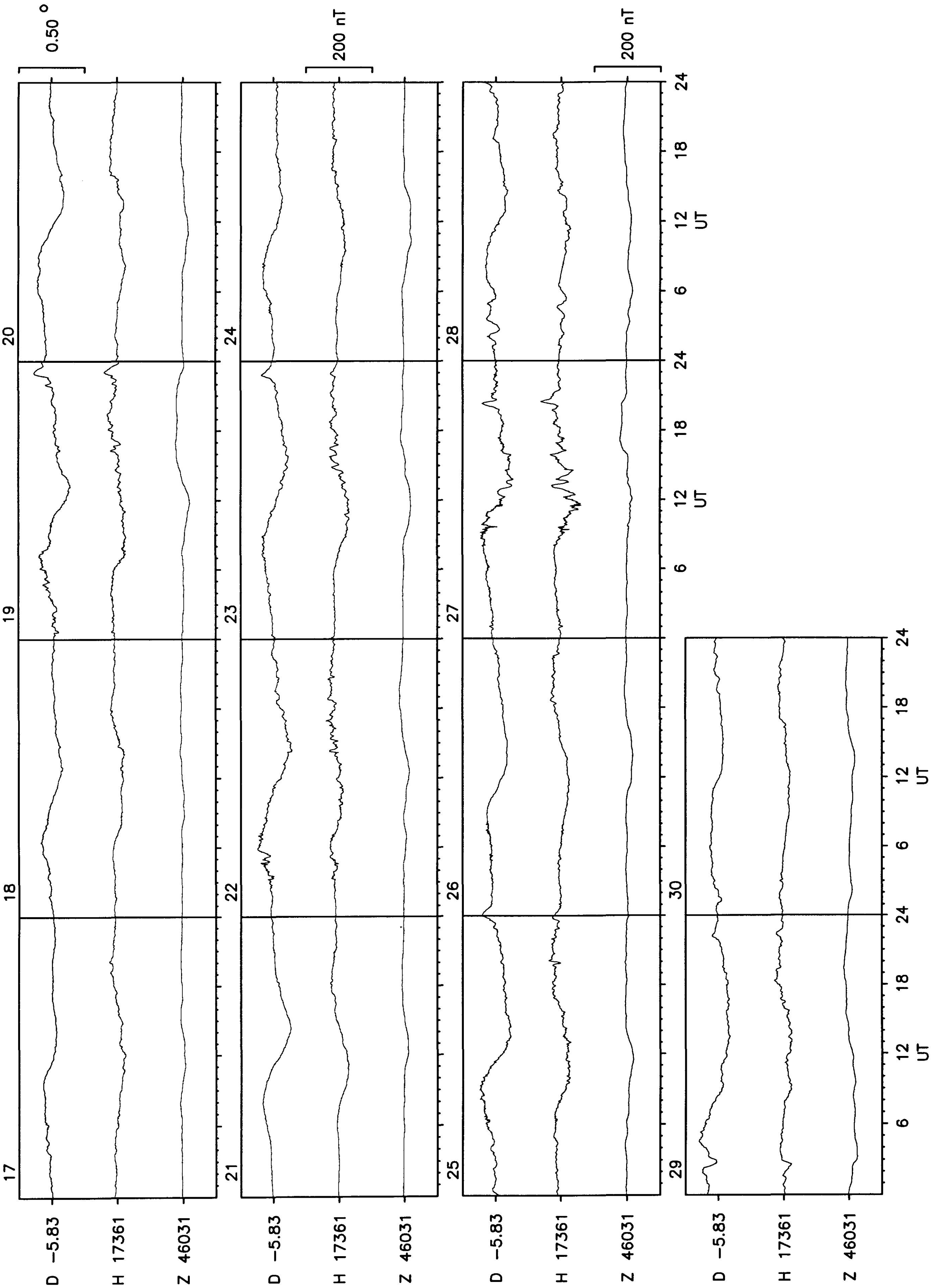
LE 5 97

Eskdalemuir June 1997

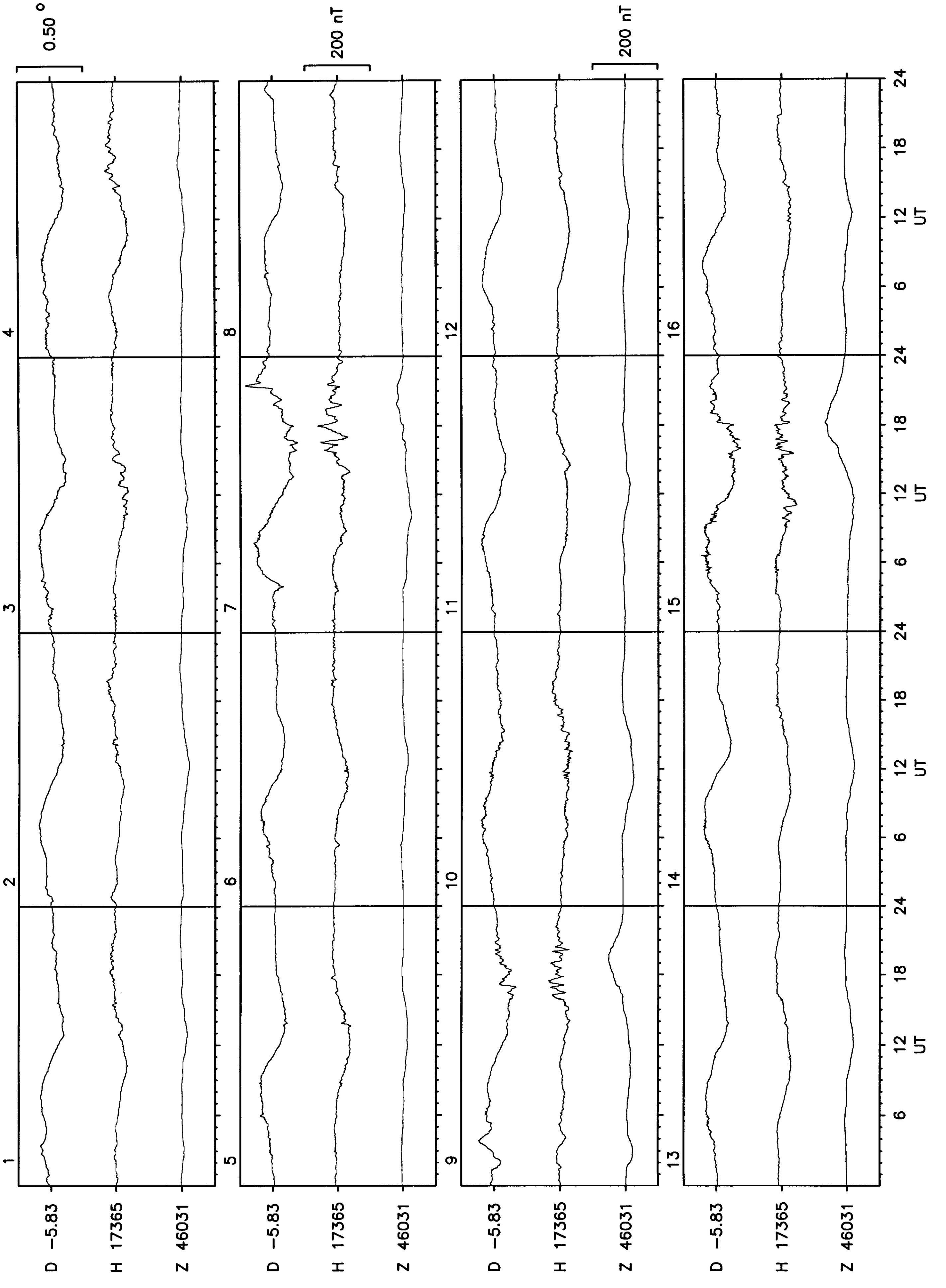


LE 6 97

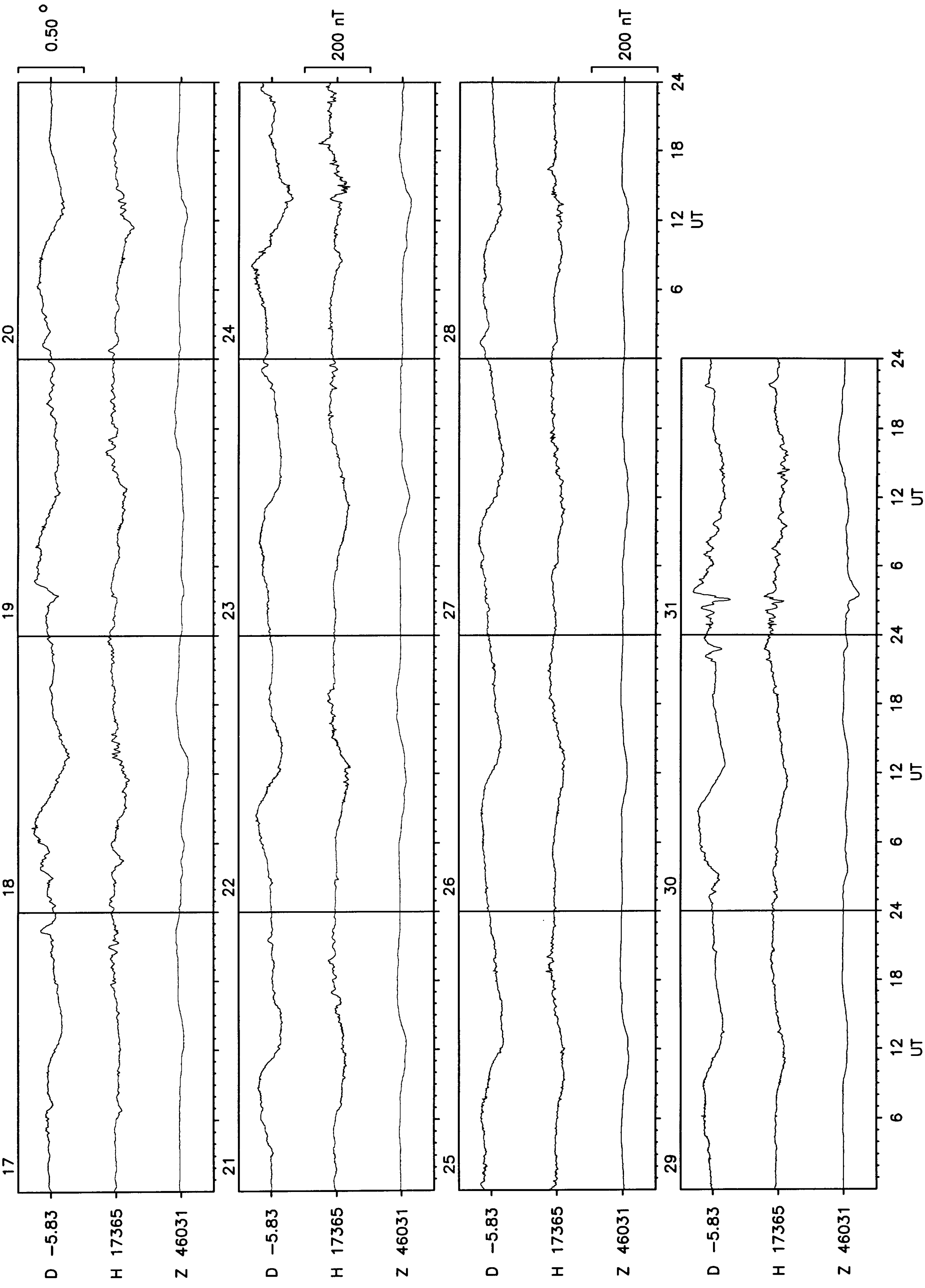
Eskdalemuir June 1997



Eskdalemuir July 1997

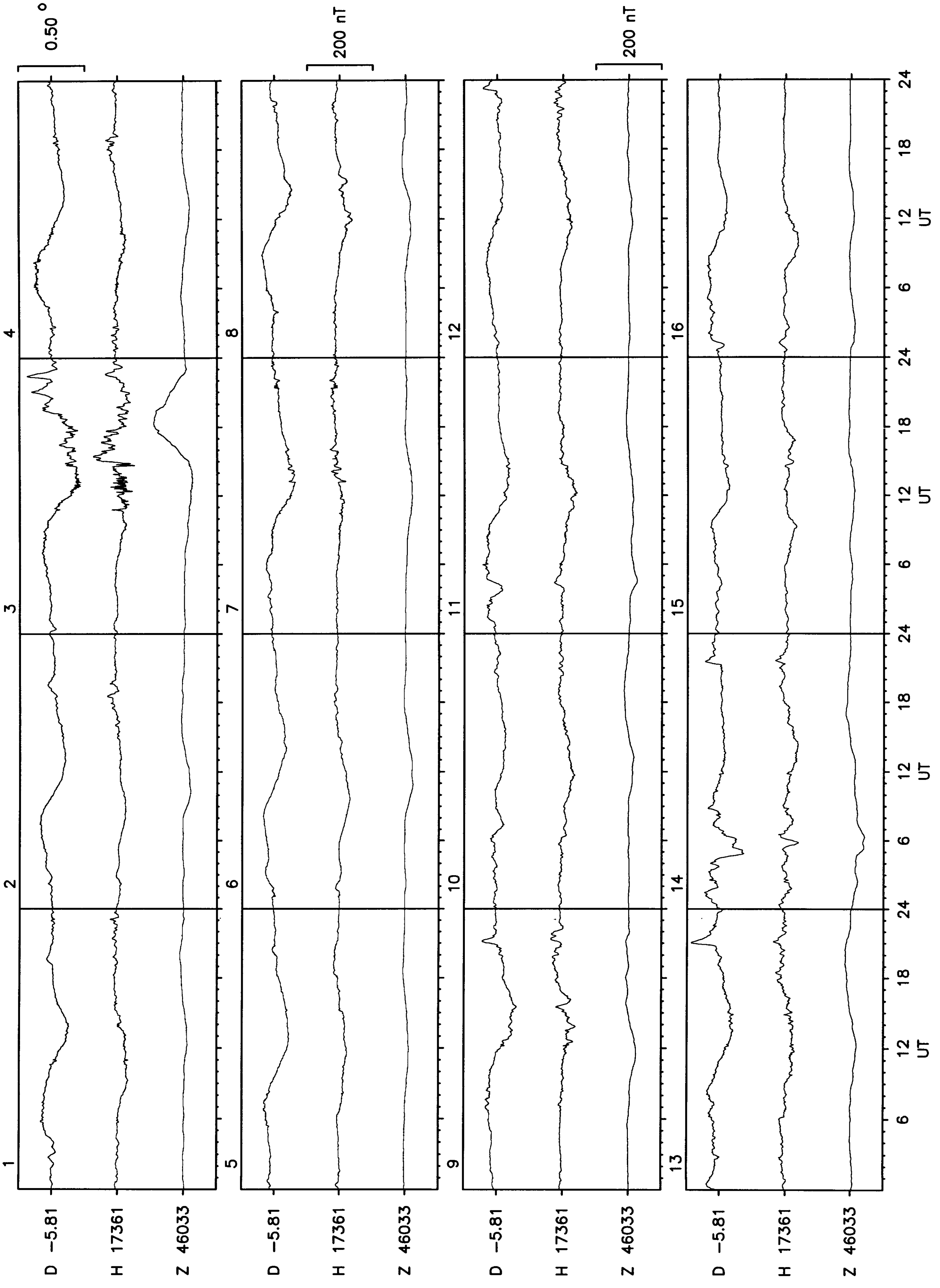


Eskdalemuir July 1997



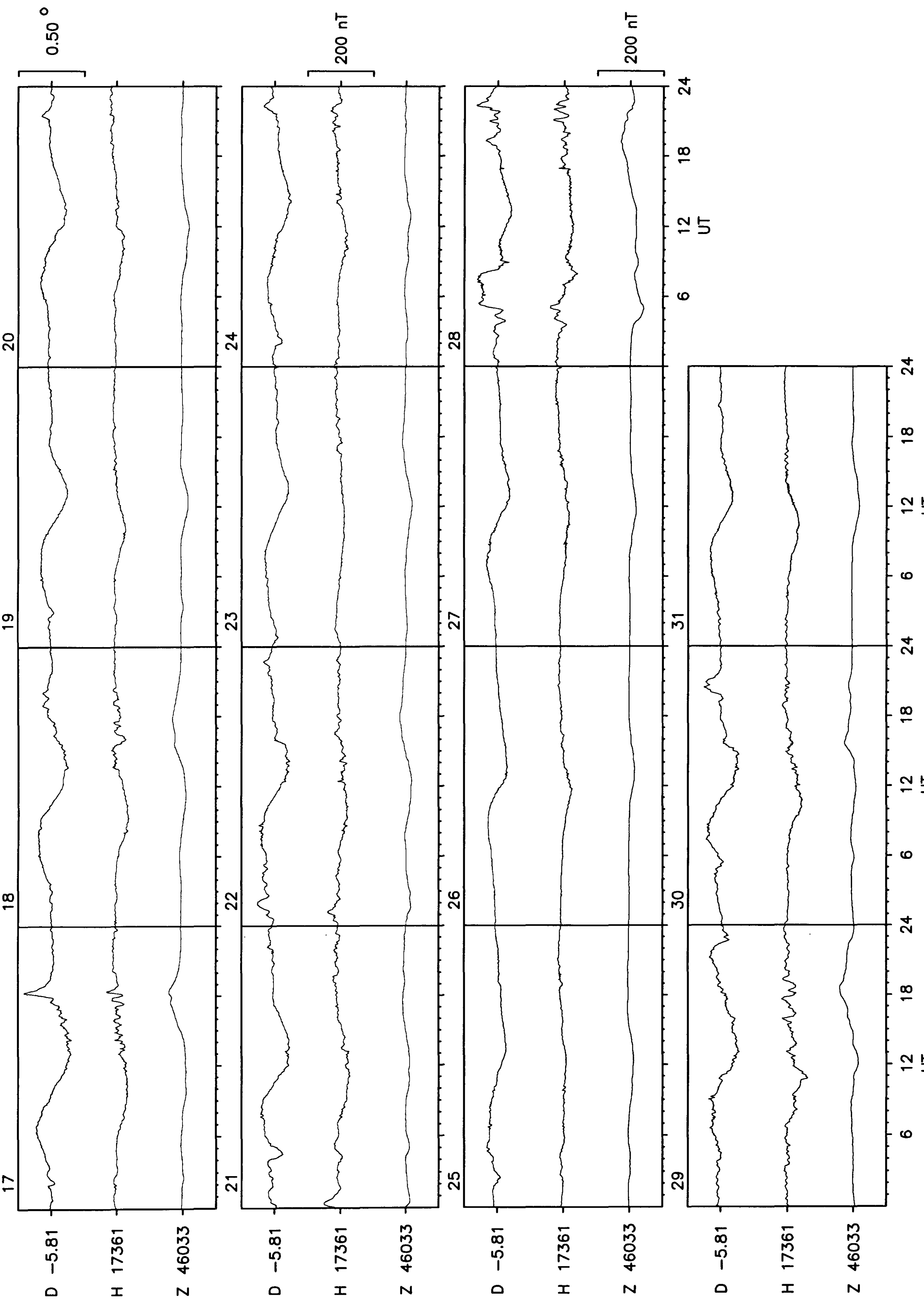
LE 7 97

Eskdalemuir August 1997



LE 8 97

Eskdalemuir August 1997



LE 8 97

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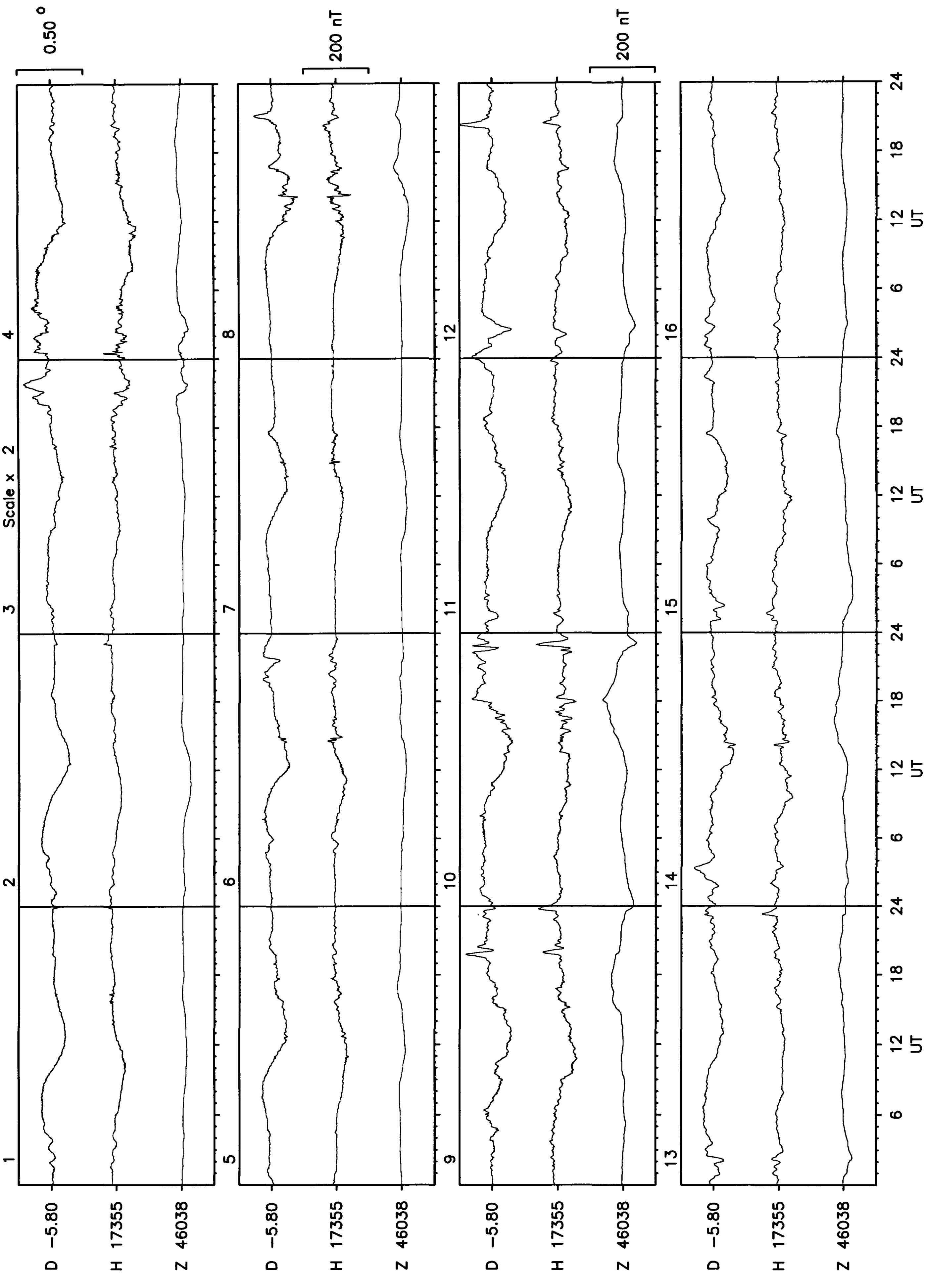
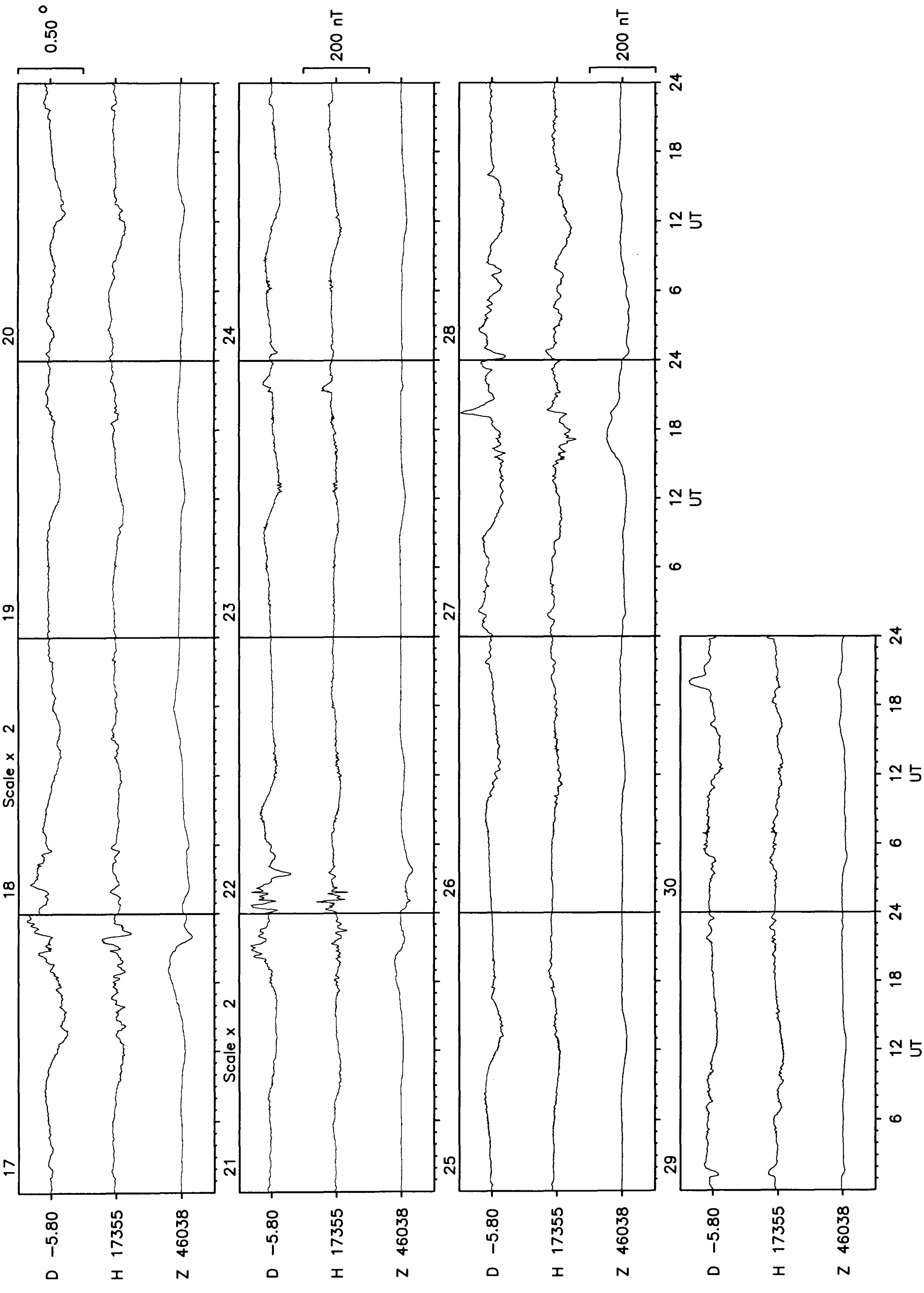
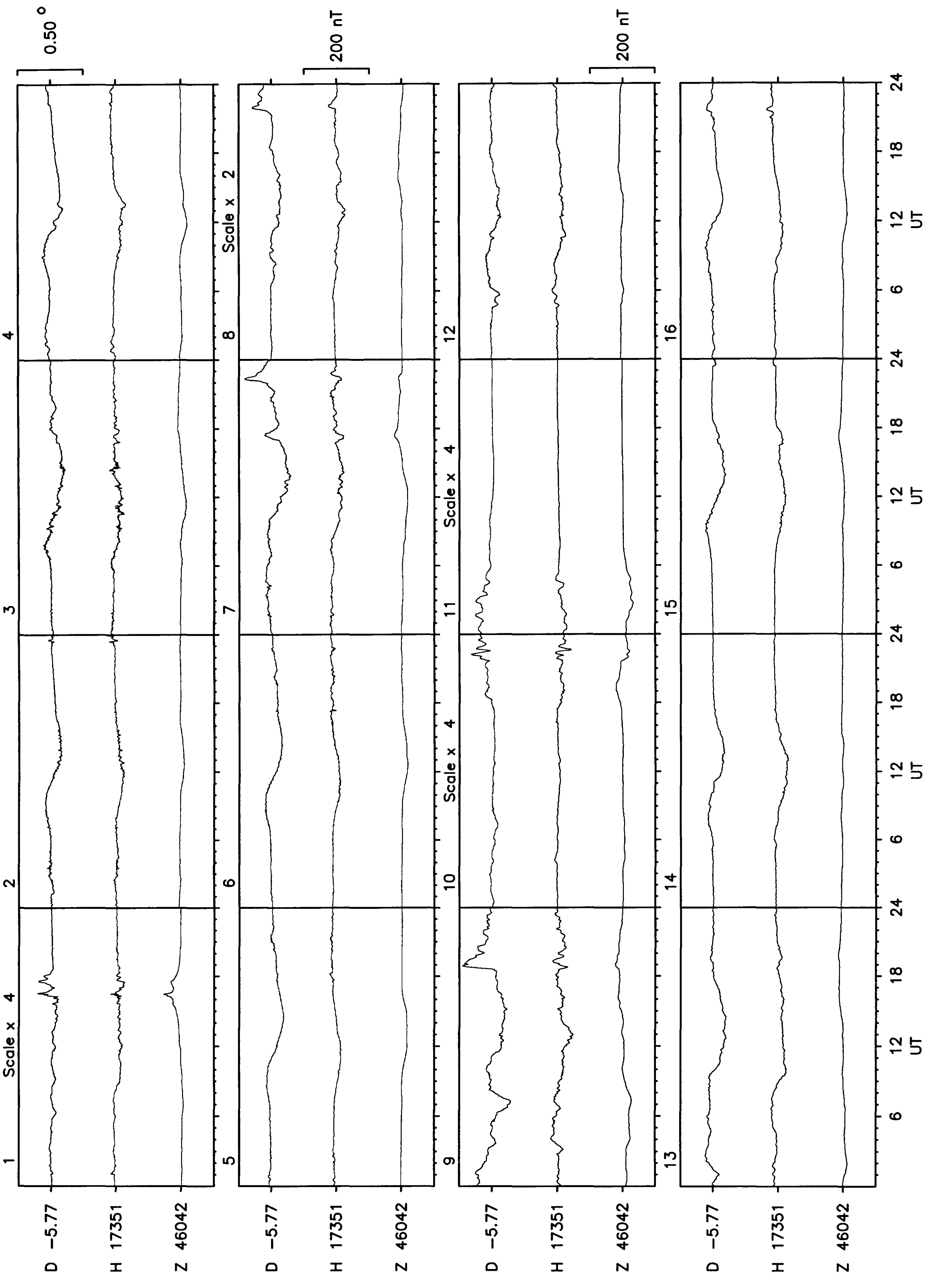


