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Magnetic Results 1991

LERWICK, ESKDALEMUIR AND HARTLAND OBSERVATORIES

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Compilers

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1 INTRODUCTION

This bulletin is a report of the measurements made between 1 January and 31 December 1991 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 and a description is given of the Automatic Remote Geomagnetic Observatory System (ARGOS), deployed at each observatory since 1st January 1987 (Riddick *et al.* 1990). 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 plots of daily and hourly mean values for each year, and complete sets of daily magnetograms derived from minute values. An IBM diskette containing the hourly mean values has been produced as a companion to this volume and is available on request.

2 DESCRIPTIONS OF THE OBSERVATORIES

The locations of the UK magnetic observatories are shown on the front cover of the bulletin. The history of the current UK geomagnetic observatories, and of other observatories that have operated in the British Isles, is described by Robinson (1982).

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 outcropping rock. 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. There are no members of BGS staff stationed at Lerwick.

Figure 1 is a site diagram of Lerwick observatory. During 1991 no major changes were made at the site. Routine maintenance work was carried out on the observatory buildings.

The observatory coordinates are:

	Geographic	Geomagnetic
Latitude	60°08'N	62°06'N
Longitude	358°49'E	89°28'E
Height above *msl*	85 m	

(Geomagnetic coordinates used in this report are relative to a geomagnetic pole position of 79°10'N, 71°11'W, computed from the 6th generation International Geomagnetic Reference Field at epoch 1991.5.)

Eskdalemuir (Dumfries & Galloway, Scotland)

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

Eskdalemuir is a synoptic meteorological station involved in measurement of solar radiation, levels of atmospheric pollution, and chemical sampling. The observatory operates a US standard seismograph and an International Deployment Accelerometer Program (IDAP) 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.

Mr W E Scott, Mr C R Pringle and Mrs H Middleton, who are responsible for the general maintenance of the observatory, are now the only members of BGS staff stationed at Eskdalemuir.

Figure 2 is a site diagram of Eskdalemuir observatory. The heating system in the underground variometer chamber was upgraded at the end of January 1991. At the end of December 1991 telephone communications were lost to the observatory when local hunters shot through the telephone line. British Telecom rectified the fault the day after being notified.

The observatory coordinates are:

	Geographic	Geomagnetic
Latitude	55°19'N	57°58'N
Longitude	356°48'E	84°03'E
Height above *msl*	245 m	

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 a seismic outstation in South Wales is 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 control of Hartland observatory, from the Royal Greenwich Observatory, in 1968.

Since June 1987 Mr K E Johns (caretaker) has been the only member of BGS staff stationed at Hartland.

Figure 3 is a site diagram of Hartland observatory. Routine maintenance was carried out on all the observatory buildings during 1991.

The observatory coordinates are:

	Geographic	Geomagnetic
Latitude	51°00'N	54°06'
Longitude	355°31'E	80°20'
Height above *msl*	95 m	

3 INSTRUMENTATION

3.1 Absolute observations

At each observatory absolute measurements are made in a single Absolute Hut (see the site diagrams). Since 1st January 1990 absolute measurements 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	**PVM**
Lerwick	ELSEC 810	ELSEC 8801 Proton precession magnetometer mounted in ELSEC 5920 coils
Eskdalemuir	Bartington MAG 01H	ELSEC 8801 Proton precession magnetometer mounted in ELSEC 5920 coils
Hartland	ELSEC 810	ELSEC 8801 Proton precession magnetometer mounted in ELSEC 5920 coils

3.2 ARGOS: Variometer Measurements

The essential components of the ARGOS systems are a three-component fluxgate magnetometer (EDA FM100C), two proton magnetometers (ELSEC 820M), and a Digital Equipment Corporation PDP 11/23 processor which controls the operation of the system. A block diagram of the ARGOS system is given in figure 4. The fluxgate sensors measure the X, Y and Z components of the geomagnetic field. The fluxgate magnetometer is operated in 'full field' mode, providing an analogue output of 5 V in a field of 50,000 nT. The three fluxgate sensors are located in a temperature-controlled variometer chamber, on a large single pier, with individual mountings separated by about 1.5 m. Each sensor is mounted inside a calibration coil which can apply a bias field to the sensor when required. The current to the calibration coil is supplied by a Time Electronics 9818 programmable current supply. The temperature of the variometer chamber is monitored continuously. The proton magnetometers are sited in non-magnetic huts. Proton magnetometer P1 is used to make measurements of total field F, and proton magnetometer P2 is mounted inside a set of two orthogonal Helmholtz coils which apply bias fields to measure changes in declination and inclination for the baseline reference measurements (see section 3.3).

A Thaler Corporation VRE 105CA precision reference supply is used to generate a reference signal of 5 V. In routine operation the analogue outputs from the three channels of the fluxgate magnetometer, the temperature sensor and the voltage reference are switched in turn, by a Hewlett-Packard HP3488A scanner, to the input of a Datron 1061A digital voltmeter and the five signals are measured. At the same time the PDP 11/23 processor triggers one of the proton magnetometers (P1) which performs an F (total intensity) measurement. (The second proton magnetometer (P2) is routinely inhibited.) This measurement sequence is repeated every 10 seconds, with the timing reference provided by a CMOS digital clock connected to the PDP 11/23 through a parallel interface. Communications between the PDP 11/23 processor and the other instruments and peripherals are via an IEEE instrument bus and RS232 serial ports.

A 7-point cosine filter is applied to the 10-second samples to produce minute values, centred on the minute, (Green, 1985). At the end of each hour the 60 minute values of X, Y, Z and F are written to a DC100 data cartridge together with hourly mean values, one-hour and three-hour activity indices based on the range in the X-component, the temperature of the variometer chamber, the reference voltage, and items of "housekeeping" information. An hour's data is written, in ASCII, as two 512 byte blocks. The cartridge drive is a TU58 dual drive. The system program is loaded from tape on drive 0, and data are written to the tape mounted on drive 1. The tape capacity is sufficient to store up to ten days' data. At each observatory the data collected are displayed on a VDU, and updated every minute, to enable the status of ARGOS to be monitored locally. A printer, normally disabled, can be switched on to obtain hard-copy of the display.

A British Telecom Datel 4122 modem (operating at 1200 baud) allows remote communication with the ARGOS systems via the public switched telephone network (PSTN). ARGOS can be called up manually by an operator in Edinburgh using the Processing and Remote Interrogation System (PARIS), based on a PDP 11/23 computer. The operator in Edinburgh can examine the system status and control a number of other ARGOS functions which include resetting the system clock, repositioning the data tape, and restarting ARGOS in the event of a system failure.

A second modem connected to a Data Track Technology Tracker 2000 solid state memory has been installed at each observatory. This communicates data to an IBM PS/2 in Edinburgh, which has been programmed to collect data automatically. Data can be retrieved every hour if necessary, but are normally collected every three hours.

Each ARGOS system is supported by a 500 VA Merlin-Gerin SX500 Uninterruptible Power Supply which has internal batteries capable of powering the full system for 30 minutes in the event of mains failure. Each observatory also has a stand-by diesel generator designed to start automatically within two minutes of loss of mains power. In the event of a sustained mains break and failure of the stand-by generators a further battery supply will maintain power to the fluxgates and the system clock for up to 7 days. This avoids deterioration in data quality due to drifts which are almost always severe when a fluxgate magnetometer is switched on after being powered down. The time from the system clock is essential for restarting ARGOS remotely when power is restored.

3.3 ARGOS: Baseline Reference Measurements

A consequence of the automation of the observatories was the removal of on-site staff, and so the loss of the guaranteed supply of regular absolute observations made by experienced BGS observers. Baseline reference measurements (BRMs) are designed to compensate for this change in observatory practice, enabling the standards achieved with manned operation to be maintained with an automated system.

The apparatus used to make BRMs is similar to a proton vector magnetometer (PVM), in which a proton precession magnetometer (PPM) is mounted at the centre of a set of coils which are used to apply bias fields to the magnetometer. Full PVM absolute observations require a sequence of measurements to be made with the coils rotated into positions which enable errors due to imperfect alignment of the magnetic axis to be eliminated. In a BRM the coils 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 is (practically) constant. Comparisons of BRM results with measurements made by the ARGOS fluxgates then show up short-term drifts in the fluxgate magnetometers which would not be detected by comparisons made with the less frequent absolute measurements. In effect, BRMs provide a means for interpolating between absolute observations.

The practice of making one BRM manually over the PARIS link each working day was discontinued at the end of 1990. Software had been installed at each of the observatories to enable BRMs to be made automatically every hour. These measurements differed from the manual measurements in that no independent measurement of Z was made. Instead of performing a measurement of Z using Nelson's method, Z was calculated from F and H measured by Serson's method.

This system for making automatic BRMs was further changed during 1991 by the installation of ΔD/ΔI coils on the P2 proton precession magnetometer. Measurements are controlled by a microprocessor based BRM controller driven by interrupts from the ARGOS PDP 11/23. The new BRM controllers and ΔD/ΔI coils were installed at Eskdalemuir on 27th May, at Hartland on the 12th June and at Lerwick on the 31st July. It is no longer possible to make BRMs manually using the PARIS link. The P1 proton magnetometer is not needed for BRMs and it now makes uninterrupted measurements of F every 10 seconds which are filtered to provide one-minute values.

3.4 Summary of Technical Specifications of the ARGOS Equipment

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

a) FM100C fluxgate magnetometer

Sensitivity:	0.1 mV/nT
Dynamic range:	±100,000 nT
Temperature coefficient:	(in the range) 0.1 - 1 nT/°C

b) ELSEC 820M proton precession magnetometer

Resolution:	0.1 nT
Accuracy:	±1 nT
Measurement range:	14,000-90,000 nT

c) System clock
Accuracy: 1 second per week

d) Datron 1061A digital voltmeter (DVM)
Accuracy: 1 part in 10^7
Temperature coefficient: 0.2 μV/°C

e) Time Electronics 9818 programmable current supply
Maximum current: 1A
Accuracy: 1μA

f) Thaler Corporation VRE 105CA precision reference supply
Reference voltage: 5V
Accuracy: ±0.4 mV
Temperature coefficient: 0.6 ppm/°C

3.5 Back-up Systems

At each observatory an EDA FM 100B three-axis fluxgate magnetometer, completely independent of ARGOS, is maintained to provide back-up data in the event of a total ARGOS failure. The fluxgate sensors are aligned in the H, D (magnetic east-west) and Z directions. The analogue outputs of the magnetometer are input to a 12-bit A/D converter and sampled every 10 seconds. The 10-second samples are written to a DC300XL cartridge tape to ECMA 46 standard. The cartridge is changed every 14 days and sent by post to BGS, Edinburgh, for transcription. The dynamic range of the magnetometers at Lerwick is ±2000 nT, at Eskdalemuir and Hartland it is ±1000 nT.

3.6 Calibration of geomagnetic measurements

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

Provided drift in the voltage reference used by the DVM is less than that of the fluxgate sensors, long term changes in the measurement of the magnetic field are only due to drift in the sensors. The DVM is calibrated every three months by comparing it with a second DVM which is calibrated anually to comply with National Physical Laboratory (NPL) standards. Its accuracy is quoted as 1 part in 10^7. Checks are also made every three months using standard cells which are maintained at each observatory. A check of the fluxgate sensitivity is also carried out by applying a bias field to the sensor. This is done by passing a known current through Helmholtz coils with an accurately known coil constant. The current is supplied by a constant current power supply which is calibrated by measuring the voltage across a standard resistor using the DVM. The change in the applied magnetic field can then be related to the change in voltage output from the sensor.

The PPM measures the frequency of emitted radiation from a sample of proton rich fluid, which is related to the ambient magnetic field by the proton gyromagnetic ratio. The conversion from frequency to magnetic field value carried out by the PPM is checked by irradiating the sensor with a signal of known frequency from an oscillator. The frequency of this signal is determined by comparing it with an accurate frequency standard transmitted from Rugby. This check on the PPM is carried out every three months at each observatory.

4 DATA PROCESSING

From January 1991 the main method of retrieving data to Edinburgh from the observatories has been by a dedicated IBM PS/2 which has been programmed to call the observatories automatically every three hours. The data are transferred over a local area network to the BGS Vax 6410 mainframe for processing. (The PARIS link is still used to collect data manually each day. Since this link is via a different modem this provides a backup communication system in case the automatic collection system should fail.)

Processing of the data is carried out automatically on the Vax each day shortly after midnight. The data files are first sorted into Universal Time (UT) day files. Subsequent data processing is carried out on these day files by a single FORTRAN program on the Vax which uses subroutines to generate various data products and derivatives. The data in each day file are first put through a quality control routine which checks for a range of possible errors. The data products then generated each day are:

a A magnetogram;
b A formatted list of one-minute values of all the geomagnetic elements;
c Hourly mean values and range indices;
d A forecast of geomagnetic activity for the next 27 days;
e Hourly and daily ranges in each geomagnetic element;
f A comparison of F computed from X, Y and Z and F measured by the PPM P1;
g A list of missing data;
h Computer generated K indices;
i An analysis of BRMs;
j An analysis of ARGOS reference voltage and variometer chamber temperature;
k A plot of absolute F measured by PPM at all three observatories.

The final check on the quality of the data is still the responsibility of the operator in Edinburgh who examines the magnetograms each day for erroneous values which may not have been detected by the automatic quality control procedures.

The prompt retrieval of data from the three UK observatories, made possible by ARGOS, immediately generated scientific and commercial demand for rapid access to the data. The Vax is connected to the UK Joint Academic Network (JANET) which enables transfer to academic users worldwide; commercial users can access the Vax using a British Telecom X25 gateway or dial-up modem. The Geomagnetism Information and Forecasting Service (GIFS) was created in 1988 to provide a 'user-friendly' interface between enquirers and the data sets, (Kerridge and Harris, 1988). GIFS, originally set up for academic users, now has separate academic and commercial sections. The data sets on GIFS derived from UK observatory data are updated daily.

At the end of each month any gaps in the ARGOS data are filled using data from the back-up magnetometers. The 10-second back-up data are filtered in the same way as the ARGOS raw samples to produce minute values. The resulting complete day files are archived on magnetic tape (two copies) on the Vax and also on data cartridge. The (unfiltered) back-up data are maintained as a high time-resolution data set. A monthly bulletin is issued for each observatory which includes magnetograms (with gaps filled), lists of K indices, the results of absolute observations and BRMs made during the month, tables of hourly mean values of H, D and Z, and a list of events associated with solar activity.

The number of missing minute values during 1991 at each observatory, resulting from failure of the ARGOS and back-up systems during the same periods of time, were as follows:

	No. of missing minute values	Date
Lerwick	0	-
Eskdalemuir	125	20 Sep (Z component only)
Hartland	61	11 Jun
	10	26 Sep
	11	21 Nov

5 CORRECTION OF FLUXGATE VARIOMETER DATA TO ABSOLUTE VALUES

Where variometer records are made photographically a physical mark, a baseline, is made on the photographic paper. Absolute observations are used to allocate a value to the baseline using the sensitivity of the magnetometer (the scale value, usually expressed in nT/mm), to relate the offset of the trace at the time of an absolute observation (the ordinate) to the baseline. For a fluxgate magnetometer a baseline value may be taken to be the value of the geomagnetic field at an arbitrary output voltage of the magnetometer. An alternative view is that the fluxgate magnetometer sensitivity (usually expressed in mV/nT) is used to, in effect, deduce the magnetometer output in zero magnetic field. The absolute observations enable corrections to be made for any such zero-field offset, (which is likely to vary with time), and the site difference between the location of the fluxgate sensor and the appropriate absolute pier.

The zero-field offset corrections allocated for each observatory for 1991 are shown in Figures 5-7. (The results for each observatory are discussed in detail below.) The zero-field offset correction is derived by comparing the fluxgate measurements with absolute measurements taken simultaneously. In each of the figures the top two panels show the comparison between the absolute measurements and the fluxgate measurements for H (plotted in the sense absolute - fluxgate) and the BRMs and the fluxgate measurements for H (plotted as daily average BRM - fluxgate value). The next two panels show the same for D and the next two panels show the same for Z. The bottom panel shows the daily mean temperature in the fluxgate chamber. In the panels showing the absolute - fluxgate comparison, the symbols represent the observed values and the full line shows the correction adopted, derived from polynomial fits to the observed values computed using the method of least squares. In deriving the polynomials the points immediately before the beginning and after the end of the year were used, but are not shown in the plots. This ensured that unrealistic discontinuities were not introduced at the year boundaries. The plots of the polynomial fits are stepped because the values computed from the polynomials have been rounded to the nearest nT or 0.1 min.

Lerwick (Figure 5)

Absolute measurements were made by BGS staff during service visits to the observatory in January, April, August and November. These show on the plots as clusters of measurements made within a few days. The measurements in between service visits were made by Meteorological Office staff. Measurements of D with the ARGOS fluxgate have been very steady throughout the year, and only slight drift is apparent in measurements of H. The drift in the fluxgate measurements of Z may be related to the general rise in the temperature in the fluxgate chamber during the summer. The BRM curves indicate that since the installation of the new systems at the end of July some tilting of the apparatus has occurred. The rate of tilt is decreasing and when the apparatus has settled the BRMs may be used to interpolate the zero-field offset correction between absolute measurements.

The table below lists the *rms* differences of the observed zero-field corrections from the allocated values. The *rms* differences for 1988-90 are also listed. The number of observations of each element in each year is given in brackets.

Year	H(nT)	D(min)	Z(nT)
1988	2.59 (31)	0.50 (23)	1.38 (30)
1989	2.97 (19)	0.48 (18)	1.57 (19)
1990	1.69 (25)	0.37 (24)	1.95 (25)
1991	0.82 (19)	0.58 (19)	0.74 (20)

Eskdalemuir (Figure 6)

Absolute measurements are made weekly by staff of the Meteorological Office at Eskdalemuir, supplemented by occasional measurements made by BGS staff. No large drift in any of the three components derived from fluxgate measurements occurred during 1991. Since the installation of the new BRM system on 27th May some initial settlement of the coils has given rise to drift in the BRM - fluxgate comparisons but the rate of tilt has decreased. Towards the end of December the fluxgate measurements became noisy, and eventually the sensors failed. The initial warning of this problem was provided by the sudden change in the comparison between the Proton magnetometer measurements of F and the value of F calculated from the fluxgate measurements. The failure of the fluxgate sensors is seen on the BRM plots at the end of December, which demonstrates that BRMs are a useful tool for on-line quality control of data from a remote observatory. Data from the backup system have been used during the time the ARGOS fluxgate sensors were out of action.

The table below lists the *rms* differences of the observed zero-field corrections from the allocated values. The *rms* differences for 1988-90 are also listed. The number of observations of each element in each year is given in brackets.

Year	H(nT)	D(min)	Z(nT)
1988	2.32 (26)	0.85 (21)	0.95 (27)
1989	1.77 (15)	0.61 (21)	1.06 (15)
1990	2.63 (38)	0.81 (38)	1.59 (38)
1991	1.67 (42)	0.44 (43)	1.09 (42)

Hartland (Figure 7)

Absolute measurements are made weekly by the caretaker at Hartland Observatory and by Edinburgh staff during service visits. No large drift in any of the components derived from fluxgate measurements occurred during 1991. The step in the zero-field offset for D at the end of February occurred as a result of a servicing the ARGOS equipment. The new BRM system was installed on 12th June, and the Z and H measurements (both derived from the measurements of ΔI) have settled down quickly. The step in the BRMs in October is unexplained but is likely to be due to movement of the coils. The D BRMs appear to be drifting but should settle down in 1992.

The table below lists the *rms* differences of the observed zero-field corrections from the allocated values. The *rms* differences for 1988-90 are also listed. The number of observations of each element in each year is given in brackets.

Year	H(nT)	D(min)	Z(nT)
1988	0.67 (50)	0.18 (8)	1.02 (50)
1989	1.24 (44)	0.24 (5)	1.03 (44)
1990	1.88 (55)	0.49 (57)	1.11 (56)
1991	1.03 (48)	0.17 (49)	1.09 (47)

6 PRESENTATION OF RESULTS

The data are organised by observatory in the order Lerwick, Eskdalemuir and Hartland. The results presented for each observatory are:

a Daily magnetograms of H, D and Z;
b Plots of hourly mean values of H, D and Z;
c Plots of daily mean values of H, D and Z;
d Plots of annual mean values and secular variation for H, D, and Z;
e Tables of monthly and annual mean values of all geomagnetic elements;
f Tables of K indices;
g A list of rapid variations noted during the year.

The daily magnetograms of H, D and Z are plotted 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 nanotesla for H and Z. 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.

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. In the plots of daily mean values secular variation is quite clear in H, D and Z, 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.

ARGOS data are corrected using BRMs and absolute observations to produce a series of absolute minute values of H, D and Z centred on the minute. Hourly mean values, centred on the UT half-hour, are computed from minute values, daily mean values from hourly means, and monthly mean values from daily means. (Hourly means are not computed if there are more than six one-minute values missing; daily means are not computed if there are more than two hourly means missing.) Annual mean values are calculated from the monthly mean values weighted according to the number of days in the month. At each stage of processing the remaining mean values of the geomagnetic elements are calculated from the corresponding mean values of H, D and Z. The monthly mean and annual mean values for all the geomagnetic elements are tabulated. Declination and inclination are expressed in degrees and decimal minutes, the units of all the other elements are nanoteslas.

The K index summarises geomagnetic activity at an observatory by assigning a code, an integer from 0 to 9, to each 3-hour Universal Time (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 K index has a local time (LT) and seasonal dependence associated with the geographic and geomagnetic coordinates of the observatory. The K indices for each of the UK observatories are tabulated.

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 LT 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. (Definitive values of the indices recognised by IAGA are published by the International Service for Geomagnetic Indices, Paris.) Daily mean, monthly mean and annual mean values of the aa index are listed following the tables of K indices for Hartland. The derivation of the geomagnetic activity indices mentioned here is described in great detail by Mayaud (1980).

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

The annual mean values at each observatory since operations began are tabulated. Declination and inclination are expressed in degrees and decimal minutes, 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

Hourly mean values of H, D, Z and F for each observatory for 1991 are available on an IBM-compatible 3.5" (or 5.25") diskette. The diskette contains a file 'README' which explains the content and format of each file on the diskette. Other data included in this bulletin can be obtained in digital form by application to:

Data Services
Geomagnetism Group
British Geological Survey
Murchison House
West Mains Road — ☎: 031 667 1000
Edinburgh EH9 3LA — Fax: 031 668 4368
Scotland UK — Telex: 727343 SEISED G

8 GEOMAGNETISM GROUP STAFF LIST 1991

Edinburgh

Group Manager (Grade 7)	Dr D J Kerridge
PSec	Mrs M Milne
Grade 7	D R Barraclough
SSO	J C Riddick
HSO	Dr T D G Clark T J Harris Dr S Macmillan E M Reader Dr A W P Thomson (started Jun 1991)
SO	J G Carrigan (started May 1991) A Carruthers (started Apr 1991) M D Firth (started Sep 1991) S Flower
ASO	F J Campbell (started Apr 1991) Miss E Clarke
Craftsman	J McDonald
Casual	C B Turbitt (started Sep 1991)

Eskdalemuir

Industrial	C R Pringle
Craftsman	W E Scott
Cleaner	Mrs H Middleton

Hartland

PGS E	K G Johns

Staff changes during 1991

Dr W F Stuart retired as Group Manager at the end of October, and Mr D R Barraclough became acting Group Manager until Dr D J Kerridge was appointed in December.

REFERENCES

Green, C A. 1985. Geomagnetic hourly average and minute values from digital data. *BGS Geomagnetism Research Group Report 85/19.*

Kerridge, D J and Clark, T D G. 1991. The new standard for absolute observations at the UK geomagnetic observatories. *British Geological Survey Technical Report*, WM/91/17.

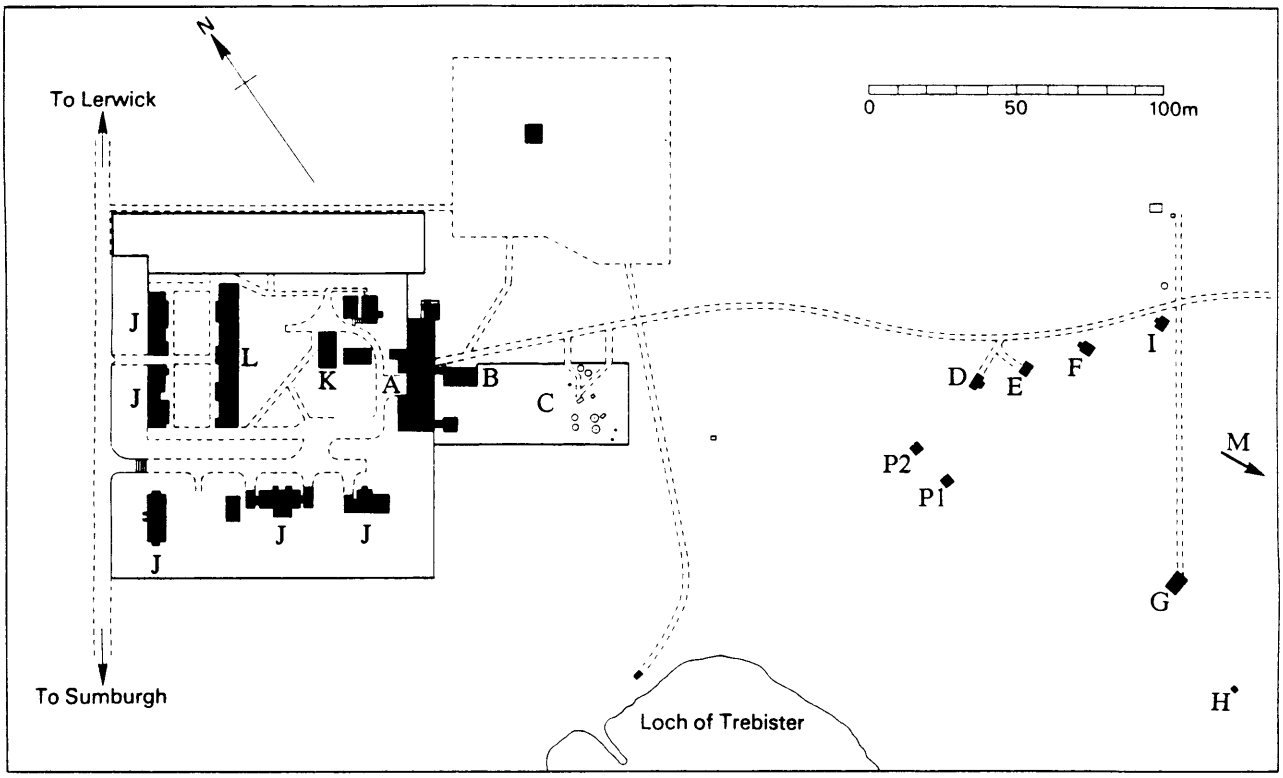
Kerridge, D J and Harris, T J. 1988. GIFS: the Geomagnetism Information and Forecast Service. *British Geological Survey Technical Report*, WM/88/16.