Eskdalemuir September 1997



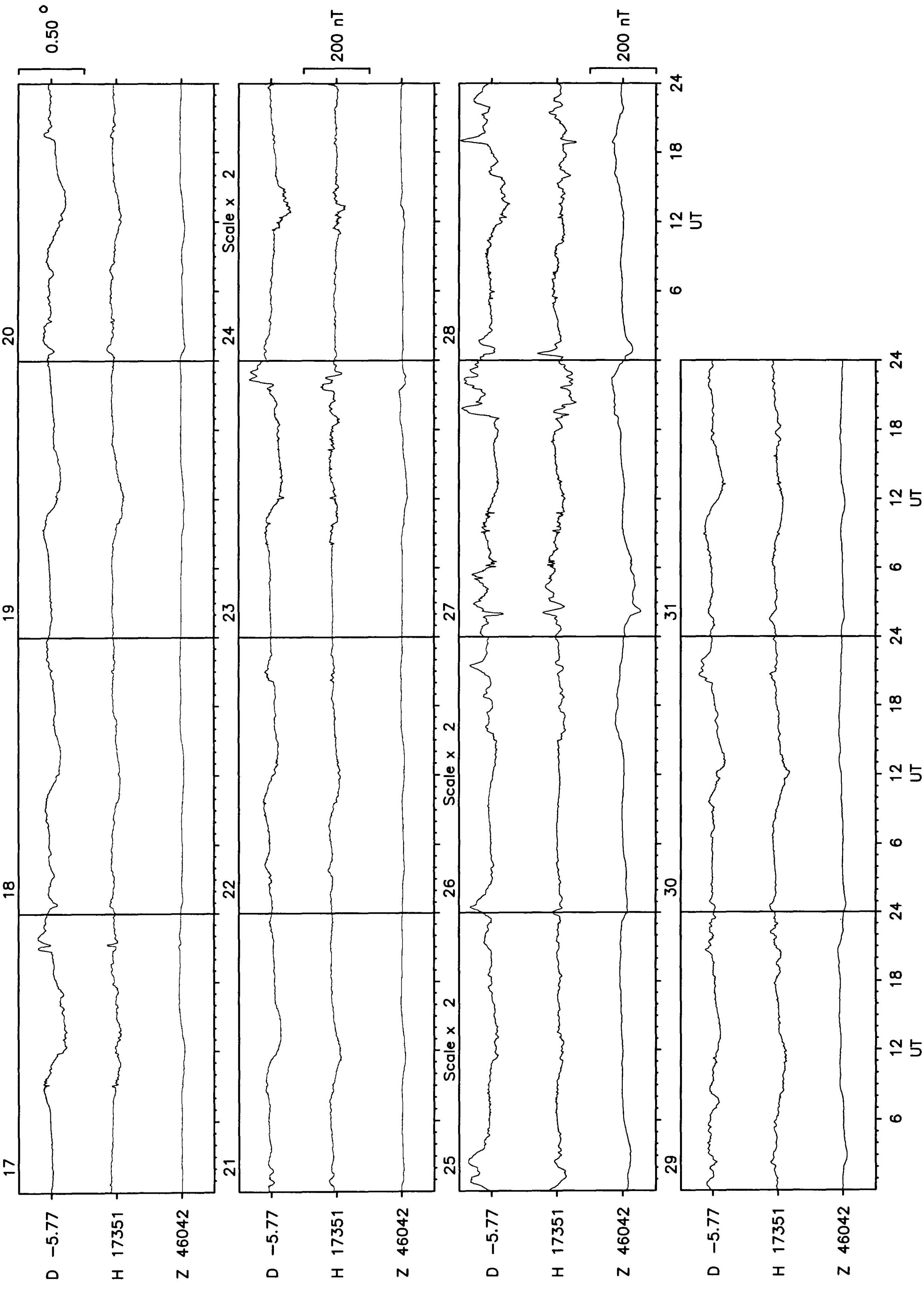
LE 9 97

Eskdalemuir October 1997



LE 10 97

Eskdalemuir October 1997



LE 10 97

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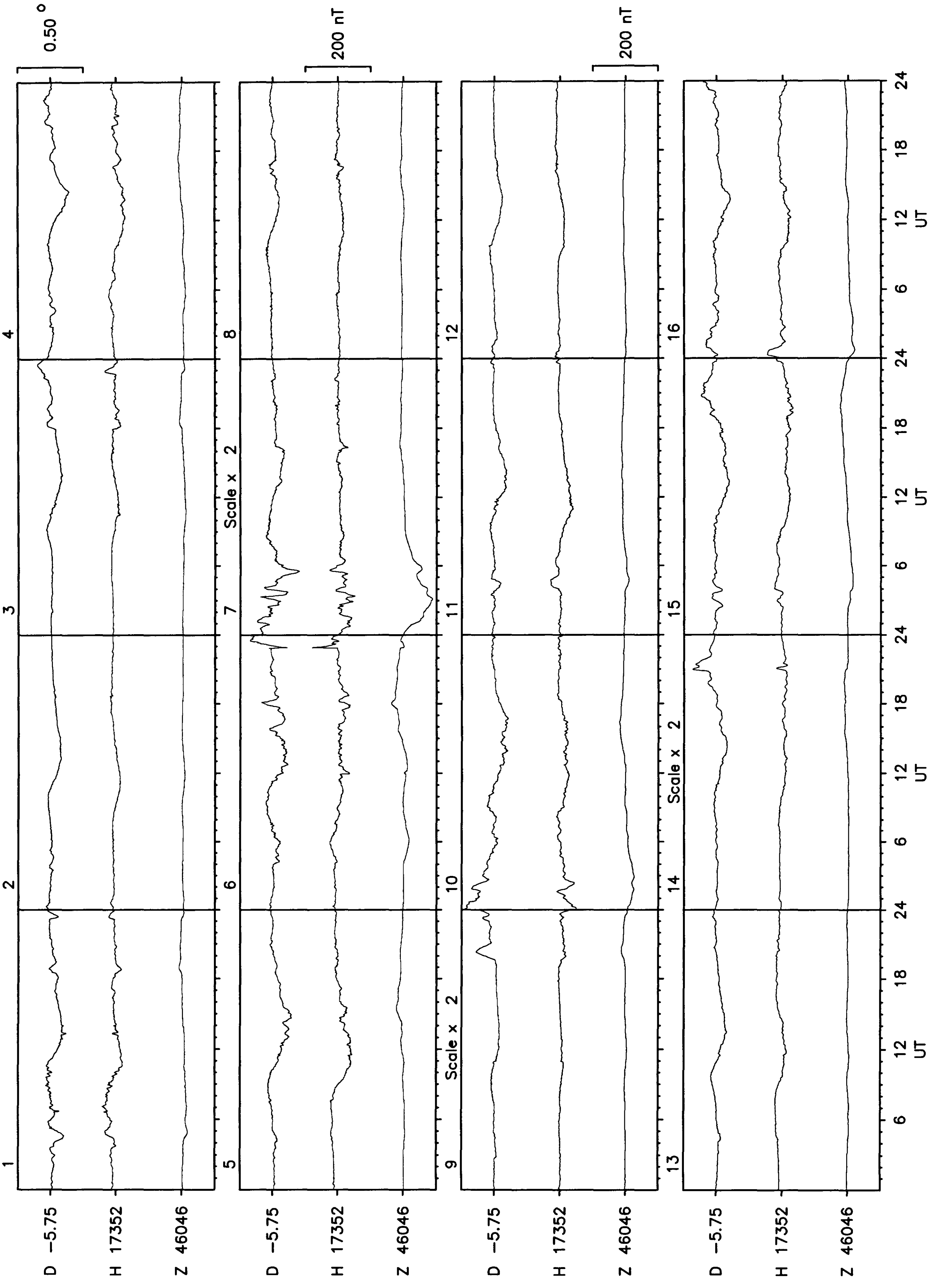

LE 11 97

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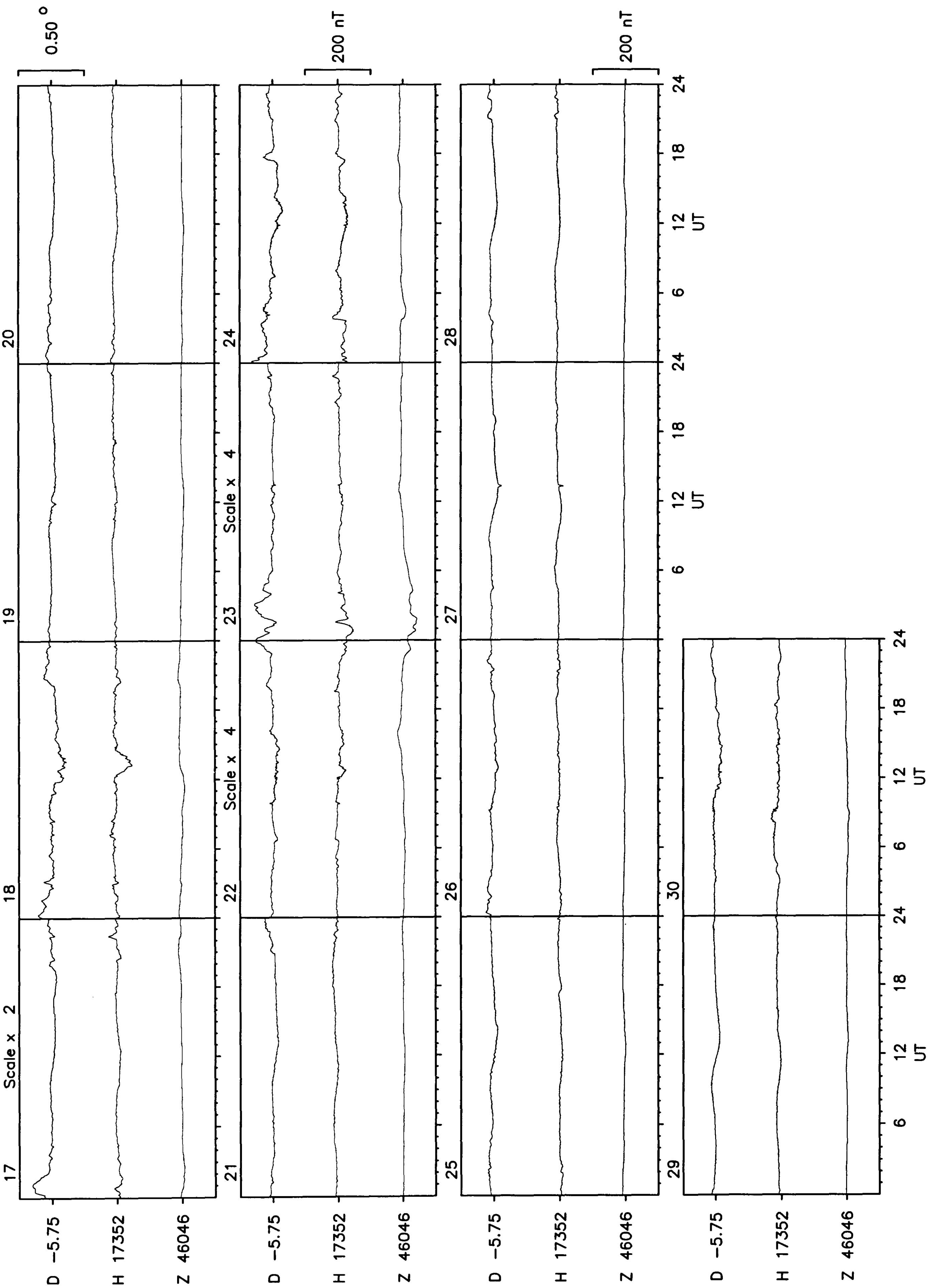
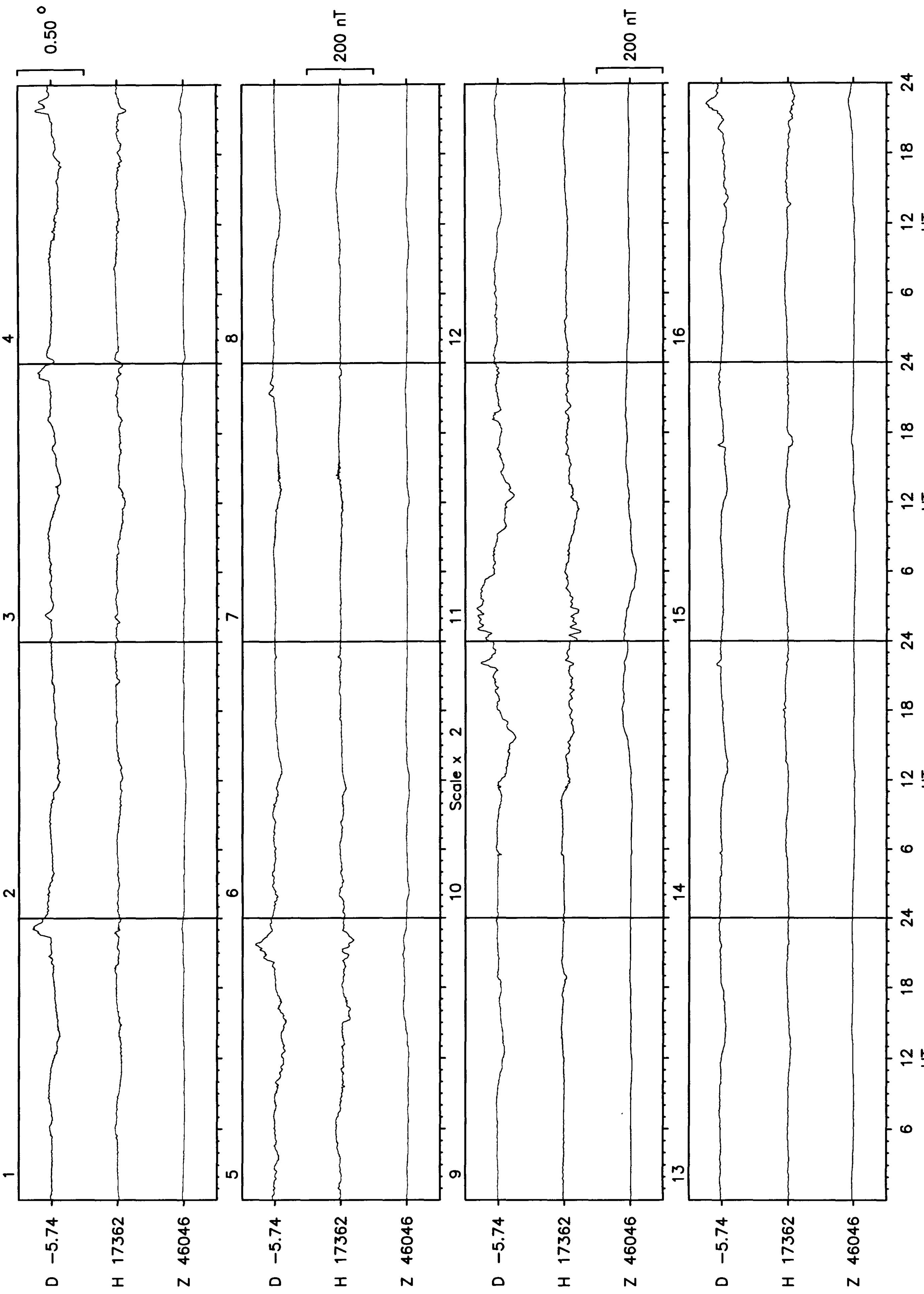


LE 11 97

Eskdalemuir December 1997



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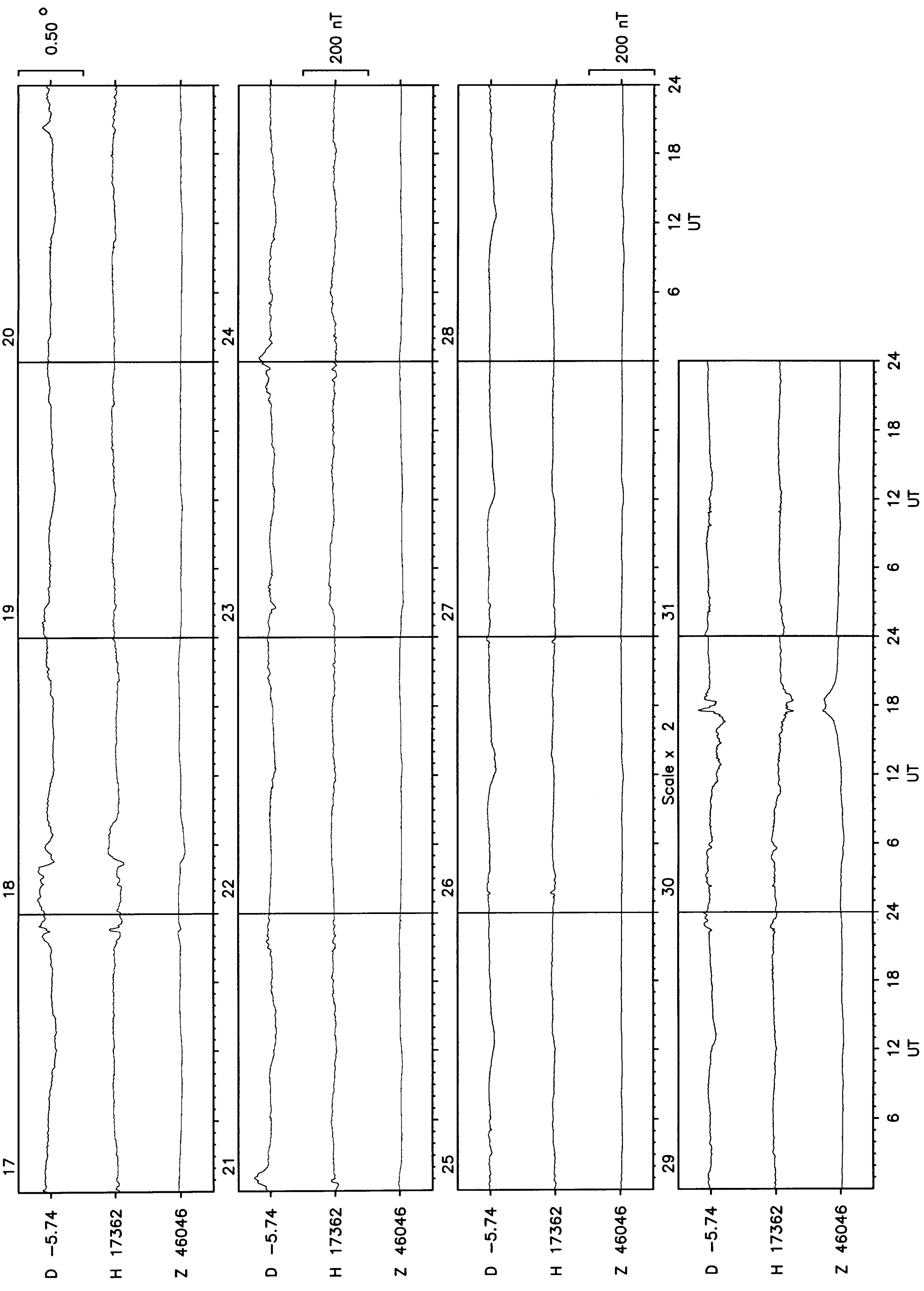
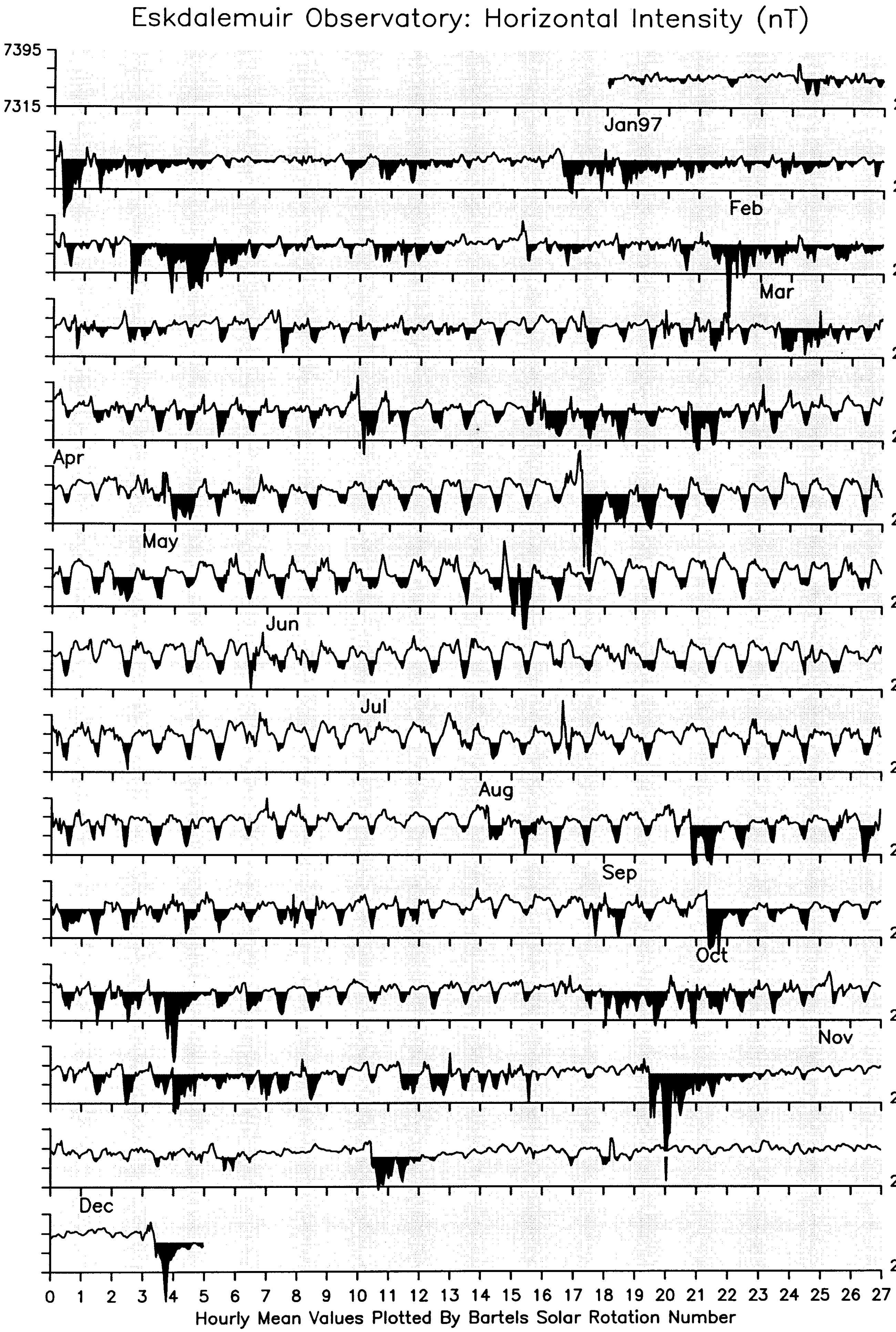
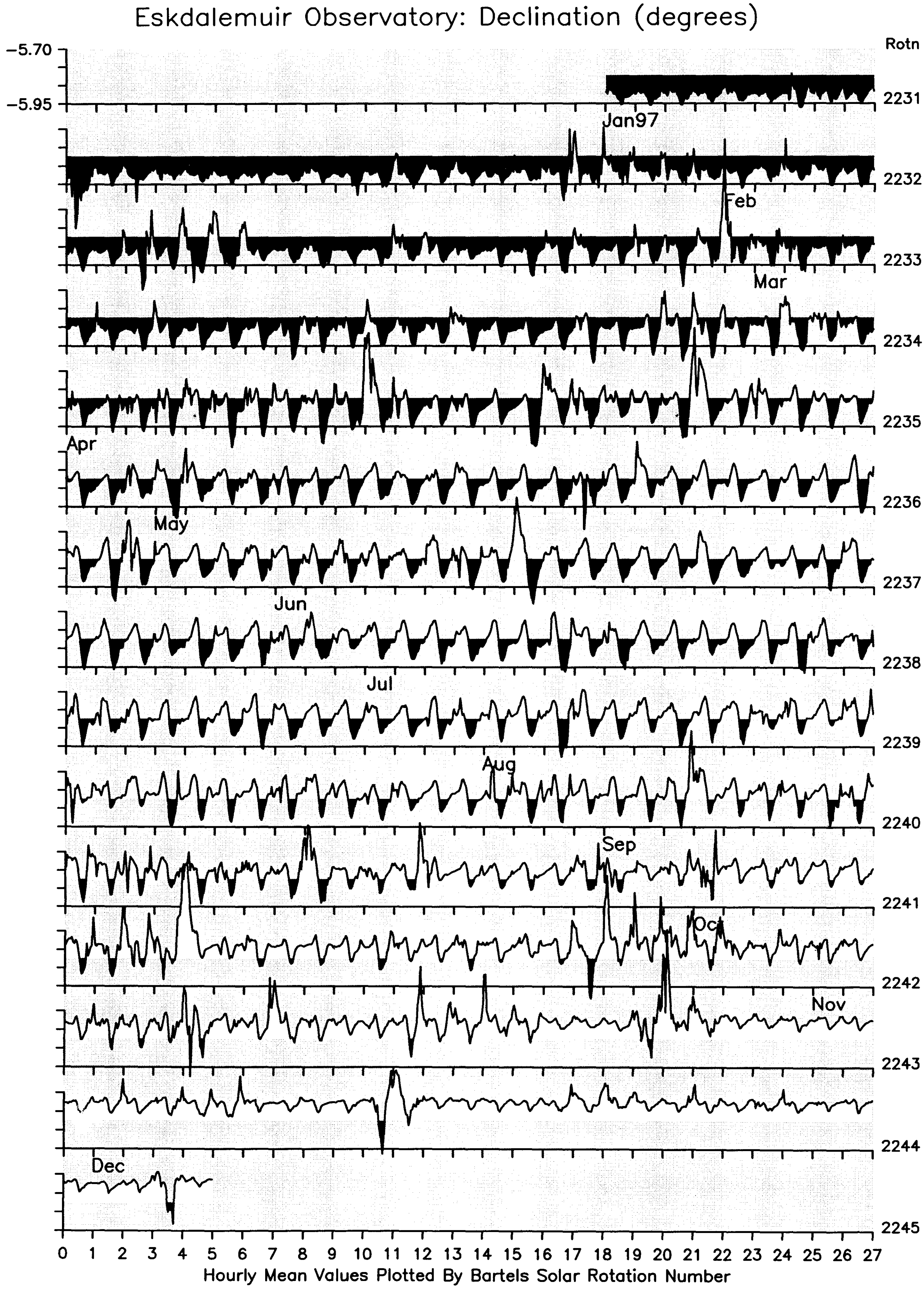