Mayaud, P N. 1980. Derivation, meaning, and use of geomagnetic indices, *American Geophysical Union, Geophysical Monograph 22*, Washington DC: American Geophysical Union, 154pp.

Riddick, J R, Greenwood, A C, and Stuart, W F. 1990. The automatic geomagnetic observatory system (ARGOS) operated in the UK by the British Geological Survey. *Physics of the Earth and Planetary Interiors*, **59**, 29-44.

Robinson, P R. 1982. Geomagnetic observatories in the British Isles. *Vistas in Astronomy*, **26**, 347-367.

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

J Staff houses

K Standby generator

L Staff hostel

M To position of GOES-East satellite transmitter

P1 ARGOS Proton magnetometer 1

P2 ARGOS Proton magnetometer 2

Instrument Deployment

Absolute Hut
PVM (used for H/Z/F measurements)
D/I Fluxgate Theodolite

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

Instrument Hut
PVM electronics
ARGOS electronics
ARGOS uninterruptible power supply (UPS)

Variometer House
ARGOS fluxgate sensors (X,Y,Z)
Back-up fluxgate sensors (H,D,Z)

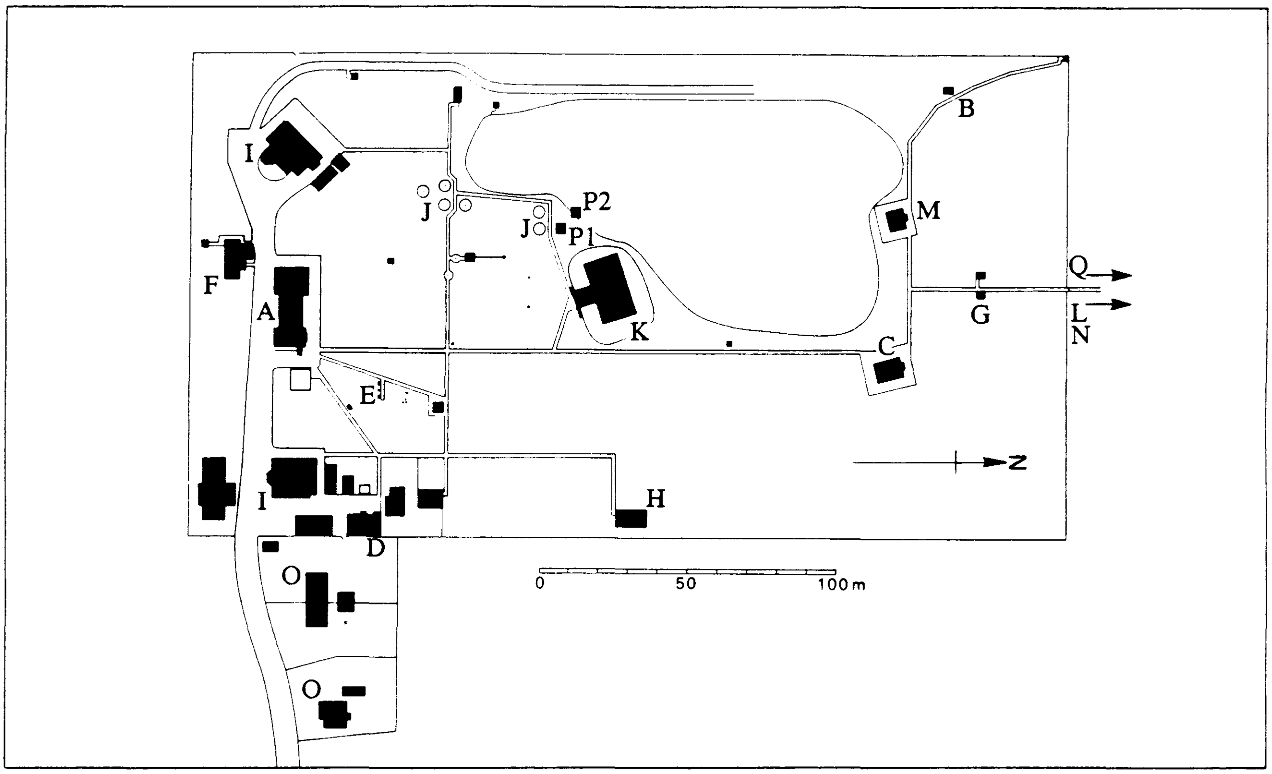
The Variometer House is constructed from non-magnetic concrete and has internal dimensions of 4.9 by 3 metres. The roof is semi-circular in cross section. The temperature of the house is controlled to a diurnal range of ±1°C. The meridian at the time of construction is defined on the north and south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

Previous descriptions

Harper W.G. 1950. Lerwick Observatory. *Meteorological Magazine. Vol.79. 309-314.*
Tyldesley, J.B. 1971. Fifty years of Lerwick Observatory. *Meteorological Magazine. Vol.100. 173-179.*

Figure 1. 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, instrument room containing data loggers

L Seismic vault, 280 metres from boundary wall

M West Absolute Hut

N Chemical sampling by Warren Spring Laboratory, 75 metres from boundary wall

O Private houses, formerly housing observatory staff

P1 ARGOS Proton magnetometer 1

P1 ARGOS Proton magnetometer 2

Q GOES-East satellite transmitter, 300 metres from boundary wall

Instrument Deployment

Hut G contains the PVM electronics, the digital clock and the printer used to record values during absolute observations.

East Absolute Hut
PVM (used for H/Z/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 of the hut.

Underground Variometer Chamber
ARGOS fluxgate sensors (X,Y,Z)
Back-up sensors (H,D,Z)

The variometer chamber comprises two separate rooms inside a domed chamber covered with a thick layer of earth to form a mound. The instruments and the greater part of the rooms are thus below the level of the surrounding ground. The temperature of the chamber is controlled to a diurnal range of ±0.5°C. The instrument room has been created by extending the former porch back into the stairwell and entrance, leaving a compartment under the floor for standby batteries. The entrance to the room is protected by an external porch.

West Absolute Hut
The hut contains three instrument piers. The fixed mark is viewed through a shutter in the south wall of the hut.

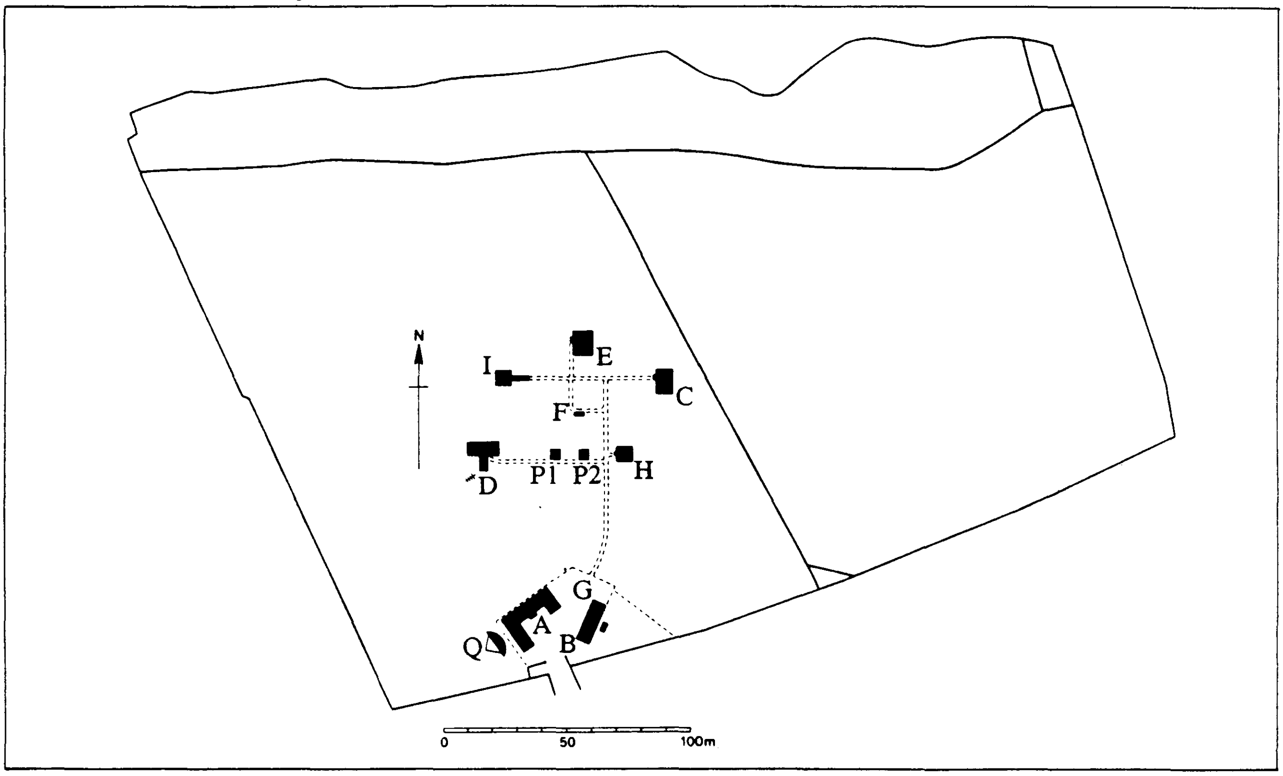
Non-Magnetic Laboratory
The laboratory is used for instrument development and testing. It contains two rooms, a sensor room with three piers and a larger instrument room with a single pier.

Previous descriptions

Blackwell, M.J 1958. Eskdalemuir Observatory - the first 50 years. *Meteorological Magazine, London Vol. 87, 129.*
Crichton, J. 1950. Eskdalemuir Observatory. *Meteorological Magazine, London, Vol.79, 337.*

Figure 2. Eskdalemuir observatory site diagram

Hartland Observatory



Observatory Layout

A Main observatory building,

B Caretakers house

C Absolute Hut

D Non-Magnetic laboratory, GOES-East satellite transmitter

E Variometer House

F Instrument Hut

G Garage

H Test 2 Hut

I Test 1 Hut

P1 ARGOS Proton magnetometer 1

P2 ARGOS Proton magnetometer 2

Q GOES-E Satellite receiver

Instrument Deployment

Absolute Hut
PVM (used for H/Z/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 of the hut.

Non-Magnetic Laboratory
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. At present, a 3-component fluxgate (H,D,Z) is in operation. This is connected to a data collection platform transmitting data to the GOES-East satellite.

Variometer House
ARGOS fluxgate sensors (X,Y,Z)
Back-up sensors (H,D,Z)

The Variometer House comprises an entrance porch and a main room, which contains two separate internal rooms, each divided into three compartments. The temperature of the house is controlled to a diurnal range of ±0.5°C. Two cable ducts connect the Variometer House to the Instrument Hut.

Instrument Hut
PVM electronics
ARGOS electronics
Standby batteries and ARGOS uninterruptible power supply (UPS)

Test Hut 1
The hut contains an orthogonal coil system and its power supplies. The inner coil, a vertical-axis square coil, was previously used for BMZ calibration. Two additional 2 metre square coils, for creating horizontal fields parallel and normal to the meridian, were added in 1983 to create a near zero field facility for investigating the magnetic signature of the AMPTE satellite.

Test Hut 2
Auxilliary measurement position

The fixed mark (azimuth 12° 52'33" E of N) is viewed through a window in the north wall.

Previous descriptions

Finch, H.F. 1960. Geomagnetic measurement. *Journal of the Royal Naval Scientific Service. Vol.15, No.1, 26-31*

Figure 3. Hartland observatory site diagram

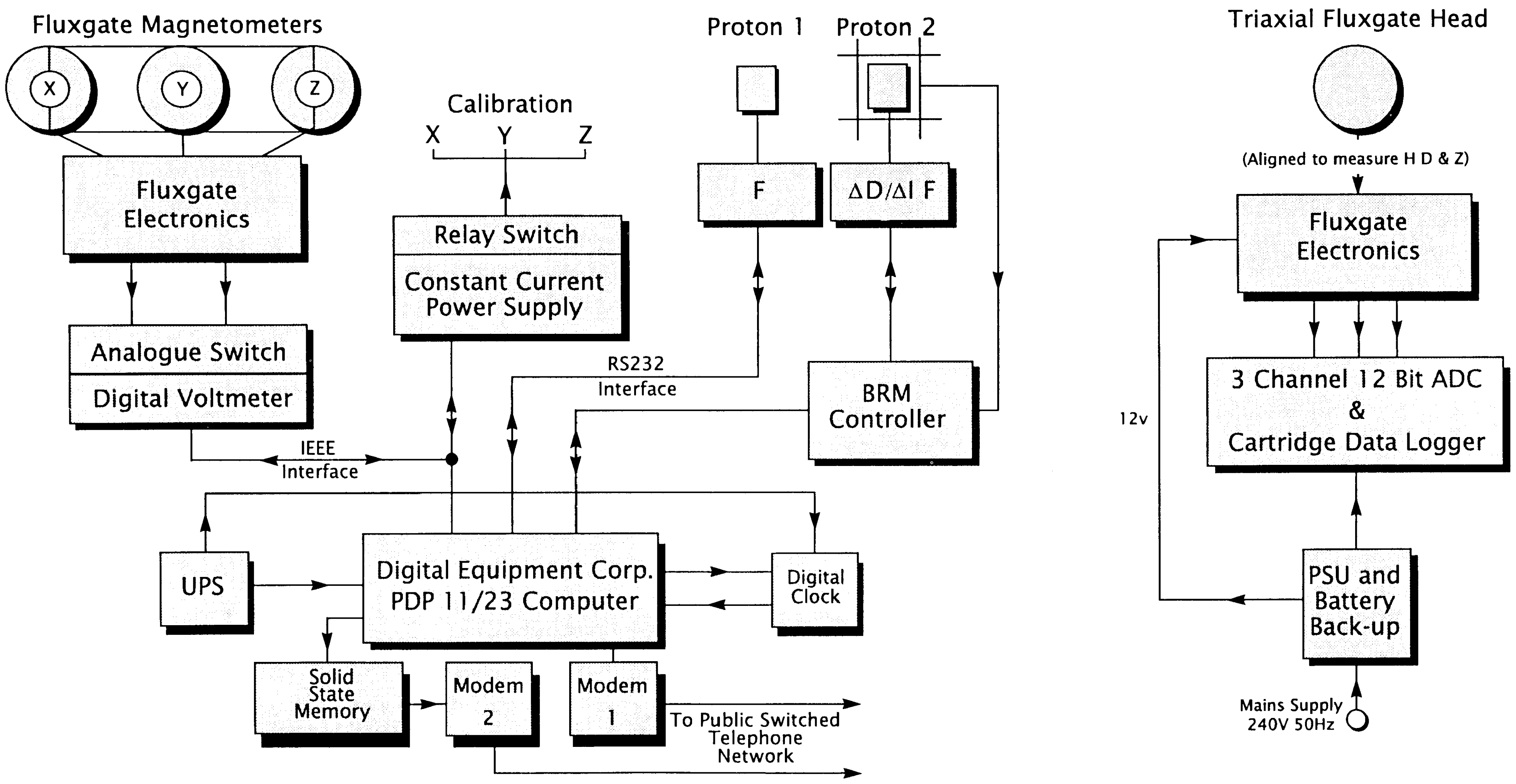
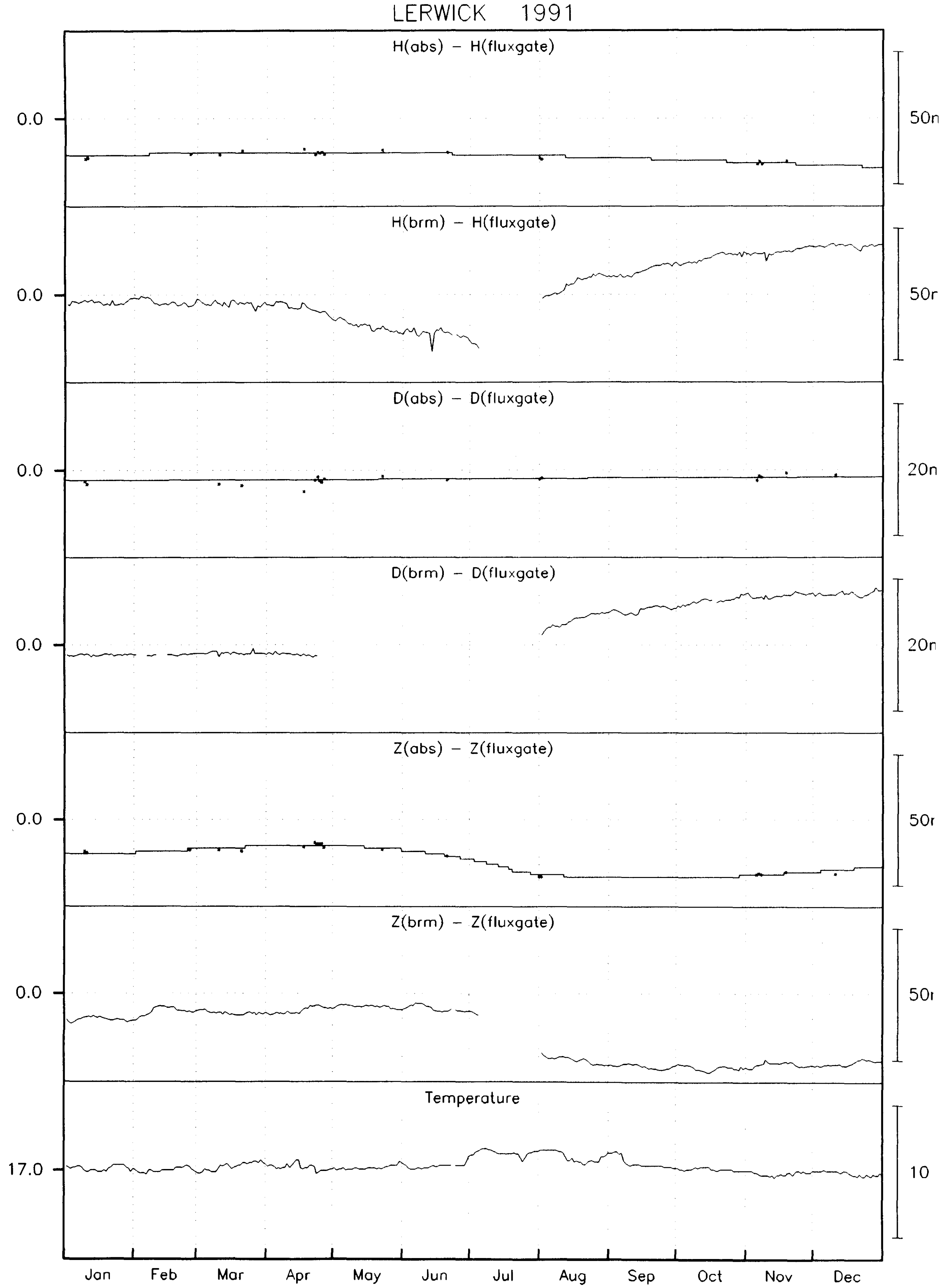


Figure 4. Block diagram of ARGOS and backup system



LERWICK 1991
H(abs) – H(fluxgate)
0.0
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H(brm) – H(fluxgate)
0.0
50r
D(abs) – D(fluxgate)
0.0
20n
D(brm) – D(fluxgate)
0.0
20n
Z(abs) – Z(fluxgate)
0.0
50r
Z(brm) – Z(fluxgate)
0.0
50r
Temperature
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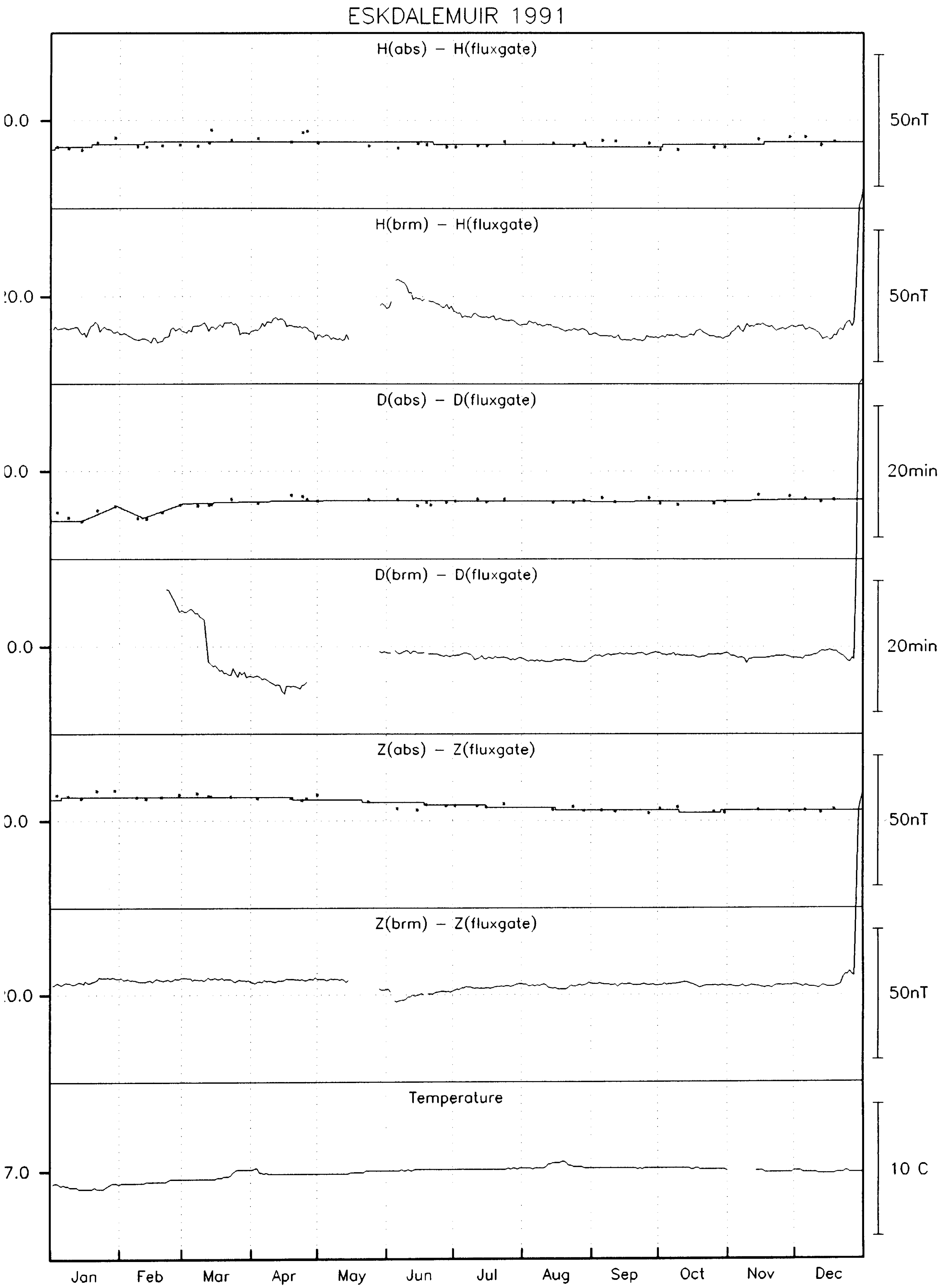
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Figure 5.


ESKDALEMUIR 1991
H(abs) – H(fluxgate)
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H(brm) – H(fluxgate)
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D(abs) – D(fluxgate)
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20min
D(brm) – D(fluxgate)
0.0
20min
Z(abs) – Z(fluxgate)
0.0
50nT
Z(brm) – Z(fluxgate)
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Figure 6.

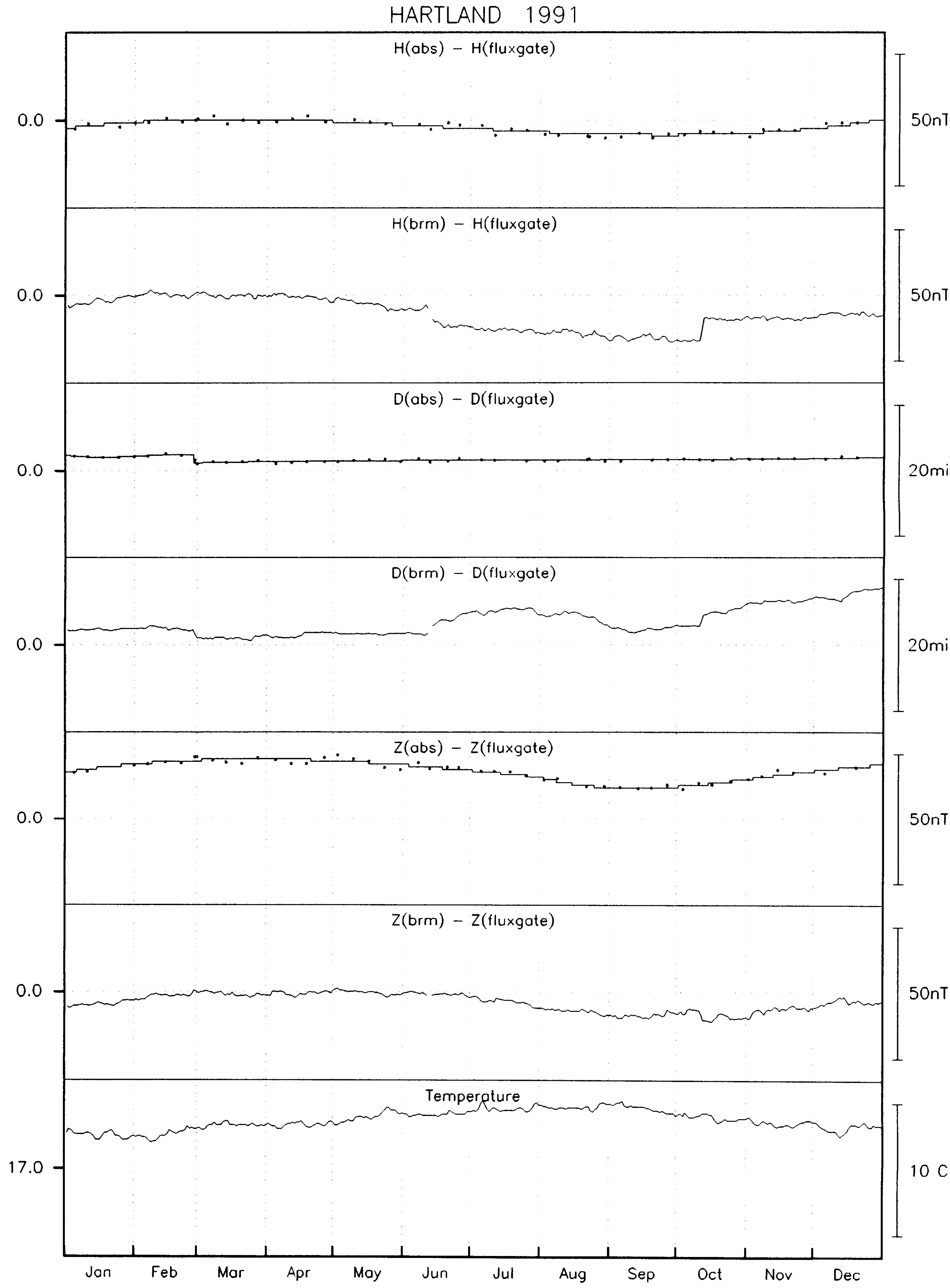
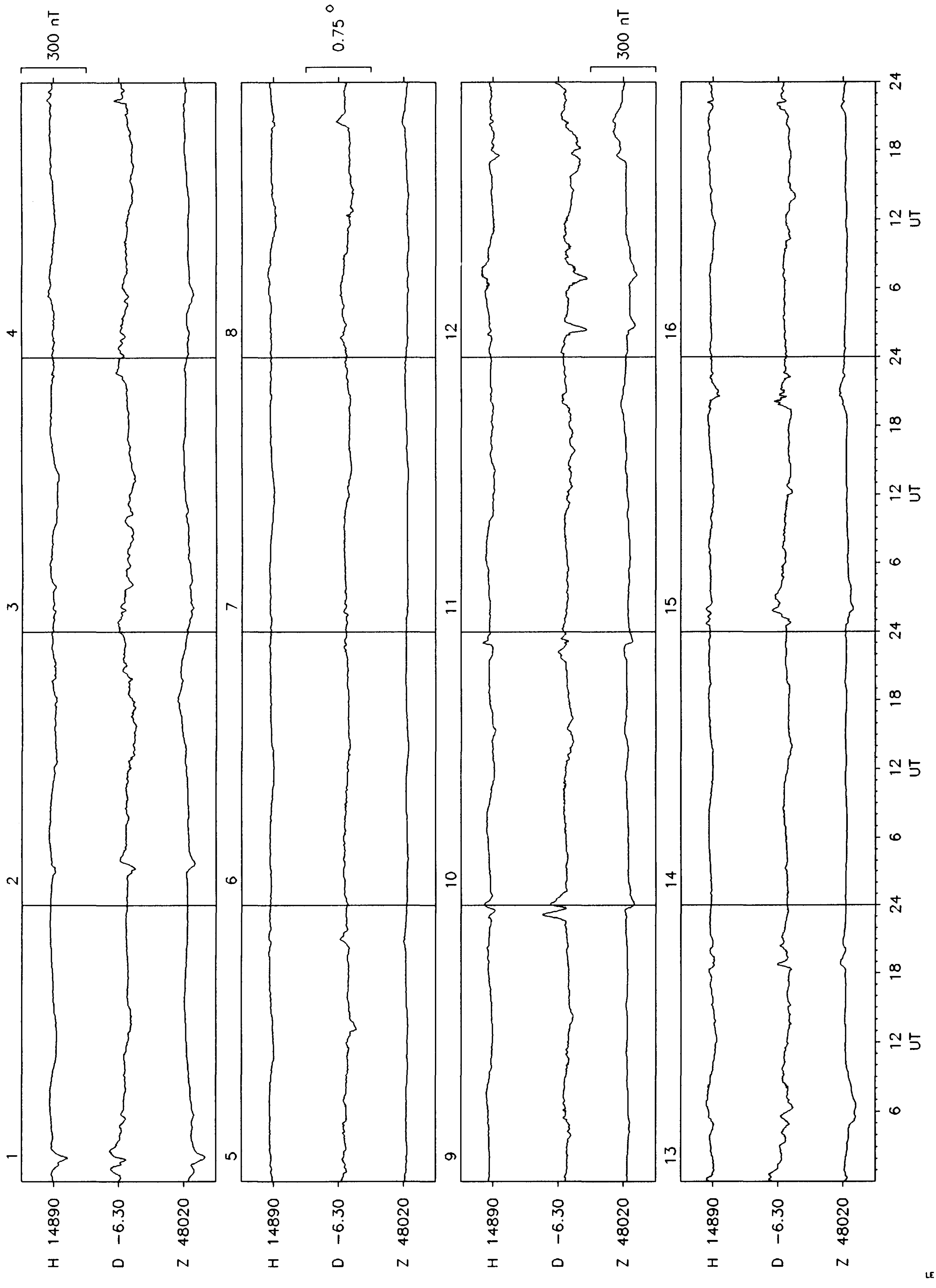


Figure 7. Zero-field corrections and BRMs, Hartland 1991

Lerwick 1991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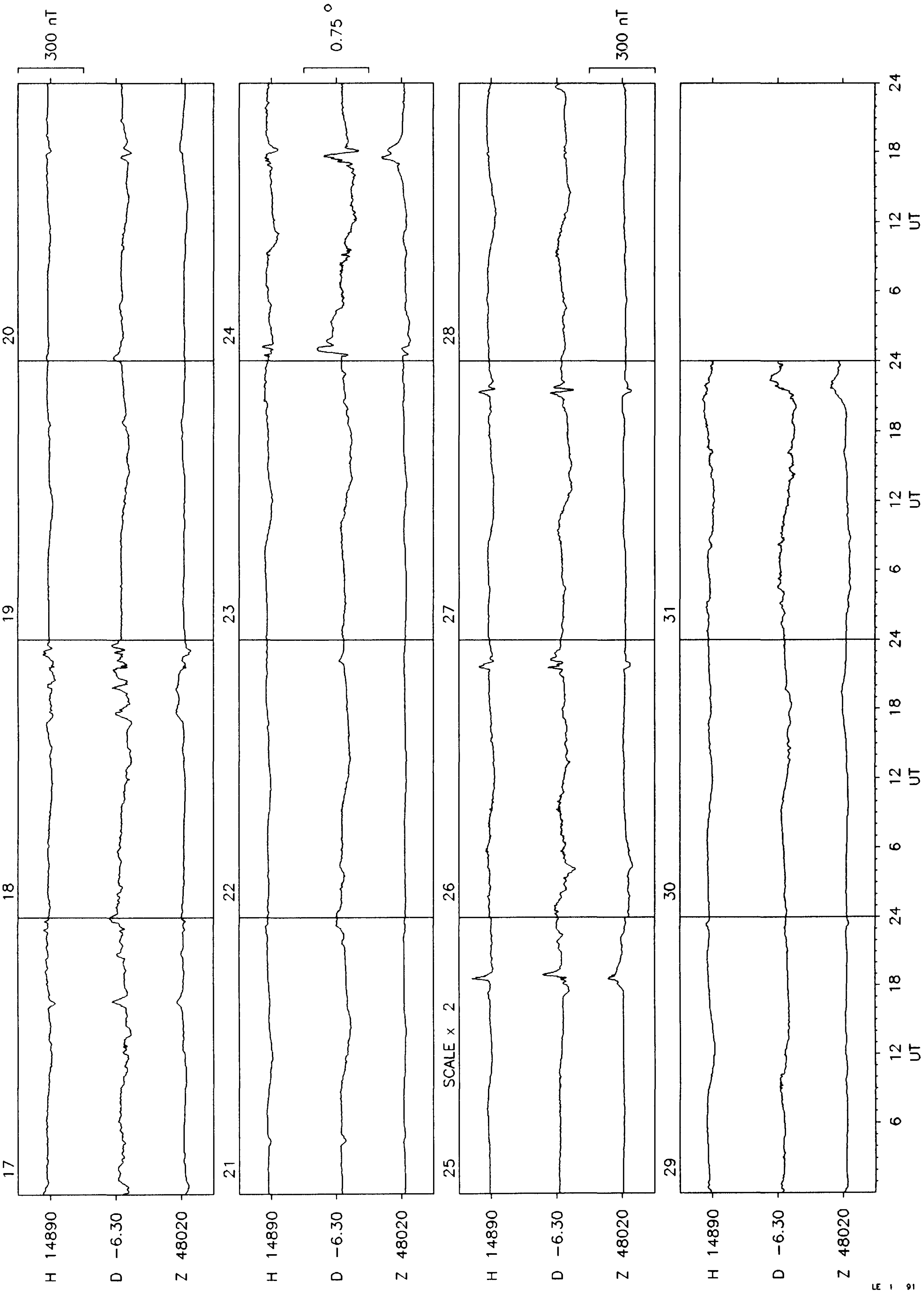

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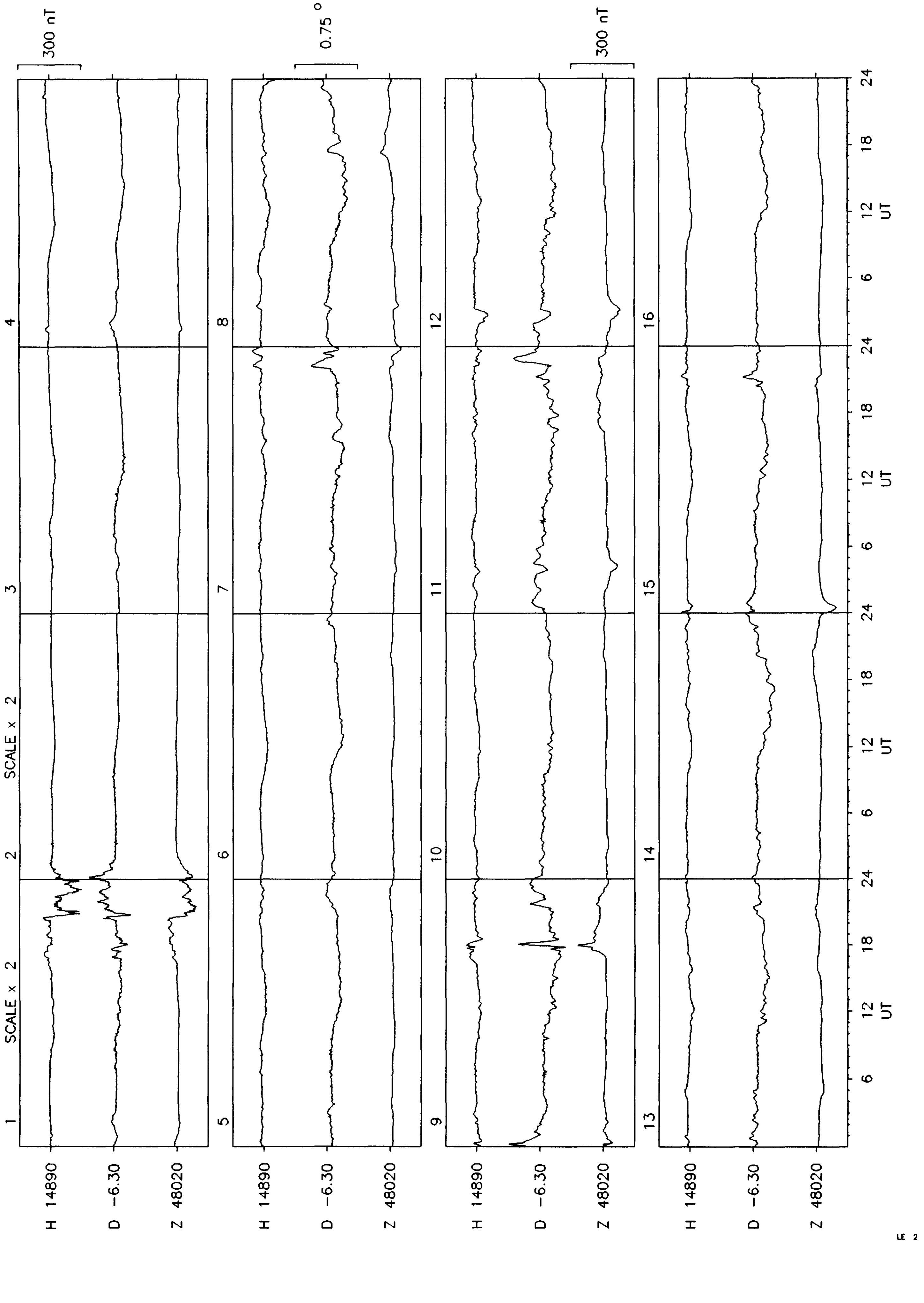