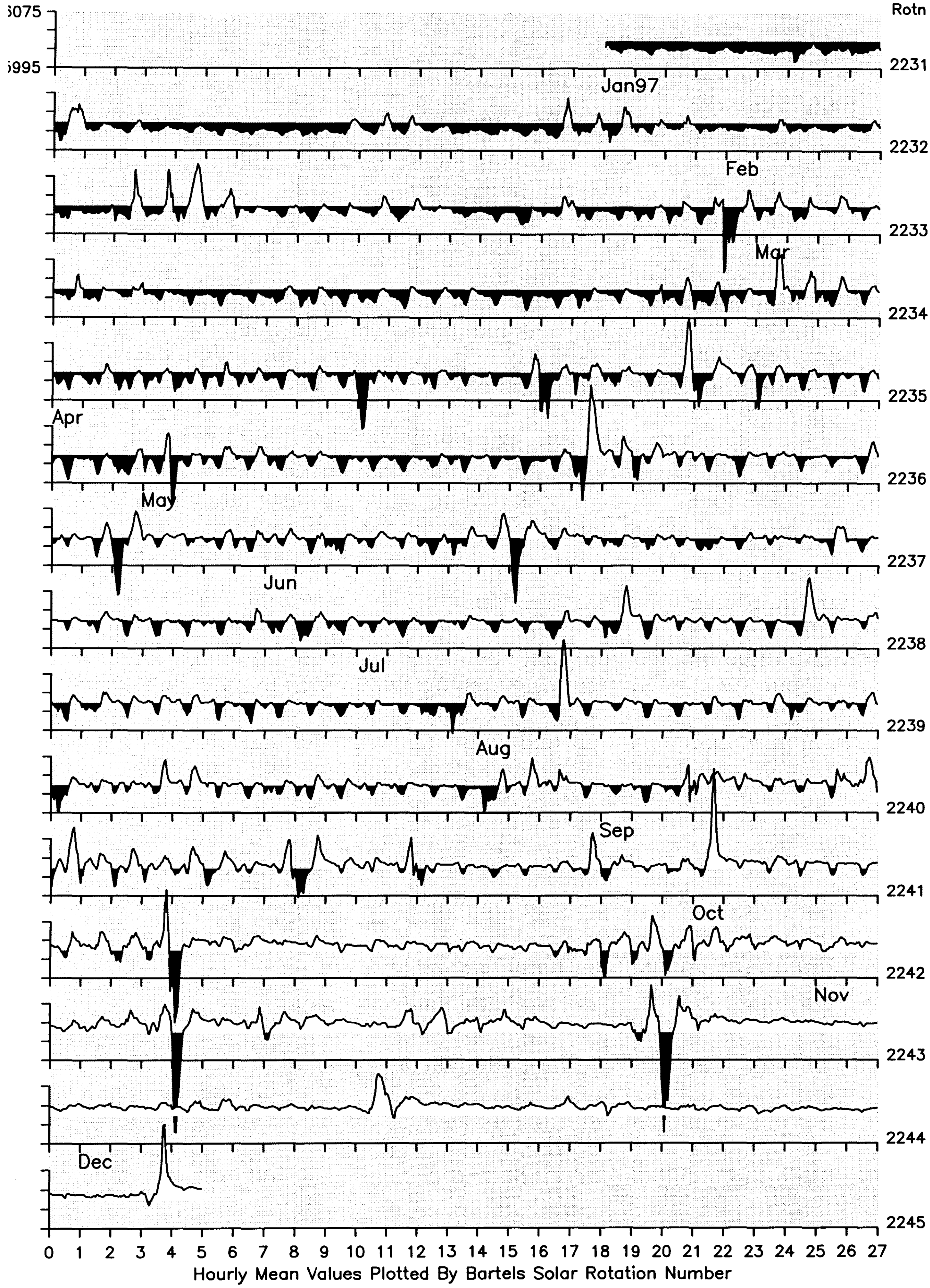
LE 12 97

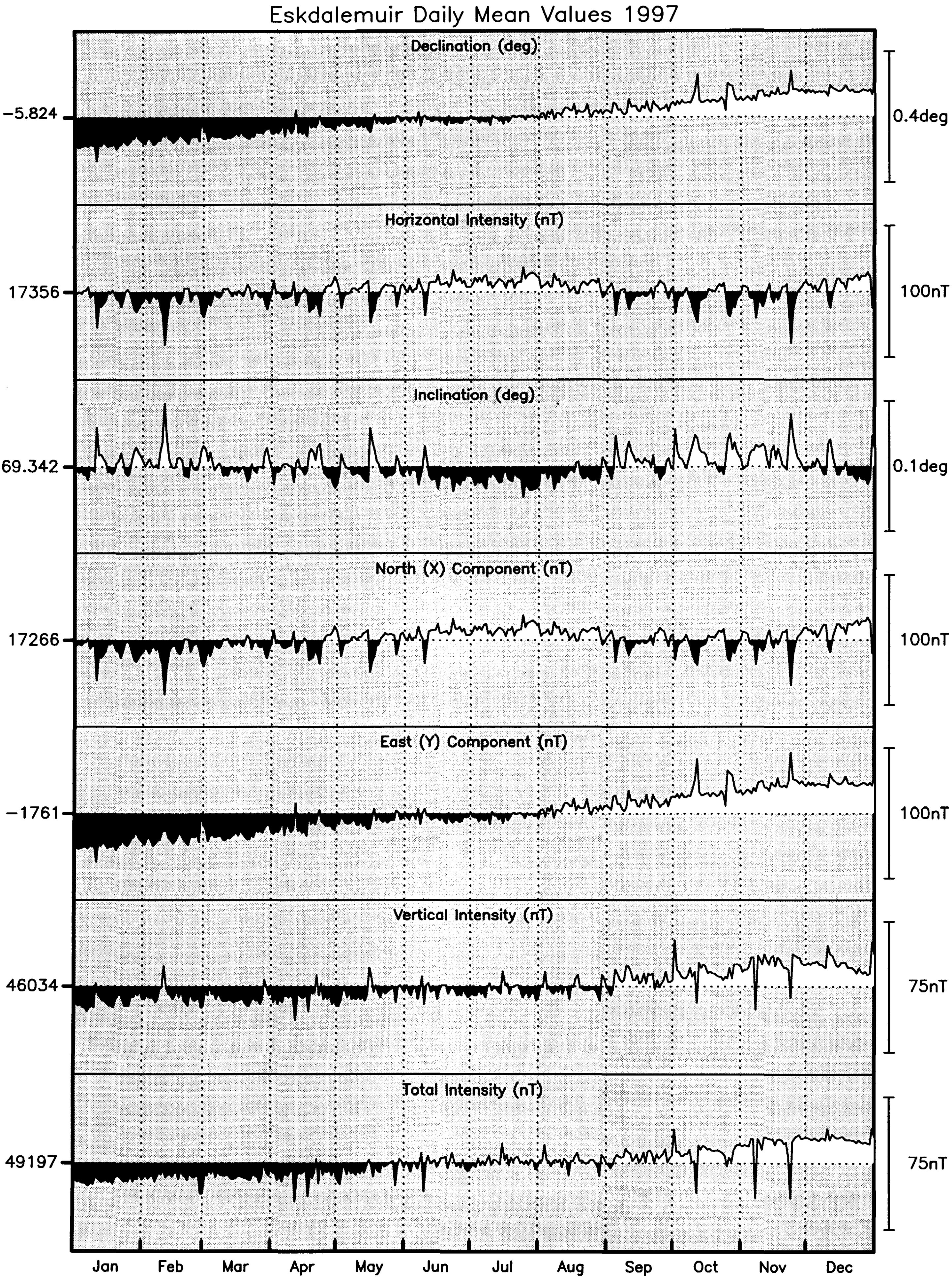

Eskdalemuir Observatory: Horizontal Intensity (nT)
7395
7315
Rotn
2231
Jan97
2232
Feb
2233
Mar
2234
2235
Apr
2236
May
2237
Jun
2238
Jul
2239
Aug
2240
Sep
2241
Oct
2242
Nov
2243
2244
Dec
2245
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Hourly Mean Values Plotted By Bartels Solar Rotation Number

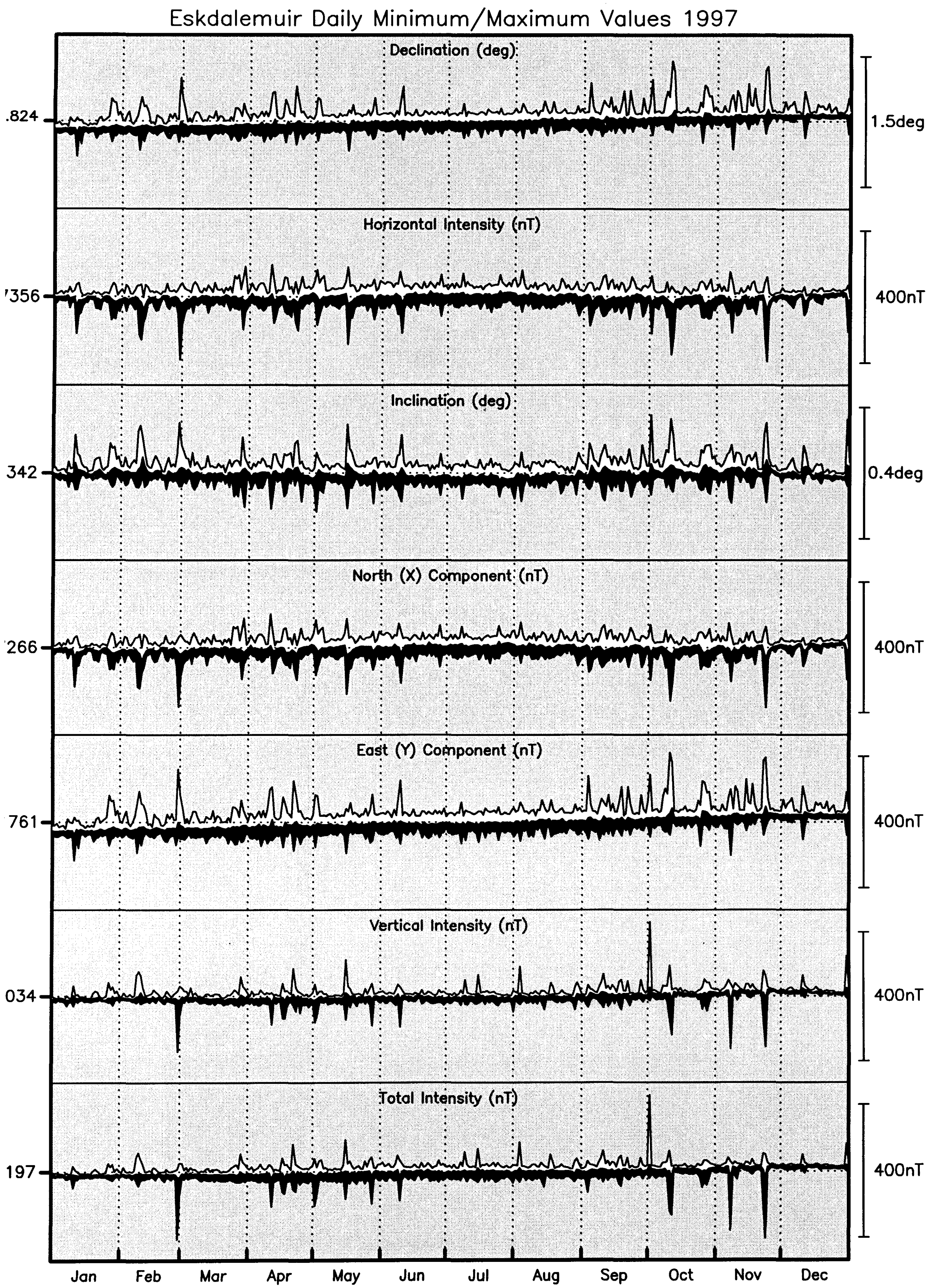


Eskdalemuir Observatory: Declination (degrees)
-5.70
-5.95
Rotn
2231
2232
2233
2234
2235
2236
2237
2238
2239
2240
2241
2242
2243
2244
2245
Jan97
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Hourly Mean Values Plotted By Bartels Solar Rotation Number

Eskdalemuir Observatory: Vertical Intensity (nT)




Eskdalemuir Daily Mean Values 1997
Declination (deg)
-5.824
0.4deg
Horizontal Intensity (nT)
17356
100nT
Inclination (deg)
69.342
0.1deg
North (X) Component (nT)
17266
100nT
East (Y) Component (nT)
-1761
100nT
Vertical Intensity (nT)
46034
75nT
Total Intensity (nT)
49197
75nT
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Eskdalemuir Daily Minimum/Maximum Values 1997
Declination (deg)
.824
1.5deg
Horizontal Intensity (nT)
'356
400nT
Inclination (deg)
342
0.4deg
North (X) Component (nT)
'266
400nT
East (Y) Component (nT)
761
400nT
Vertical Intensity (nT)
034
400nT
Total Intensity (nT)
197
400nT
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Monthly Mean Values for Eskdalemuir 1997

Month	D	H	I	X	Y	Z	F
Based on All Days							
January	-5° 54.3′	17351 nT	69° 20.6′	17259 nT	-1785 nT	46025 nT	49187 nT
February	-5° 53.2′	17349 nT	69° 20.8′	17258 nT	-1779 nT	46028 nT	49189 nT
March	-5° 52.6′	17354 nT	69° 20.5′	17263 nT	-1777 nT	46027 nT	49190 nT
April	-5° 51.3′	17354 nT	69° 20.5′	17264 nT	-1770 nT	46027 nT	49190 nT
May	-5° 50.5′	17356 nT	69° 20.5′	17266 nT	-1766 nT	46030 nT	49193 nT
June	-5° 49.9′	17361 nT	69° 20.1′	17271 nT	-1764 nT	46031 nT	49196 nT
July	-5° 49.7′	17365 nT	69° 19.8′	17276 nT	-1763 nT	46031 nT	49198 nT
August	-5° 48.5′	17361 nT	69° 20.2′	17272 nT	-1757 nT	46033 nT	49198 nT
September	-5° 47.7′	17355 nT	69° 20.7′	17267 nT	-1753 nT	46038 nT	49200 nT
October	-5° 46.1′	17351 nT	69° 21.1′	17263 nT	-1744 nT	46042 nT	49203 nT
November	-5° 45.1′	17352 nT	69° 21.1′	17265 nT	-1739 nT	46046 nT	49207 nT
December	-5° 44.6′	17362 nT	69° 20.5′	17275 nT	-1738 nT	46046 nT	49211 nT
Annual	**-5° 49.4′**	**17356 nT**	**69° 20.5′**	**17266 nT**	**-1761 nT**	**46034 nT**	**49197 nT**
International quiet day means							
January	-5° 54.7′	17357 nT	69° 20.2′	17265 nT	-1788 nT	46022 nT	49186 nT
February	-5° 53.6′	17355 nT	69° 20.4′	17264 nT	-1782 nT	46026 nT	49189 nT
March	-5° 53.2′	17358 nT	69° 20.1′	17267 nT	-1780 nT	46025 nT	49189 nT
April	-5° 51.5′	17363 nT	69° 19.9′	17272 nT	-1772 nT	46026 nT	49192 nT
May	-5° 50.5′	17360 nT	69° 20.2′	17270 nT	-1767 nT	46029 nT	49194 nT
June	-5° 50.2′	17362 nT	69° 20.1′	17272 nT	-1766 nT	46032 nT	49198 nT
July	-5° 49.7′	17366 nT	69° 19.8′	17276 nT	-1764 nT	46030 nT	49197 nT
August	-5° 48.5′	17362 nT	69° 20.1′	17272 nT	-1757 nT	46032 nT	49197 nT
September	-5° 48.2′	17360 nT	69° 20.3′	17271 nT	-1755 nT	46035 nT	49200 nT
October	-5° 46.5′	17357 nT	69° 20.7′	17269 nT	-1747 nT	46041 nT	49204 nT
November	-5° 45.1′	17360 nT	69° 20.5′	17273 nT	-1740 nT	46046 nT	49210 nT
December	-5° 44.7′	17366 nT	69° 20.1′	17279 nT	-1738 nT	46044 nT	49210 nT
Annual	**-5° 49.7′**	**17361 nT**	**69° 20.2′**	**17271 nT**	**-1763 nT**	**46032 nT**	**49197 nT**
International disturbed day means							
January	-5° 54.1′	17341 nT	69° 21.4′	17250 nT	-1783 nT	46030 nT	49188 nT
February	-5° 51.8′	17333 nT	69° 21.9′	17243 nT	-1771 nT	46031 nT	49186 nT
March	-5° 52.1′	17349 nT	69° 20.9′	17258 nT	-1774 nT	46030 nT	49191 nT
April	-5° 49.7′	17343 nT	69° 21.2′	17253 nT	-1761 nT	46027 nT	49186 nT
May	-5° 50.6′	17344 nT	69° 21.3′	17254 nT	-1766 nT	46031 nT	49190 nT
June	-5° 49.8′	17355 nT	69° 20.5′	17266 nT	-1763 nT	46031 nT	49194 nT
July	-5° 50.2′	17368 nT	69° 19.7′	17278 nT	-1766 nT	46032 nT	49199 nT
August	-5° 48.6′	17358 nT	69° 20.4′	17269 nT	-1757 nT	46033 nT	49197 nT
September	-5° 47.1′	17348 nT	69° 21.2′	17260 nT	-1748 nT	46040 nT	49200 nT
October	-5° 45.4′	17343 nT	69° 21.6′	17256 nT	-1740 nT	46043 nT	49201 nT
November	-5° 44.5′	17339 nT	69° 21.7′	17252 nT	-1735 nT	46038 nT	49195 nT
December	-5° 44.6′	17350 nT	69° 21.4′	17263 nT	-1737 nT	46052 nT	49212 nT
Annual	**-5° 49.0′**	**17348 nT**	**69° 21.1′**	**17258 nT**	**-1758 nT**	**46035 nT**	**49195 nT**

Eskdalemuir Observatory K Indices 1997

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2101 1101	1000 2100	2121 2442	3421 2112	3110 3545	1111 2322	1200 2211	1201 2122	2100 1211	4343 4641	1323 2122	0000 1013
2	1111 1121	1121 1343	1332 2311	2221 2232	4221 3313	1101 2233	2100 2121	2100 1231	2100 1112	1100 2103	1100 0010	1001 1011
3	1001 0112	3001 0122	0012 1323	3311 1021	1111 3341	2231 2323	2102 3210	2013 4444	3212 3345	1122 3220	0001 0223	2101 2113
4	1001 0001	0011 1011	2000 1011	4331 2233	2210 2342	2111 1221	2110 2321	3221 0131	4322 1221	2011 2101	2210 2222	2001 1123
5	1101 1100	1001 2321	0000 2333	3311 0234	3201 2212	1100 0111	1110 2100	1010 1110	1001 1311	1000 0111	0111 2211	1111 1223
6	0000 1000	2332 2012	3221 2200	2122 2313	2001 2210	3112 3223	0211 1121	2100 1110	1221 3223	0000 1212	1223 3334	1101 1001
7	2321 2322	1100 0024	0022 2213	3311 2323	1010 1102	3311 4323	1431 3444	0111 3212	0000 3310	1111 2324	4641 2432	0000 2001
8	3310 2112	3102 5543	2101 2202	1000 1022	1100 1212	0213 2434	1110 2212	1202 3211	0002 4333	1123 3324	1101 1210	0000 0000
9	2121 1022	2222 3454	0000 0100	2101 1213	1111 1100	5544 3332	3310 2432	0011 3333	1332 2344	2331 3242	1112 1143	0000 0010
10	3354 3342	3333 3344	0000 0112	3000 2335	1110 1111	1110 1220	0112 2320	1221 1121	3122 3435	3332 2446	4221 2211	0203 3434
11	4313 3222	3322 3344	2101 1000	4532 3434	2111 2000	1110 0111	1010 2221	2312 3211	3111 2223	4521 1100	1311 1101	3211 2121
12	1142 2322	3220 0000	2232 3232	3112 2210	0000 0000	1111 2111	1100 1111	1002 1223	4221 3342	0212 1001	2000 0100	1100 0000
13	2211 2121	1011 2101	2110 1232	0311 2313	0000 0010	1000 1101	0100 1111	2222 2344	3210 1223	3101 1121	0001 1010	0000 0000
14	0000 1121	2012 0112	2111 1011	2110 1200	1001 1333	0000 1100	0100 1210	3442 2223	3322 3222	0001 2000	1111 2254	0000 0101
15	0000 1200	0002 2210	4121 1011	2001 0000	4355 5534	2211 2221	1223 3333	1111 3210	3222 2212	0001 1201	2210 1233	0000 0200
16	1000 0001	0111 2133	2221 1211	0000 3444	2221 3313	0112 3221	1101 2111	3111 1100	2211 1212	0111 0012	3201 2113	0000 1023
17	0000 0011	2233 2133	1110 1233	4433 2344	4202 2232	0100 2110	0121 0223	2101 2341	1101 2334	0002 2233	4201 1134	1000 0003
18	2110 1110	2111 1101	2210 1112	3232 3232	1111 2222	0100 2110	2322 3212	1110 2321	4422 3322	2100 0101	3222 3122	2320 0011
19	1000 2221	1000 0000	1100 2000	2232 3233	1000 1110	2222 2323	2321 3322	2100 0110	0001 0121	0001 1100	0001 1101	1000 0010
20	0011 1323	1001 1111	0100 0120	0000 0123	1121 1210	1110 2210	3112 3110	0102 2012	2110 2102	2210 1121	1100 0000	0000 0021
21	3111 2221	1323 2202	0011 1101	0002 4444	0110 1221	0000 0111	1111 1221	3311 2122	1122 1244	2010 0001	0000 0001	3000 0111
22	1100 1122	3101 1323	2322 2210	4301 2122	1000 1211	1212 3321	1012 3220	3111 2212	4311 2110	1201 0022	3334 5445	0000 0001
23	2000 1100	2222 2212	0000 2210	1102 2234	0001 1110	1012 3222	1111 1122	2000 0211	0010 2113	0012 2234	6533 3235	2100 0102
24	0100 1113	0122 3103	0112 2134	4321 2222	1112 2322	0101 1111	1122 4333	2101 2123	2010 1111	2223 4224	3321 2322	2100 0110
25	2100 1033	3100 1122	3211 2334	2101 2222	1210 2221	1111 2232	2111 1121	2111 0010	0000 1110	4422 3223	1000 0101	0100 0000
26	2201 3354	3223 3321	2222 3344	1100 1111	0001 3333	2110 1122	1100 1111	0000 1110	0002 1112	4200 2334	1001 1001	2000 1001
27	2322 1334	3221 3346	3000 1131	0000 1212	4531 2223	1114 4342	1111 2211	0011 1112	3111 2442	4322 2243	0000 2000	0000 0000
28	2322 4353	4432 3453	1001 3454	1000 1110	1112 3110	2211 2222	2111 3211	2442 1333	4331 1221	4222 2343	0100 0001	0000 0000
29	2111 2232		3323 3335	0000 1221	1000 0011	3311 1222	0111 1111	1223 3333	3222 1112	2121 1122	0000 0000	0000 1002
30	3220 3443		1322 3231	3311 1232	1110 3333	2100 1211	3300 1113	1221 2233	1221 2233	2011 2223	1122 1111	2312 2541
31	2201 1123		1100 1232		2111 3333		4432 3213	1001 1110		2110 1211		1001 0000

SIs and SSCs

Day	Month	UT		Type	Quality	H(nT)	D(min)	Z(nT)
8	2	06	27	SSC*	C	4.0	1.10	
8	2	09	50	SSC*	C	7.0	1.00	
9	2	13	19	SSC*	B	27.0	2.70	-3.0
5	3	13	56	SSC*	B	20.4	-3.70	-1.8
20	3	20	42	SI*	C	16.6	-0.70	-2.2
21	3	15	29	SI*	C	6.4	-1.20	
10	4	17	44	SSC*	B	40.3	-1.60	-1.5
16	4	13	19	SSC*	A	22.9	-3.00	-1.4
21	4	13	00	SSC*	C	-29.9	4.80	2.9
1	5	12	42	SSC*	B	34.6	-3.41	-3.2
12	5	03	35	SSC*	C	7.5	+1.30/-0.96	
15	5	01	59	SSC	B	61.4	-4.37	-8.4
20	5	06	01	SSC	C	7.3	-1.29	
25	5	14	33	SSC*	C	13.0	-1.10	
26	5	09	57	SSC*	B	-8.3	0.61	
26	5	15	51	SI	C	-20.7	1.33	1.3
8	6	11	03	SSC	C	19.9	-1.34	
19	6	00	31	SSC*	C	9.3	-2.28	-2.2
22	6	03	11	SSC*	C	8.7	-2.14	-1.9
27	6	07	57	SSC*	B	+6.2/-7.1	-1.53	1.8
15	7	03	12	SSC	C	9.4	-1.23	
15	7	10	09	SI*	C	-15.2	-2.67	1.8
29	7	06	08	SI	B	-3.3	1.34	3.2
3	8	10	42	SSC	B	28.2	-1.71	-3.0
28	8	15	51	SSC	B	33.9	-1.81/+1.67	
2	9	22	58	SSC*	B	23.6	-1.42	-2.5
17	9	13	48	SSC*	C	-14.4	1.51	
21	9	15	40	SSC	C	-7.4	0.69	
1	10	00	59	SSC	B	47.0	-4.19	-6.1
6	10	17	17	SSC	C	-19.8	0.67	
10	10	16	12	SSC	C	28.0	-1.62	
23	10	08	05	SSC*	B	-10.0	1.30	1.4
1	11	06	35	SSC*	B	-10.9	-2.67	
3	11	11	19	SI*	C	-3.9/+5.6	-0.98	
6	11	11	52	SSC	B	-29.5	-1.70	5.5
6	11	22	48	SSC*	A	78.1	-8.23	12.3
9	11	17	41	SSC	C	5.9	-0.24	
22	11	09	49	SSC*	B	-23.8	5.24	2.0
10	12	05	25	SSC*	A	10.7	-3.94	2.0
30	12	02	09	SSC*	B	17.1	-2.72	2.7

Notes

A * indicates that the principal impulse was preceded by a smaller reversed impulse.

The quality of the event is classified as follows :

A = very distinct

B = fair, ordinary, but unmistakable

C = doubtful

The amplitudes given are for the first chief movement of the event.

SFEs

Day	Month	Universal Time						H(nT)	D(min)	Z(nT)
		Start		Maximum		End				
2	9	12	27	12	31	12	39	-2.7	-0.91	
27	11	13	13	13	19	13	28	-14.3	-1.44	2.8

Notes

The amplitudes given are for the chief movement of the event.

Annual Values of Geomagnetic Elements

Eskdalemuir

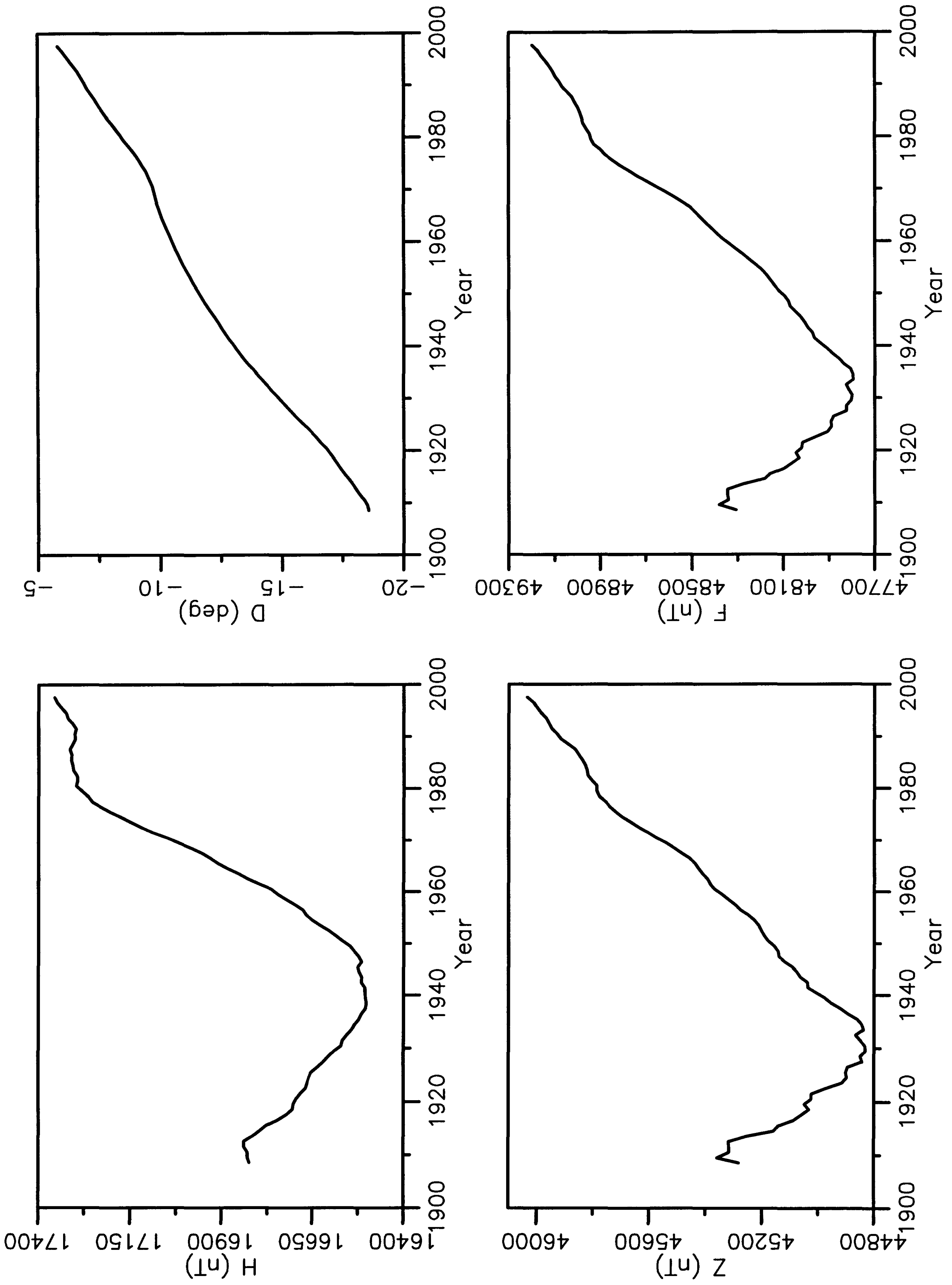
Year	D		H	I		X	Y	Z	F
1908.5	-18	33.3	16821	69	37.3	15947	-5353	45283	48306
1909.5	-18	30.1	16826	69	38.9	15956	-5339	45360	48380
1910.5	-18	23.3	16826	69	37.8	15967	-5308	45317	48340
1911.5	-18	12.4	16836	69	37.1	15993	-5260	45317	48343
1912.5	-18	3.9	16836	69	37.2	16006	-5221	45318	48344
1913.5	-17	54.9	16811	69	37.3	15996	-5171	45254	48276
1914.5	-17	45.3	16793	69	36.1	15993	-5121	45159	48180
1915.5	-17	35.9	16775	69	36.9	15990	-5072	45142	48158
1916.5	-17	26.1	16744	69	37.6	15975	-5017	45088	48097
1917.5	-17	17.1	16720	69	38.6	15965	-4968	45061	48063
1918.5	-17	8.1	16703	69	39.0	15962	-4921	45034	48032
1919.5	-16	58.7	16700	69	39.6	15972	-4877	45049	48045
1920.5	-16	49.6	16693	69	39.5	15978	-4832	45026	48021
1921.5	-16	37.2	16681	69	40.3	15984	-4771	45025	48016
1922.5	-16	25.8	16666	69	40.0	15985	-4714	44974	47963
1923.5	-16	13.8	16661	69	38.8	15997	-4657	44915	47906
1924.5	-16	1.2	16657	69	38.7	16010	-4597	44898	47889
1925.5	-15	48.4	16650	69	39.3	16020	-4535	44902	47890
1926.5	-15	35.3	16632	69	40.3	16020	-4469	44896	47878
1927.5	-15	22.7	16615	69	40.2	16020	-4406	44843	47822
1928.5	-15	10.5	16602	69	41.2	16024	-4346	44849	47823
1929.5	-14	58.8	16586	69	41.9	16022	-4287	44832	47802
1930.5	-14	47.1	16568	69	43.2	16019	-4228	44834	47797
1931.5	-14	34.8	16565	69	43.7	16032	-4170	44850	47812
1932.5	-14	23.7	16553	69	45.0	16033	-4115	44867	47823
1933.5	-14	12.1	16539	69	45.2	16033	-4058	44839	47792
1934.5	-14	0.6	16531	69	45.9	16039	-4002	44845	47795
1935.5	-13	48.8	16520	69	47.0	16042	-3944	44861	47806
1936.5	-13	37.4	16512	69	48.4	16047	-3889	44894	47834
1937.5	-13	26.9	16501	69	49.8	16049	-3837	44920	47855
1938.5	-13	17.1	16499	69	50.7	16057	-3791	44953	47885
1939.5	-13	7.3	16502	69	51.1	16071	-3746	44977	47909
1940.5	-12	57.9	16503	69	51.8	16082	-3703	45008	47938
1941.5	-12	48.2	16503	69	52.5	16093	-3657	45037	47965
1942.5	-12	39.8	16513	69	51.9	16111	-3620	45039	47971
1943.5	-12	31.2	16511	69	52.7	16118	-3579	45064	47994
1944.5	-12	23.0	16518	69	52.5	16134	-3542	45076	48007
1945.5	-12	14.5	16522	69	52.6	16146	-3503	45093	48025
1946.5	-12	5.9	16512	69	54.0	16145	-3461	45120	48046
1947.5	-11	57.1	16520	69	53.9	16162	-3421	45140	48068
1948.5	-11	48.9	16532	69	53.2	16182	-3385	45144	48076
1949.5	-11	40.9	16544	69	52.8	16201	-3350	45158	48093
1950.5	-11	33.2	16564	69	52.0	16228	-3317	45180	48121
1951.5	-11	25.5	16581	69	51.1	16252	-3284	45193	48139
1952.5	-11	18.0	16601	69	50.0	16279	-3253	45203	48155
1953.5	-11	11.0	16625	69	48.7	16309	-3224	45213	48173
1954.5	-11	3.4	16647	69	47.6	16338	-3193	45228	48194
1955.5	-10	56.3	16665	69	46.9	16362	-3162	45250	48221
1956.5	-10	49.7	16674	69	47.0	16377	-3132	45277	48250
1957.5	-10	43.6	16695	69	46.0	16403	-3107	45296	48275
1958.5	-10	38.0	16719	69	45.0	16432	-3085	45320	48306
1959.5	-10	32.1	16742	69	44.1	16460	-3061	45344	48336
1960.5	-10	26.3	16761	69	43.5	16484	-3037	45370	48367
1961.5	-10	20.9	16792	69	41.8	16519	-3016	45385	48392
1962.5	-10	15.7	16825	69	39.8	16556	-2997	45396	48414
1963.5	-10	10.2	16850	69	38.6	16585	-2975	45413	48438
1964.5	-10	5.3	16880	69	36.9	16619	-2957	45427	48462
1965.5	-10	0.8	16907	69	35.5	16649	-2940	45440	48483
1966.5	-9	56.4	16928	69	34.6	16674	-2922	45460	48509
1967.5	-9	52.1	16949	69	33.8	16698	-2905	45486	48541
1968.5	-9	48.6	16979	69	32.5	16731	-2893	45514	48578
1969.5	-9	45.4	17013	69	31.0	16767	-2883	45542	48616
1970.5	-9	41.6	17046	69	29.6	16803	-2870	45576	48659
1971.5	-9	36.8	17084	69	27.8	16844	-2853	45604	48699
1972.5	-9	31.5	17112	69	26.7	16876	-2832	45635	48738