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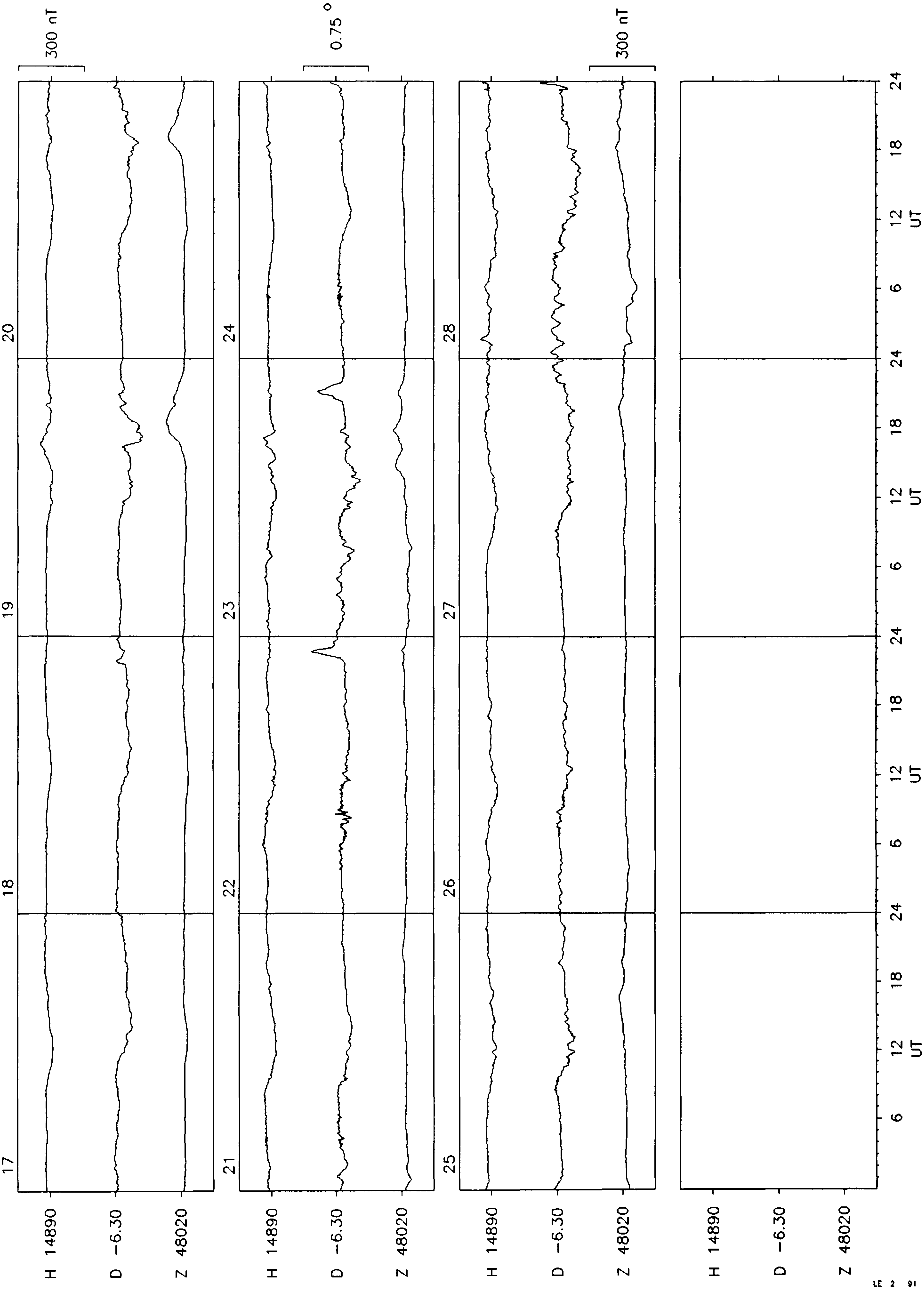
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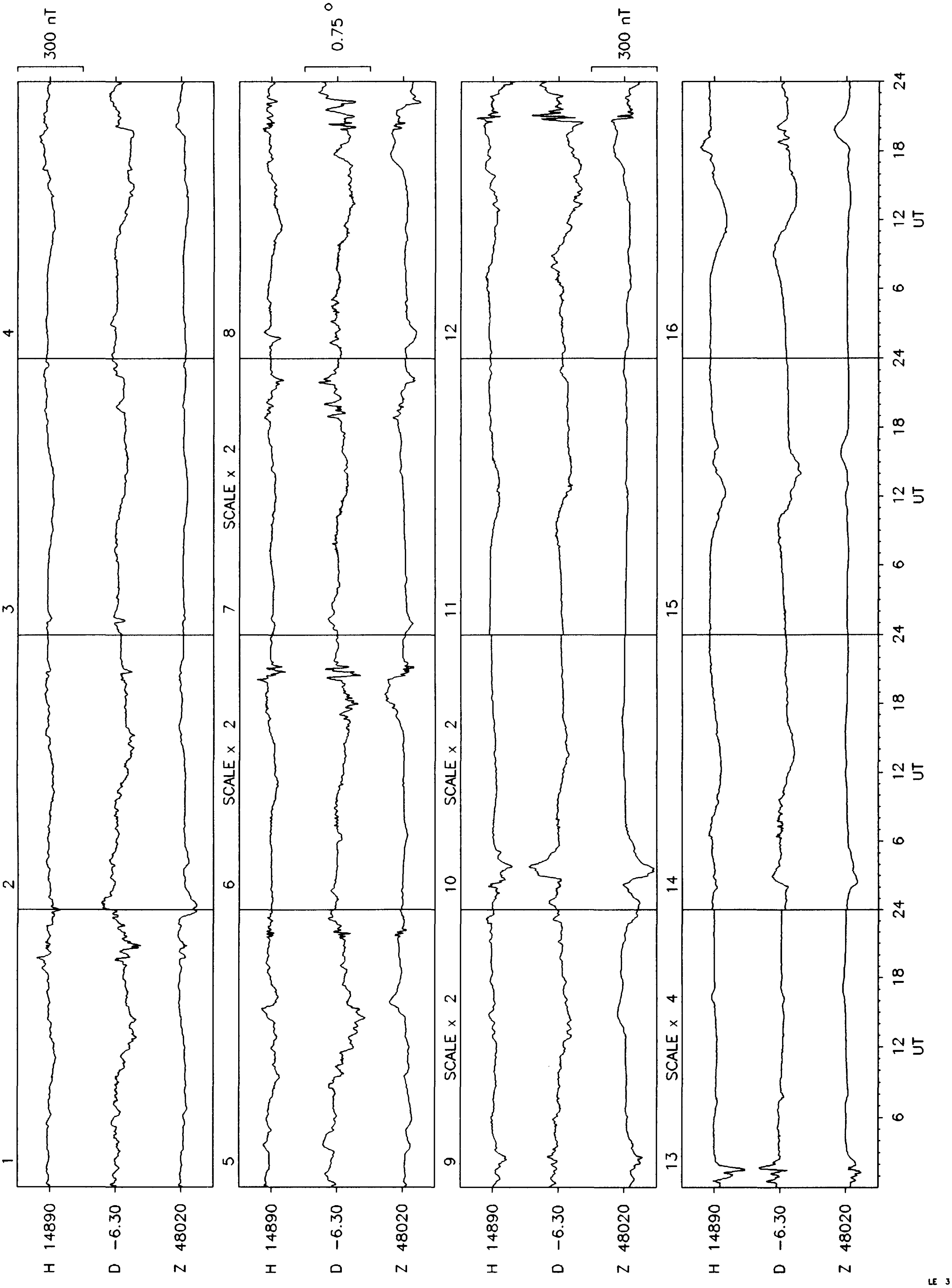
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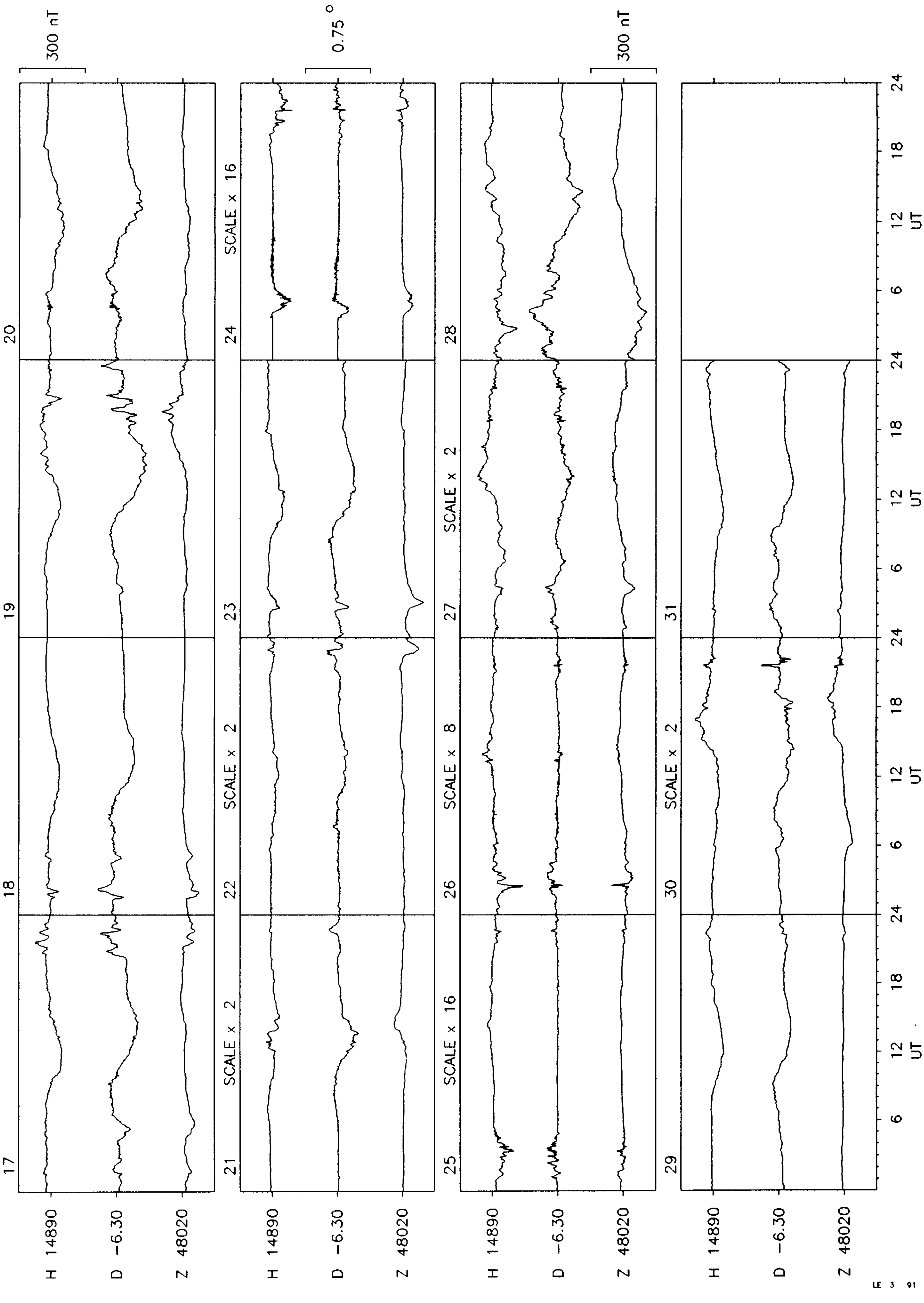
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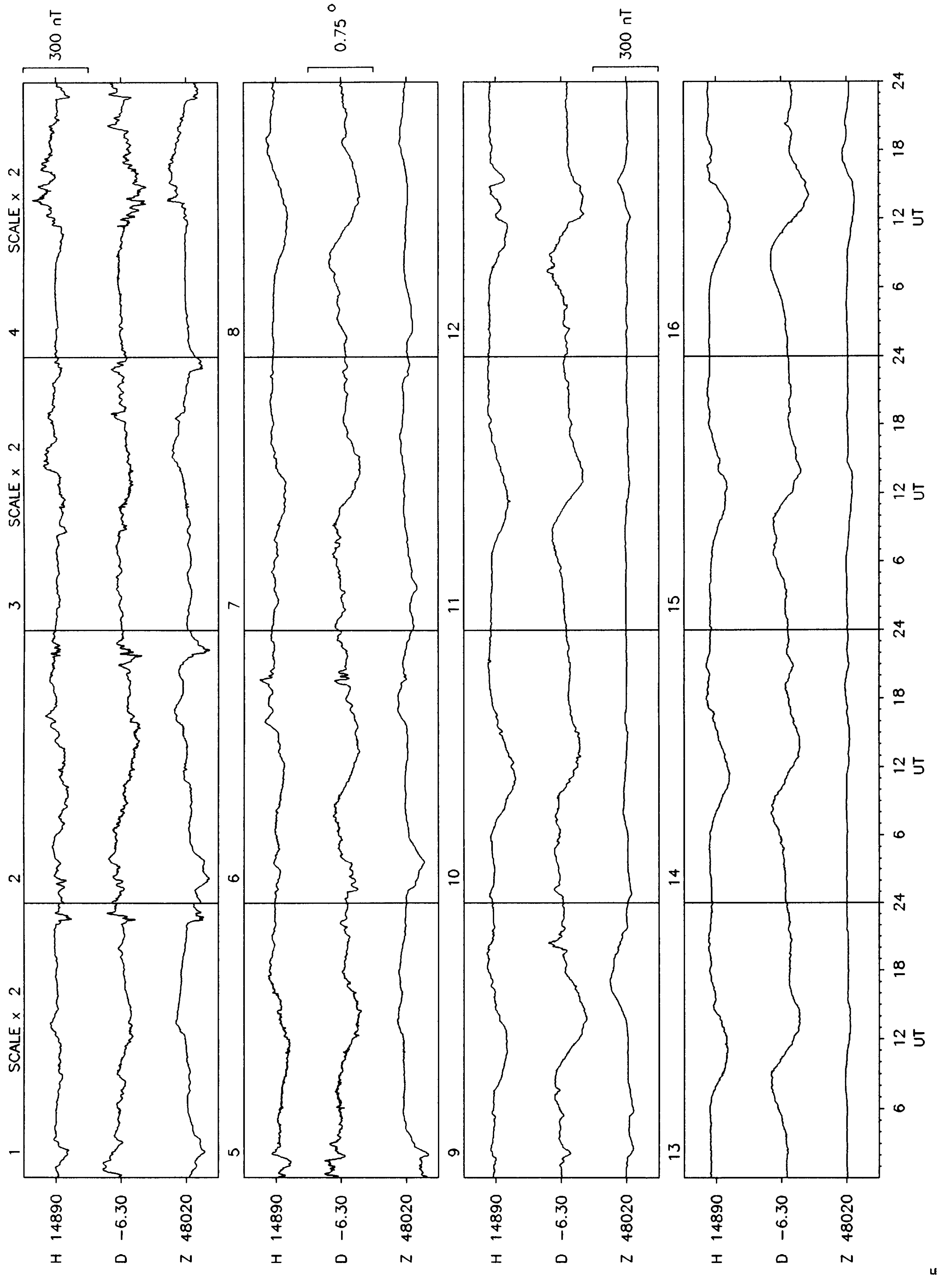
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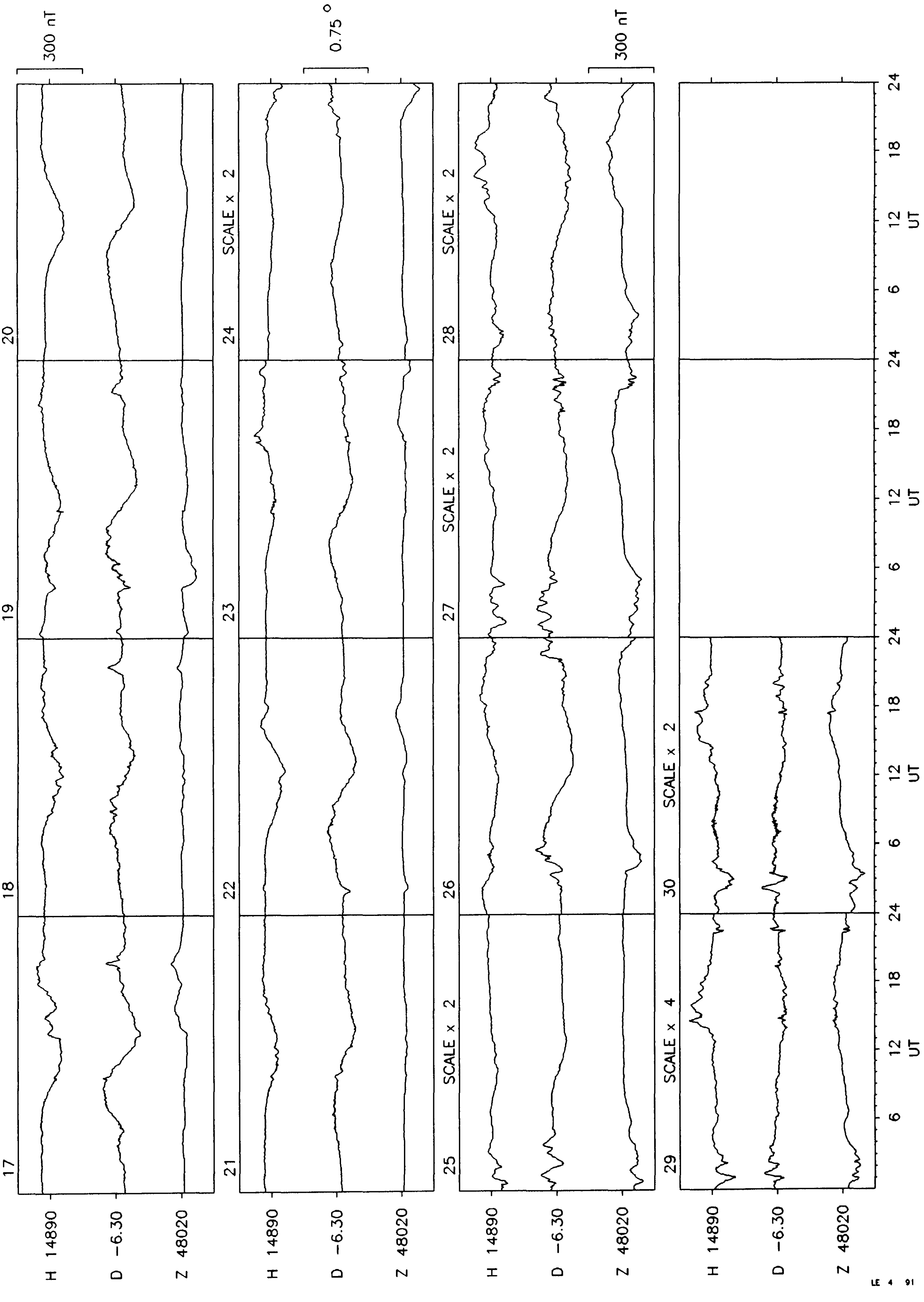
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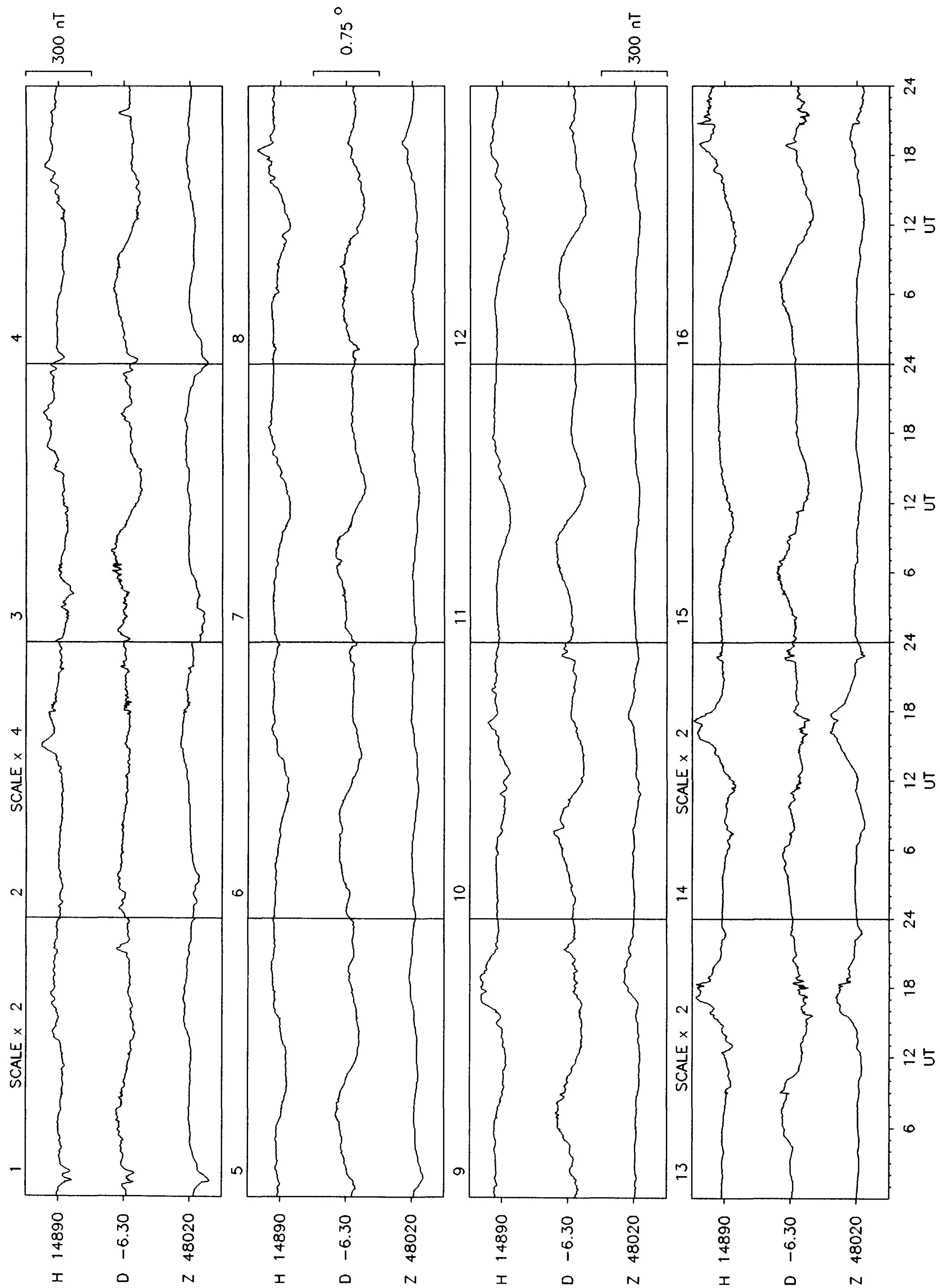
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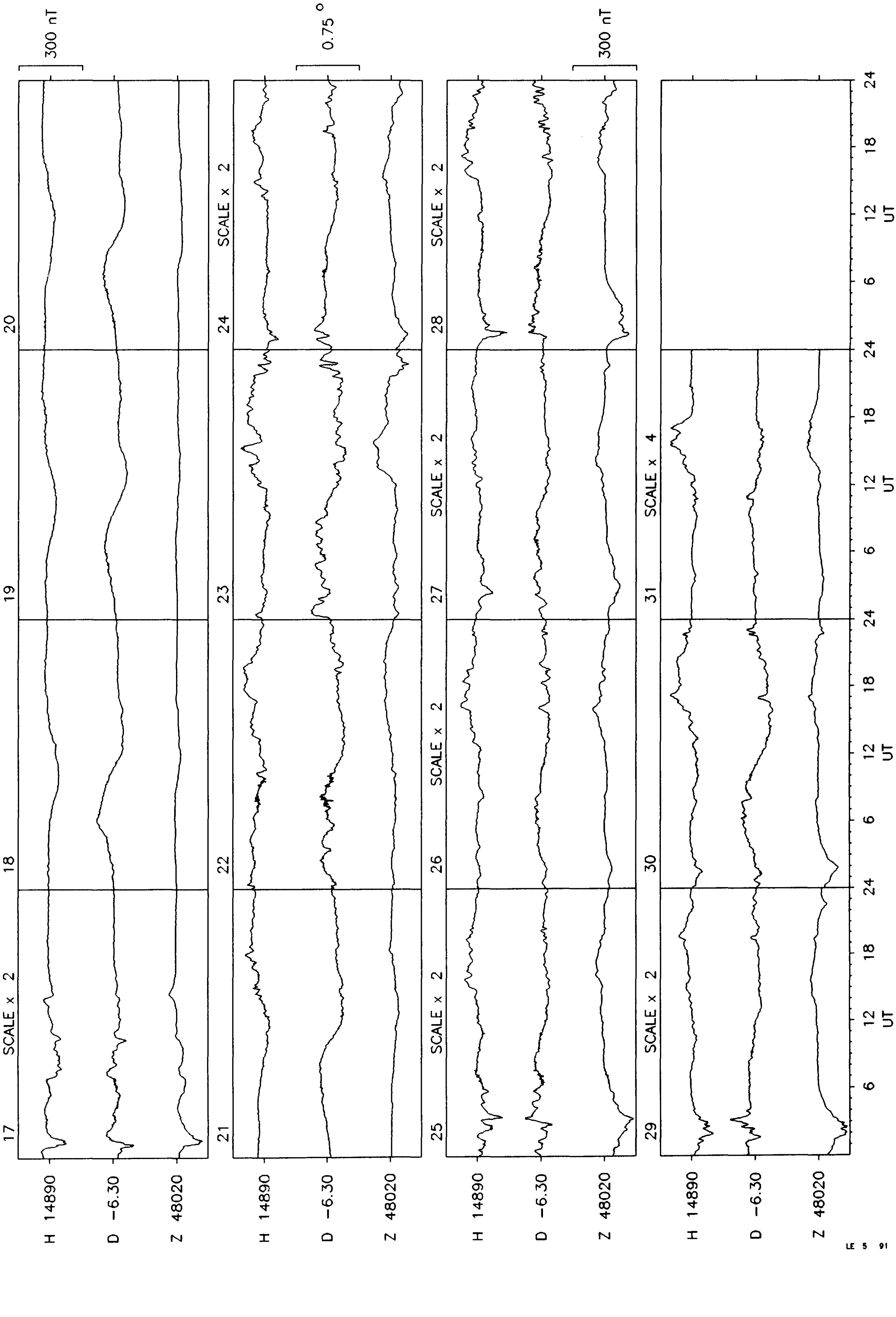
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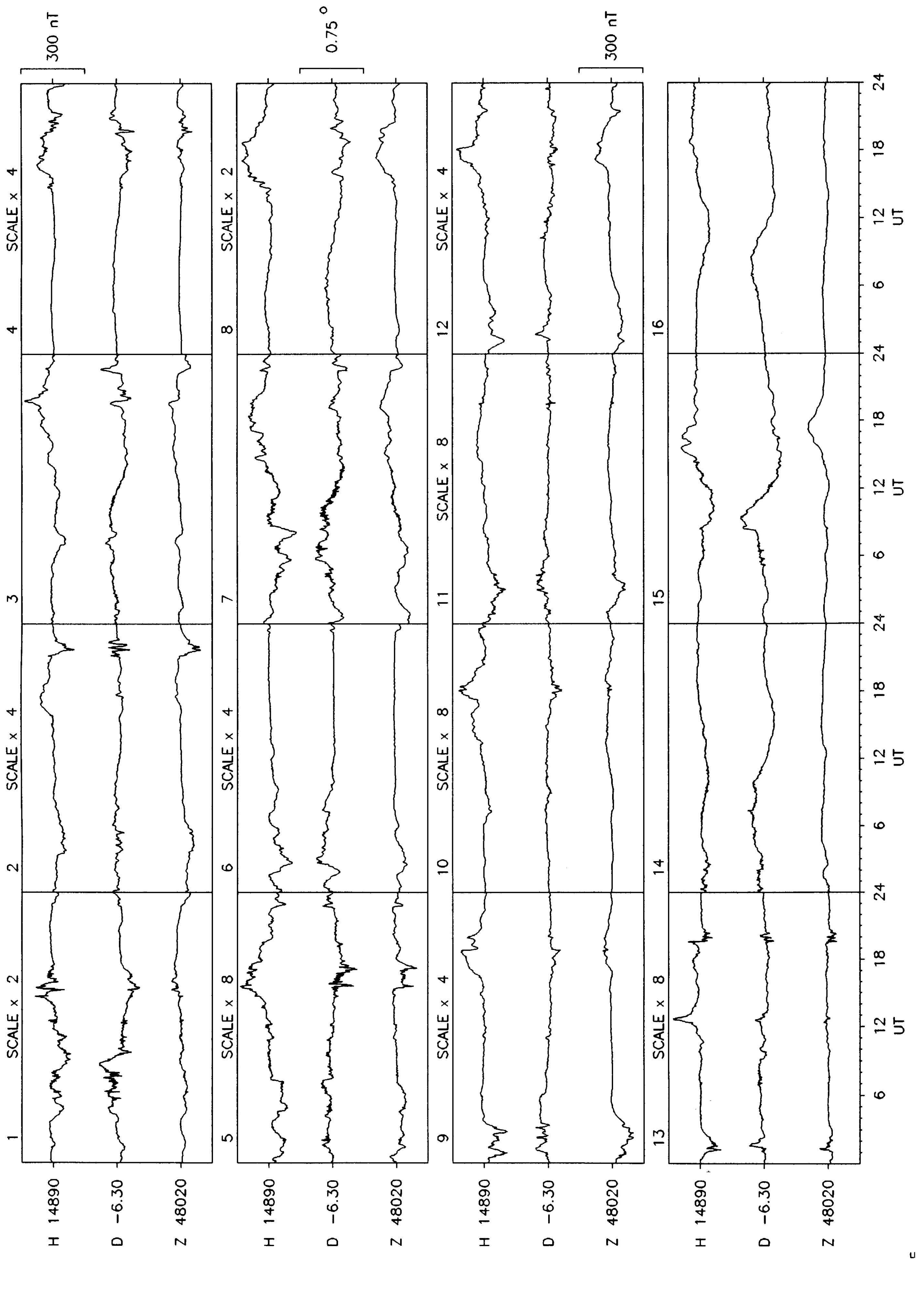
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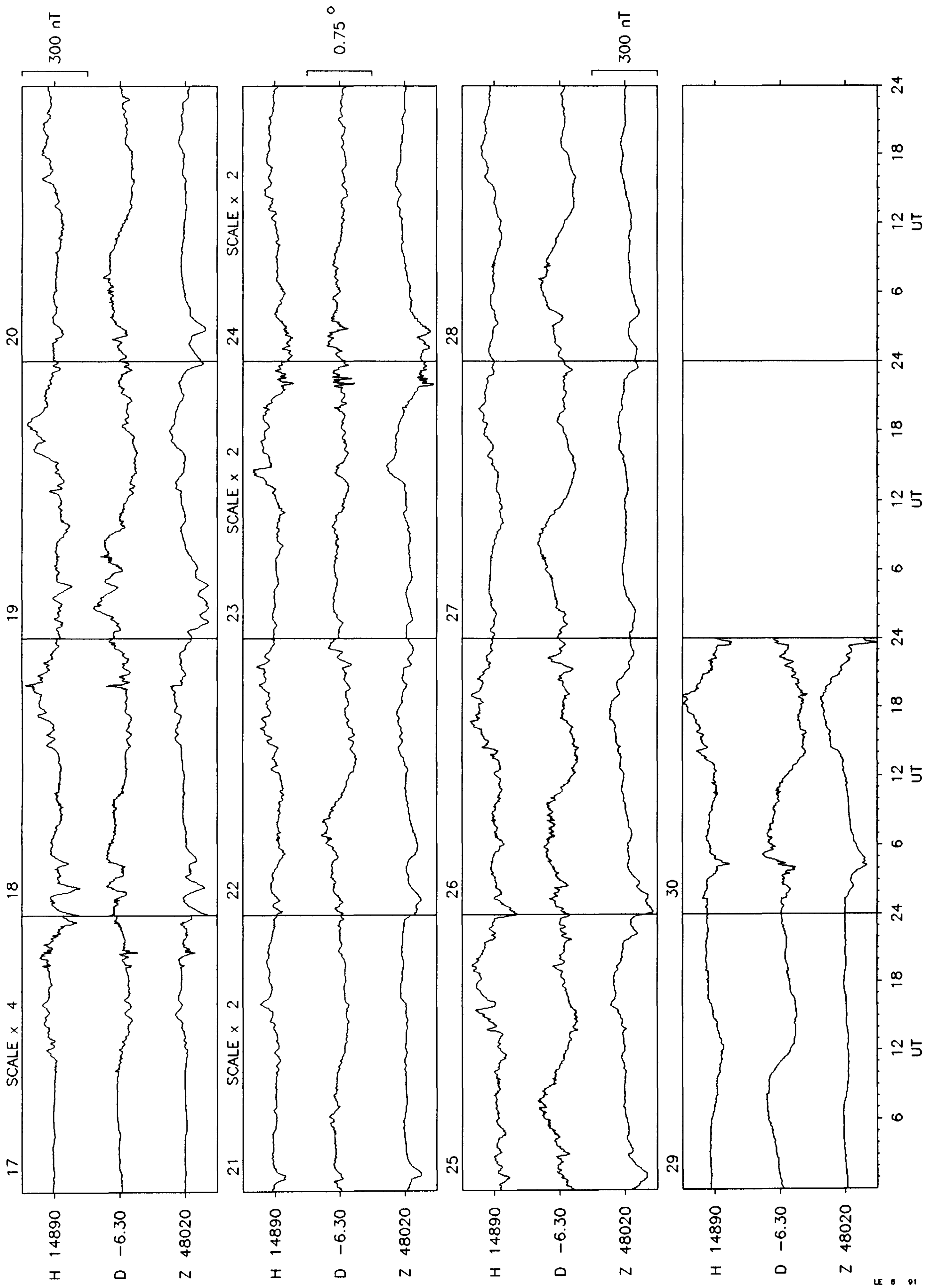