Year	D		H	I		X	Y	Z	F
1973.5	-9	25.2	17141	69	25.5	16910	-2805	45664	48775
1974.5	-9	17.4	17169	69	24.5	16944	-2772	45696	48815
1975.5	-9	9.8	17200	69	23.0	16981	-2739	45719	48847
1976.5	-9	1.1	17227	69	21.8	17014	-2700	45741	48877
1977.5	-8	51.2	17249	69	20.6	17044	-2655	45755	48899
1978.5	-8	40.5	17260	69	20.5	17063	-2603	45780	48926
1979.5	-8	30.5	17277	69	19.6	17087	-2556	45788	48939
1980.5	-8	21.3	17294	69	18.5	17110	-2513	45788	48945
1981.5	-8	11.2	17291	69	19.2	17114	-2462	45806	48961
1982.5	-8	1.3	17292	69	19.4	17123	-2413	45820	48975
1983.5	-7	51.7	17301	69	18.9	17138	-2366	45824	48981
1984.5	-7	42.5	17304	69	18.9	17147	-2321	45830	48988
1985.5	-7	33.8	17307	69	18.9	17156	-2278	45840	48998
1986.5	-7	25.1	17306	69	19.4	17161	-2234	45854	49011
1987.5	-7	17.2	17311	69	19.3	17171	-2196	45866	49024
1988.5	-7	8.6	17304	69	20.4	17170	-2152	45889	49043
1989.5	-7	0.2	17297	69	21.5	17168	-2109	45916	49066
Note 1	0	0.0	11	0	-0.2	11	-1	22	25
1990.5	-6	52.7	17309	69	21.6	17184	-2073	45952	49104
1991.5	-6	45.1	17305	69	22.3	17185	-2034	45972	49121
1992.5	-6	37.5	17315	69	21.9	17199	-1998	45981	49133
1993.5	-6	29.2	17327	69	21.3	17216	-1957	45990	49146
Note 2	0	0.0	-8	0	0.0	-8	1	-23	-24
1994.5	-6	19.7	17324	69	21.4	17218	-1910	45986	49141
1995.5	-6	10.0	17337	69	20.9	17237	-1862	46000	49159
1996.5	-6	0.1	17349	69	20.5	17254	-1814	46012	49174
1997.5	-5	49.4	17356	69	20.5	17266	-1761	46034	49197

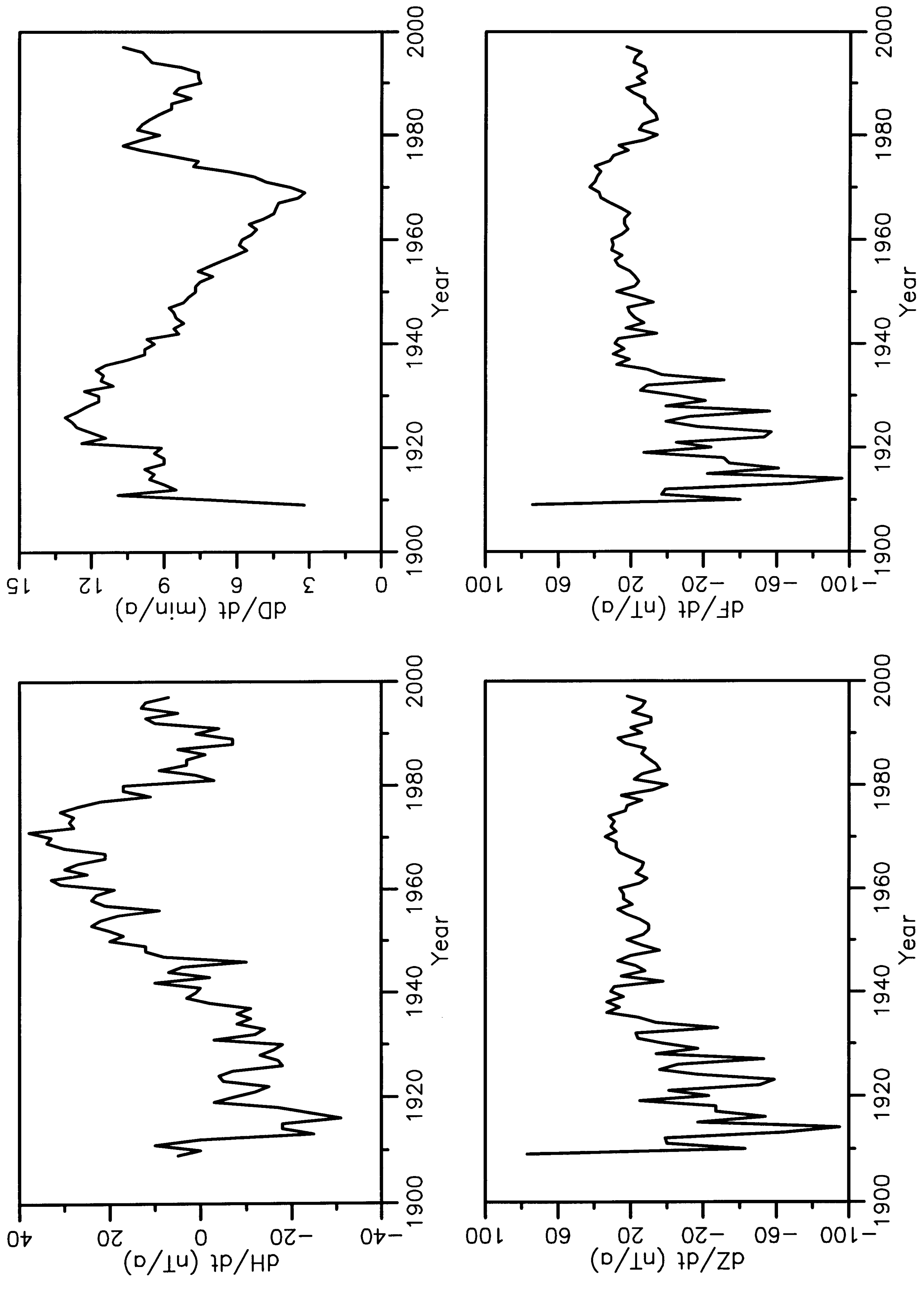
1 Site differences 1 Jan 1990 (new value - old value)
2 Site differences 1 Jan 1994 (new value - old value)

D and I are given in degrees and decimal minutes
All other elements are in nanoteslas

Annual Mean Values at Eskdalemuir

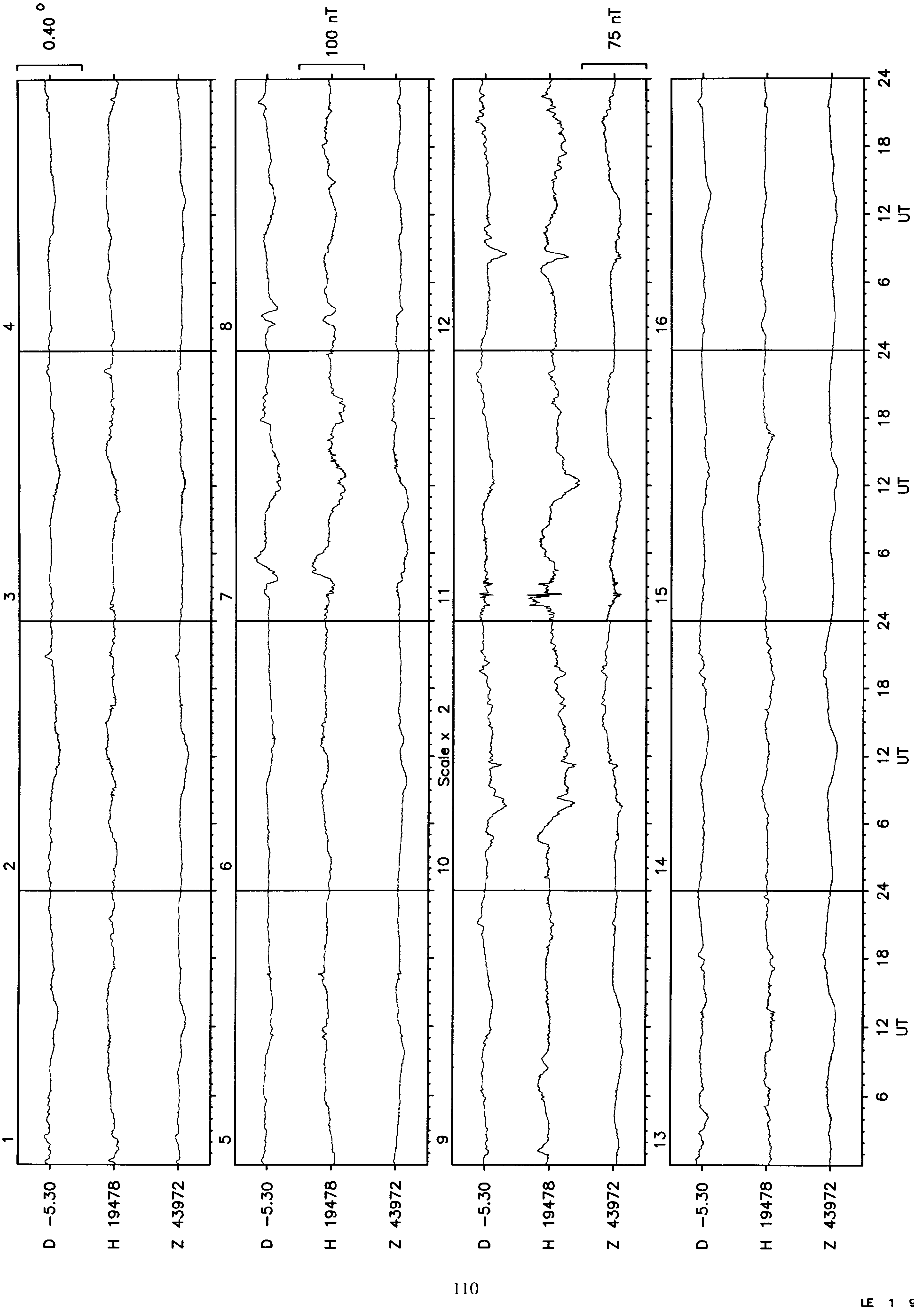


Rate of Change of Annual Mean Values at Eskdalemuir



Hartland 1997 Results

Hartland January 1997



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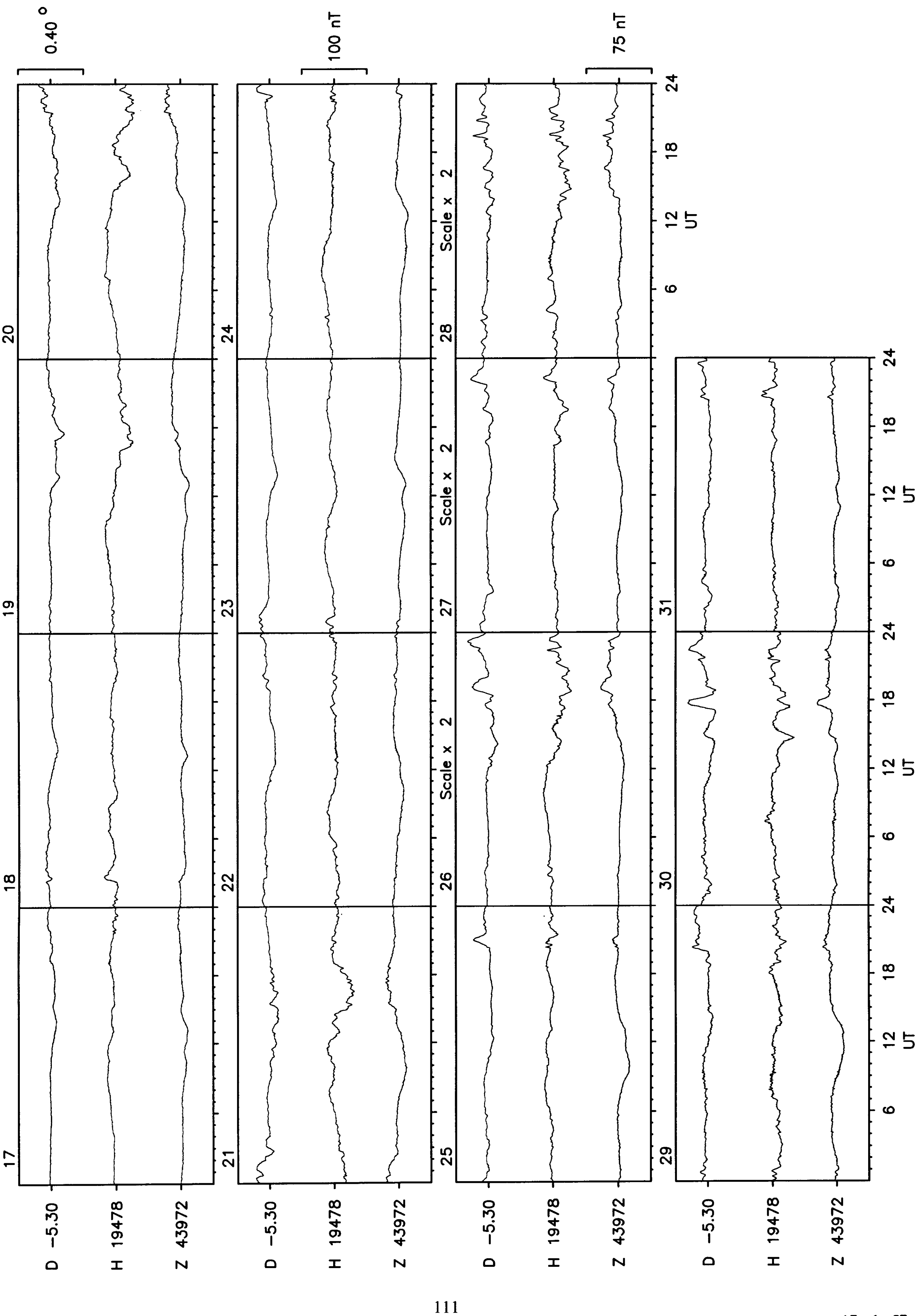

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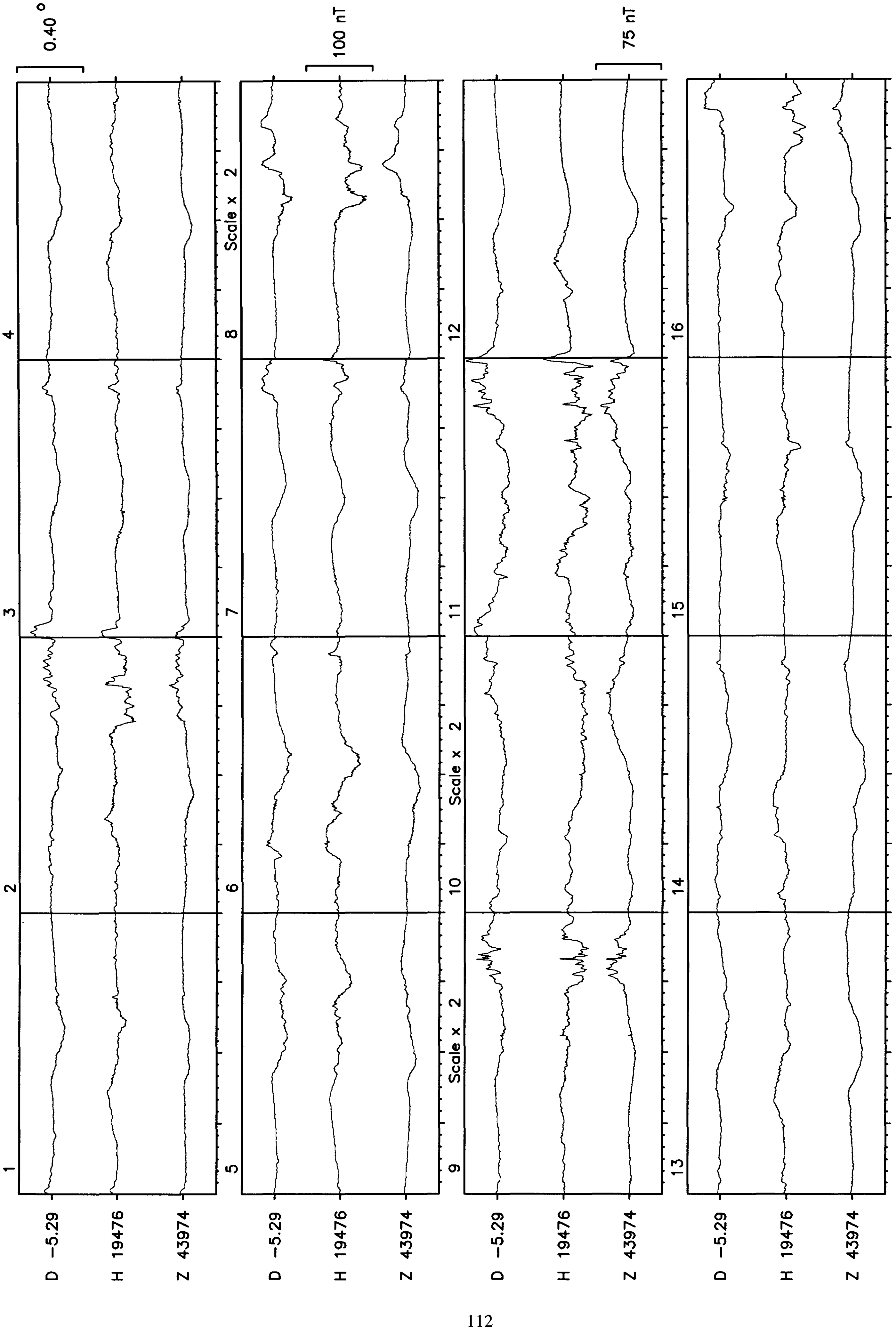

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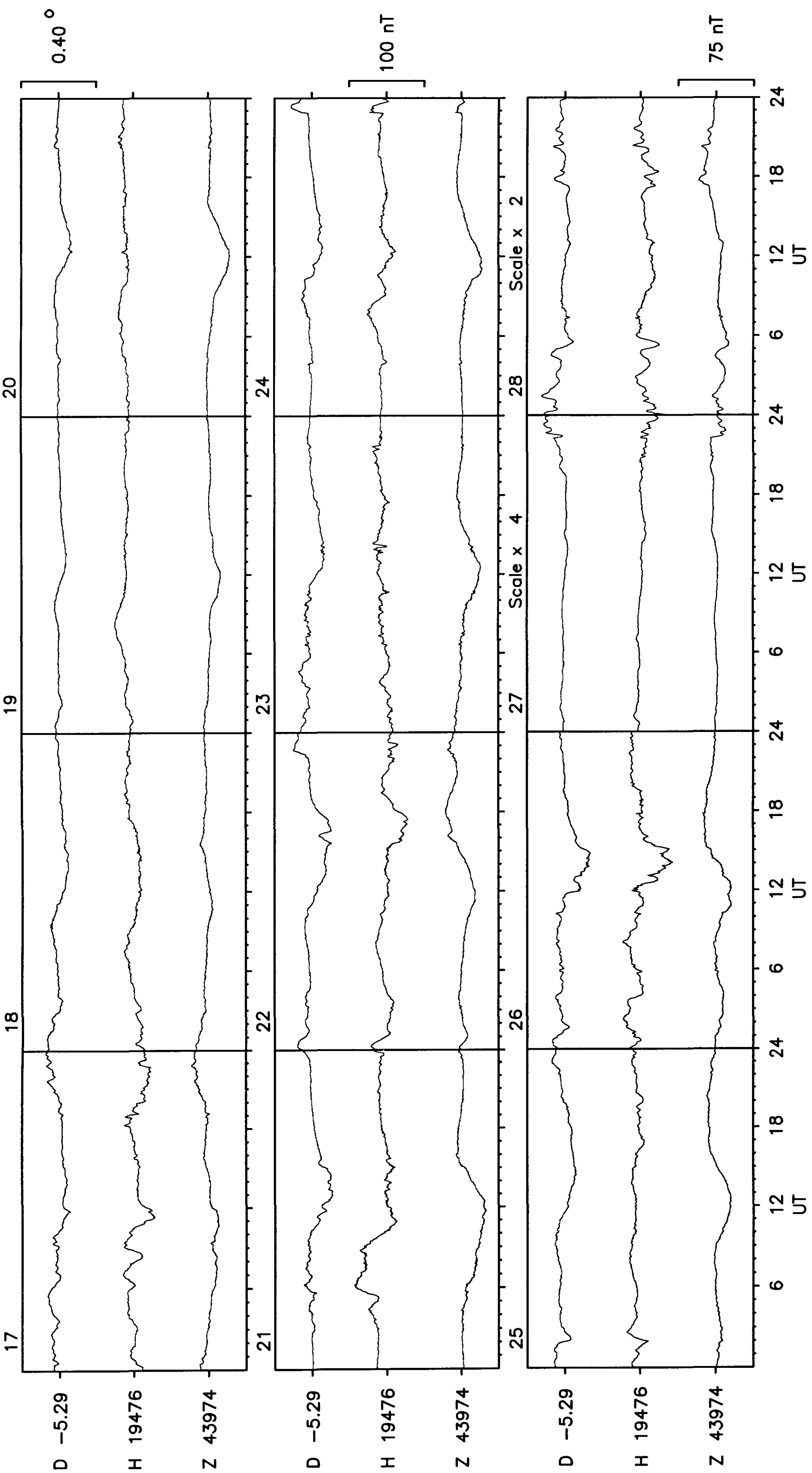

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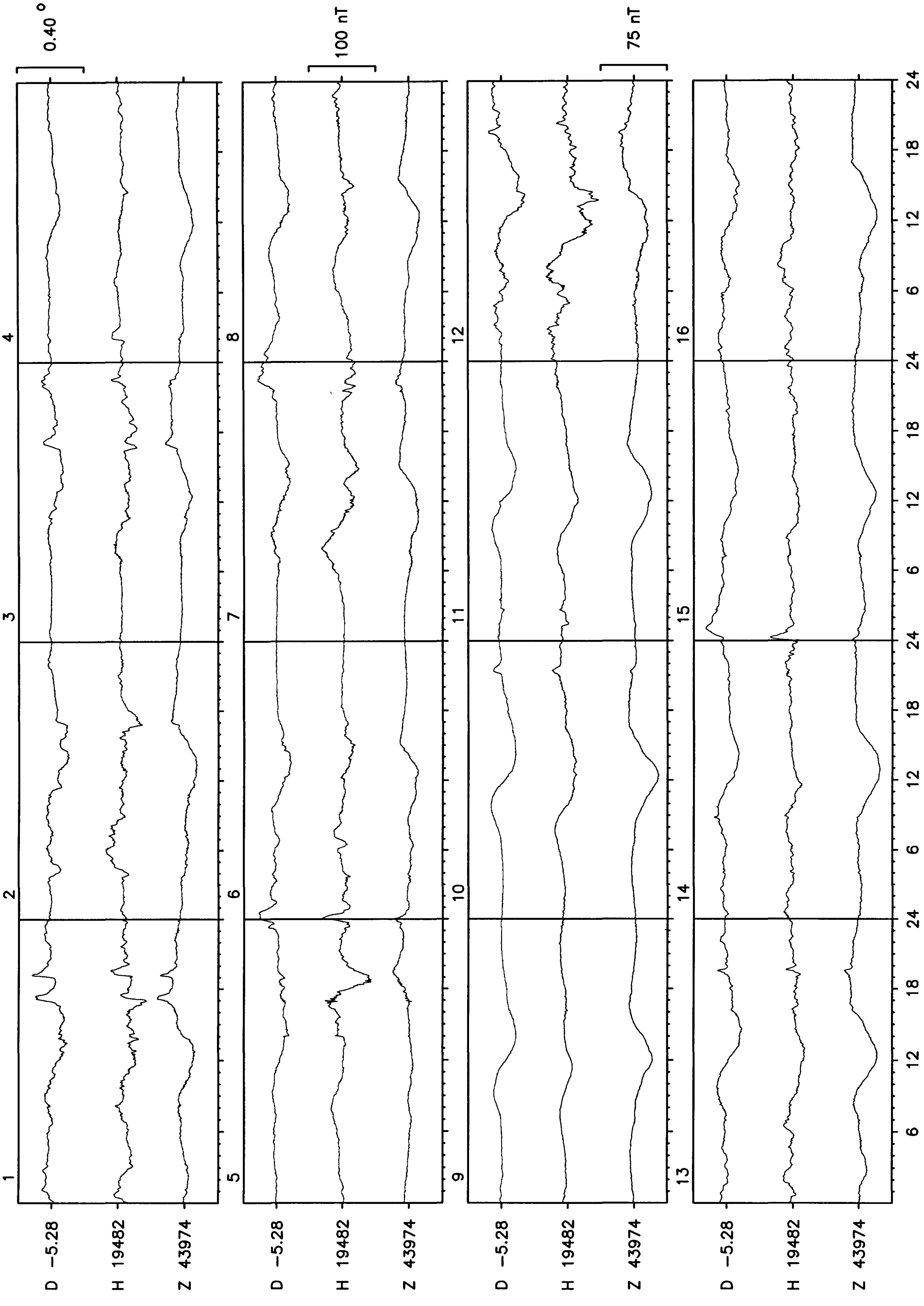

LE 3 97

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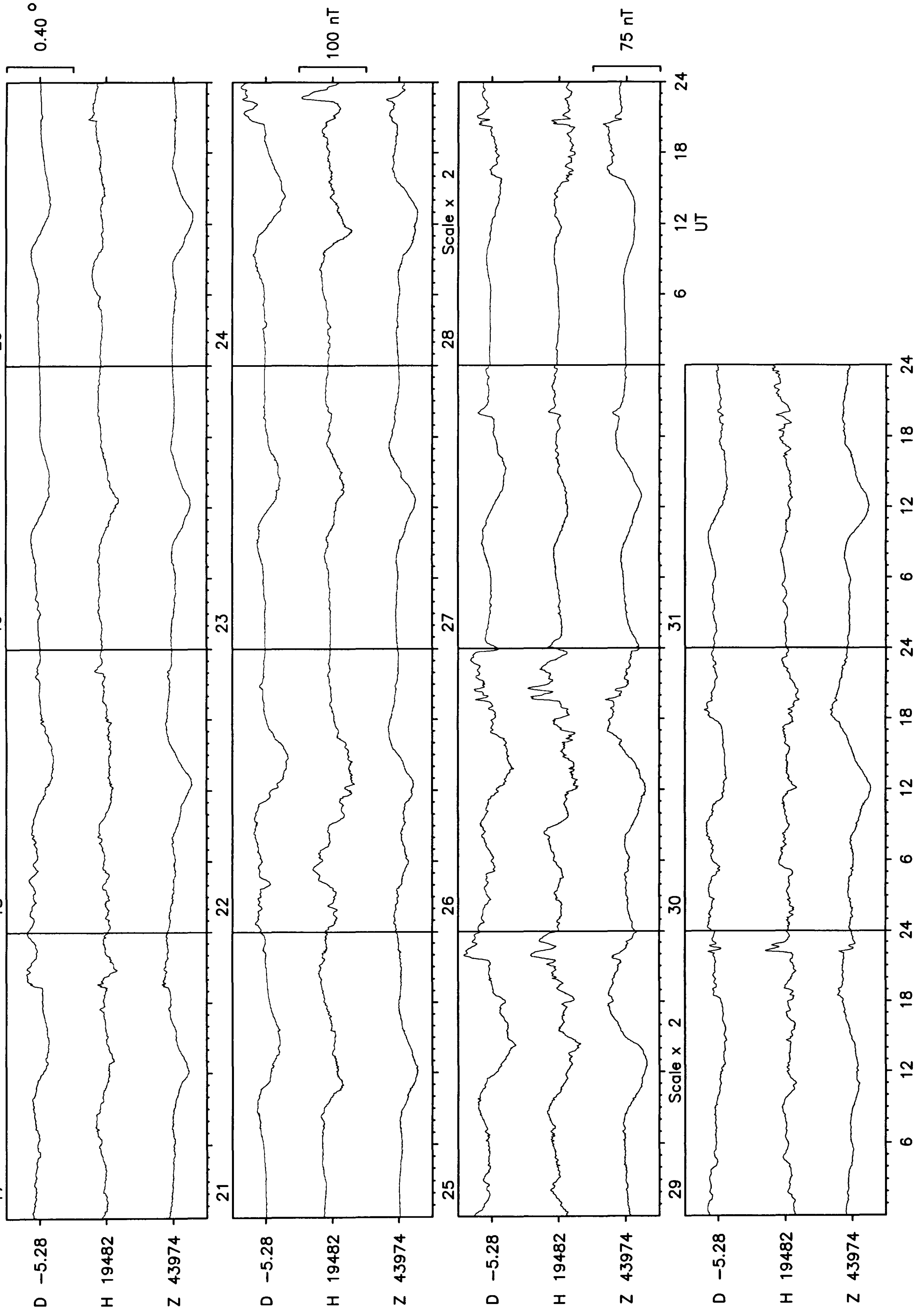