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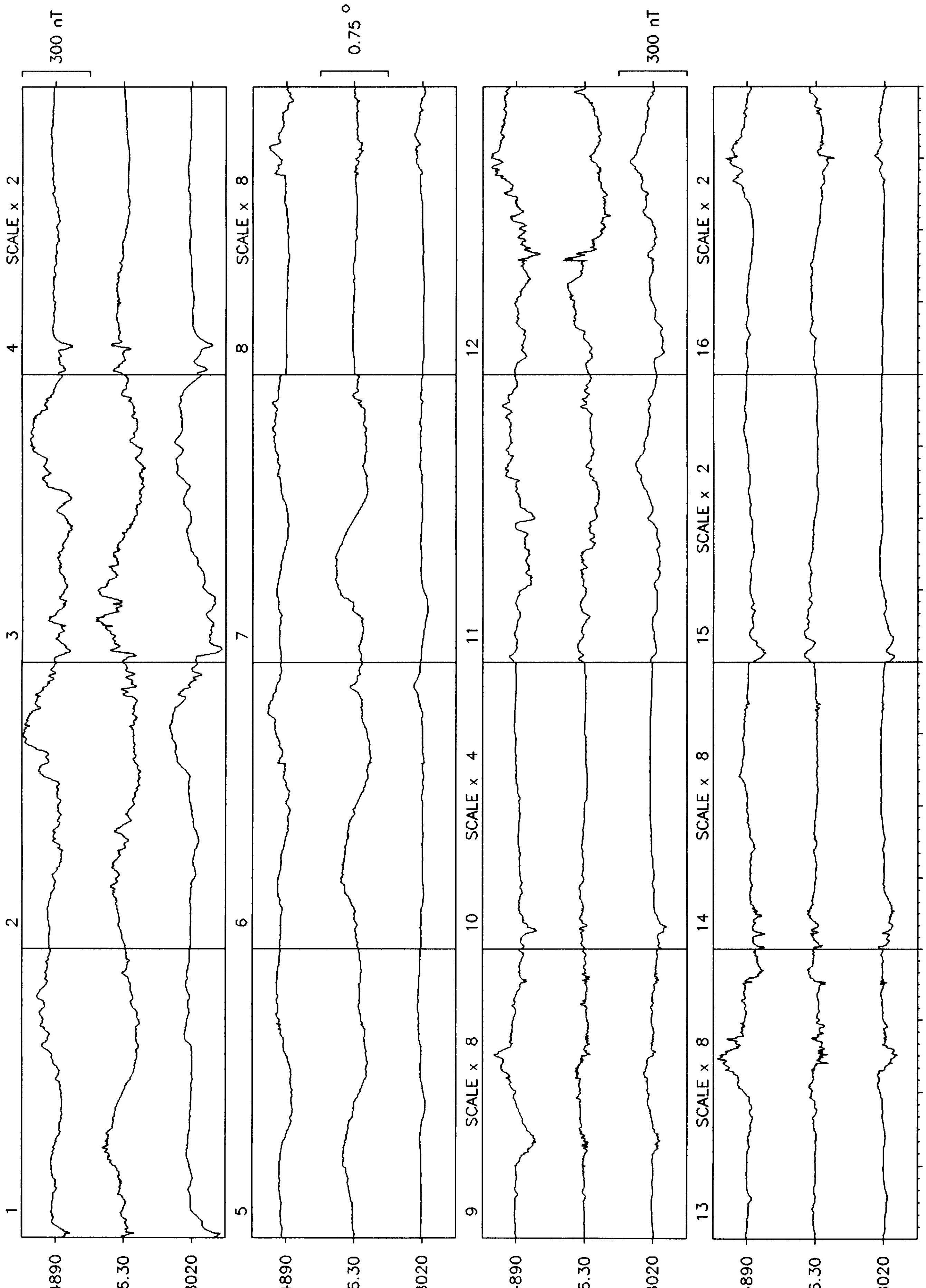
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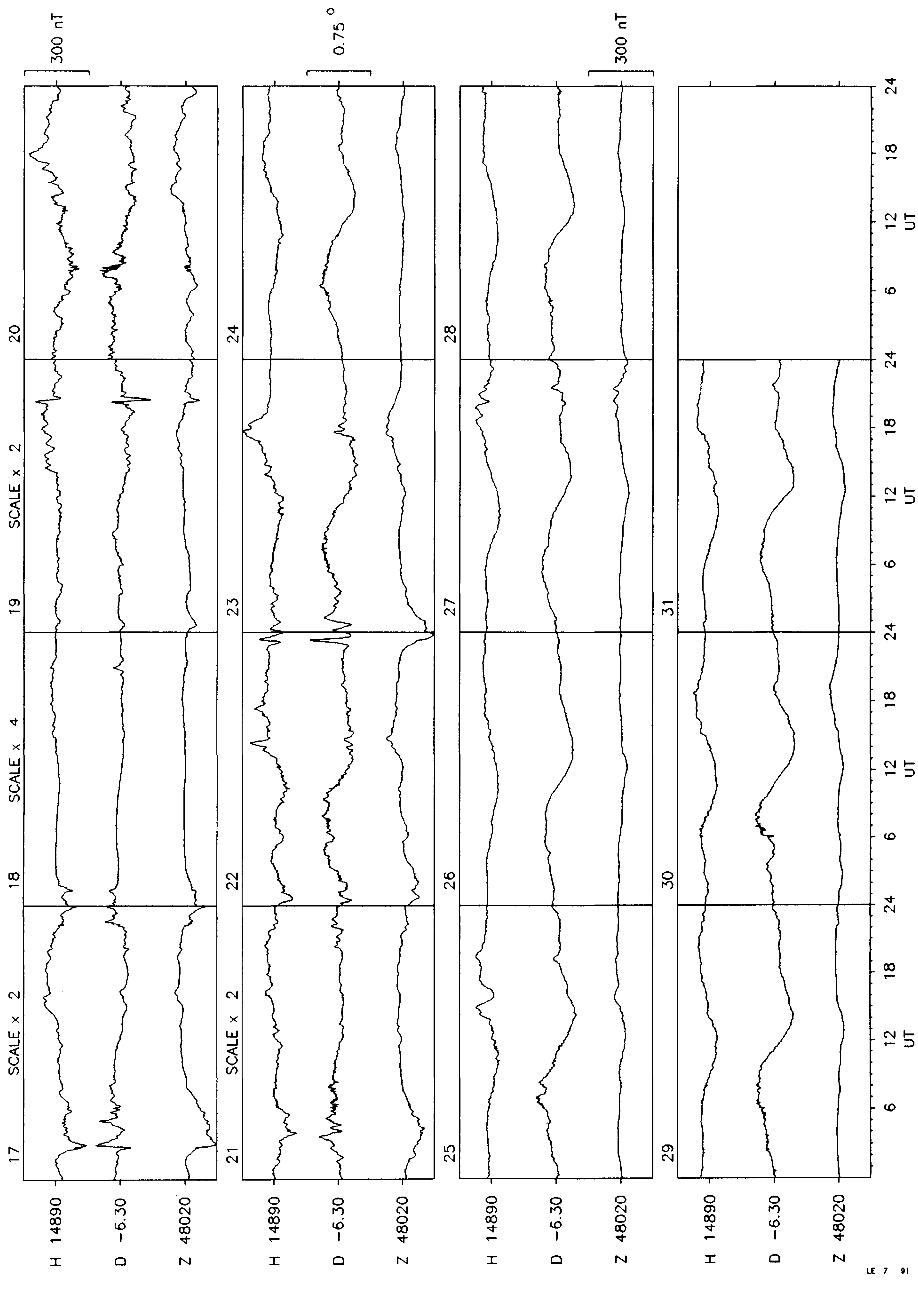
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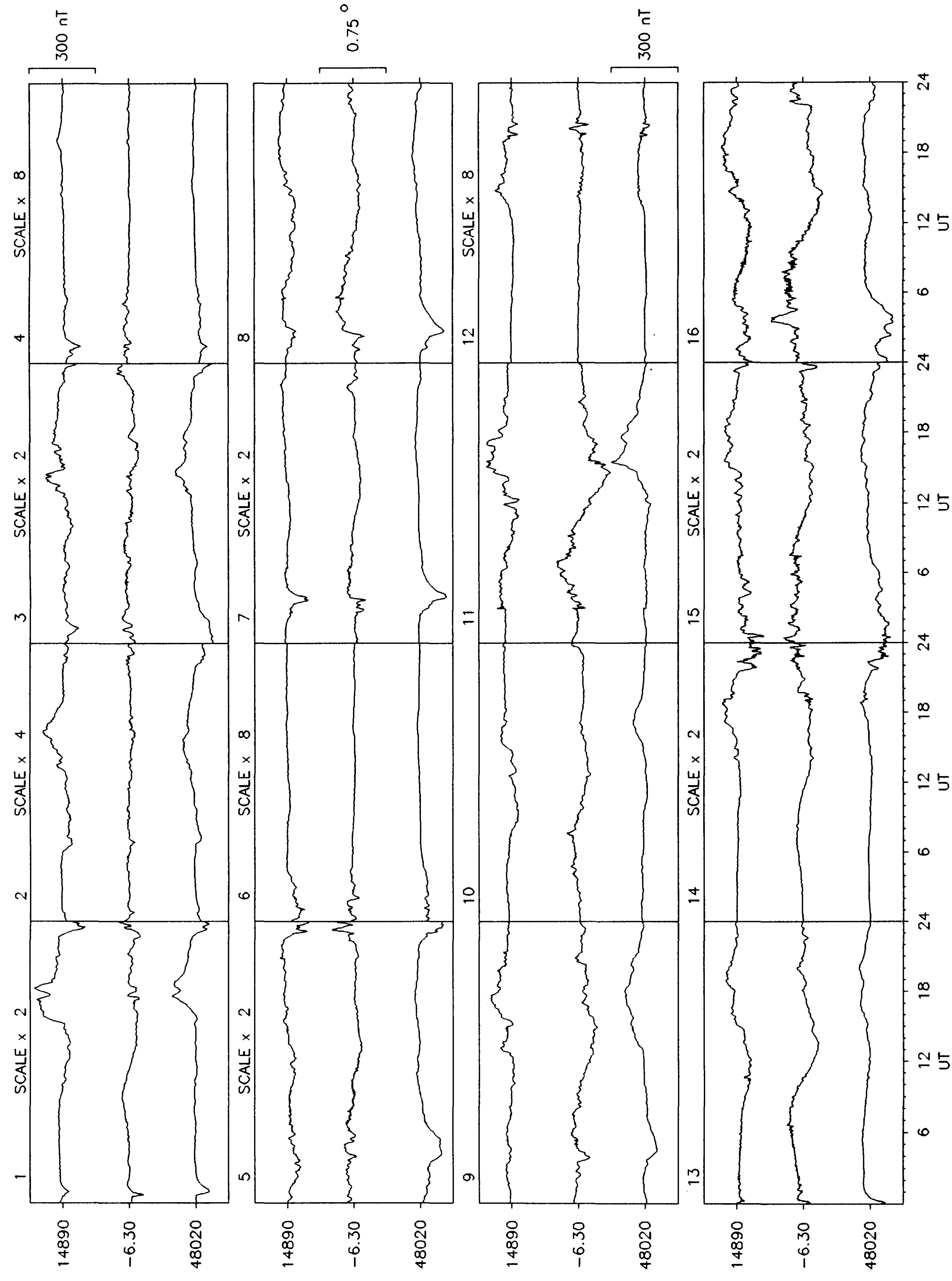
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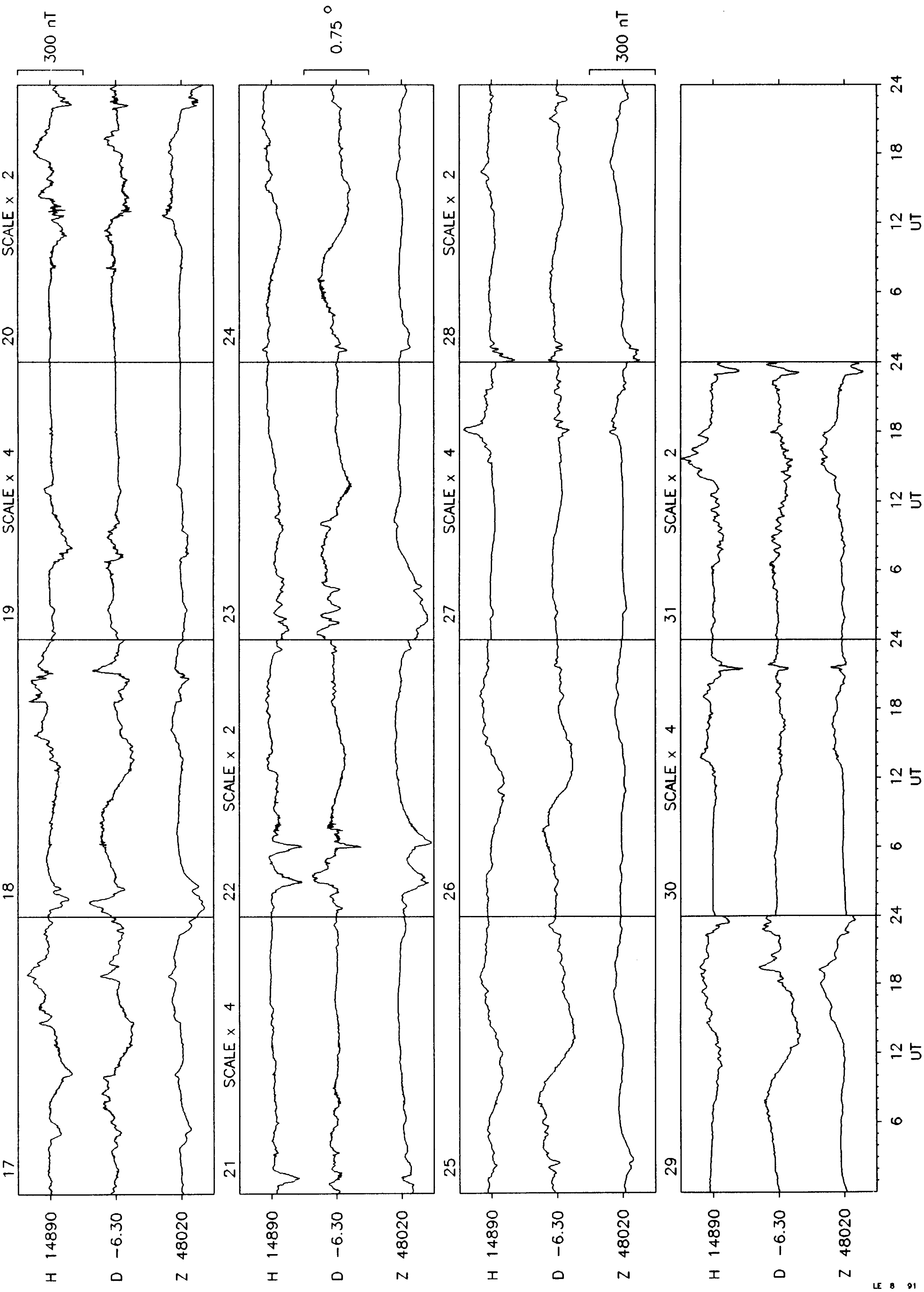
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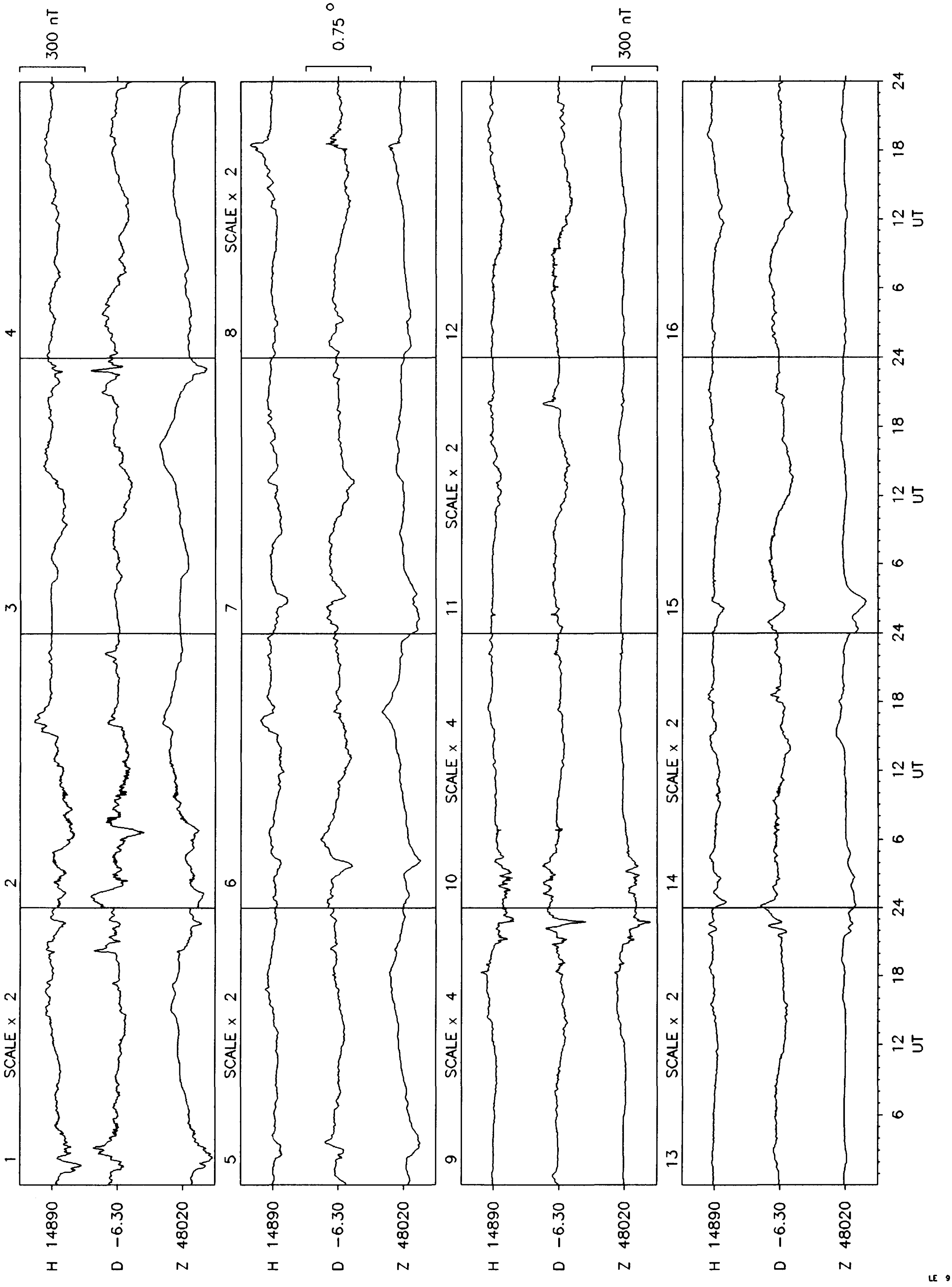
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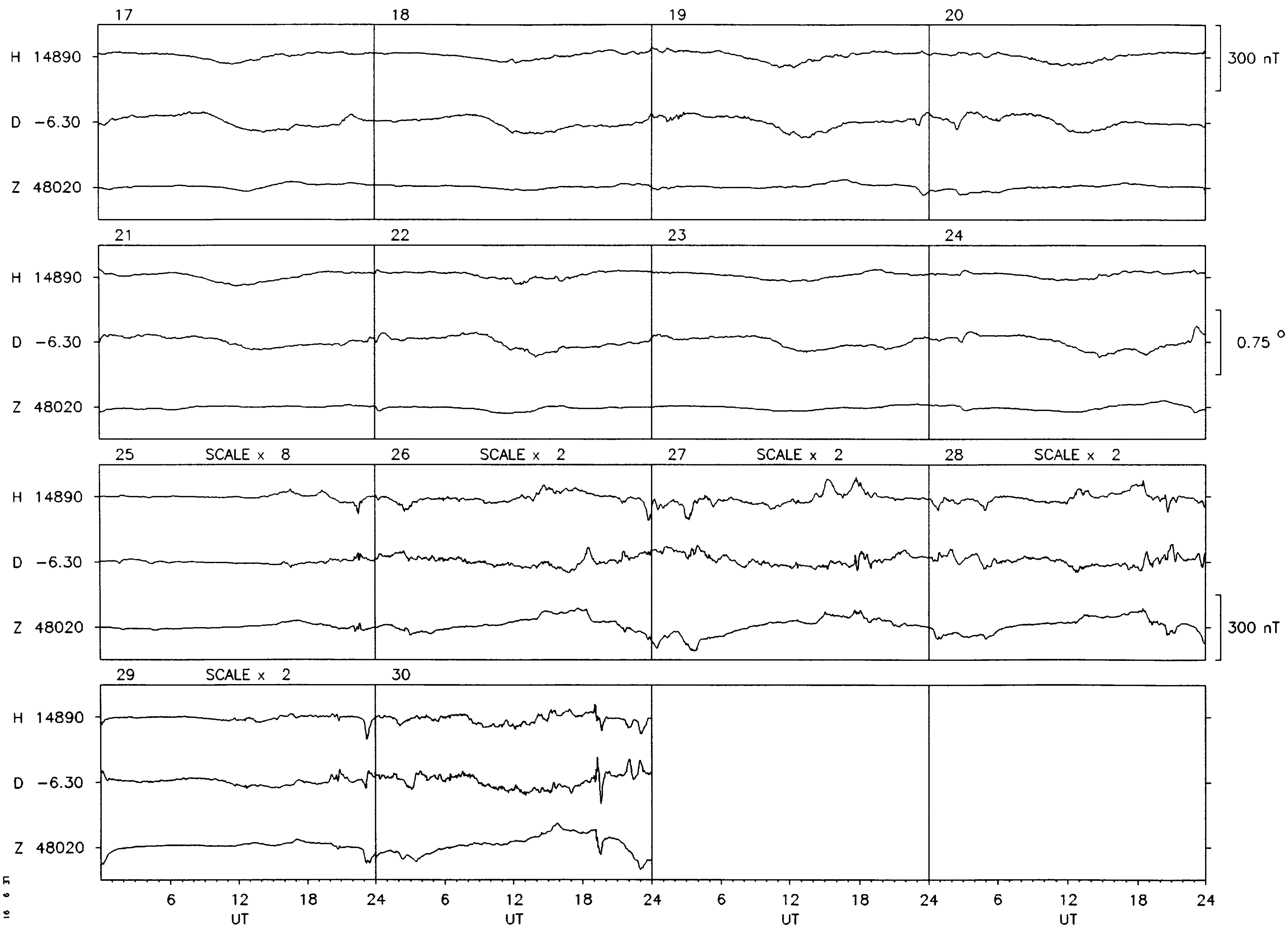

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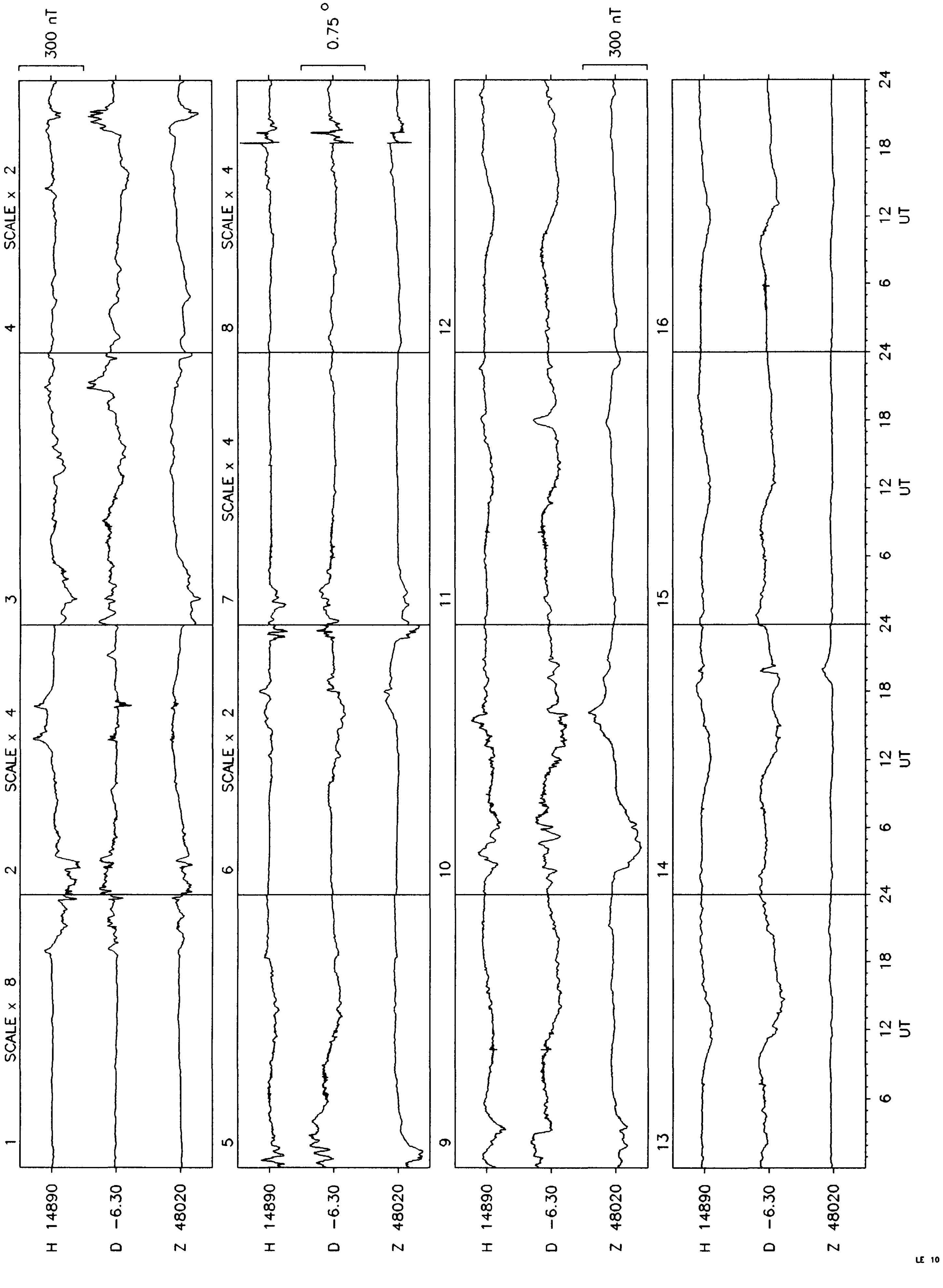
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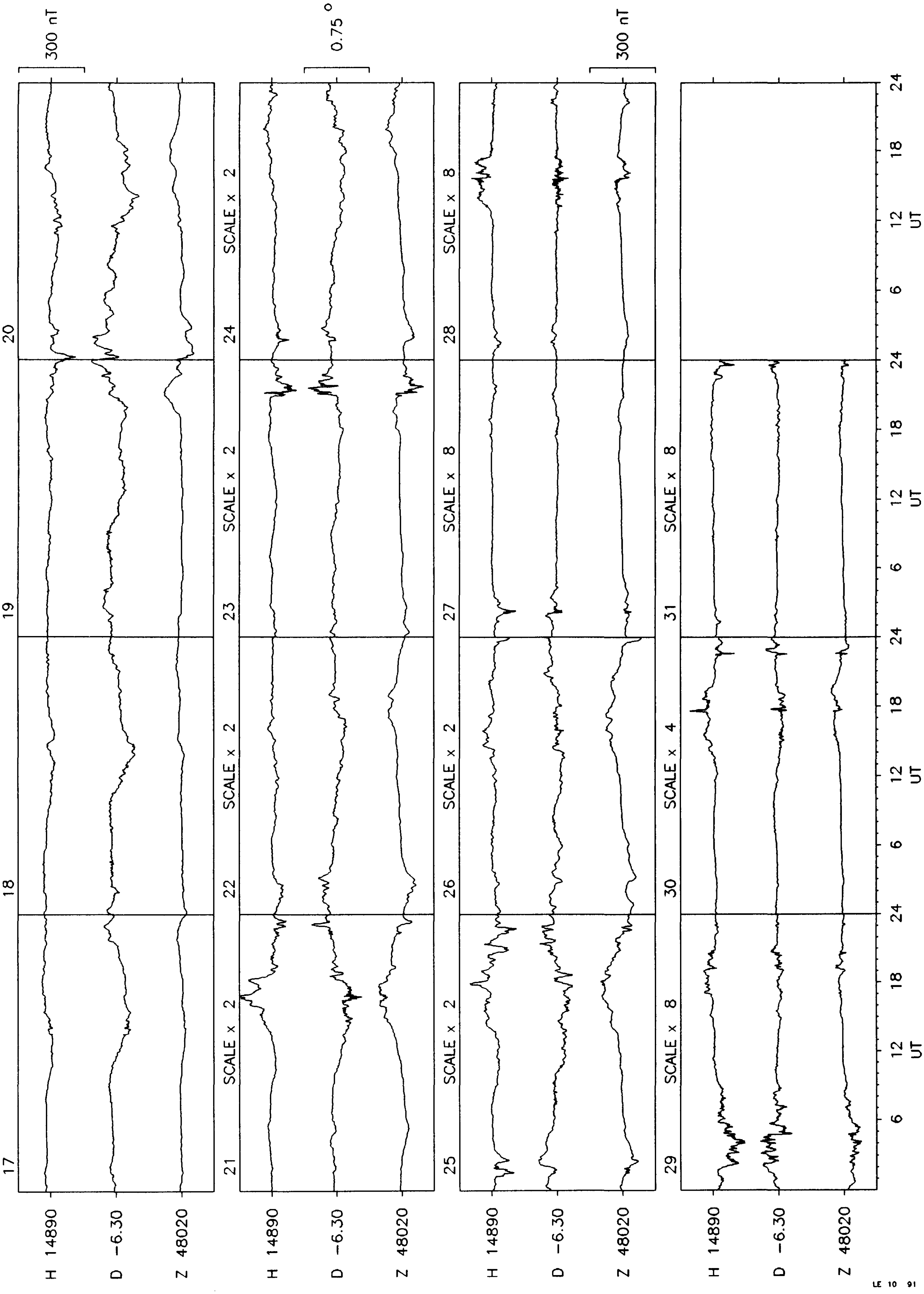
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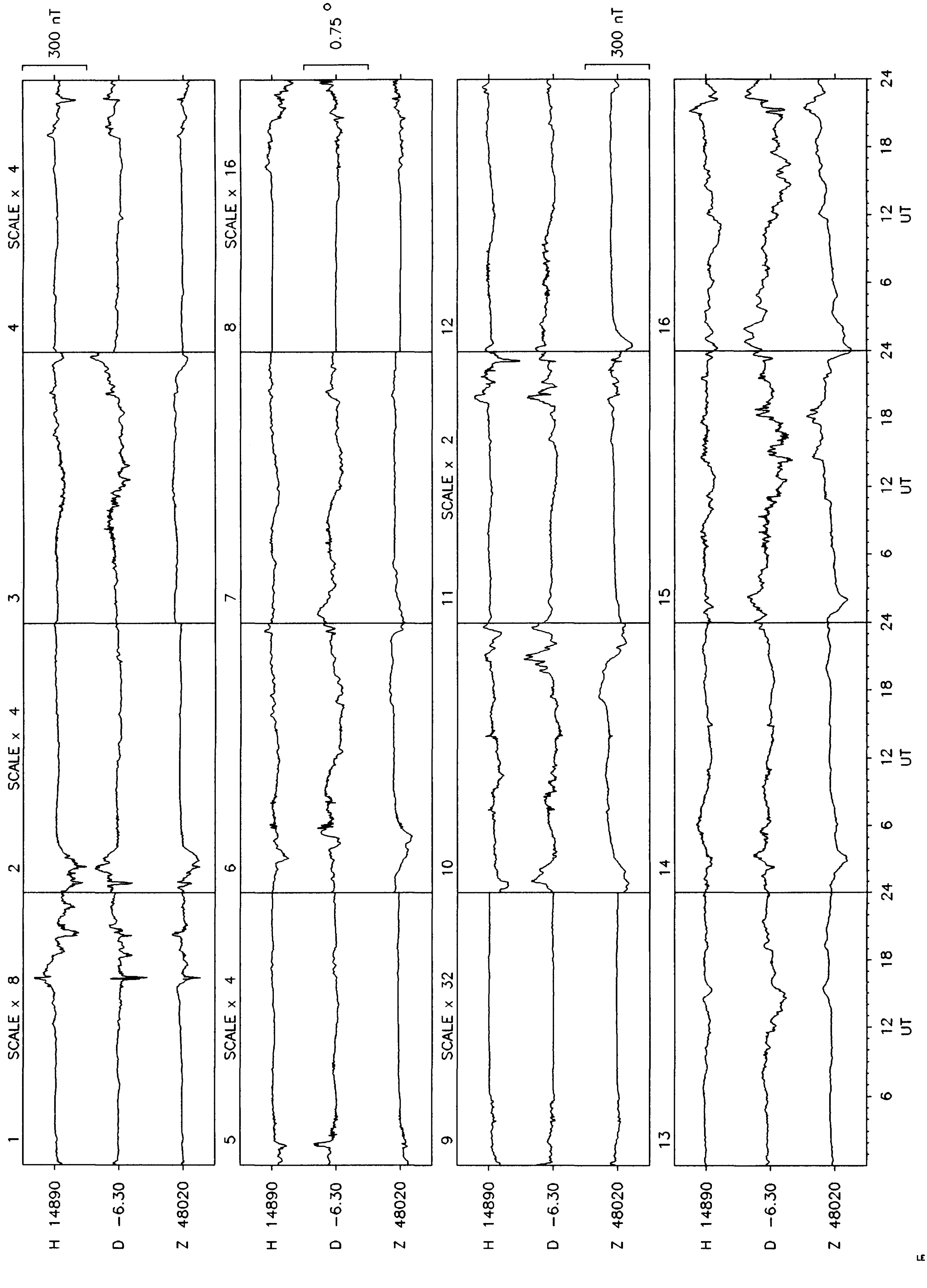
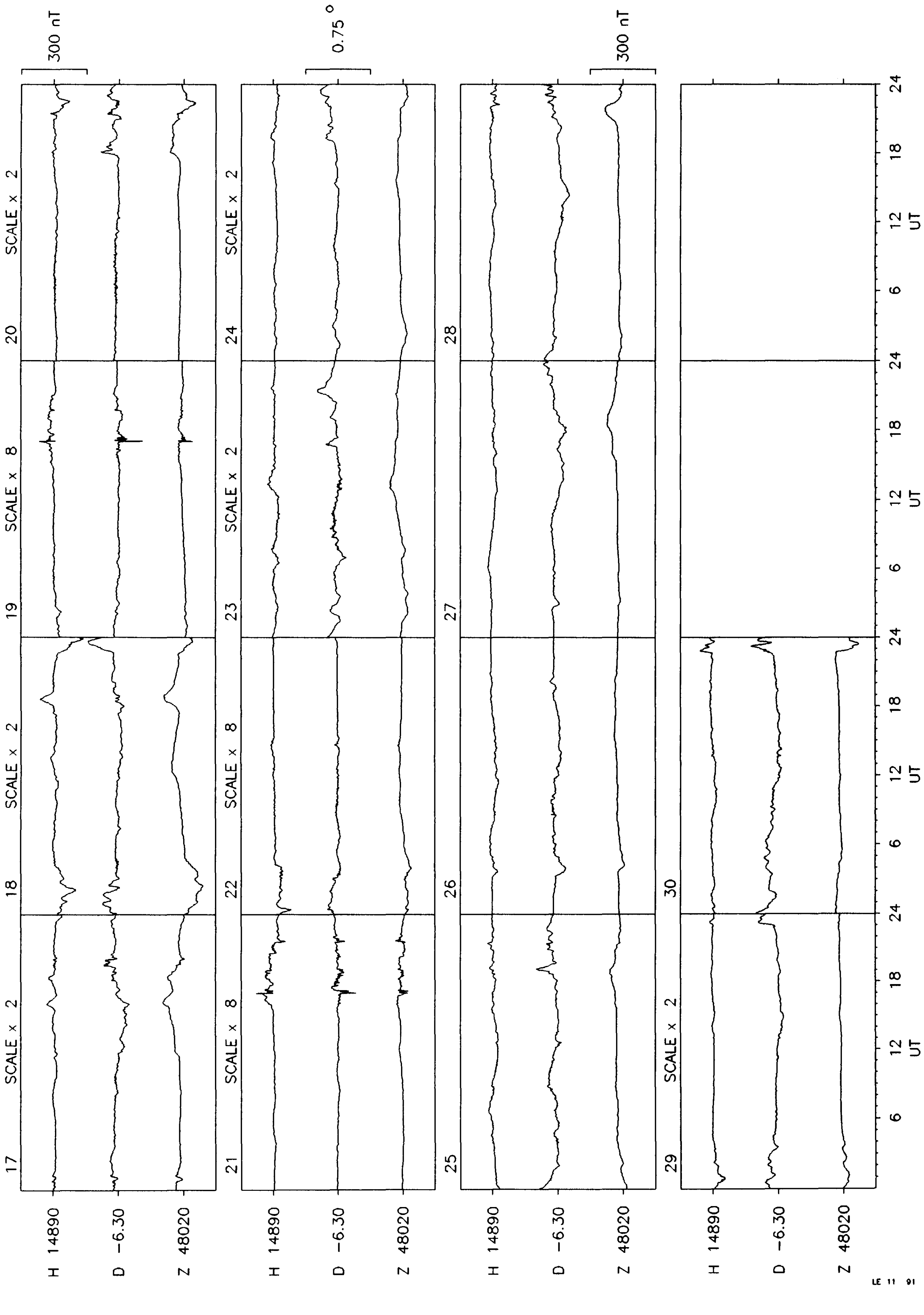