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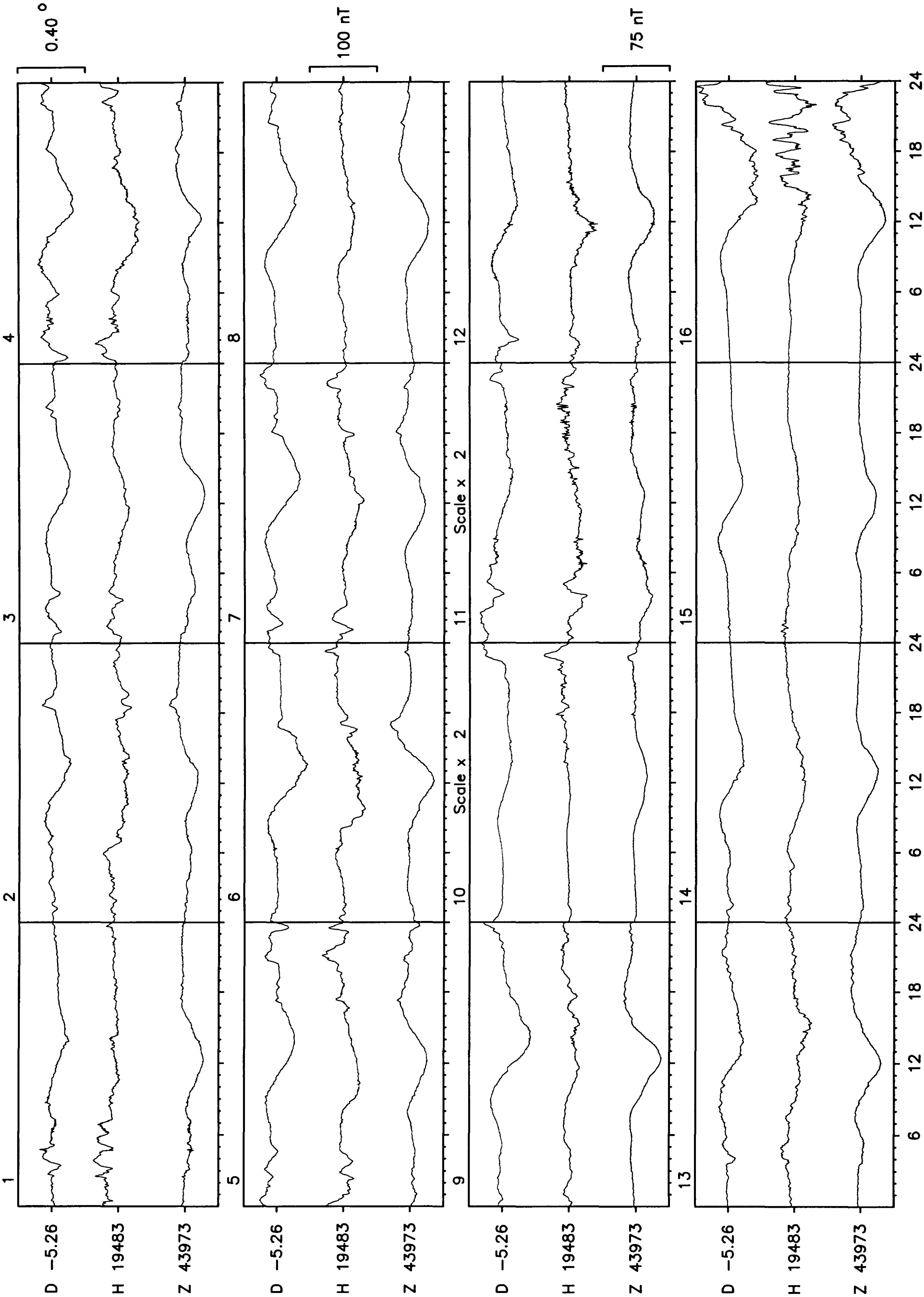

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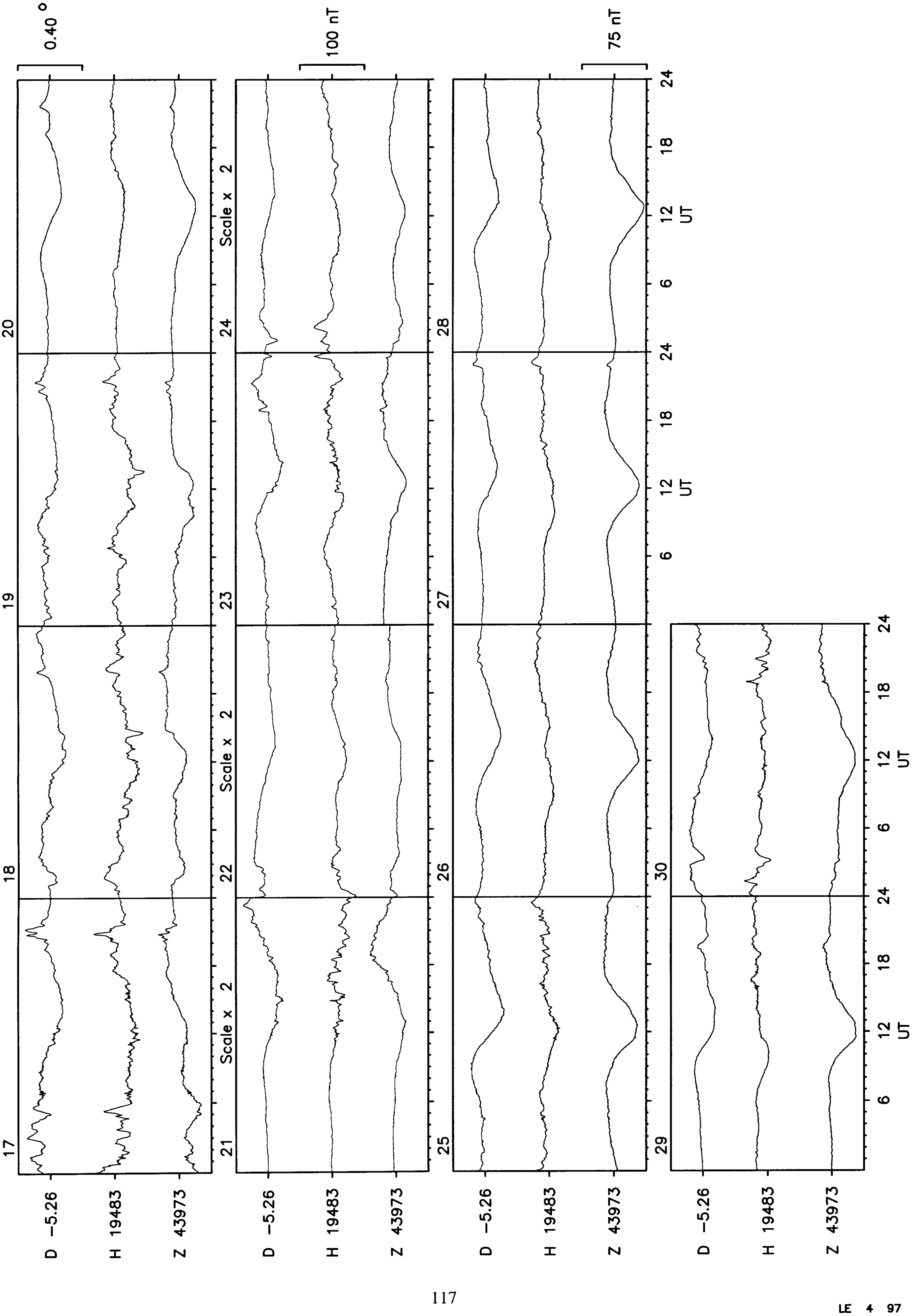

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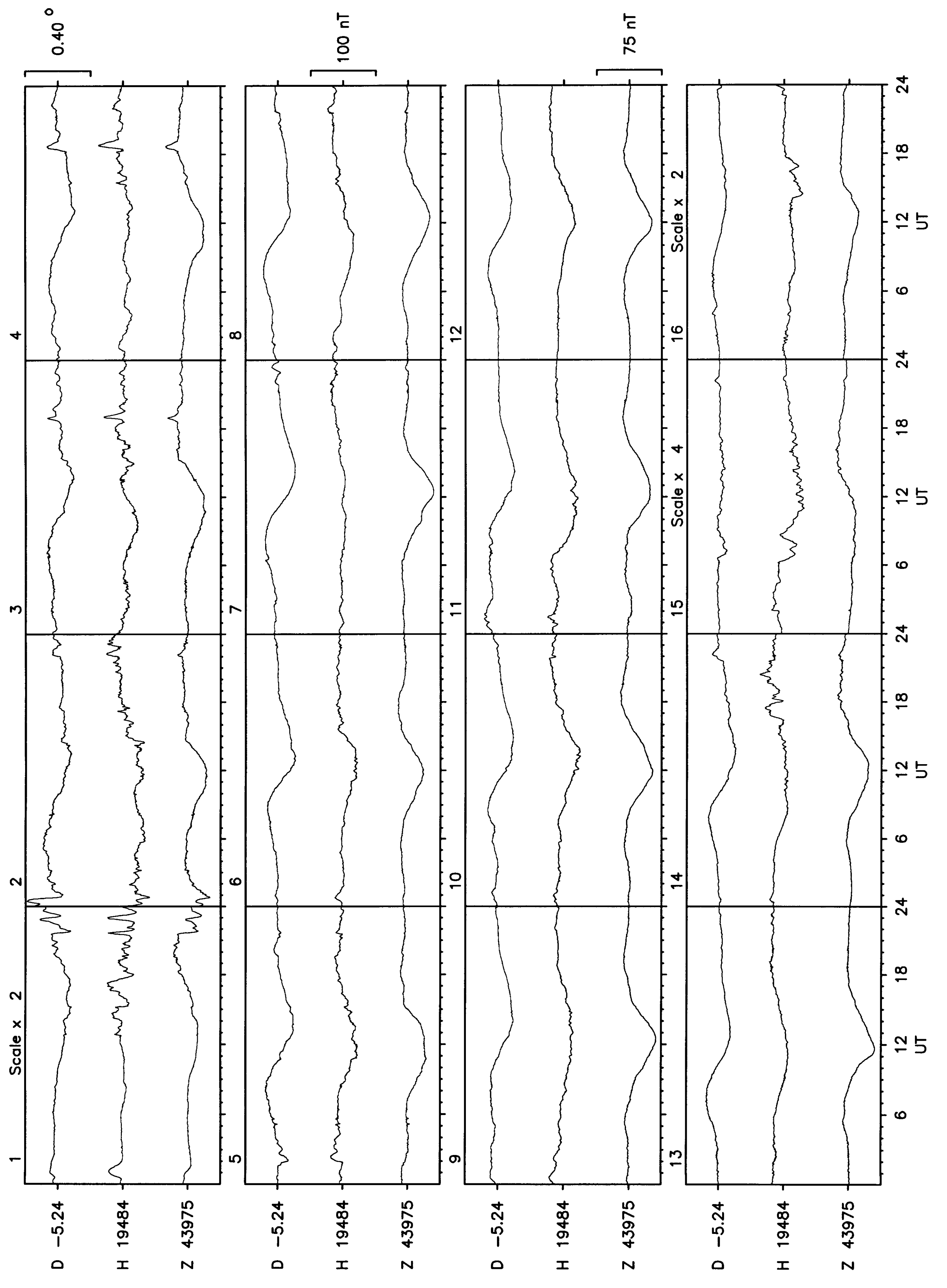

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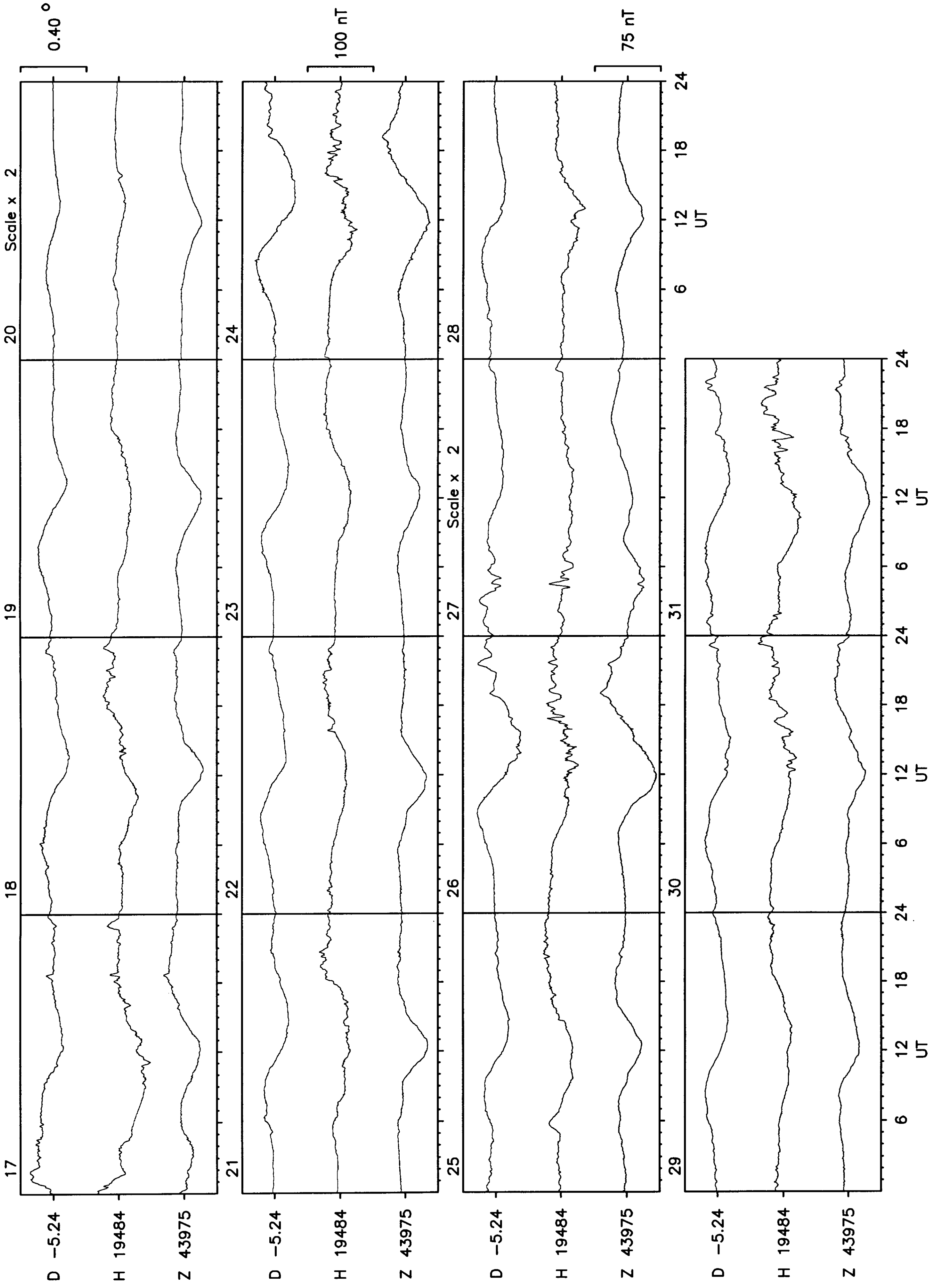
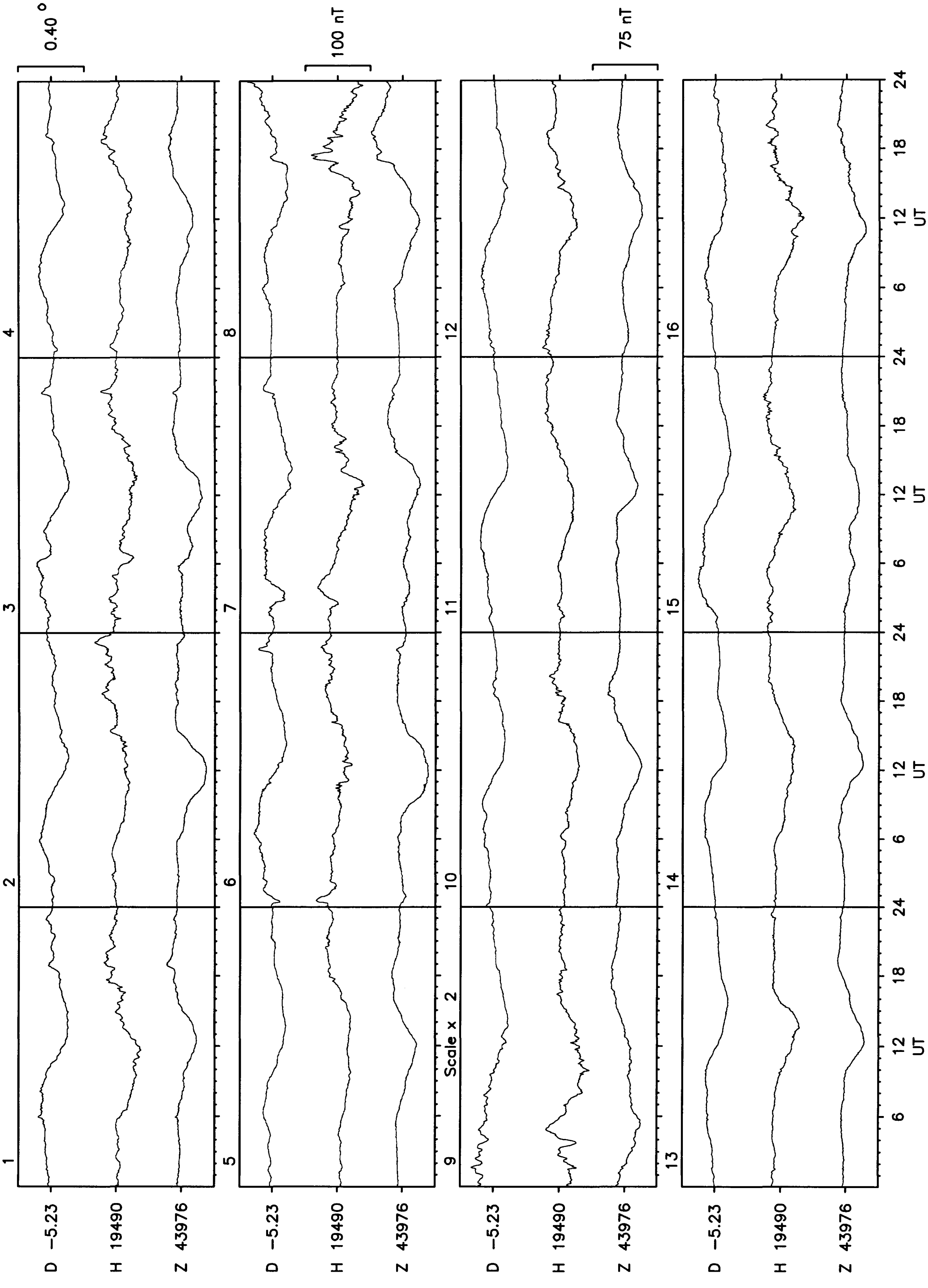


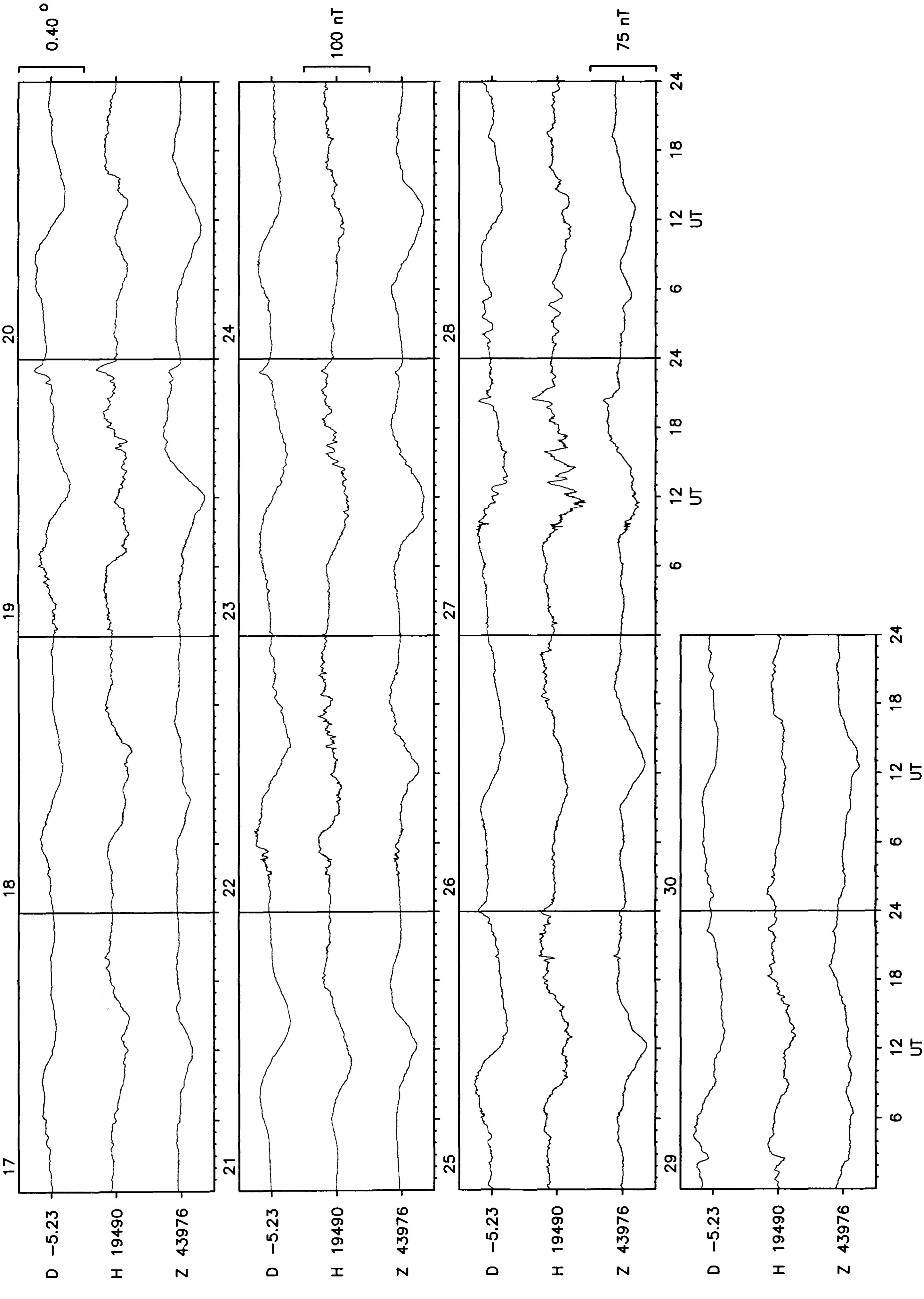
LE 5 97

Hartland June 1997

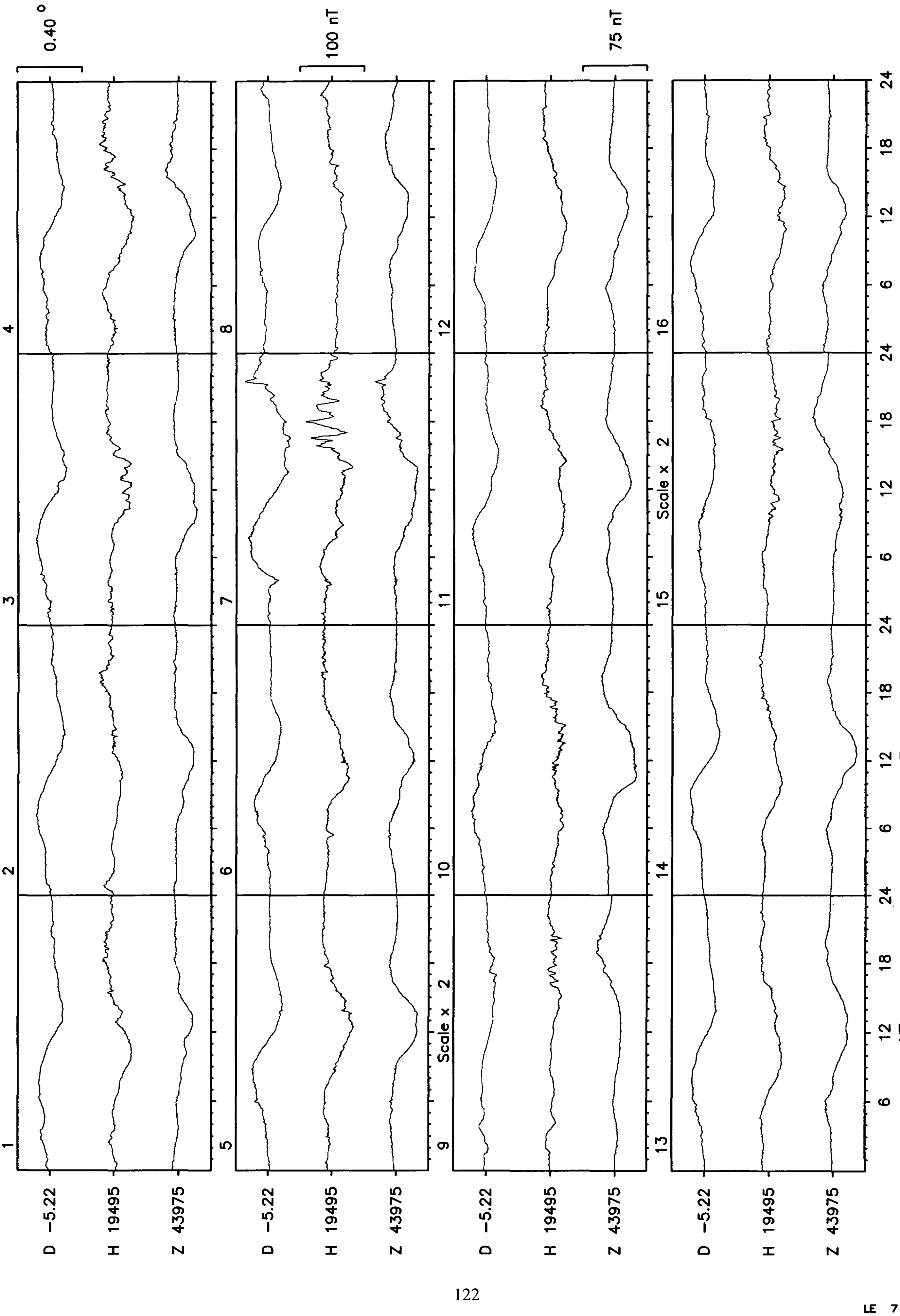


LE 6 97

Hartland June 1997



Hartland July 1997



LE 7 97

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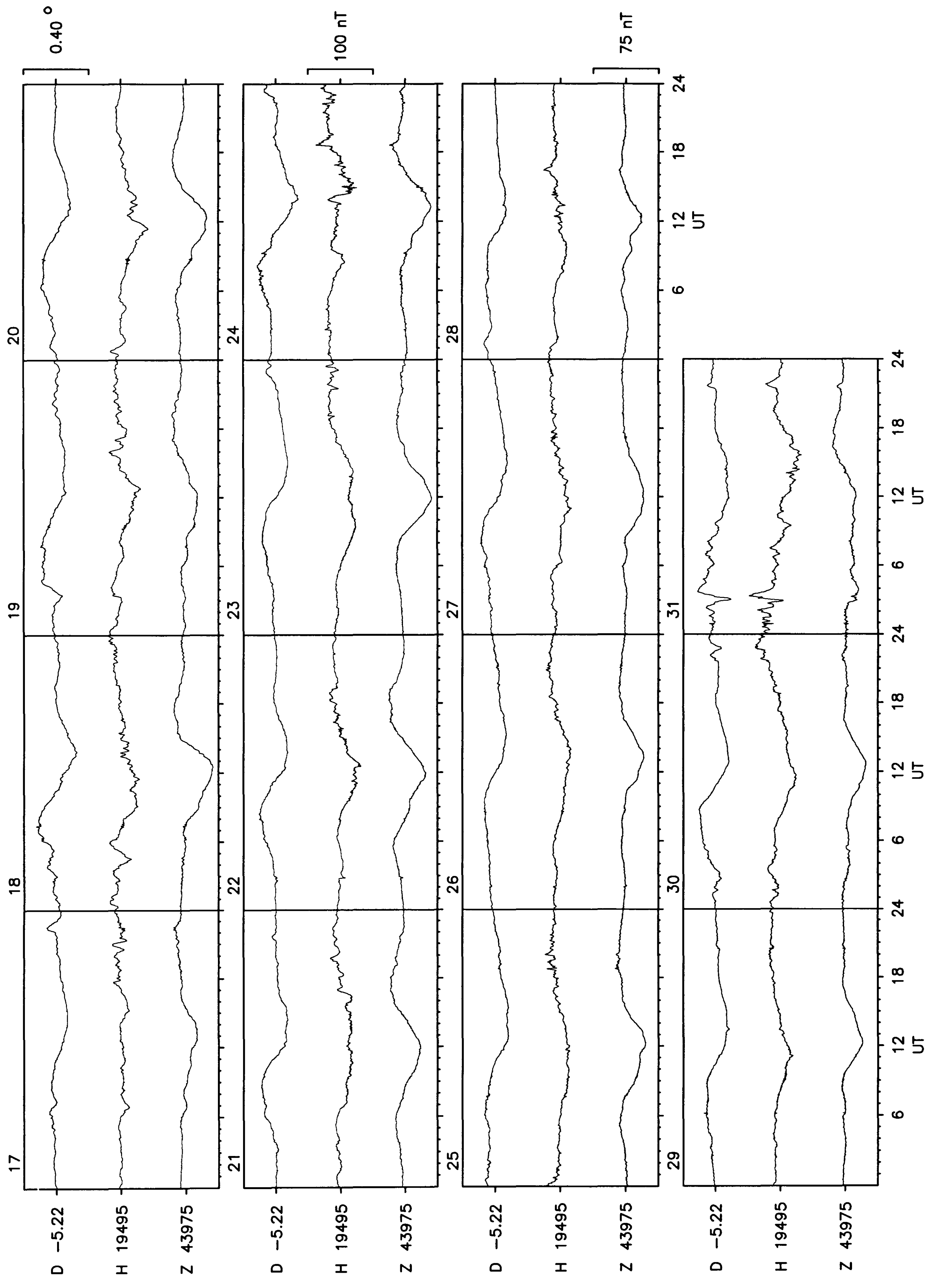