300 nT
0.75 °
300 nT
SCALE x 8
SCALE x 4
SCALE x 4
SCALE x 16
SCALE x 32
SCALE x 2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
H 14890
D −6.30
Z 48020
UT
6
12
18
24



300 nT
0.75 °
300 nT
17
SCALE x 2
18
SCALE x 2
19
SCALE x 8
20
SCALE x 2
21
SCALE x 8
22
SCALE x 8
23
SCALE x 2
24
SCALE x 2
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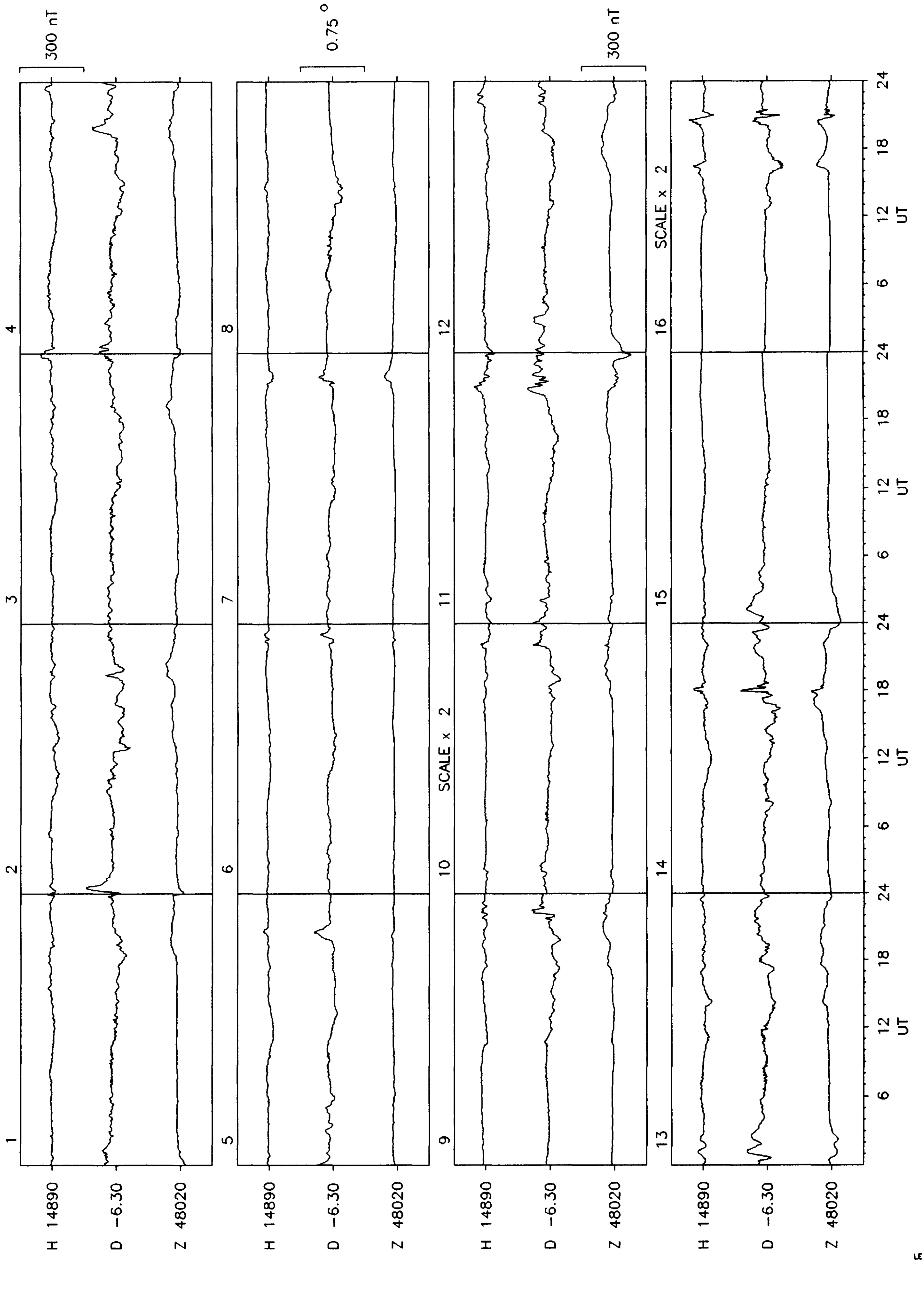
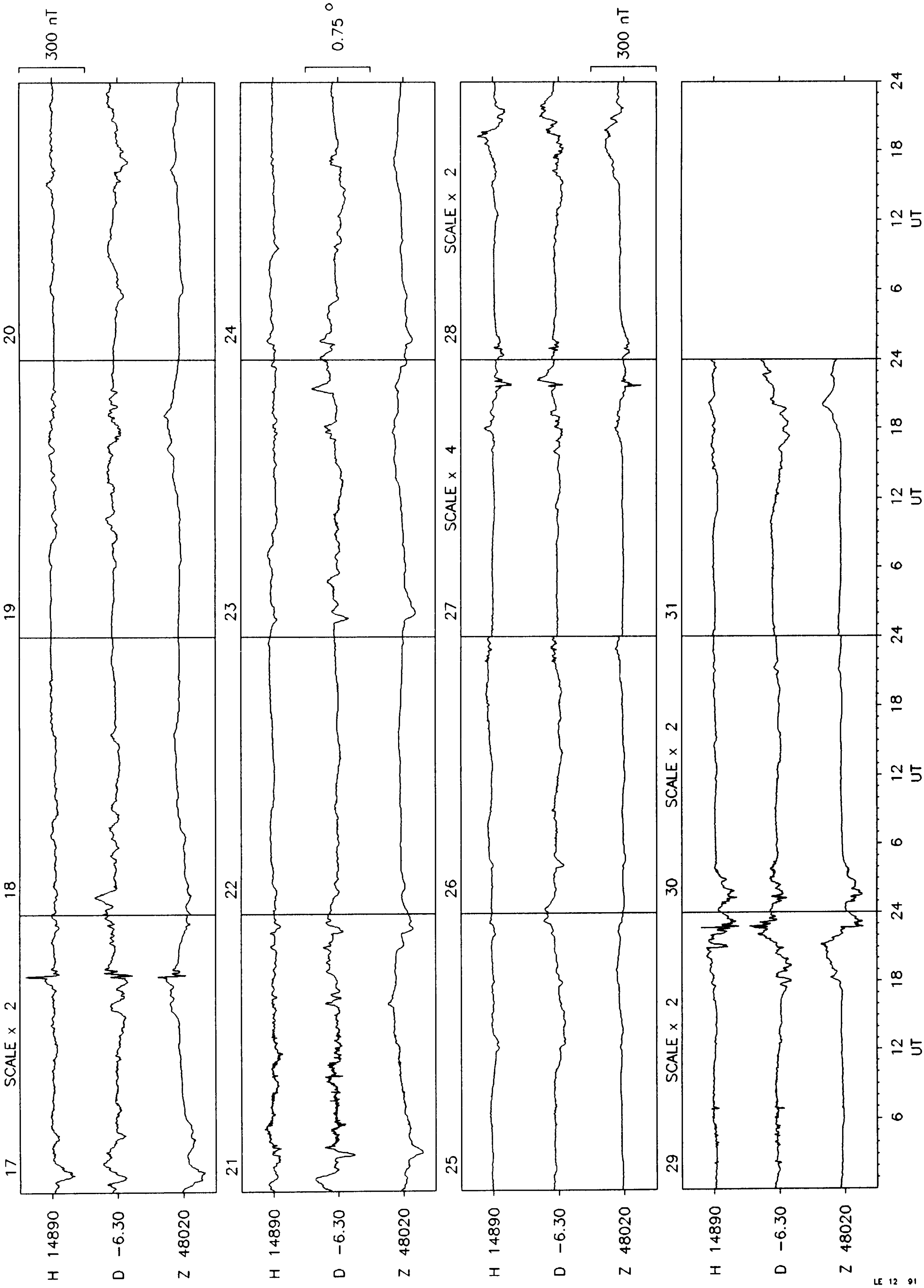
26
27
28
29
SCALE x 2
30
H 14890
D −6.30
Z 48020
6
12
18
24
UT


300 nT
0.75 °
300 nT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SCALE x 2
SCALE x 2
H 14890
D −6.30
Z 48020
6
12
18
24
UT



300 nT
0.75 °
300 nT
17
18
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20
21
22
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24
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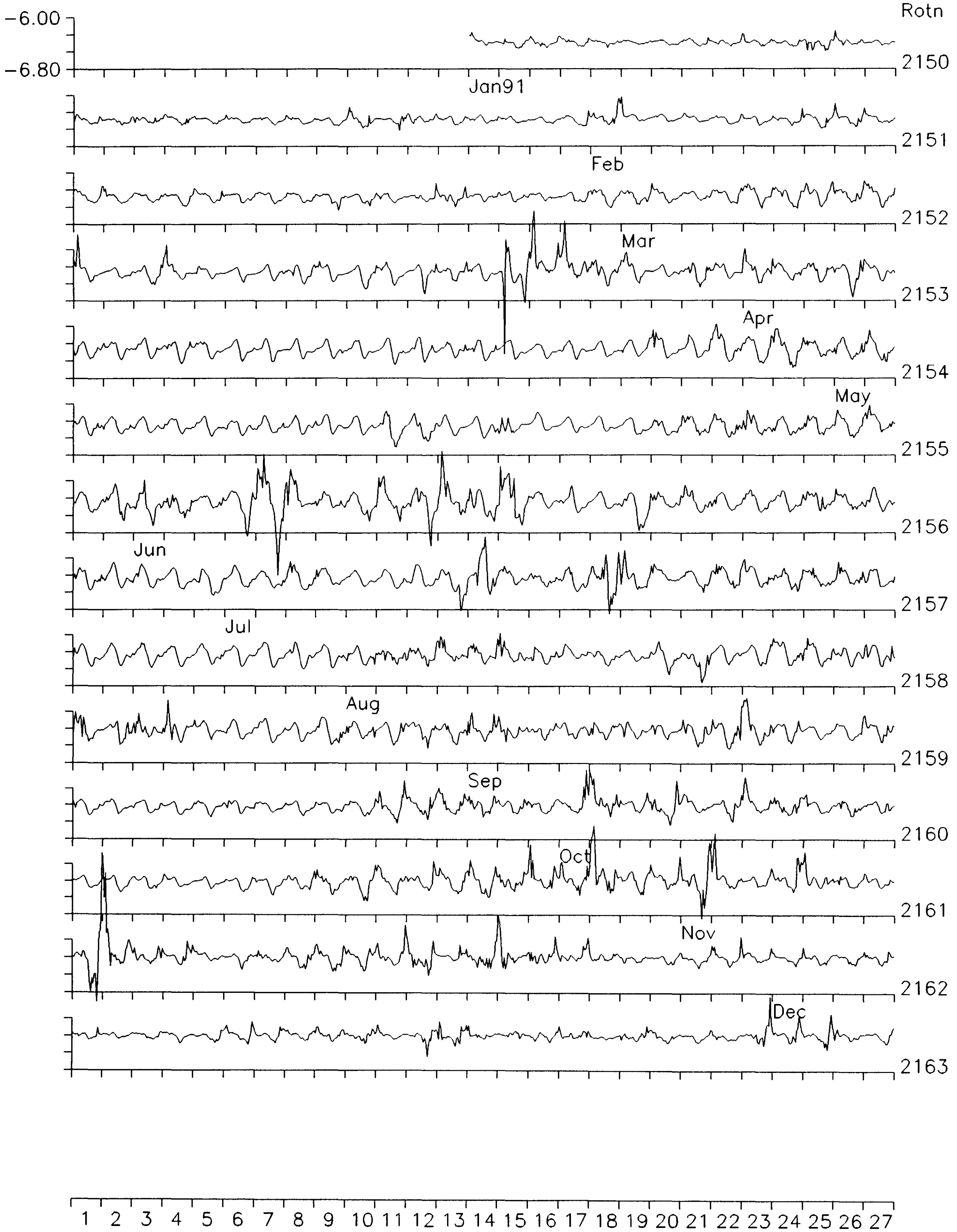
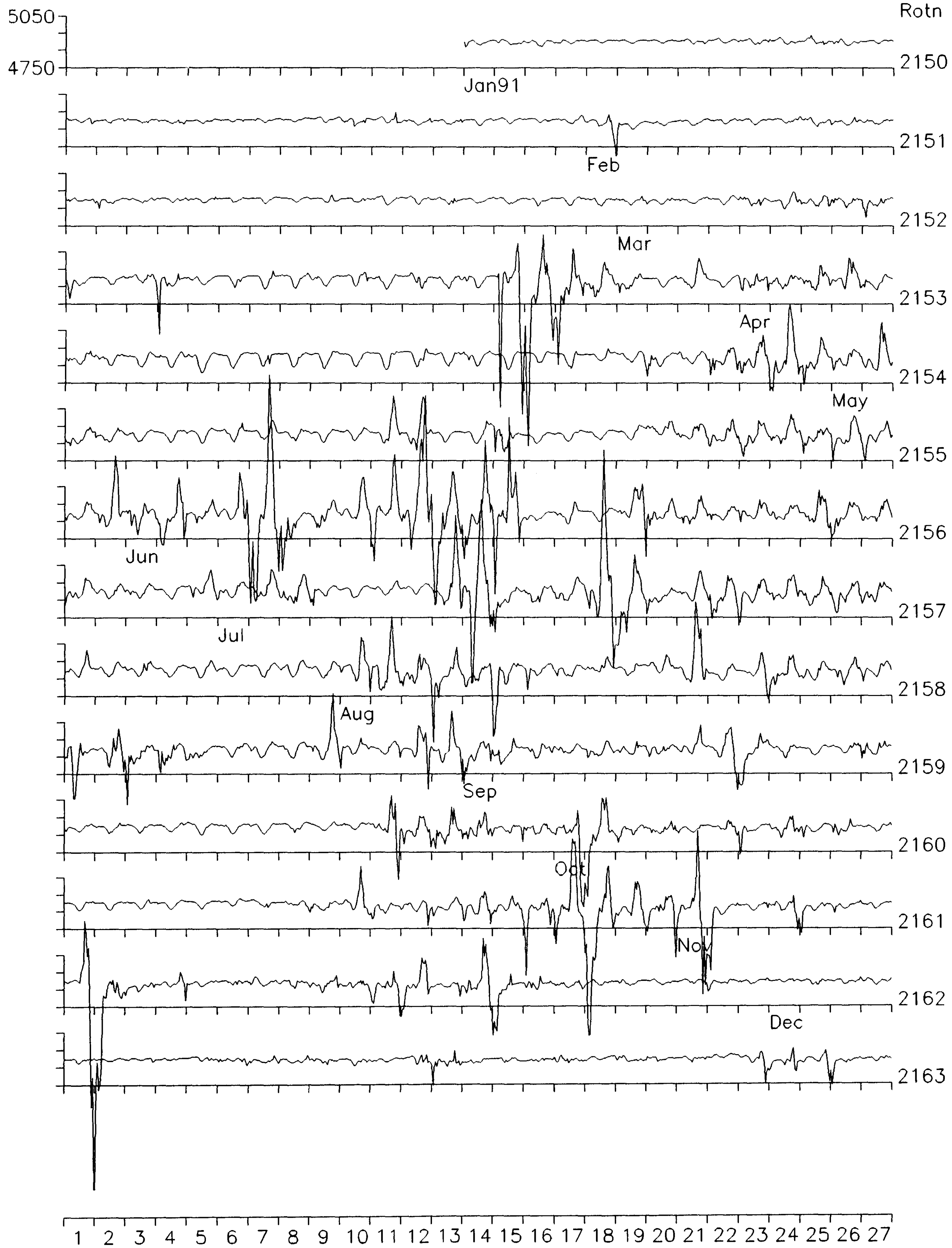
26
27
28
29
30
31
SCALE x 2
SCALE x 4
SCALE x 2
SCALE x 2
SCALE x 2
H 14890
D −6.30
Z 48020
UT
LE 12 91

Lerwick Observatory: Declination (degrees)



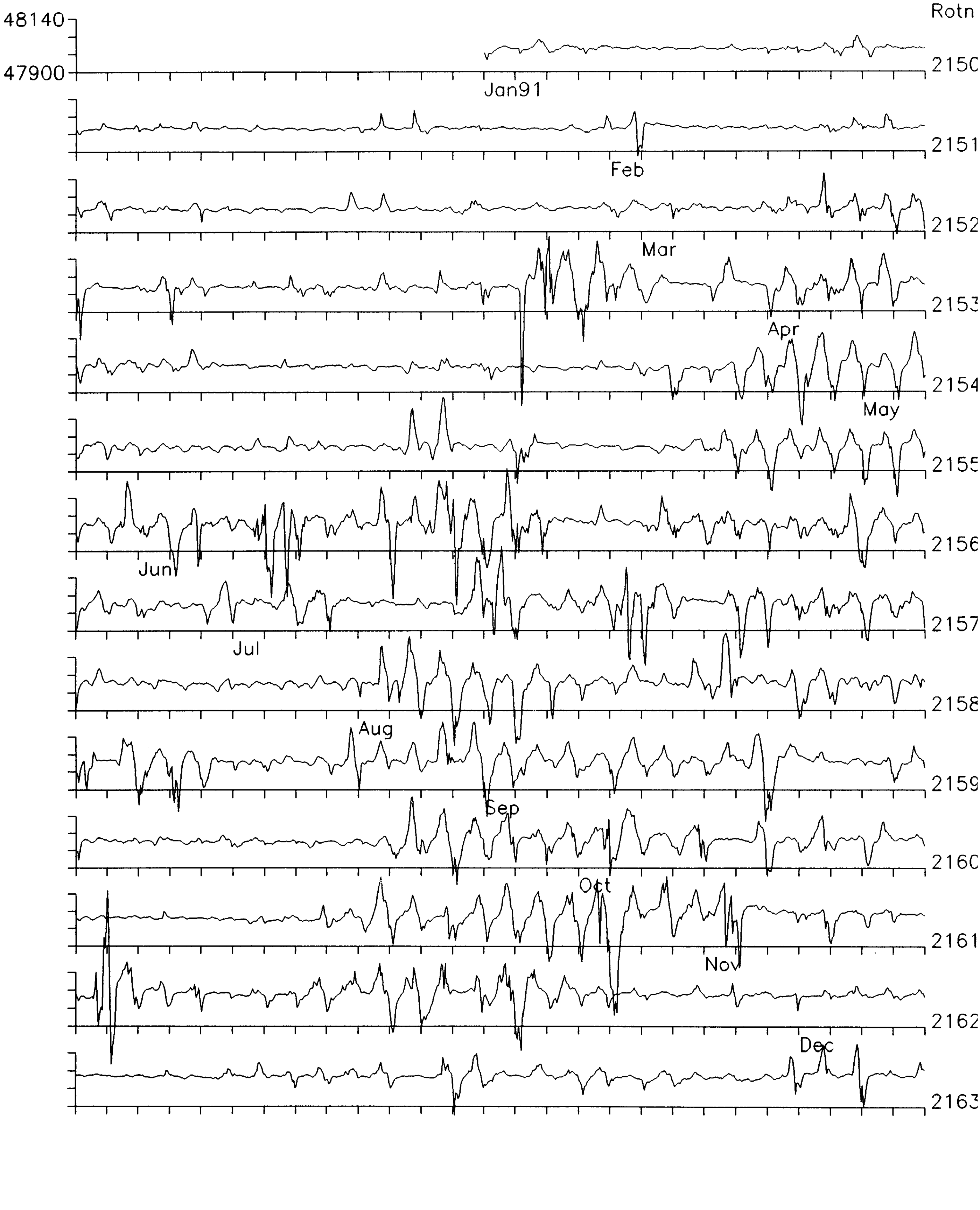
Hourly Mean Values Plotted by Bartels Solar Rotation Number

Lerwick Observatory: Horizontal Intensity (nT)

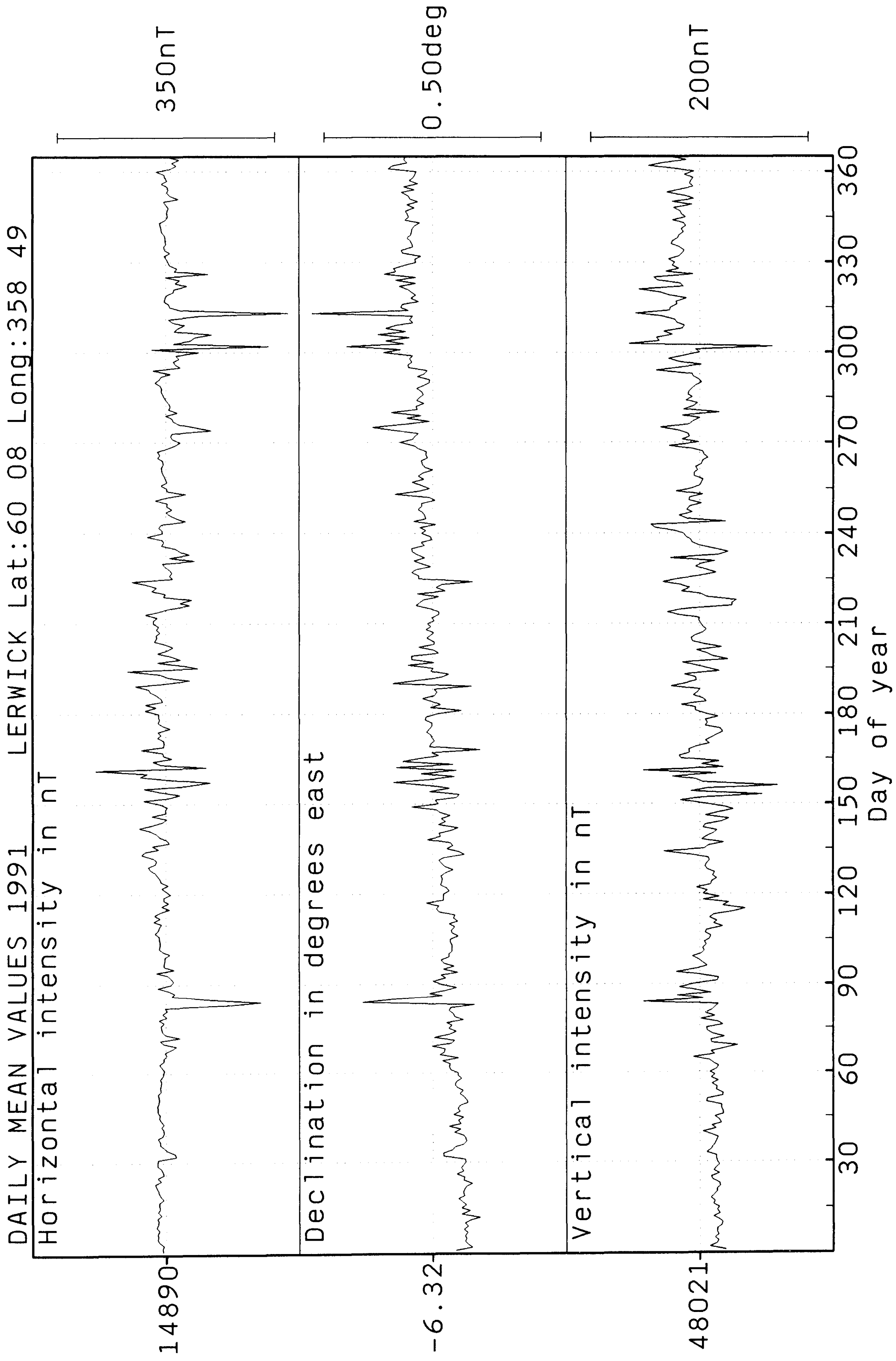


Hourly Mean Values Plotted by Bartels Solar Rotation Number

Lerwick Observatory: Vertical Intensity (nT)