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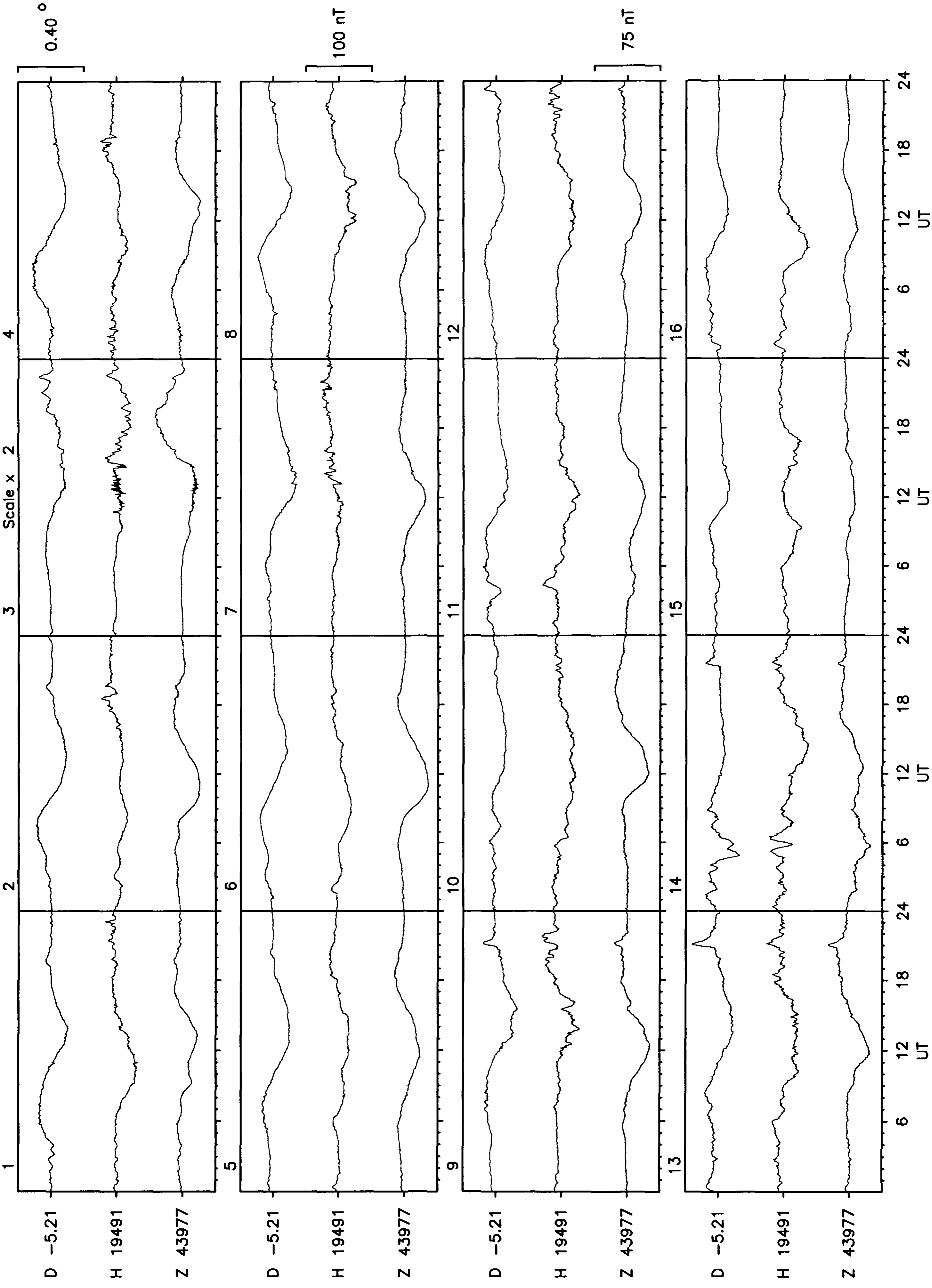

LE 8 97

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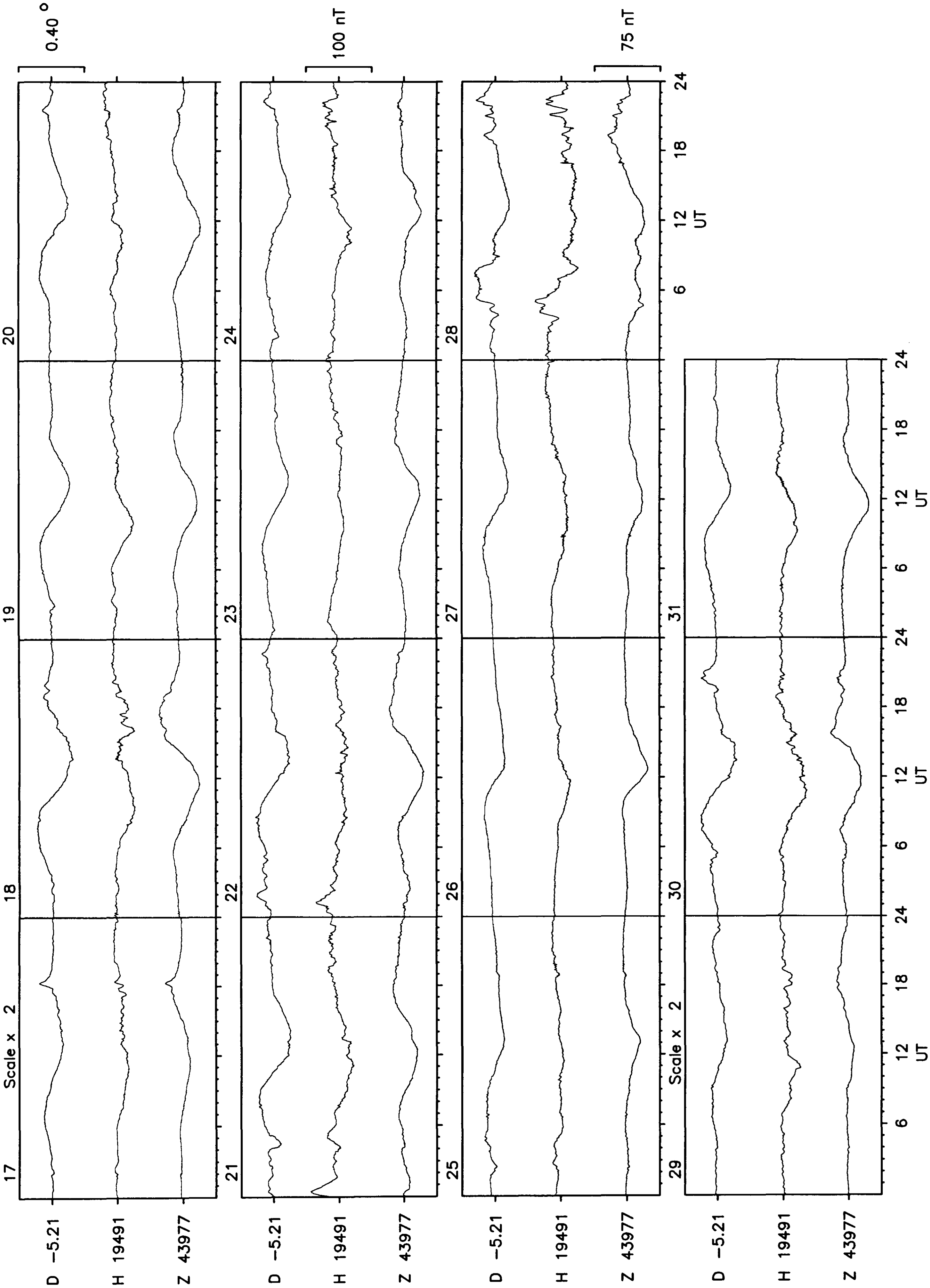

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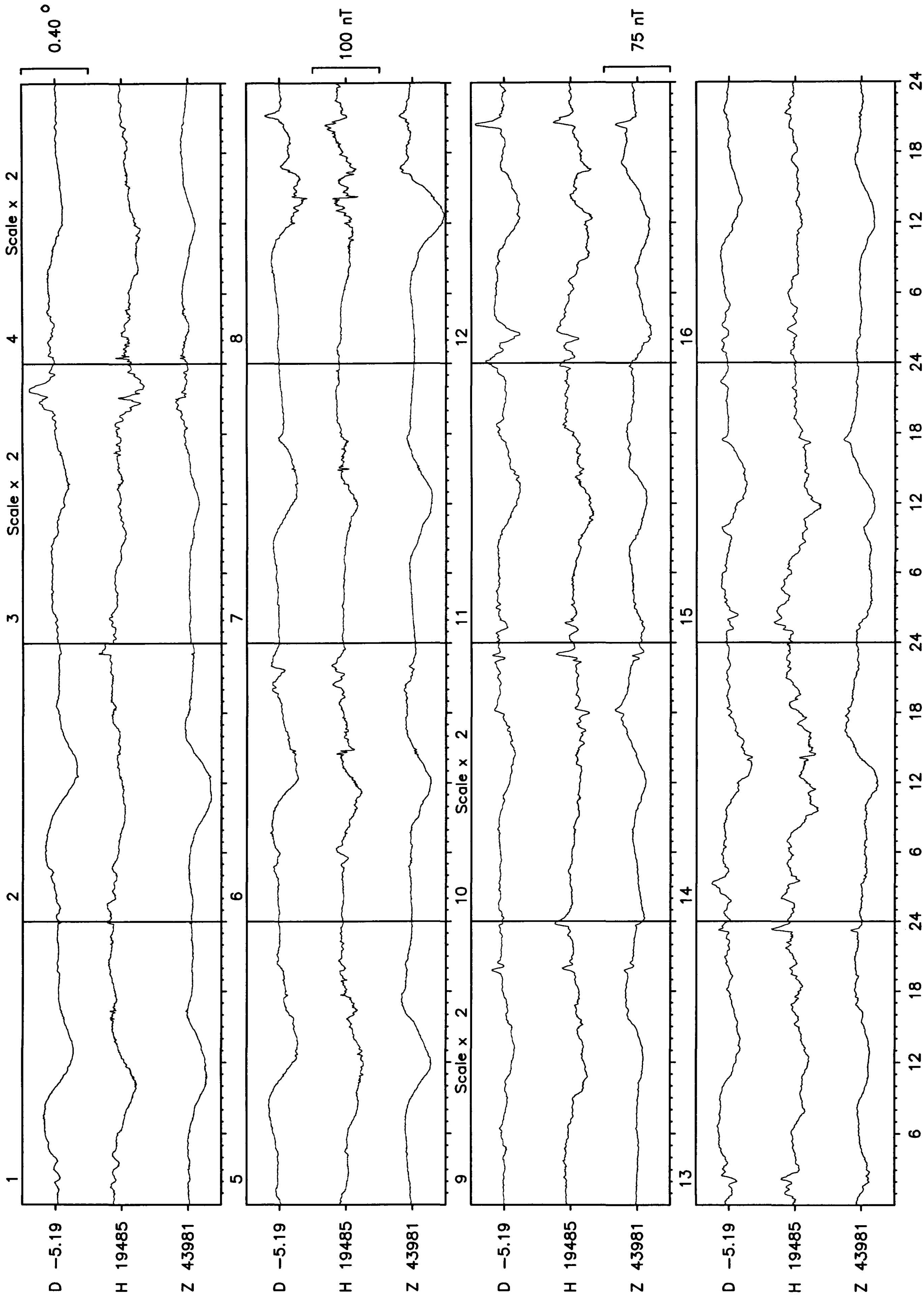

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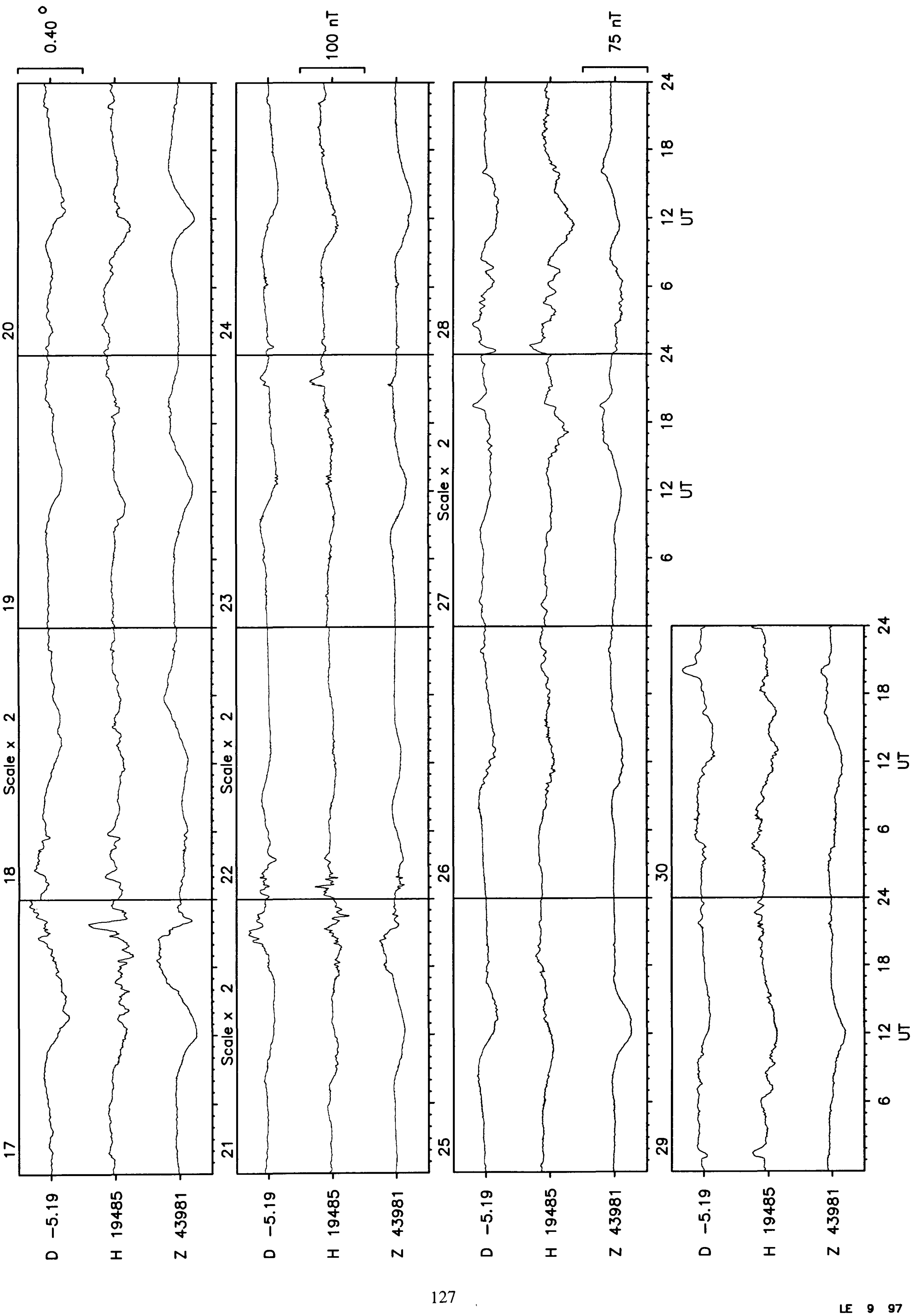
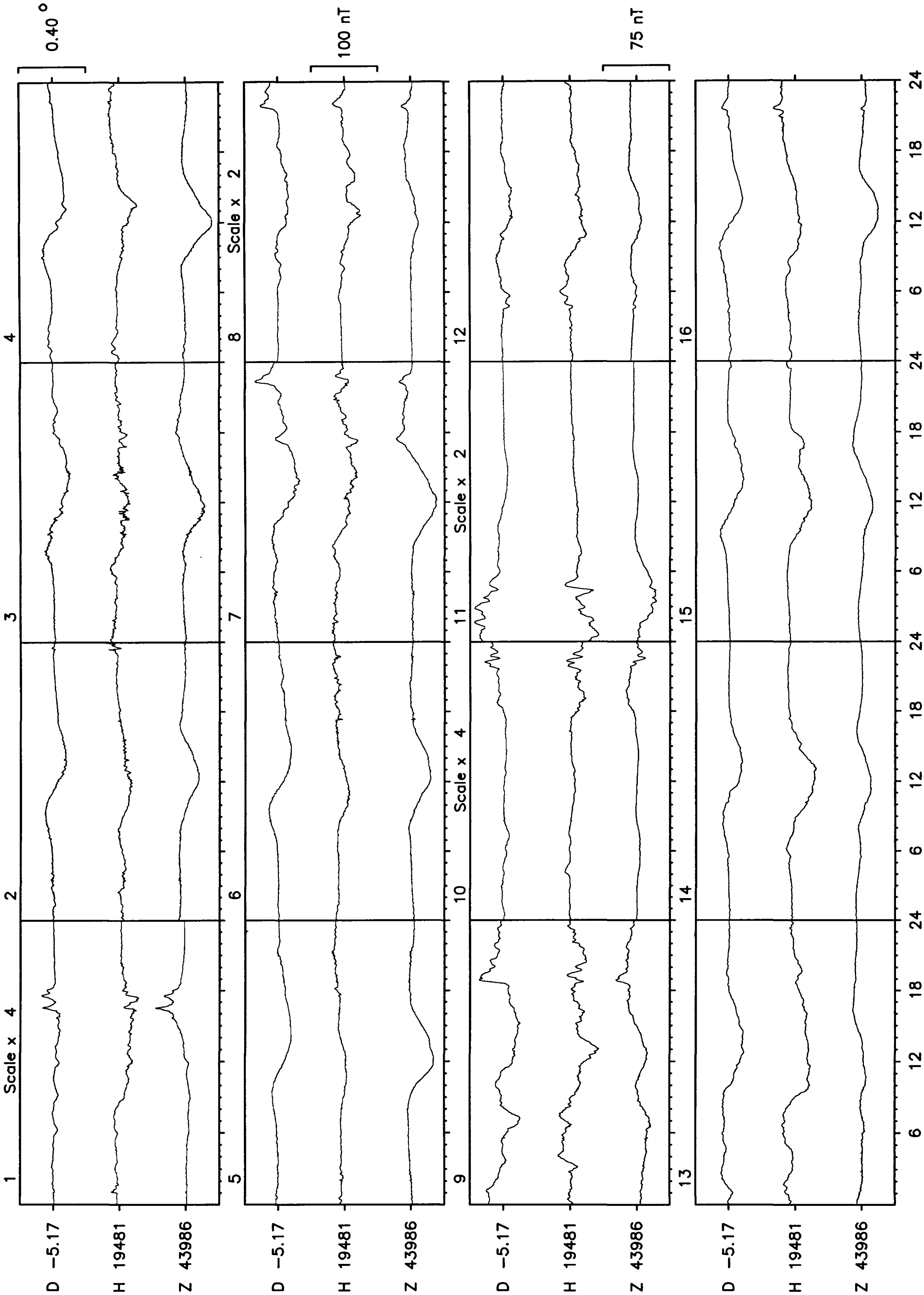


Hartland October 1997



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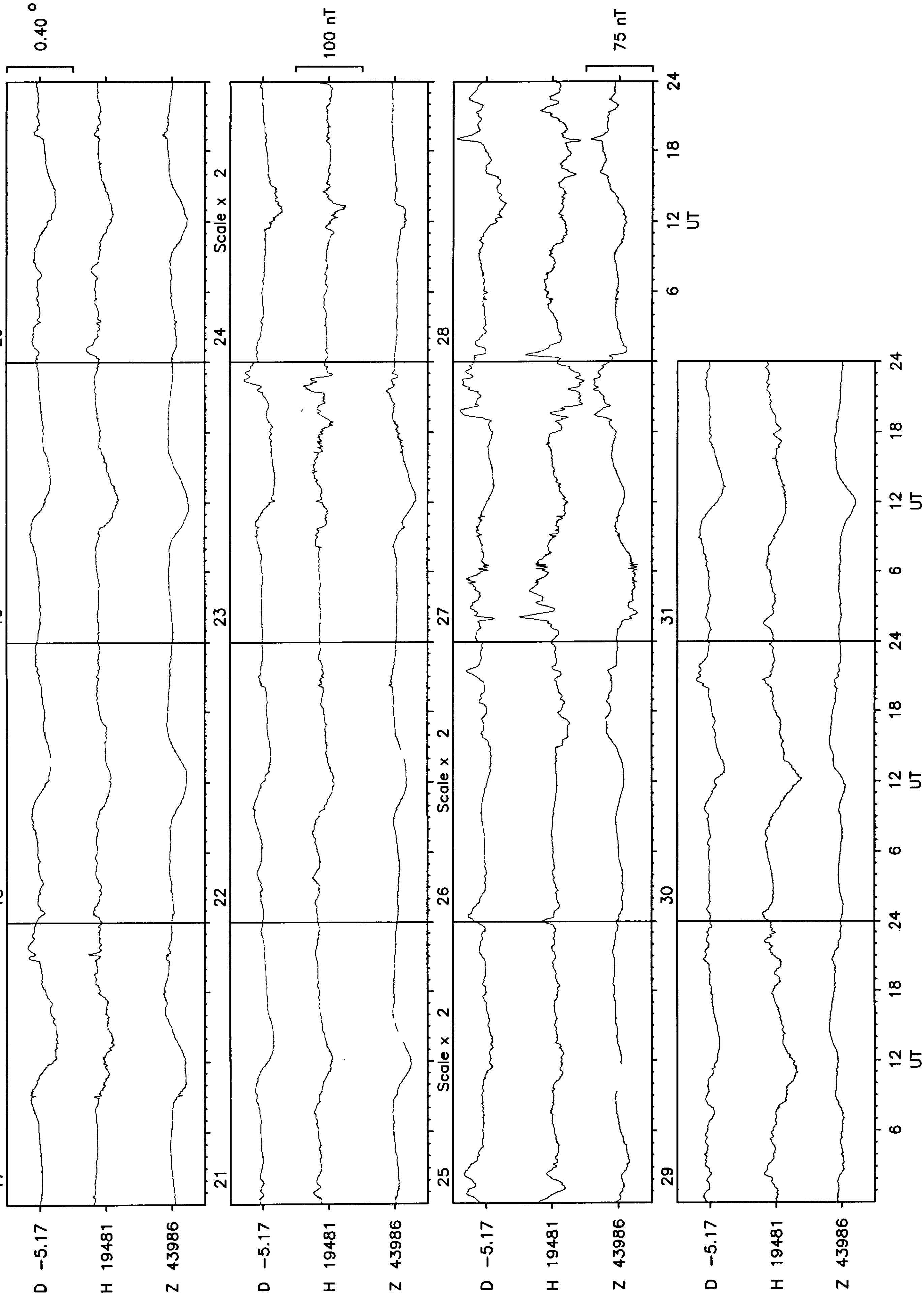

LE 10 97

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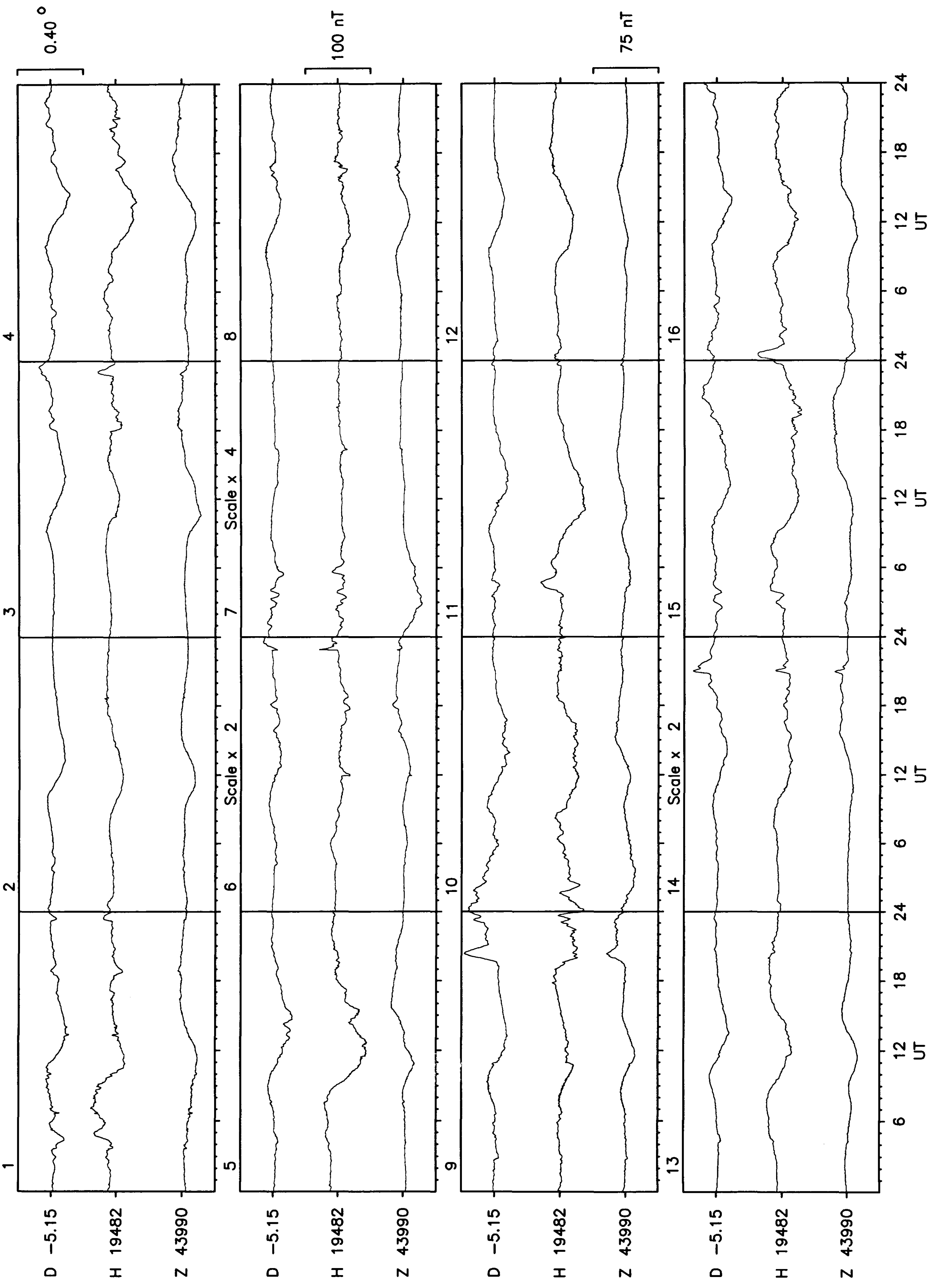

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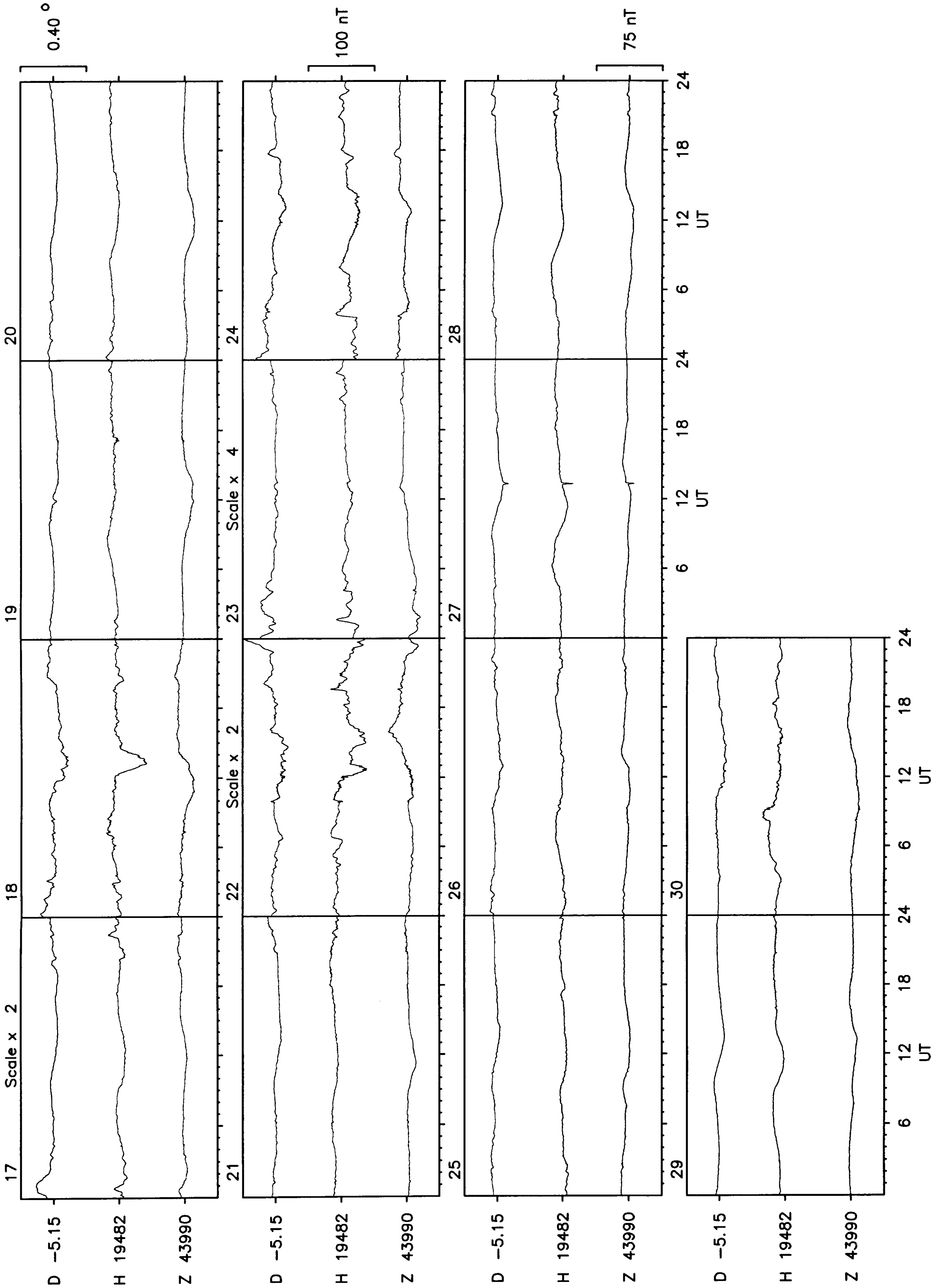