Hourly Mean Values Plotted by Bartels Solar Rotation Number


DAILY MEAN VALUES 1991 LERWICK Lat:60 08 Long:358 49
Horizontal intensity in nT
Declination in degrees east
Vertical intensity in nT
350nT
0.50deg
200nT
14890
-6.32
48021
30
60
90
120
150
180
210
240
270
300
330
360
Day of year

Monthly and annual mean values for Lerwick 1991

Month	D	H	I	X	Y	Z	F
Jan	-6 23.5	14901	72 45.3	14808	-1659	48005	50265
Feb	-6 22.6	14897	72 45.6	14805	-1655	48007	50265
Mar	-6 20.6	14880	72 46.9	14789	-1644	48014	50267
Apr	-6 21.0	14895	72 45.9	14804	-1647	48012	50269
May	-6 20.6	14904	72 45.3	14813	-1647	48013	50273
Jun	-6 19.3	14898	72 45.7	14807	-1640	48015	50273
Jul	-6 18.7	14899	72 45.8	14809	-1638	48022	50280
Aug	-6 18.2	14890	72 46.5	14800	-1635	48026	50281
Sep	-6 17.3	14887	72 46.7	14797	-1631	48026	50280
Oct	-6 15.8	14876	72 47.5	14787	-1623	48031	50282
Nov	-6 14.8	14867	72 48.4	14779	-1618	48047	50295
Dec	-6 15.8	14889	72 46.8	14800	-1624	48039	50293
Annual	-6 19.0	14890	72 46.4	14800	-1638	48021	50277

D and I are given in degrees and decimal minutes
H, X, Y, Z and F are given in nanotesla

LERWICK OBSERVATORY K INDICES 1991

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	3100 0000	2122 2466	2222 2133	4334 3225	5222 4324	3455 5634	4220 2332	4123 3656	5533 3355	3232 3388	6233 5898	2111 1223
2	2310 1121	5211 1000	3111 2221	3322 3323	4323 6654	4553 3657	1233 4434	4254 6554	4442 3413	6644 6634	7632 3233	4112 3231
3	1212 1002	0111 1000	2111 1122	3243 5444	3321 2332	2131 2343	4433 4432	4333 5435	1212 4334	4322 3344	1122 3233	1122 2123
4	2210 1102	2000 0001	1100 2232	2224 5444	3111 2312	1222 4666	5222 3210	7542 4354	3222 2223	3321 4355	3324 2356	3221 1233
5	1100 2022	1111 1112	2222 3323	4222 2322	1110 1211	7776 8877	1001 1110	4433 4336	4422 2332	4322 2120	6432 2331	2211 1132
6	0000 0000	1001 1011	3133 2465	3221 2332	1110 2112	7655 4213	1211 2223	7633 3331	2422 2322	1022 3445	3431 2222	1101 0002
7	1000 0000	1211 2214	3232 3244	2222 2221	2122 1110	3443 4333	3200 1212	3521 1213	3332 3221	6532 3223	2211 1122	1111 1013
8	1110 2021	2211 2323	3212 2344	1211 1221	2122 2231	2222 4554	2234 4776	3222 2212	3311 4552	3233 4483	1232 5799	0111 2100
9	0111 1013	4112 2443	4332 3323	2211 2232	1111 2432	6633 4664	3487 8866	1321 3422	3233 4367	4422 1211	9865 4464	0001 1223
10	3000 1103	2111 1111	5521 2210	2211 2111	1122 2322	3365 7886	6322 4221	1121 2202	6642 3433	3432 3321	3223 3244	3221 2234
11	0001 1120	3321 1224	0011 1102	0011 1111	2000 1200	8854 6455	2224 4323	3333 4321	3122 4343	2122 2332	3221 1356	3211 1234
12	3132 1332	3312 2111	1232 2344	2223 3310	0100 1211	6534 5775	3334 4433	3333 7675	1122 2111	1111 1112	3221 1112	2311 2222
13	2220 1131	2102 2222	7332 2310	1111 2111	1324 4553	8446 8684	4556 8858	2112 2221	2221 2335	1121 2111	1112 3222	3112 2323
14	0000 0010	1101 1222	3221 0100	0111 1221	1244 5533	3221 1111	7655 6453	0011 3445	4323 4332	1011 2232	3322 2112	1121 2433
15	3200 1032	3011 2123	0002 3200	1111 2110	2222 1010	1232 2321	5221 2121	5433 4344	3111 1121	1110 1110	3233 3333	3210 1000
16	1001 2112	1001 1112	0001 2231	0001 3221	1111 1243	0011 2221	2211 2553	3432 4333	1111 2121	0201 1110	3223 3334	0011 3453
17	2101 2323	1000 1101	2212 2133	1223 3431	6354 4210	2215 5557	6543 4336	2333 4343	1010 1212	1001 2212	3122 3434	5433 3463
18	2101 1333	0000 1002	3221 1100	1123 3223	1210 1100	5433 3443	6212 4444	4122 3344	0001 1112	2111 2212	5422 3346	3221 1210
19	0000 0111	0001 2331	0111 3343	2322 2123	0100 0121	4433 3443	3333 5464	4365 5432	2111 2212	2222 1233	6443 4764	0022 2322
20	2000 0220	0011 0222	1222 2120	0001 1111	0100 1100	3222 2322	2433 3543	2235 6555	3221 1111	4223 3321	1222 2345	0211 2321
21	0100 0001	2212 1110	0123 4323	0012 2211	0002 3331	4233 4423	4543 3434	7443 3323	2100 1001	1212 4565	2433 3777	4423 2323
22	1100 0001	1232 1114	1233 3124	3111 3210	3233 2332	3322 3334	4333 5324	6663 4224	2011 2211	4422 2432	7644 5323	2100 0000
23	1000 1111	2232 3334	3211 2221	1112 1322	3222 3424	3234 5445	4212 3442	3313 2111	1001 0011	3221 1356	3343 4434	3221 1223
24	4223 2431	0110 1113	3976 4599	2111 1124	5331 5343	4432 4334	1122 1122	3221 2322	1200 2213	5322 2334	3221 0233	3212 1210
25	0011 0353	2013 2211	8945 6557	5322 2111	5543 3331	3323 4435	1122 4421	3222 2222	4432 4678	5323 4566	3121 2232	0001 2112
26	2311 1113	2221 2110	8764 7545	2410 1123	3333 4443	4332 4433	1110 1111	1212 3222	5433 5345	3332 4445	0221 1110	2211 1112
27	0001 1023	0012 2222	3433 5334	5522 3334	5323 4332	2112 2222	1111 1133	3211 3776	5533 5553	8633 3455	2110 1221	2223 2566
28	1111 1002	3322 2224	4332 3321	4321 4444	6333 3544	2321 2221	1211 1112	5211 2334	4432 4464	6434 7846	2001 2113	4111 3354
29	1001 0001		0001 0112	6434 7555	5423 2243	0011 2111	1121 2011	0012 2234	3112 3345	8866 4675	4201 2214	3331 2356
30	0000 1110		1233 4445	5533 5432	3121 2422	3412 4444	2231 1221	3223 6467	3332 3343	3223 5666	3211 1113	5411 2122
31	1221 2213		2222 0013		2445 6633		1110 2212	2244 5646		6244 3448		1000 2232

SIs and SSCs

Day	Month	UT		Type	Quality	H(nT)	D(min)	Z(nT)
12	1	01	52	SSC	C	16	-2.7	-11
1	2	18	42	SI	B	40	5.0	-23
4	2	22	14	SSC*	B	16	-1.2	-6
4	3	16	18	SSC*	B	22	-3.0	4
9	3	22	45	SSC	B	37		-16
24	3	03	41	SSC*	A	219	-35.5	-72
4	4	11	22	SSC*	B	20	11.2	-15
19	4	10	54	SI*	B	24	-1.6	-14
13	5	08	56	SSC*	B	-18	13.6	-6
16	5	20	41	SSC*	A	79	-3.4	-33
21	5	12	27	SSC*	C	19	-2.1	-6
31	5	10	38	SSC*	B	-49	17.1	-15
7	6	22	27	SI*	B	27	-6.6	-13
9	6	00	40	SI*	C	-174	-7.2	-94
9	6	18	42	SI*	B	-164	14.1	-107
12	6	10	13	SSC	A	25	13.9	-18
17	6	10	18	SSC*	A	-39	-10.7	-18
30	6	01	15	SSC*	B	25	-3.6	-9
6	7	15	26	SI*	B	32	-2.0	-12
8	7	16	35	SSC*	A	295	-10.8	-88
12	7	09	23	SSC*	B	39	16.0	-12
13	7	14	17	SI*	A	-60	-69.7	-154
5	8	20	46	SSC	B	40	-0.9	-15
11	8	02	53	SSC*	B	39	-8.9	-14
18	8	18	33	SSC*	A	79	-3.8	-27
20	8	08	01	SSC*	B	-51	13.8	-14
27	8	15	14	SSC*	A	89	-7.2	11
10	9	06	47	SI*	B	-59	18.7	-14
11	9	01	29	SI*	B	-36	9.3	-6
1	10	18	14	SSC*	A	36	-2.1	-14
8	10	18	27	SSC*	A	-726	-68.1	-453
17	10	13	30	SSC*	B	11	-3.6	-3
23	10	20	50	SSC*	C	-91	8.5	54
23	10	21	04	SI*	B	-221	19.2	-192
28	10	10	53	SSC*	B	-17	12.0	15
28	10	13	07	SSC*	A	100	-28.0	-55
28	10	15	36	SI*	B	-516	63.1	-348
30	10	22	25	SI*	B	-353	-27.0	-136
31	10	23	25	SI*	A	-558	40.0	-289
1	11	11	41	SSC*	C	32	-10.3	-16
8	11	06	47	SSC*	B	-20	-3.6	-4
8	11	13	12	SSC*	B	15	-8.0	
11	11	17	50	SSC*	B	19	4.0	-8
19	11	04	21	SSC*	B	-43	-4.2	-15
27	12	21	38	SI*	B	113	21.2	-197

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		Maximum		End		H(nT)	D(min)	Z(nT)
23	3	12	30	12	35	12	46	28	-3.0	-9
11	4	11	14	11	17	11	28	-14		5
15	6	08	12	08	21	08	35	13	9.4	-7

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

Annual Values of Geomagnetic Elements

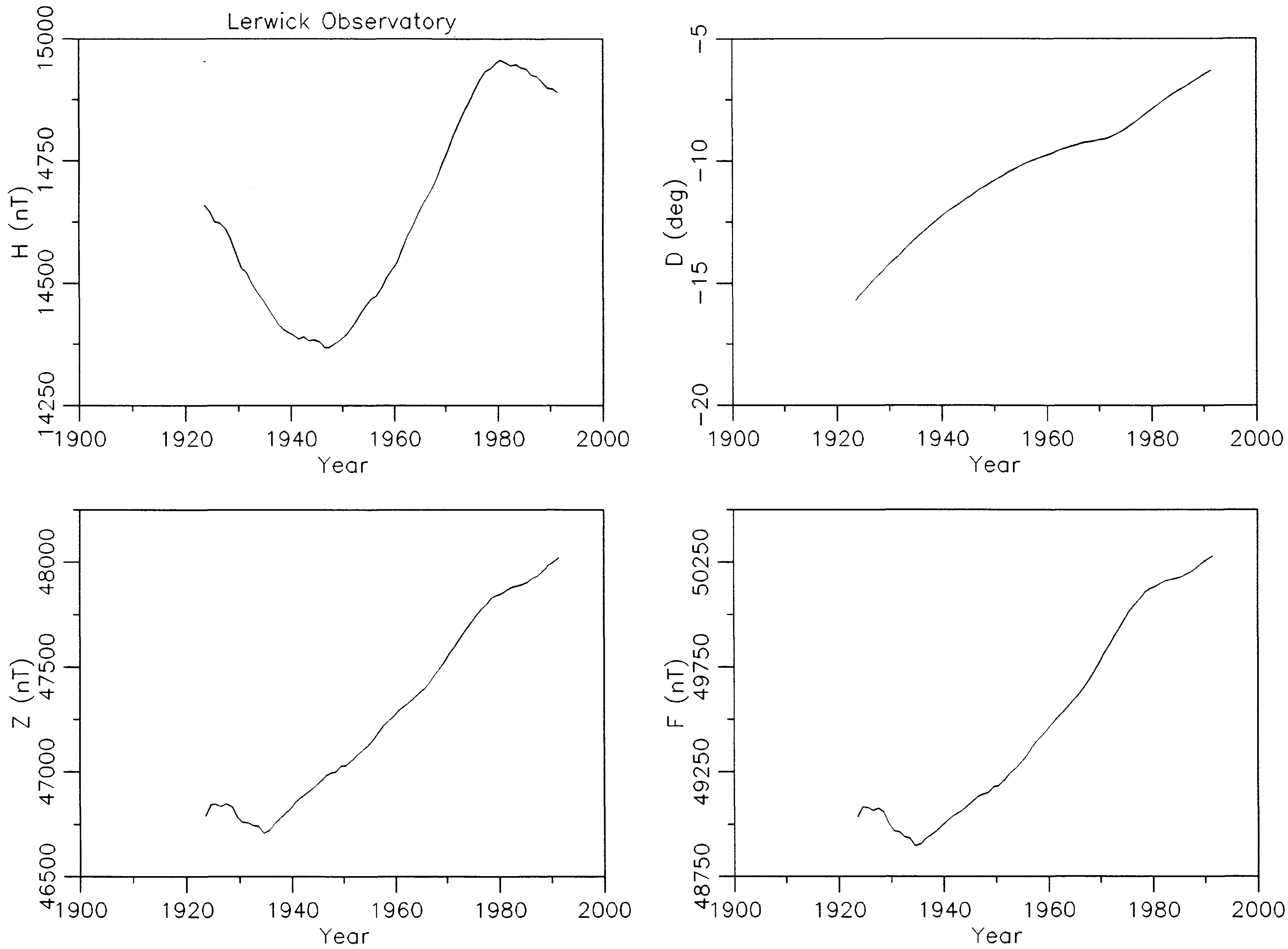
Lerwick

	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

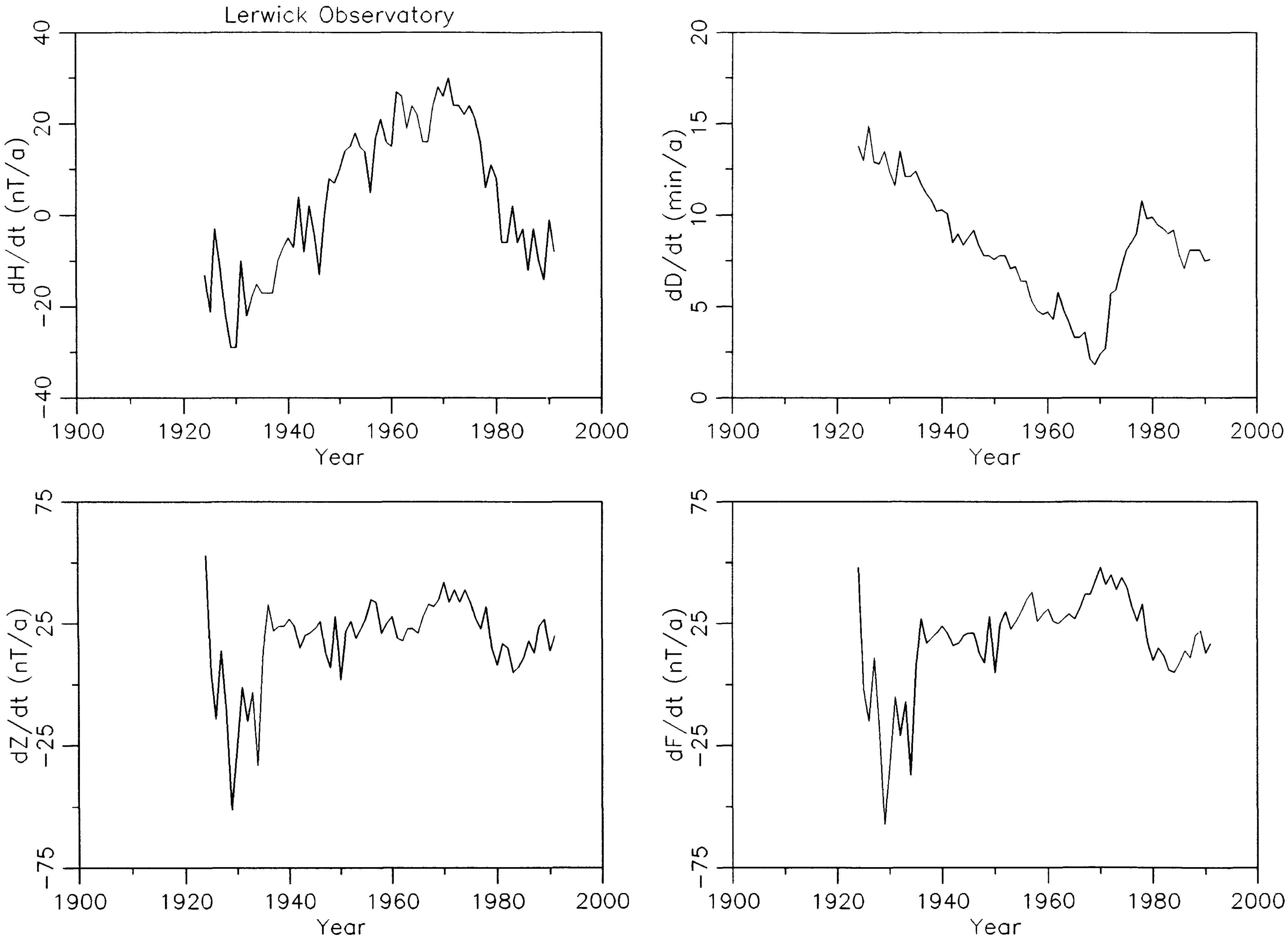
	Year	D		H	I		X	Y	Z	F
	1984.5	-7	13.4	14936	72	40.9	14818	-1878	47902	50177
	1985.5	-7	5.5	14933	72	41.3	14819	-1844	47913	50186
	1986.5	-6	58.4	14921	72	42.5	14811	-1811	47931	50200
	1987.5	-6	50.3	14918	72	43.0	14812	-1776	47944	50211
	1988.5	-6	42.2	14908	72	44.1	14806	-1740	47968	50231
	1989.5	-6	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

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

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

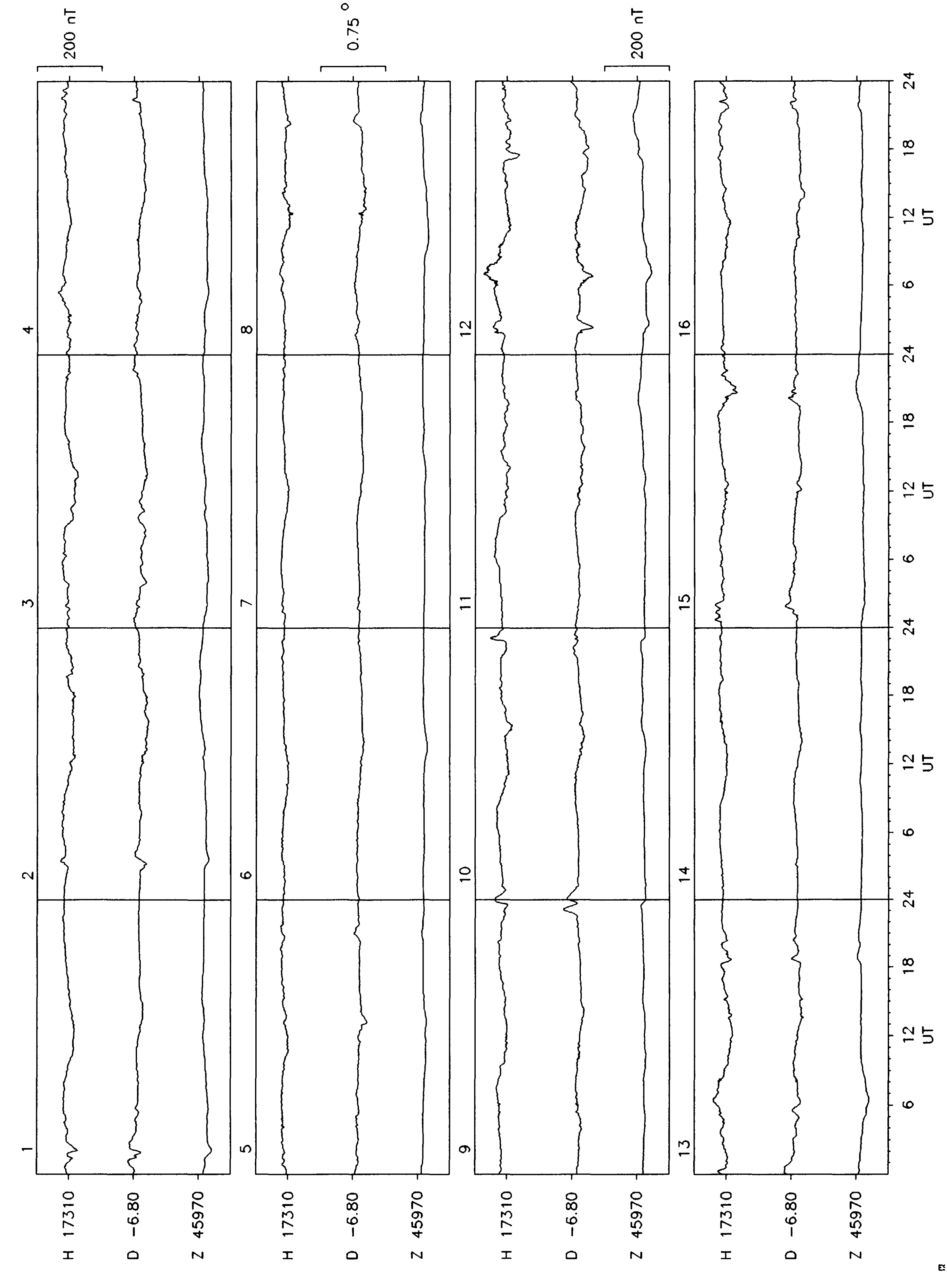


Annual mean values of H, D, Z & F at Lerwick



Rate of change of annual mean values for H, D, Z & F at Lerwick

Eskdalemuir 1991


200 nT
0.75 °
200 nT
H 17310
D −6.80
Z 45970
1
2
3
4
5
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12
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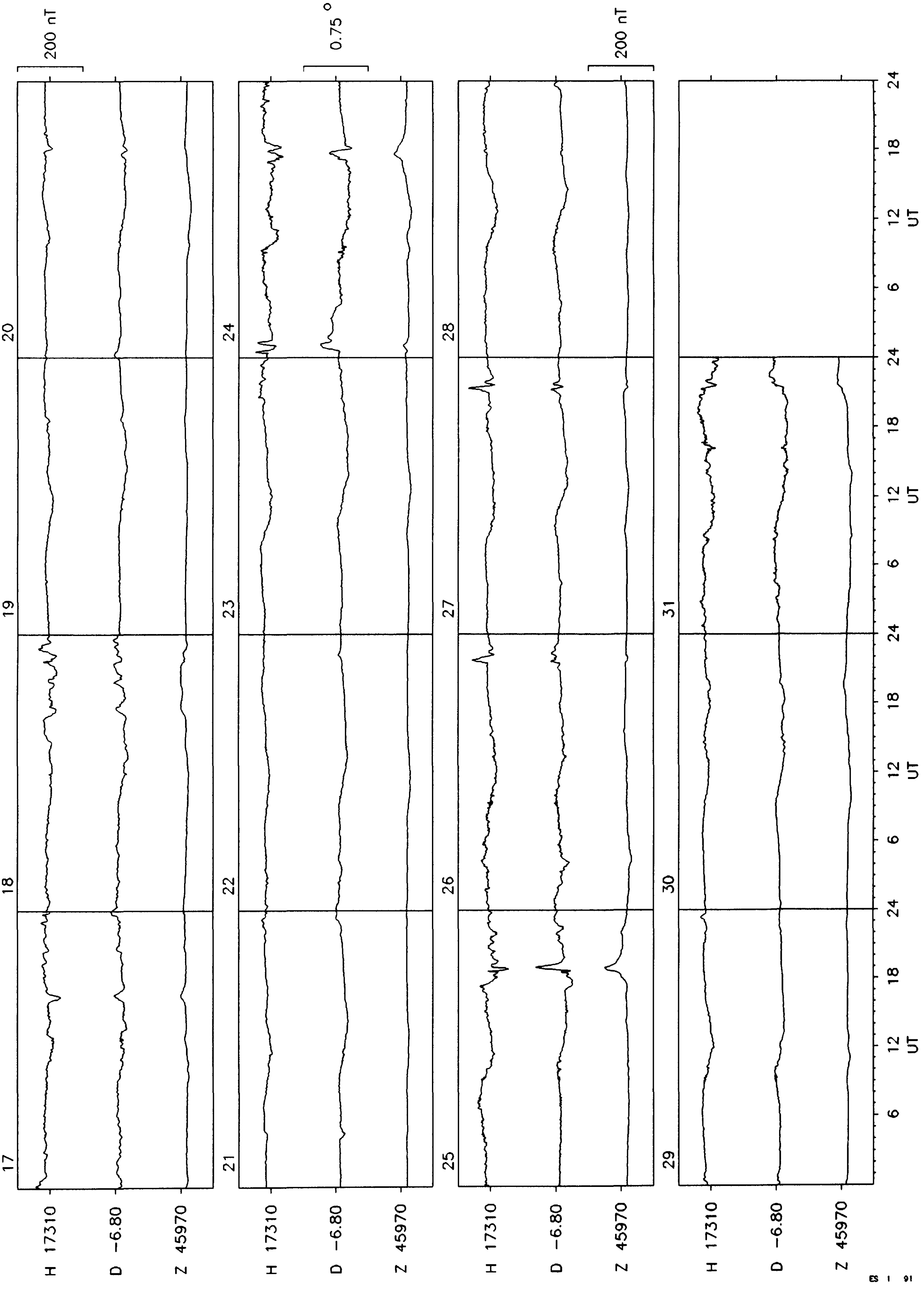
24
UT