LE 11 97

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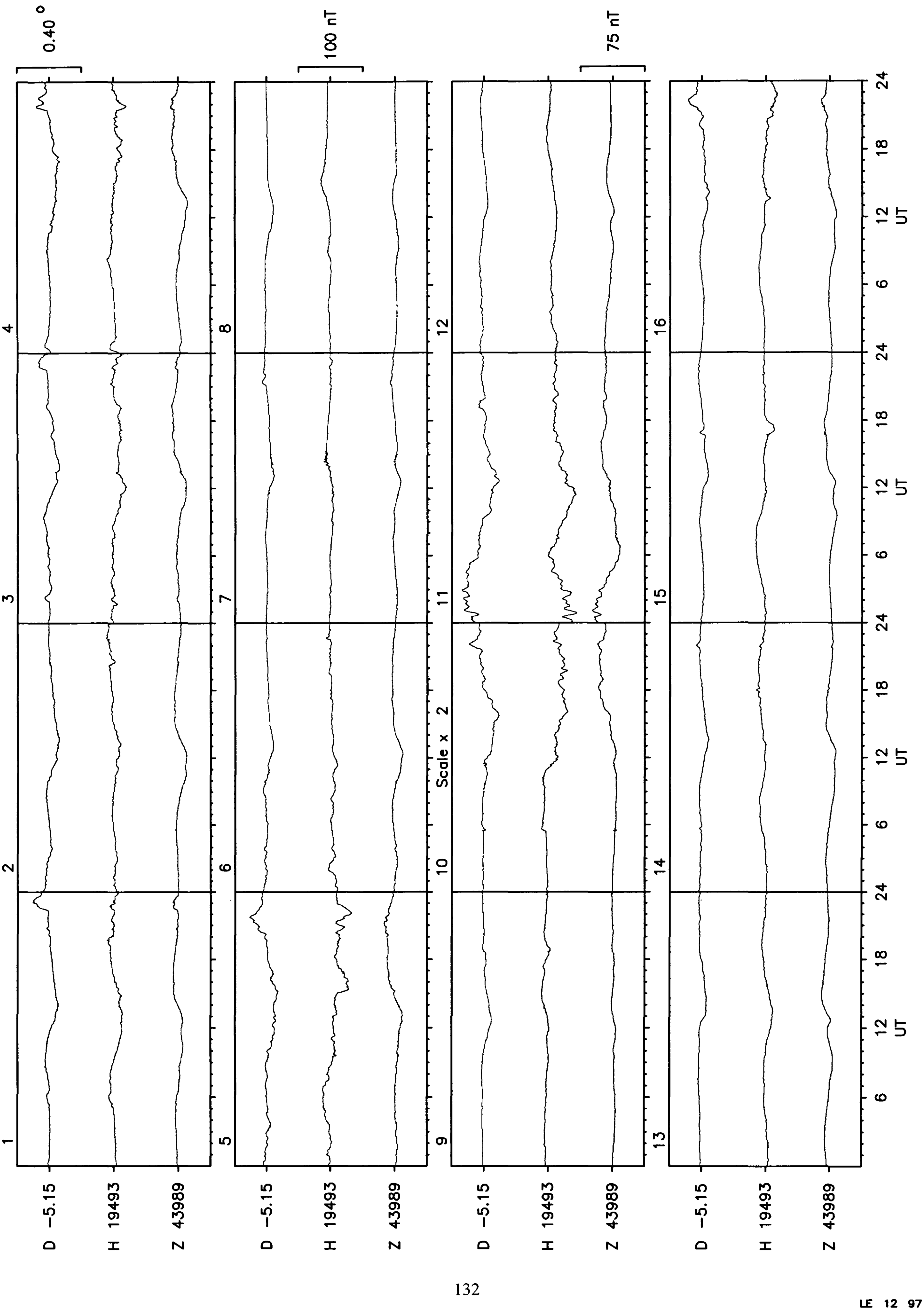
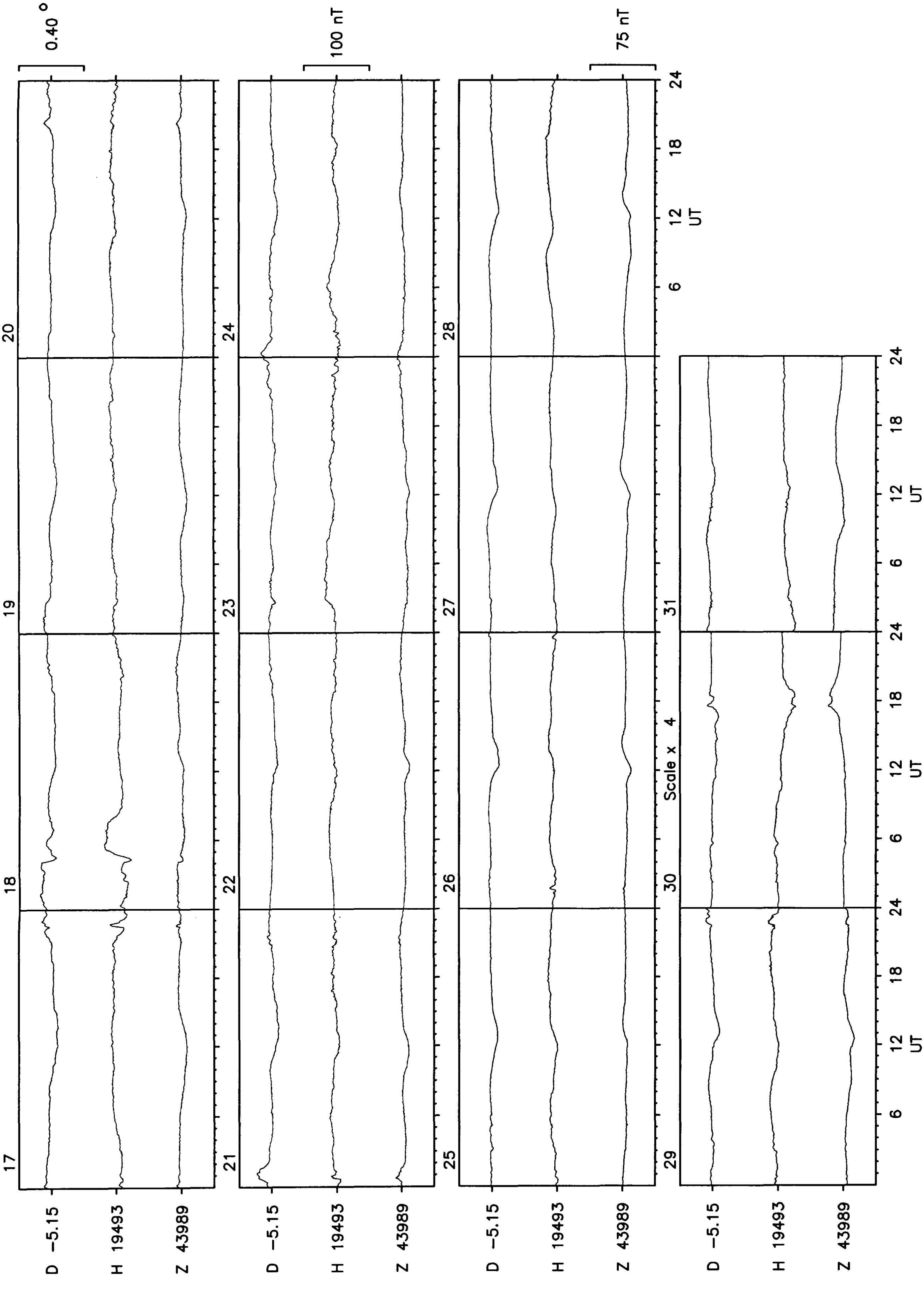
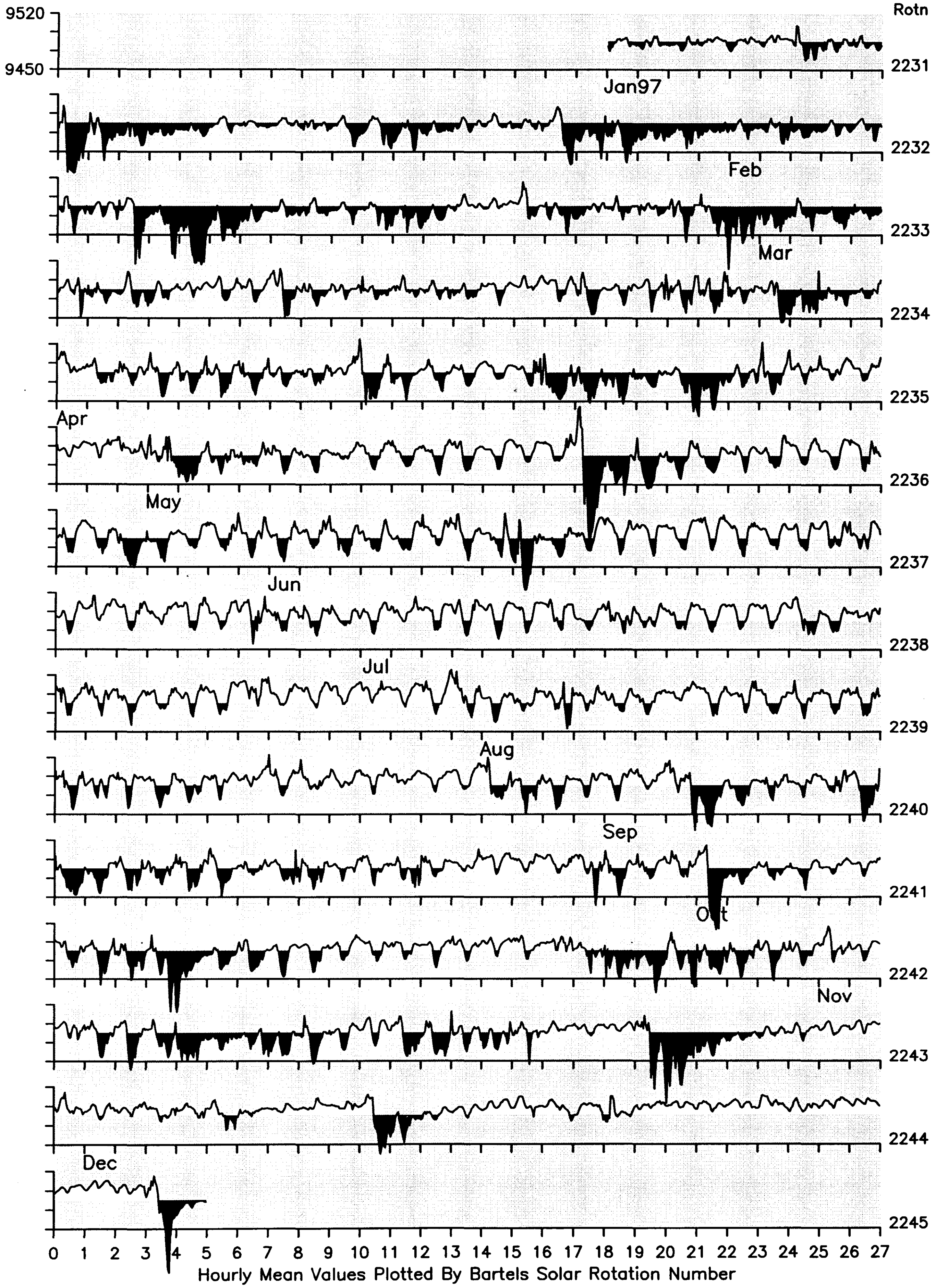


Hartland December 1997

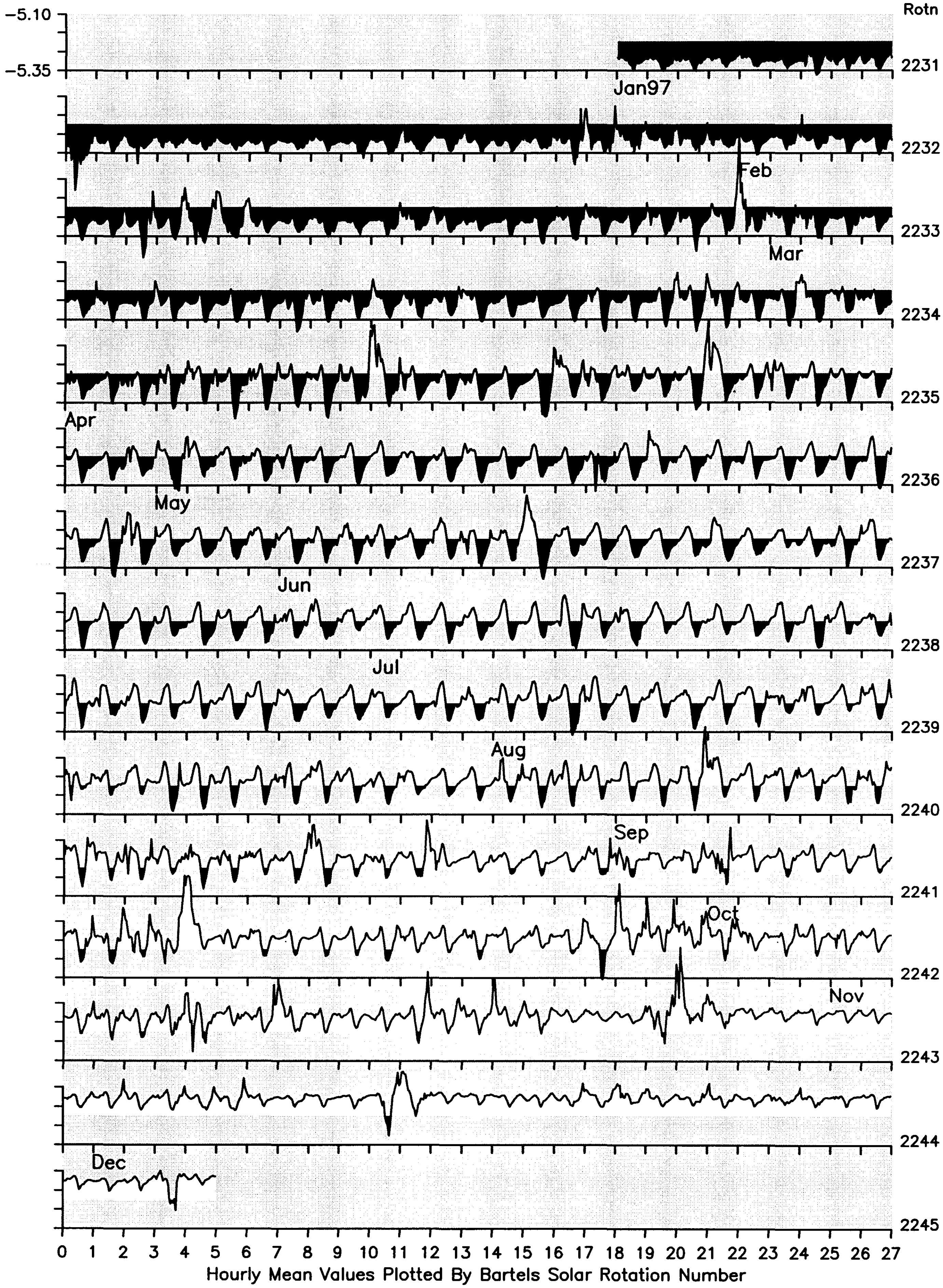


LE 12 97

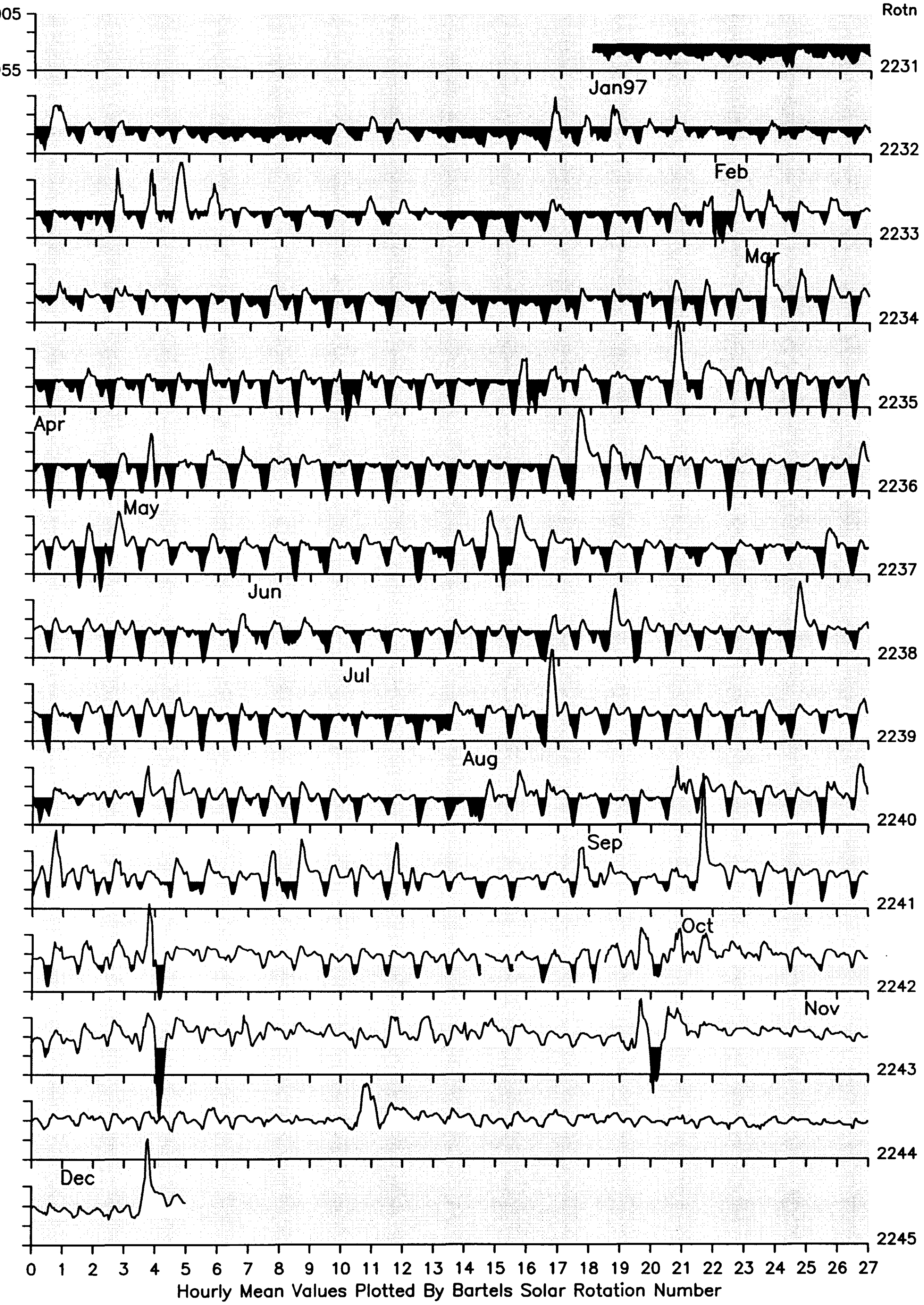
Hartland Observatory: Horizontal Intensity (nT)

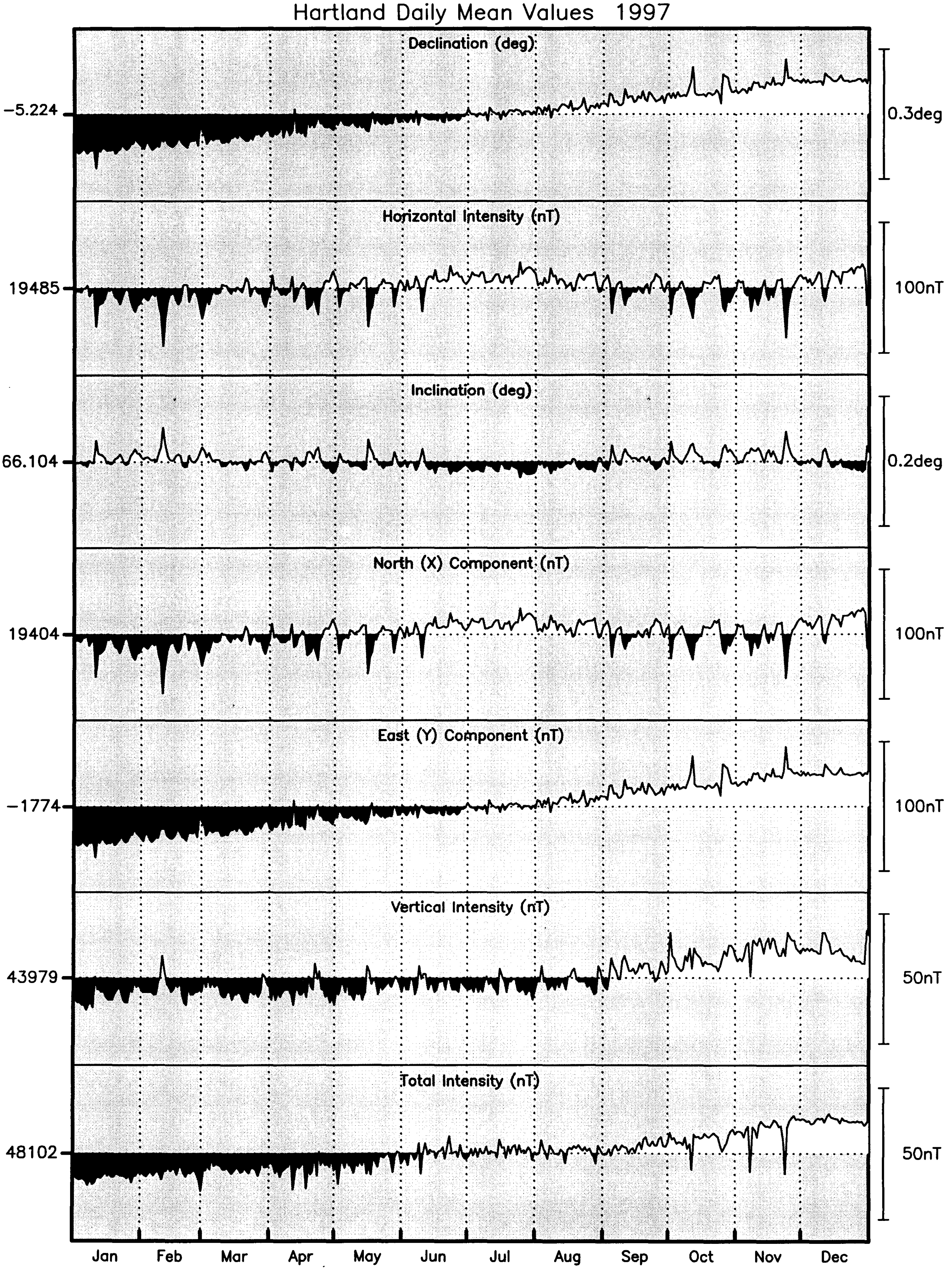


Hartland Observatory: Declination (degrees)



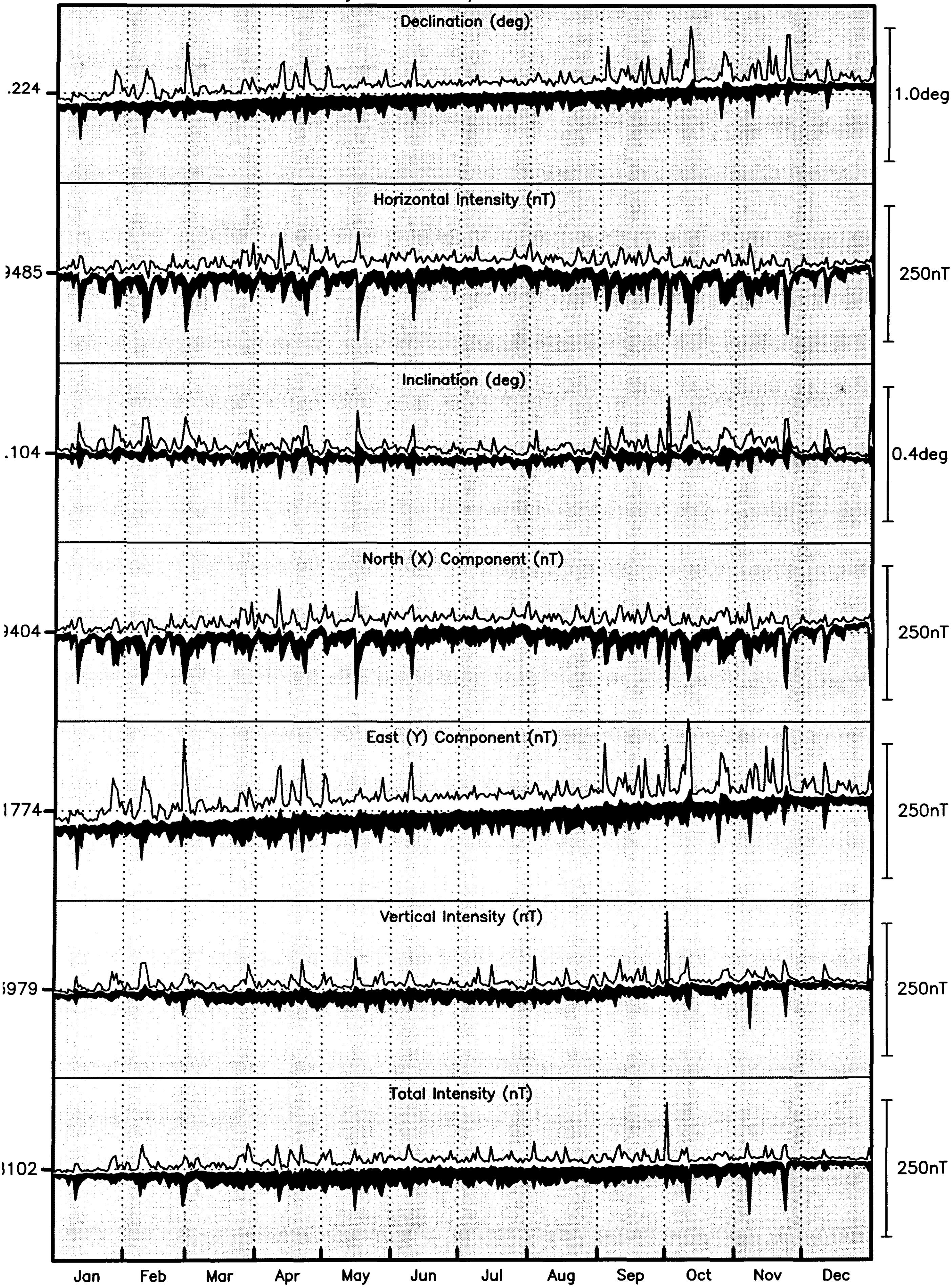
Hartland Observatory: Vertical Intensity (nT)





Hartland Daily Mean Values 1997
Declination (deg)
-5.224
0.3deg
Horizontal Intensity (nT)
19485
100nT
Inclination (deg)
66.104
0.2deg
North (X) Component (nT)
19404
100nT
East (Y) Component (nT)
-1774
100nT
Vertical Intensity (nT)
43979
50nT
Total Intensity (nT)
48102
50nT
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Hartland Daily Minimum/Maximum Values 1997



Monthly Mean Values for Hartland 1997

Based on All Days

Month	D	H	I	X	Y	Z	F
January	-5° 18.2′	19478 nT	66° 6.5′	19395 nT	-1801 nT	43972 nT	48093 nT
February	-5° 17.3′	19476 nT	66° 6.7′	19393 nT	-1795 nT	43974 nT	48094 nT
March	-5° 16.6′	19482 nT	66° 6.3′	19400 nT	-1792 nT	43974 nT	48096 nT
April	-5° 15.3′	19483 nT	66° 6.2′	19401 nT	-1785 nT	43973 nT	48096 nT
May	-5° 14.6′	19484 nT	66° 6.2′	19403nT	-1781 nT	43975 nT	48098 nT
June	-5° 14.0′	19490 nT	66° 5.8′	19409 nT	-1778 nT	43976 nT	48102 nT
July	-5° 13.3′	19495 nT	66° 5.5′	19414nT	-1774 nT	43975 nT	48103 nT
August	-5° 12.5′	19491 nT	66° 5.8′	19410 nT	-1769 nT	43977 nT	48103 nT
September	-5° 11.3′	19485 nT	66° 6.3′	19405 nT	-1762 nT	43981 nT	48104 nT
October	-5° 10.3′	19481 nT	66° 6.7′	19402 nT	-1756 nT	43986 nT	48107 nT
November	-5° 9.3′	19482 nT	66° 6.8′	19403 nT	-1750 nT	43990 nT	48111 nT
December	-5° 8.8′	19493 nT	66° 6.0′	19414 nT	-1748 nT	43989 nT	48114 nT
Annual	**-5° 13.4′**	**19485 nT**	**66° 6.2′**	**19404 nT**	**-1774 nT**	**43979 nT**	**48102 nT**

International quiet day means

Month	D	H	I	X	Y	Z	F
January	-5° 18.5′	19485 nT	66° 6.0′	19401 nT	-1802 nT	43969 nT	48093 nT
February	-5° 17.7′	19483 nT	66° 6.2′	19400 nT	-1798 nT	43972 nT	48095 nT
March	-5° 17.1′	19488 nT	66° 5.8′	19405 nT	-1795 nT	43971 nT	48096 nT
April	-5° 15.4′	19492 nT	66° 5.6′	19410 nT	-1786 nT	43971 nT	48098 nT
May	-5° 14.8′	19489 nT	66° 5.9′	19407 nT	-1782 nT	43974 nT	48099 nT
June	-5° 14.3′	19491 nT	66° 5.8′	19409 nT	-1779 nT	43977 nT	48103 nT
July	-5° 13.3′	19496 nT	66° 5.4′	19415 nT	-1774 nT	43974 nT	48102 nT
August	-5° 12.6′	19492 nT	66° 5.7′	19411 nT	-1770 nT	43976 nT	48102 nT
September	-5° 11.8′	19491 nT	66° 5.8′	19411 nT	-1765 nT	43979 nT	48105 nT
October	-5° 10.7′	19489 nT	66° 6.1′	19409 nT	-1759 nT	43984 nT	48108 nT
November	-5° 9.2′	19491 nT	66° 6.2′	19412 nT	-1751 nT	43989 nT	48114 nT
December	-5° 8.8′	19498 nT	66° 5.7′	19419 nT	-1749 nT	43987 nT	48115 nT
Annual	**-5° 13.7′**	**19490 nT**	**66° 5.8′**	**19409 nT**	**-1776 nT**	**43977 nT**	**48102 nT**

International disturbed day means

Month	D	H	I	X	Y	Z	F
January	-5° 18.1′	19468 nT	66° 7.3′	19385 nT	-1799 nT	43975 nT	48092 nT
February	-5° 16.2′	19460 nT	66° 7.9′	19378 nT	-1788 nT	43979 nT	48092 nT
March	-5° 16.3′	19476 nT	66° 6.7′	19394 nT	-1789 nT	43976 nT	48096 nT
April	-5° 14.0′	19470 nT	66° 7.1′	19389 nT	-1776 nT	43976 nT	48094 nT
May	-5° 14.6′	19471 nT	66° 7.1′	19389 nT	-1779 nT	43977 nT	48095 nT
June	-5° 14.0′	19484 nT	66° 6.3′	19403 nT	-1777 nT	43977 nT	48100 nT
July	-5° 13.7′	19496 nT	66° 5.5′	19414 nT	-1776 nT	43976 nT	48104 nT
August	-5° 12.5′	19487 nT	66° 6.1′	19406 nT	-1769 nT	43978 nT	48102 nT
September	-5° 10.7′	19477 nT	66° 6.9′	19397 nT	-1758 nT	43984 nT	48103 nT
October	-5° 9.7′	19473 nT	66° 7.3′	19394 nT	-1752 nT	43988 nT	48106 nT
November	-5° 8.8′	19469 nT	66° 7.5′	19391 nT	-1746 nT	43988 nT	48104 nT
December	-5° 8.7′	19480 nT	66° 7.0′	19401 nT	-1747 nT	43994 nT	48114 nT
Annual	**-5° 13.1′**	**19476 nT**	**66° 6.9′**	**19395 nT**	**-1771 nT**	**43981 nT**	**48100 nT**

Hartland Observatory K Indices 1997

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2111 2211	2111 2201	3222 2442	3431 2112	4110 3546	1211 1322	1200 2211	2201 2112	2200 0102	4344 3643	1333 2222	0110 1013
2	1111 2232	1221 2443	1333 2311	2231 2232	5221 3313	1111 1233	2100 2122	2100 0231	2100 1112	1100 1103	1101 0010	1101 1122
3	1111 1112	4101 0122	1012 2323	3311 1121	1111 3332	3231 2233	2112 3211	2113 4444	3222 3355	1122 3221	0001 1233	2111 2123
4	1111 1101	0012 1011	2010 1111	4332 1233	2210 1232	2101 1221	2111 2321	3221 0131	4322 1221	2012 2101	2221 2223	2011 1223
5	1111 1210	1001 2331	1010 2343	4311 0234	3211 2112	1100 0111	1210 2100	1110 1110	1111 1321	1000 0111	1121 3221	1111 1323
6	1101 1001	2332 3113	4221 2200	2122 2413	2101 1211	3112 2223	1212 1121	2100 1110	0221 3123	0000 0222	1323 3334	2111 1001
7	2421 3322	1100 0124	0022 3213	3311 2323	1010 0112	3411 3323	1421 2444	1111 3212	0001 2311	1211 2424	5542 3432	0000 1001
8	3311 2212	3112 5543	2201 2202	1110 1122	1100 1212	0222 2434	1110 2212	1212 2211	1003 3443	1133 4324	1111 1310	0000 0100
9	2121 1012	2222 3454	0000 0100	2101 1213	1110 1101	4544 4332	3310 2432	1111 3333	1333 2344	2343 3243	2212 1254	0000 1120
10	2454 2343	4332 2344	0000 1112	3010 2335	2110 1111	1111 0231	1112 2211	1231 1122	4222 2445	3341 2445	3321 2211	1214 2434
11	4323 3222	3332 3345	2101 1101	4542 3444	3111 2000	2111 1111	1111 2121	2321 2221	3211 2233	4531 1100	2311 1111	3222 3221
12	1142 2323	4221 0000	2333 3332	4113 2210	0100 0100	2111 2111	1110 1111	1011 1223	5321 3342	1222 1111	2011 0110	1100 0000
13	2221 2221	1011 2111	2220 1232	1311 2312	1000 0011	1000 1101	0110 1111	2222 2344	3221 1223	3111 1121	0111 1111	0000 1000
14	0010 1121	2121 1122	2121 0012	2110 1100	1001 1333	0100 1010	0110 1111	3442 1223	3323 3232	0111 1100	2111 2255	0000 1111
15	1100 1200	0012 2310	3121 1112	2011 0000	4455 4434	2111 1221	1223 2332	1111 2211	3223 2312	0011 1201	2221 1233	1000 1200
16	1100 1001	0112 2133	2221 2221	0001 4355	2321 4413	1112 3221	1111 2121	3211 1000	2211 1212	1111 0012	4211 2113	0000 1123
17	0000 1111	2333 2132	1110 1133	4422 2344	4202 2223	0111 2210	0121 1323	2111 2341	1111 2334	0012 2233	4211 1134	1000 0013
18	3221 1110	2111 1111	2210 1112	3232 3132	1220 2222	1110 2110	2322 2212	1110 2321	4432 3322	2100 0101	3223 4223	2420 1011
19	1001 2321	2110 0001	1100 1000	2232 3223	1100 1110	2222 2323	2421 3322	2100 1110	1011 0121	0001 1101	1001 1201	2000 0110
20	0011 2333	1111 2111	0111 1121	0110 1123	1111 1210	1110 1211	3212 2110	1111 2013	2121 2102	3220 1121	1100 0000	0001 1121
21	3111 2221	1323 2202	0011 1111	0112 4444	0111 1221	0000 0110	1111 1321	4311 2122	1222 1255	2010 0001	1000 0011	3000 0111
22	1111 1122	3101 1333	3322 2211	5311 2122	1010 0212	1322 2321	1011 2221	3221 2212	5311 1110	1211 1022	3334 5446	0000 1010
23	2001 1110	2322 2212	0001 1110	1112 2234	0010 0011	1111 2223	1111 1122	2000 0211	0111 1113	0012 2234	6534 3244	2100 1112
24	0101 1113	0222 3103	0113 1144	5321 2222	1112 3322	1101 2221	2122 4333	2101 1123	2021 1112	2223 5224	3321 2322	3111 1110
25	2110 1133	3111 1212	3212 2234	2111 2223	1210 1111	2211 2232	3111 1221	2211 0110	0000 1110	5423 3233	1000 0111	1100 1000
26	2211 4455	3324 4421	2332 3344	1110 1111	1101 3333	2110 1122	1110 1211	0000 1110	0011 2112	5311 2344	2101 1012	2101 2001
27	3312 1344	3221 3346	3001 1131	0000 0112	4531 2223	2114 4343	1111 2211	0010 1112	3221 2443	4332 2244	0100 2010	1000 1000
28	3322 4453	5533 3443	1111 2454	1000 1010	1112 2111	3311 2222	2111 2311	2442 2333	4331 1221	4223 3343	0100 0001	0000 1010
29	2121 2242		3334 2335	0001 1231	1100 0112	3311 1222	0111 1111	1224 3333	3222 1112	2221 1122	0000 0011	1100 1002
30	3221 3443		2322 2232	3311 1232	1110 2333	2100 1211	3211 1123	1321 2233	1321 2242	2012 3233	1222 1221	2323 2552
31	2301 1133		1101 1232		2211 2333		4433 3223	1101 1110		2110 1221		1101 1000

DAILY aa INDICES

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	11	12	27	23	49	13	8	11	7	63	21	11
2	12	22	23	18	26	12	9	9	8	10	5	13
3	9	12	14	11	19	20	11	34	45	20	11	11
4	8	9	7	24	13	10	12	13	25	10	17	14
5	10	12	18	20	11	6	7	6	11	4	16	20
6	7	20	16	20	10	15	9	5	16	8	30	11
7	24	9	16	17	5	23	28	11	8	19	53	6
8	15	38	12	9	7	27	8	10	24	27	13	5
9	8	35	3	10	7	51	21	17	26	29	25	7
10	58	34	5	22	9	10	14	13	36	42	24	43
11	39	47	8	48	9	7	12	17	16	22	15	21
12	20	12	25	19	3	11	5	11	28	10	7	5
13	14	10	15	16	3	5	5	23	14	10	10	4
14	8	10	10	7	12	4	5	30	22	7	28	7
15	10	12	14	6	80	9	22	12	19	8	15	9
16	7	18	14	33	24	11	7	11	9	8	20	10
17	7	31	12	40	19	6	12	21	16	17	20	8
18	13	12	10	29	11	5	17	14	33	8	25	13
19	13	7	5	22	4	18	20	5	6	6	6	7
20	18	9	7	7	8	8	12	11	12	11	4	8
21	18	19	10	36	8	3	10	15	31	6	6	8
22	10	20	18	22	7	16	9	13	17	9	62	5
23	6	18	7	16	4	12	8	5	11	18	50	9
24	9	17	21	24	15	8	26	12	9	35	18	9
25	12	11	25	13	7	15	10	6	6	32	4	5
26	39	31	40	8	17	8	6	4	9	32	8	7
27	29	50	12	6	32	31	9	7	29	32	5	4
28	43	53	37	4	10	17	10	27	25	35	5	5
29	17		36	8	5	19	6	25	15	16	4	8
30	30		27	17	13	7	12	21	20	17	13	37
31	12		11		19		28	7		10		7
Monthly Mean Value	**17.3**	**21.0**	**16.3**	**18.4**	**15.1**	**13.7**	**12.2**	**13.7**	**18.4**	**18.7**	**18.0**	**10.8**

Annual mean Value for 1997 = 16.1

SIs and SSCs

Day	Month	UT		Type	Quality	H(nT)	D(min)	Z(nT)
8	2	06	28	SSC*	C	3.0	0.90	2.0
9	2	13	21	SSC*	B	19.0	1.60	7.0
5	3	13	56	SSC*	B	11.8	-1.90	-1.8
20	3	20	42	SI*	B	8.6	+0.30/-0.30	2.4
21	3	15	30	SI*	C	4.4	-0.80	2.0
10	4	17	44	SSC*	B	23.9	-0.60	8.3
16	4	13	19	SSC*	A	12.3	-1.90	-2.4
21	4	13	00	SSC*	C	-15.7	2.70	3.6
1	5	12	42	SSC*	B	20.4	-2.50	+2.2/-2.5
12	5	03	35	SSC*	C	4.2	+0.72/-0.60	2.5
15	5	01	59	SSC	B	46.6	-1.99	+9.0/-9.1
20	5	06	01	SSC	C	5.9	-0.60	
25	5	14	34	SSC	C	9.0	-0.55	1.3
26	5	09	57	SSC*	C	-4.7	-0.72	-1.9
26	5	15	51	SI	C	-13.1		-3.3/+3.1
8	6	11	04	SSC	C	10.8		2.3
19	6	00	31	SSC*	C	7.2	-1.38	-2.1
22	6	03	13	SSC*	C	7.6	-1.54	-1.9
27	6	07	58	SSC*	B	-3.9	-0.88	-2.6
15	7	03	10	SSC	C	8.2	-0.71	
15	7	10	09	SI*	C	-12.9	-1.82	-6.3
29	7	06	07	SI	C	-3.3	1.37	3.2
3	8	10	42	SSC	B	17.1	-1.24	-5.0
28	8	15	51	SSC	B	19.2	-0.45/+0.67	5.7
2	9	22	59	SSC	B	18.0	-0.58	2.5
17	9	13	48	SSC*	C	-8.5	0.81	
21	9	15	40	SSC	C	-4.3	0.24	
1	10	00	59	SSC	B	35.3	-2.19	4.6
6	10	17	17	SSC	C	-11.5	0.11	-4.4
10	10	16	12	SSC	C	15.9	-0.56	3.3
23	10	08	05	SSC*	B	-5.5	0.63	-1.0
1	11	06	35	SSC*	B	5.4	-1.90	-4.9
6	11	11	52	SSC	B	-27.1	0.98	-7.6
6	11	22	48	SSC*	A	56.6	-4.47	6.7
9	11	17	41	SSC*	C	4.0	0.23	1.7
22	11	09	49	SSC*	A	-15.8	2.69	-2.7/+2.6
10	12	05	25	SSC*	A	8.7	-2.71	-8.1
30	12	02	09	SSC*	B	11.9	-1.65	-2.5

Notes

A * indicates that the principal impulse was preceded by a smaller reversed impulse.

The quality of the event is classified as follows :

A = very distinct

B = fair, ordinary, but unmistakable

C = doubtful

The amplitudes given are for the first chief movement of the event.

SFEs

Day	Month	Universal Time						H(nT)	D(min)	Z(nT)
		Start		Maximum		End				
2	9	12	27	12	31	12	40	-2.2	-0.85	-1.8
27	11	13	13	13	18	13	28	-15.9	-1.95	6.4

Notes

The amplitudes given are for the chief movement of the event.

Annual Values of Geomagnetic Elements

Abinger

Year	D	H	I	X	Y	Z	F
1925.5	-13 22.7	18597	66 35.2	18092	-4303	42946	46800
1926.5	-13 10.4	18581	66 36.3	18092	-4234	42947	46794
1927.5	-12 58.4	18575	66 36.2	18101	-4170	42932	46778
1928.5	-12 47.0	18564	66 37.2	18104	-4108	42941	46782
1929.5	-12 35.8	18555	66 37.2	18108	-4047	42918	46758
1930.5	-12 24.6	18542	66 38.2	18109	-3985	42924	46757
1931.5	-12 13.7	18543	66 38.1	18122	-3928	42923	46757
1932.5	-12 2.6	18536	66 39.1	18128	-3868	42940	46770
1933.5	-11 51.7	18532	66 39.4	18136	-3809	42942	46770
1934.5	-11 41.1	18533	66 39.7	18149	-3754	42955	46782
1935.5	-11 30.3	18527	66 40.9	18155	-3695	42981	46805
1936.5	-11 20.0	18524	66 41.8	18163	-3640	43007	46827
1937.5	-11 10.4	18522	66 42.7	18171	-3589	43031	46848
1938.5	-11 1.4	18522	66 43.2	18180	-3542	43050	46865
1939.5	-10 51.9	18528	66 43.5	18196	-3492	43074	46890
1940.5	-10 43.0	18533	66 43.9	18210	-3446	43099	46915
1941.5	-10 33.8	18539	66 44.3	18225	-3399	43128	46944
1942.5	-10 24.8	18554	66 43.9	18248	-3354	43146	46966
1943.5	-10 16.2	18556	66 44.5	18259	-3308	43172	46991
1944.5	-10 7.8	18566	66 44.3	18277	-3265	43189	47010
1945.5	-9 59.5	18573	66 44.3	18291	-3223	43207	47030
1946.5	-9 51.1	18569	66 45.4	18295	-3177	43235	47054
1947.5	-9 43.1	18577	66 45.2	18310	-3136	43246	47067
1948.5	-9 35.4	18593	66 44.4	18333	-3098	43255	47082
1949.5	-9 27.5	18607	66 44.0	18354	-3058	43273	47104
1950.5	-9 19.7	18628	66 43.0	18382	-3019	43288	47126
1951.5	-9 12.2	18648	66 42.1	18408	-2983	43305	47149
1952.5	-9 4.7	18670	66 41.0	18436	-2946	43316	47168
1953.5	-8 57.5	18695	66 39.5	18467	-2911	43321	47183
1954.5	-8 50.9	18720	66 38.1	18497	-2879	43332	47203
1955.5	-8 43.6	18738	66 37.4	18521	-2843	43348	47225
1956.5	-8 36.8	18750	66 37.4	18539	-2808	43376	47255
1957.1	-8 32.9	18755	66 37.6	18547	-2788	43394	47274

Hartland

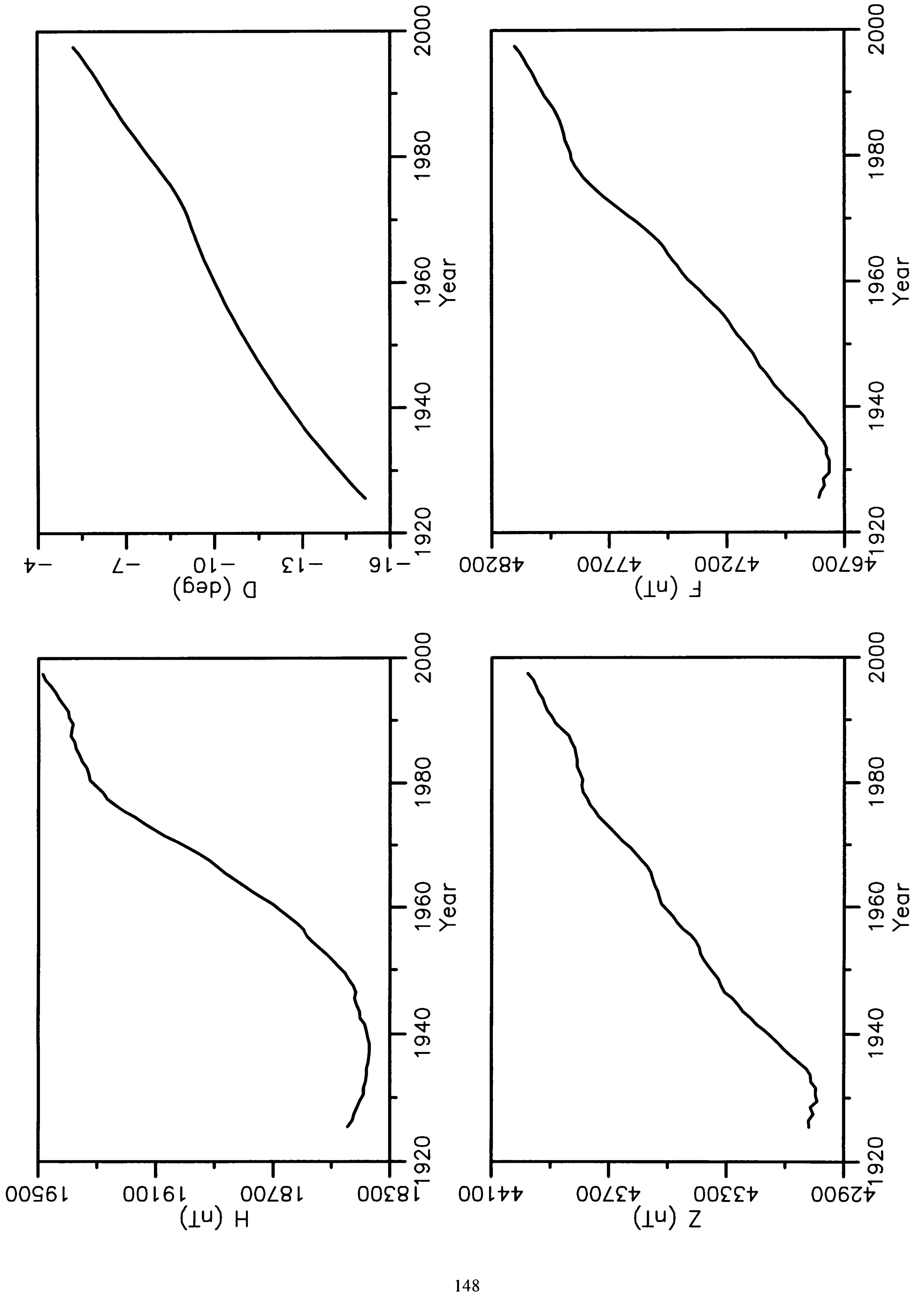
Year	D	H	I	X	Y	Z	F
Note 1	-1 -46.6	-146	0 11.4	-247	-542	56	-6
1957.5	-10 17.2	18627	66 47.7	18328	-3326	43451	47275
1958.5	-10 11.0	18655	66 46.3	18361	-3298	43465	47299
1959.5	-10 5.0	18681	66 45.1	18392	-3271	43484	47327
1960.5	-9 58.8	18707	66 43.9	18424	-3242	43504	47356
1961.5	-9 53.0	18744	66 41.7	18466	-3217	43512	47378
1962.5	-9 46.9	18779	66 39.5	18506	-3190	43517	47396
1963.5	-9 40.6	18807	66 37.9	18539	-3161	43528	47417
1964.5	-9 35.2	18840	66 36.0	18577	-3138	43535	47437
1965.5	-9 30.1	18872	66 34.0	18613	-3115	43540	47454
1966.5	-9 25.1	18897	66 32.7	18642	-3092	43554	47477
1967.5	-9 20.3	18923	66 31.5	18672	-3071	43573	47505
1968.5	-9 15.5	18956	66 29.9	18709	-3050	43592	47535
1969.5	-9 11.1	18994	66 27.9	18750	-3032	43611	47568
1970.5	-9 6.5	19033	66 26.1	18793	-3013	43636	47606
1971.5	-9 1.1	19075	66 23.8	18839	-2990	43655	47640
1972.5	-8 55.3	19110	66 22.1	18879	-2964	43676	47674
1973.5	-8 48.2	19144	66 20.5	18918	-2930	43697	47707
1974.5	-8 40.4	19175	66 19.1	18956	-2892	43719	47739
1975.5	-8 32.3	19212	66 17.0	18999	-2852	43733	47767
1976.5	-8 23.1	19240	66 15.7	19034	-2806	43749	47793
1977.5	-8 13.7	19271	66 13.9	19073	-2758	43758	47813
1978.5	-8 03.6	19286	66 13.3	19095	-2704	43773	47833
1979.5	-7 53.5	19309	66 12.0	19127	-2651	43778	47847
Note 2	0 0.0	0	0 -0.2	0	0	-6	-5
1980.5	-7 43.8	19330	66 10.3	19154	-2600	43768	47846
1981.5	-7 33.9	19335	66 10.2	19167	-2546	43777	47857
1982.5	-7 24.7	19342	66 10.1	19180	-2495	43787	47869
1983.5	-7 15.1	19358	66 9.0	19203	-2443	43787	47876

Year	D		H	I		X	Y	Z	F
1984.5	-7	5.5	19366	66	8.6	19218	-2391	43791	47882
1985.5	-6	56.1	19379	66	7.9	19237	-2340	43796	47892
1986.5	-6	47.3	19383	66	8.0	19247	-2291	43807	47904
1987.5	-6	39.2	19395	66	7.4	19264	-2247	43817	47918
1988.5	-6	30.7	19393	66	8.2	19267	-2199	43838	47936
1989.5	-6	22.9	19389	66	9.1	19269	-2155	43862	47956
Note 3	0	0.0	-6	0	1.1	-6	1	23	19
1990.5	-6	15.0	19395	66	9.7	19280	-2111	43896	47990
1991.5	-6	7.1	19398	66	10.0	19288	-2067	43912	48006
1992.5	-5	59.7	19413	66	9.3	19307	-2028	43920	48019
1993.5	-5	51.2	19429	66	8.4	19328	-1981	43928	48033
1994.5	-5	42.2	19440	66	8.1	19344	-1932	43942	48050
1995.5	-5	33.2	19457	66	7.3	19366	-1883	43951	48065
1996.5	-5	23.4	19475	66	6.4	19389	-1829	43960	48081
1997.5	-5	13.4	19485	66	6.2	19404	-1774	43979	48102

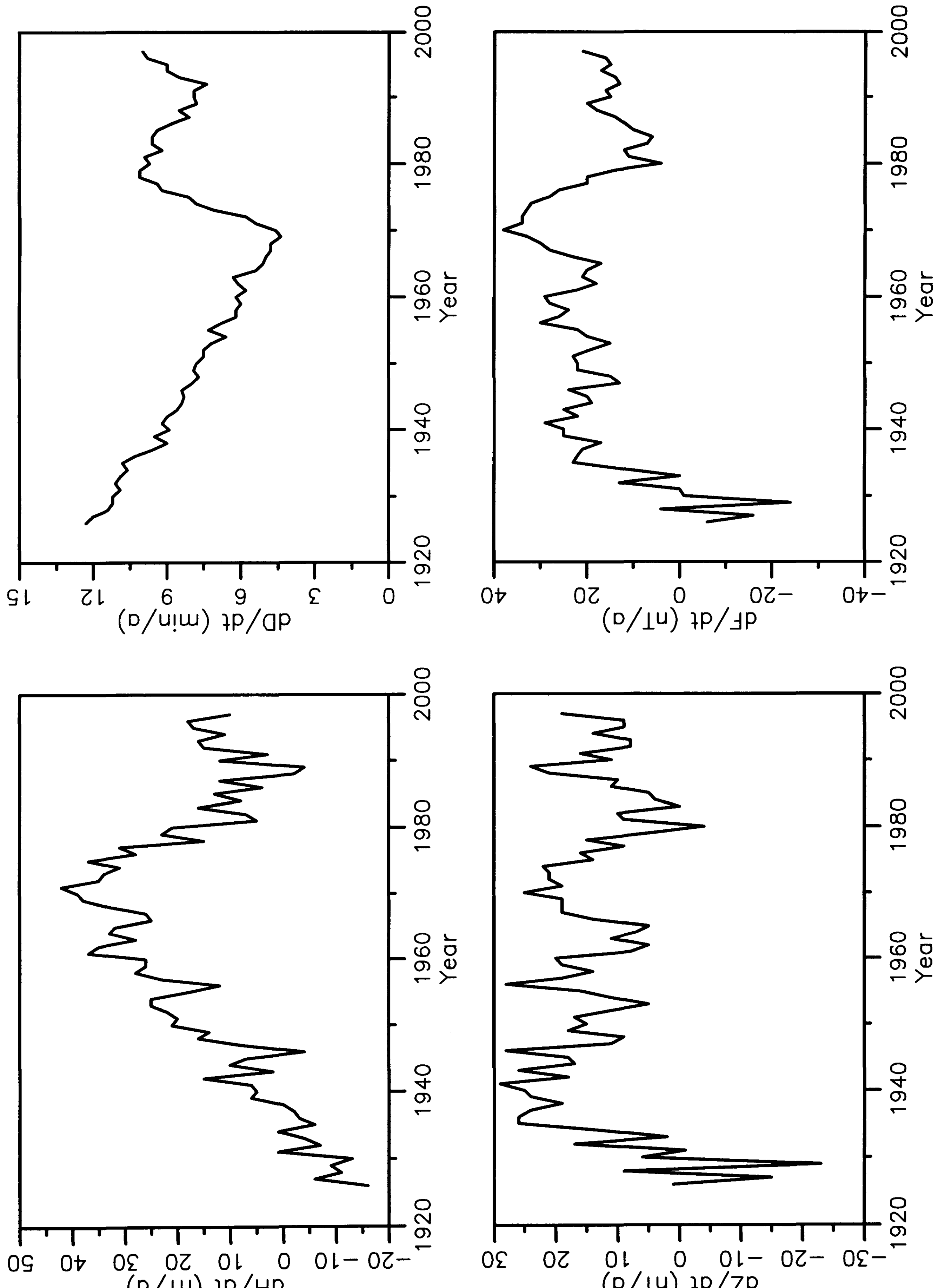
1 Site differences 1 Jan 1957 (Hartland value - Abinger value)
2 Site differences 1 Jan 1980 (new value - old value)
3 Site differences 1 Jan 1990 (new value - old value)

D and I are given in degrees and decimal minutes
All other elements are in nanoteslas

Annual Mean Values at Hartland



Rate of Change of Annual Mean Values at Hartland



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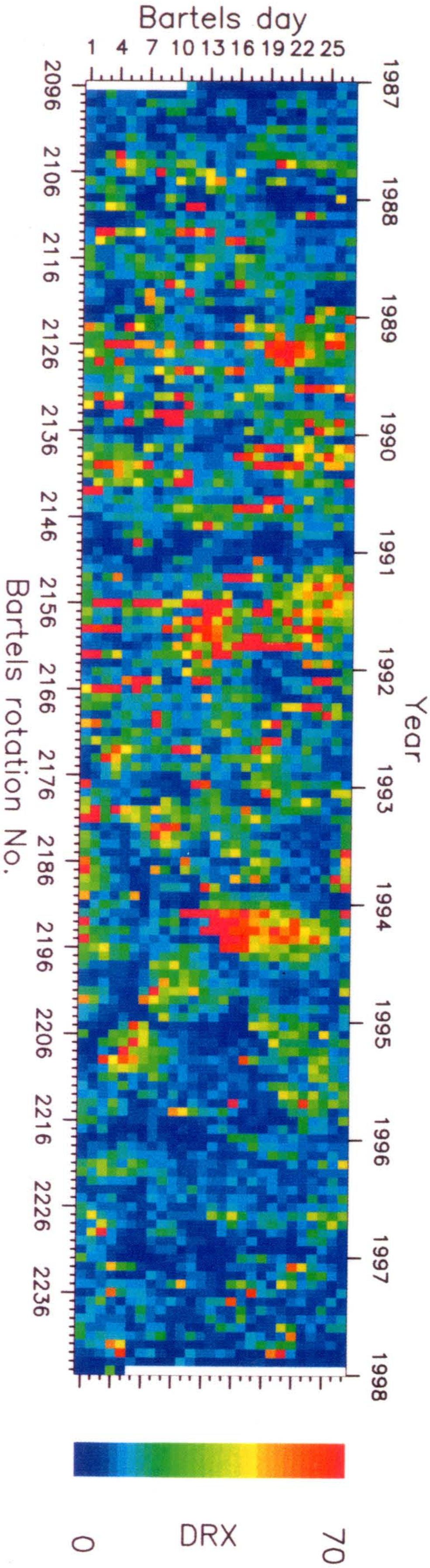
Back
The daily geomagnetic index DRX from Lerwick Observatory plotted by Bartels rotation for the years 1987–97 (inclusive)

ISBN 0 85272 325 3

Price £45.00



GEOMAGNETIC BULLETINS

1 Hartland Observatory magnetic results 1965, 1966 and 1967
2 Magnetic results 1968 Eskdalemuir, Hartland and Lerwick observatories
3 Magnetic results 1969 Eskdalemuir, Hartland and Lerwick observatories
4 Magnetic results 1970 Eskdalemuir, Hartland and Lerwick observatories
5 Magnetic results 1971 Eskdalemuir, Hartland and Lerwick observatories
6 Annual mean values of the geomagnetic elements since 1941
7 Magnetic results 1972 Eskdalemuir, Hartland and Lerwick observatories
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