200 nT
0.75 °
200 nT
17
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28
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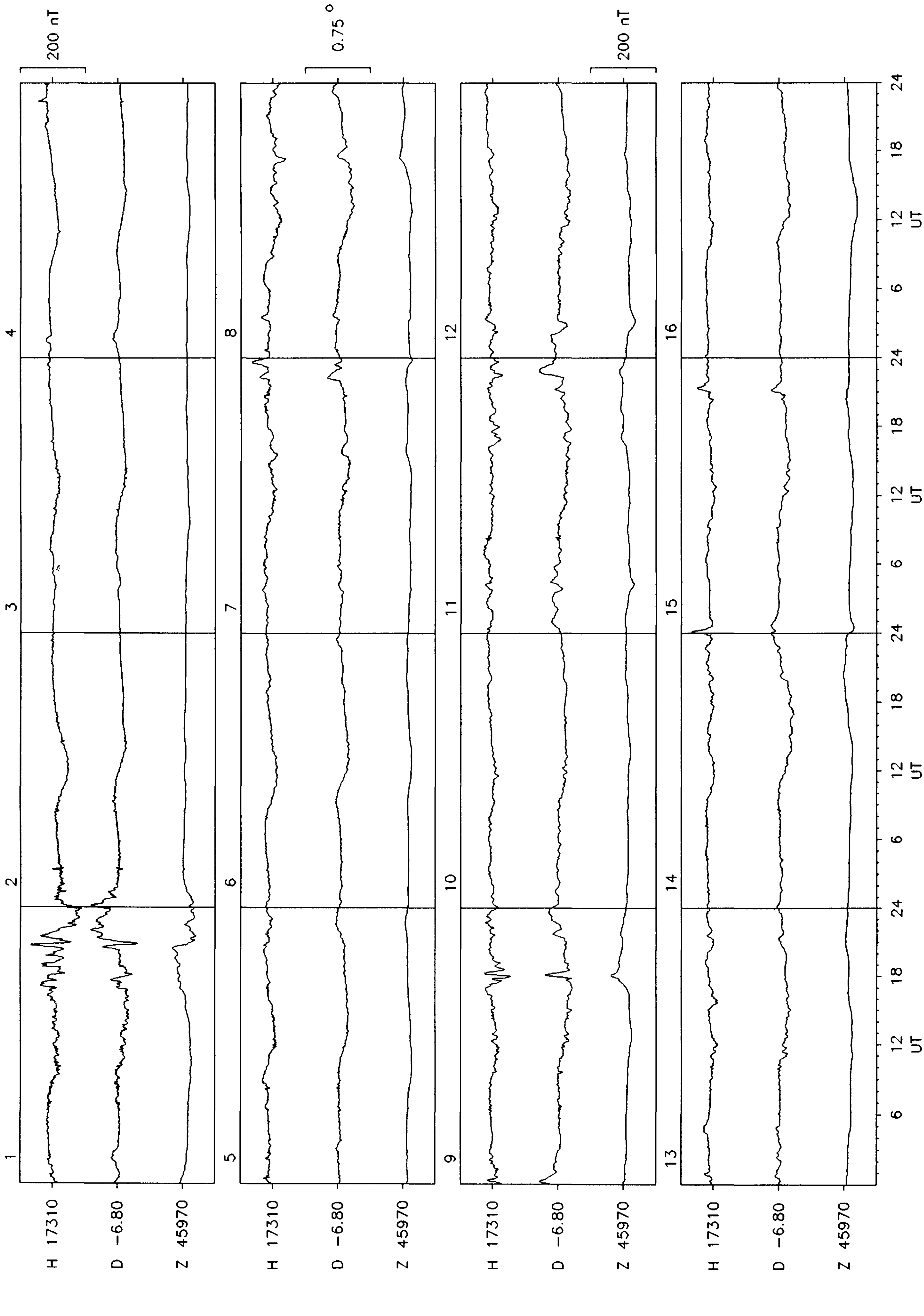
30
31
H 17310
D −6.80
Z 45970
6
12
18
24
UT


200 nT
0.75 °
200 nT
1
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11
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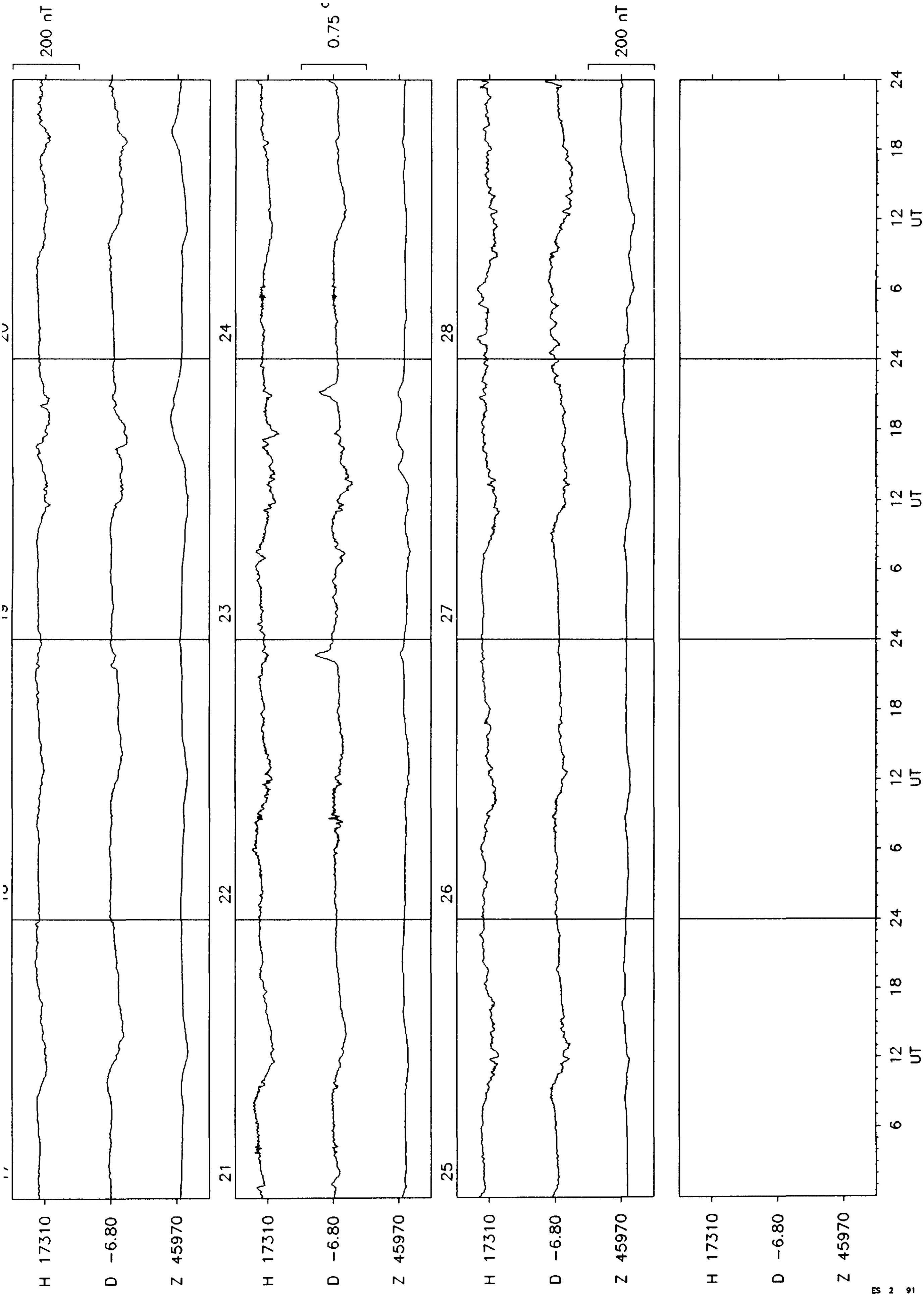
14
15
16
H 17310
D −6.80
Z 45970
6
12
18
24
UT


200 nT
0.75 °
200 nT
21
22
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28
H 17310
D −6.80
Z 45970
6
12
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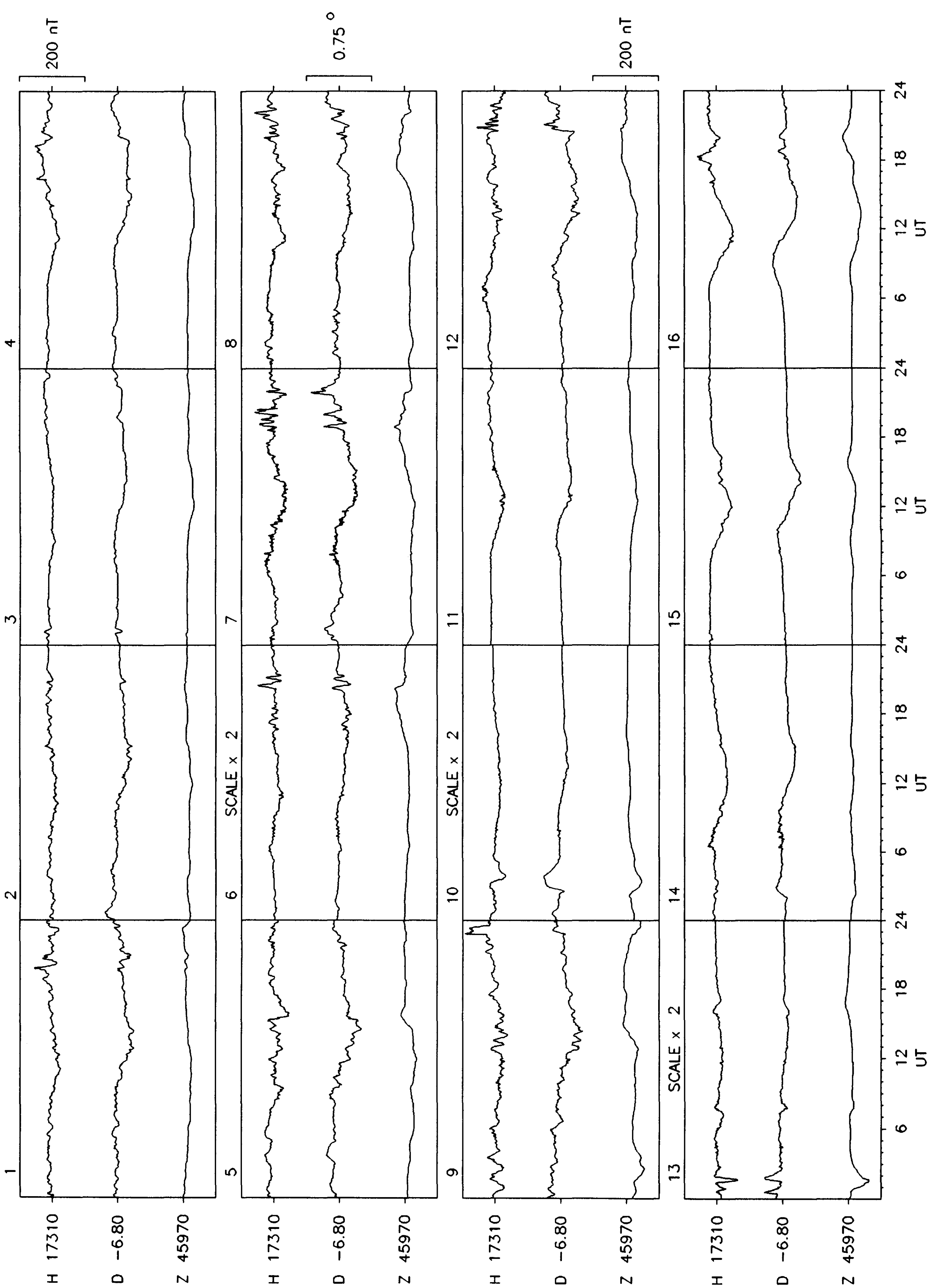
24
UT
ES 2 91


200 nT
0.75 °
200 nT
1
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11
12
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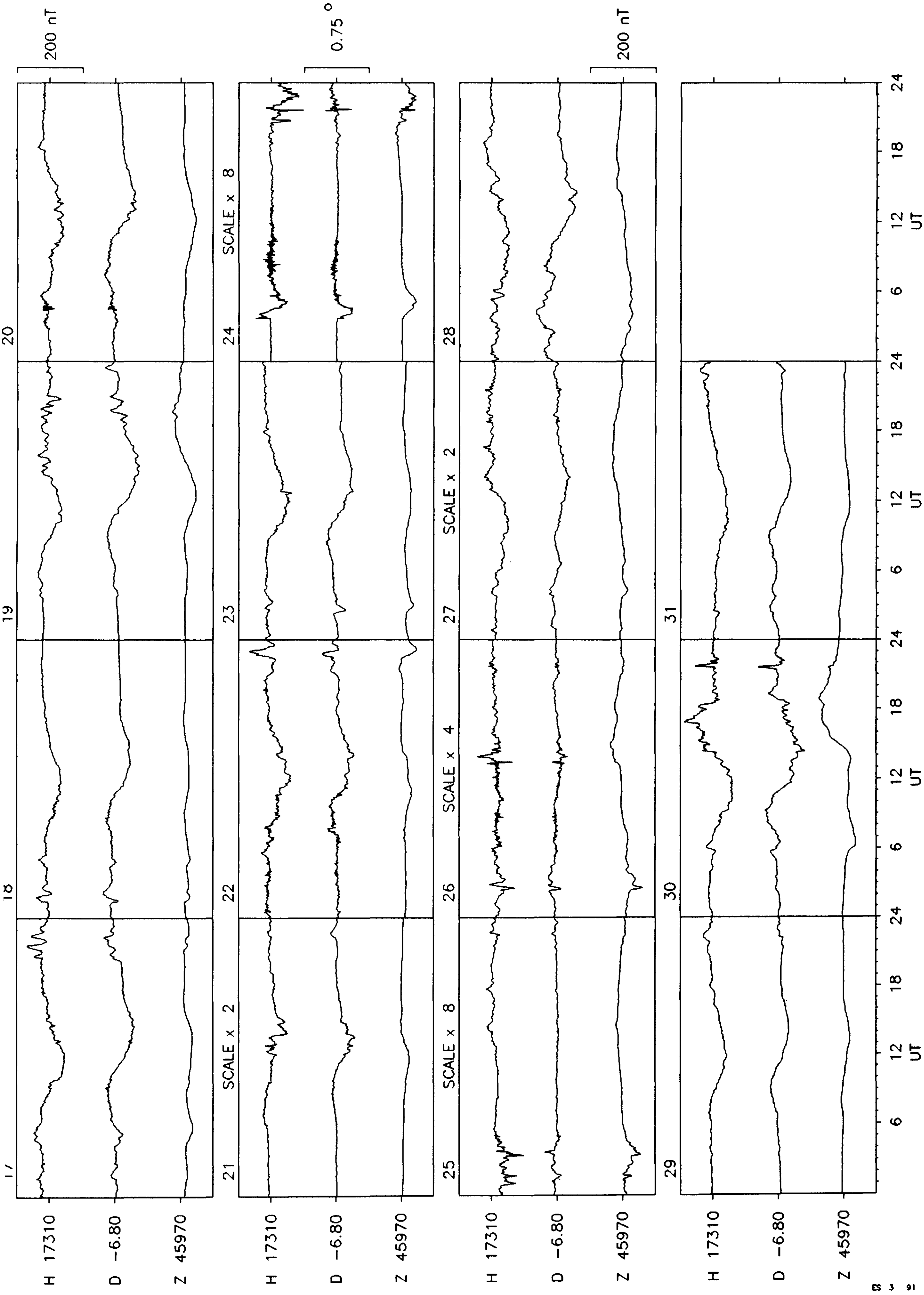
14
15
16
SCALE x 2
SCALE x 2
SCALE x 2
H 17310
D -6.80
Z 45970
H 17310
D -6.80
Z 45970
H 17310
D -6.80
Z 45970
H 17310
D -6.80
Z 45970
6
12
18
24
UT


200 nT
0.75 °
200 nT
17
18
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21
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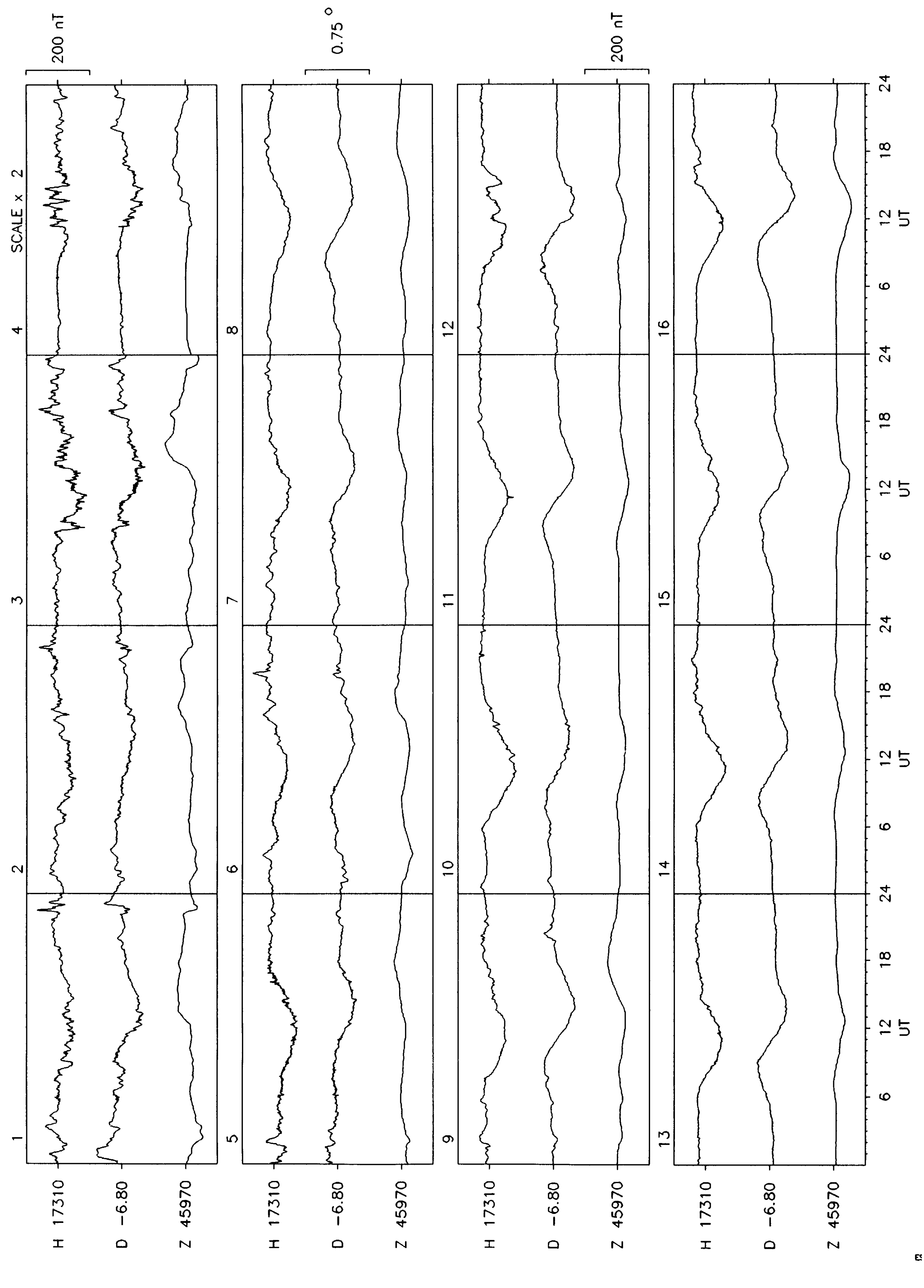
28
29
30
31
SCALE x 2
SCALE x 8
SCALE x 4
SCALE x 8
SCALE x 2
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
6
12
18
24
UT
ES 3 91



H 17310
D −6.80
Z 45970
200 nT
0.75 °
SCALE x 2
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16
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12
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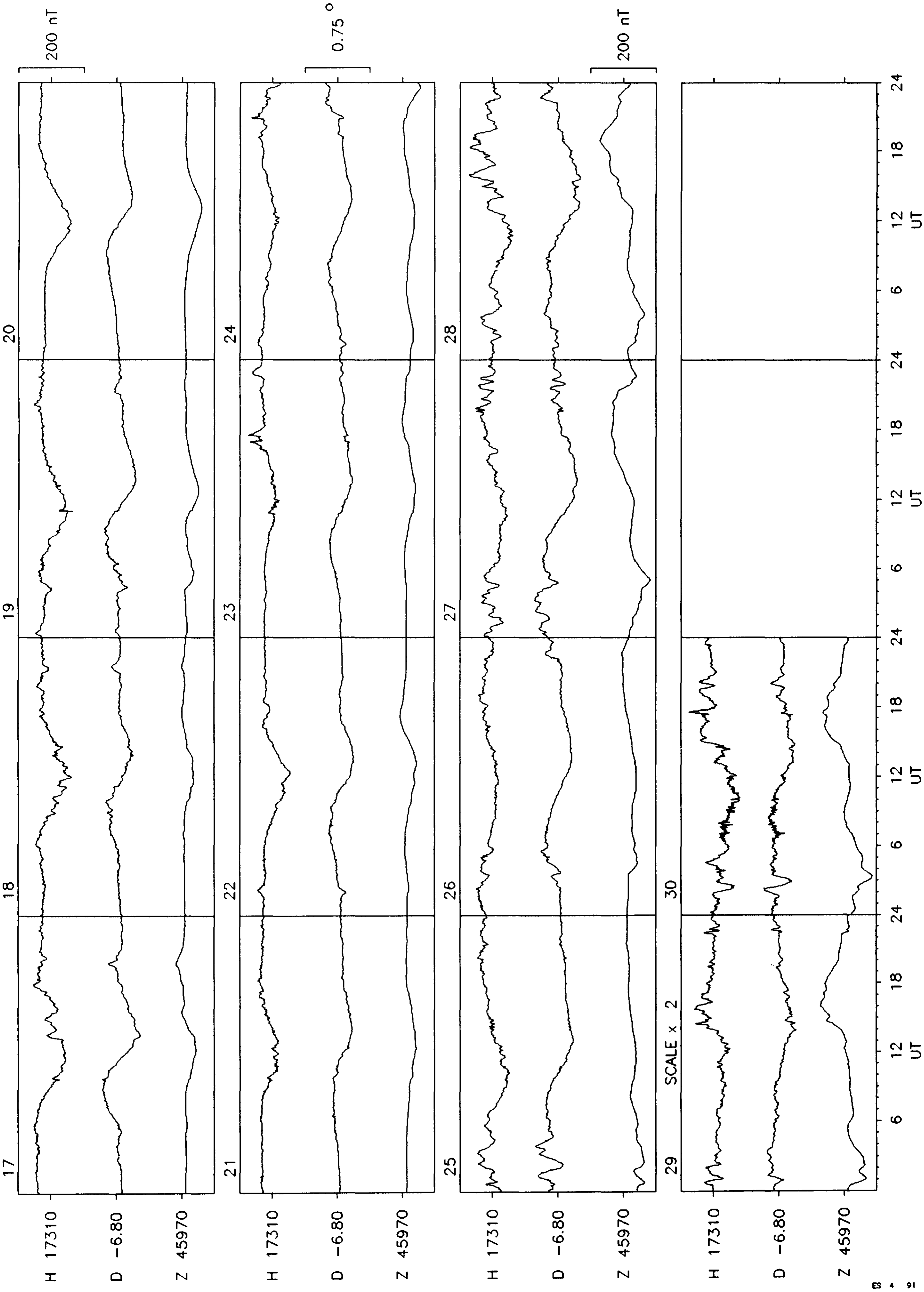
24
UT



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SCALE x 2
200 nT
0.75 °
200 nT
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
6
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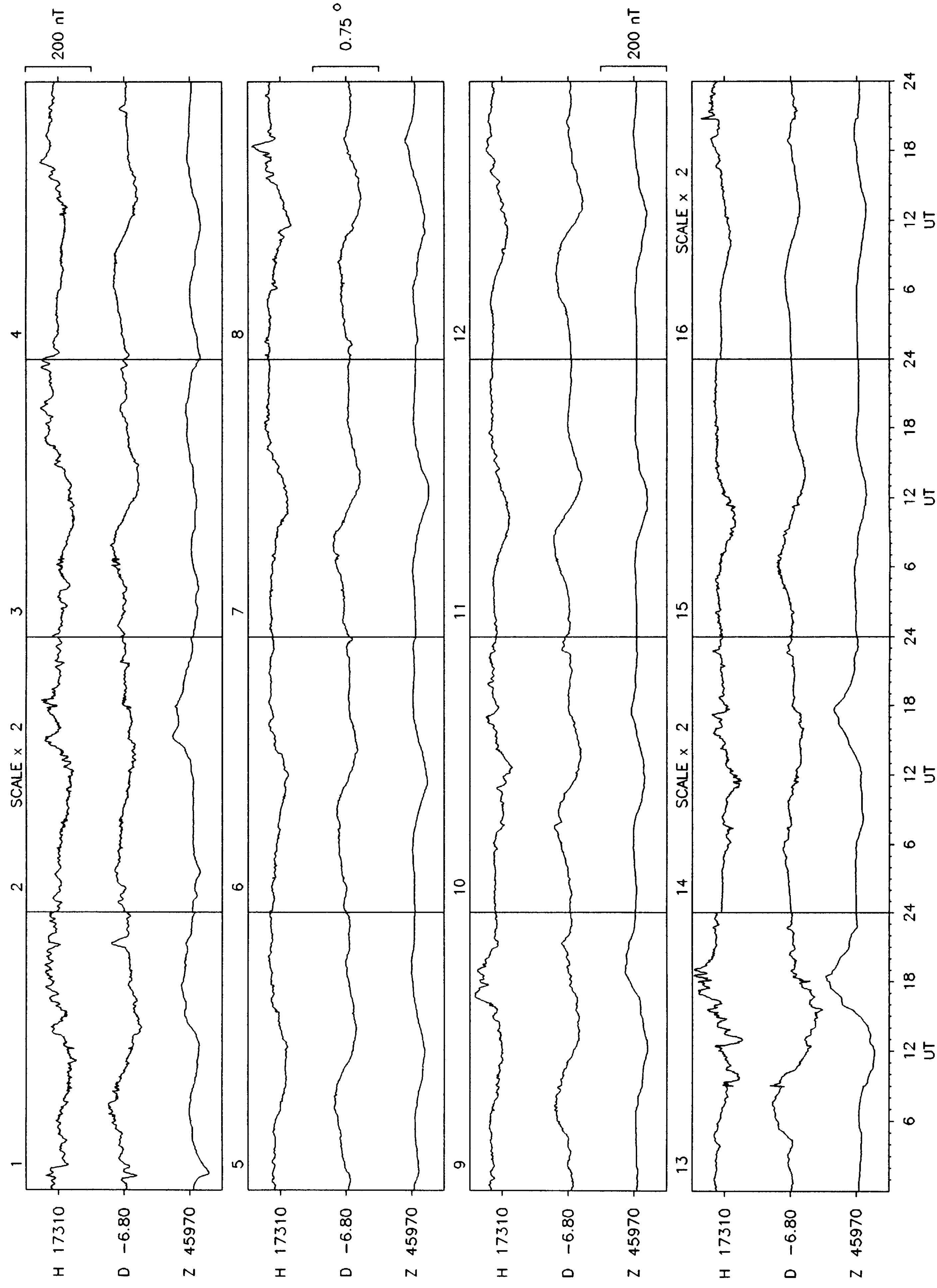
18
24
UT
ES 4 91


H 17310
D −6.80
Z 45970
200 nT
0.75 °
200 nT
SCALE x 2
SCALE x 2
SCALE x 2
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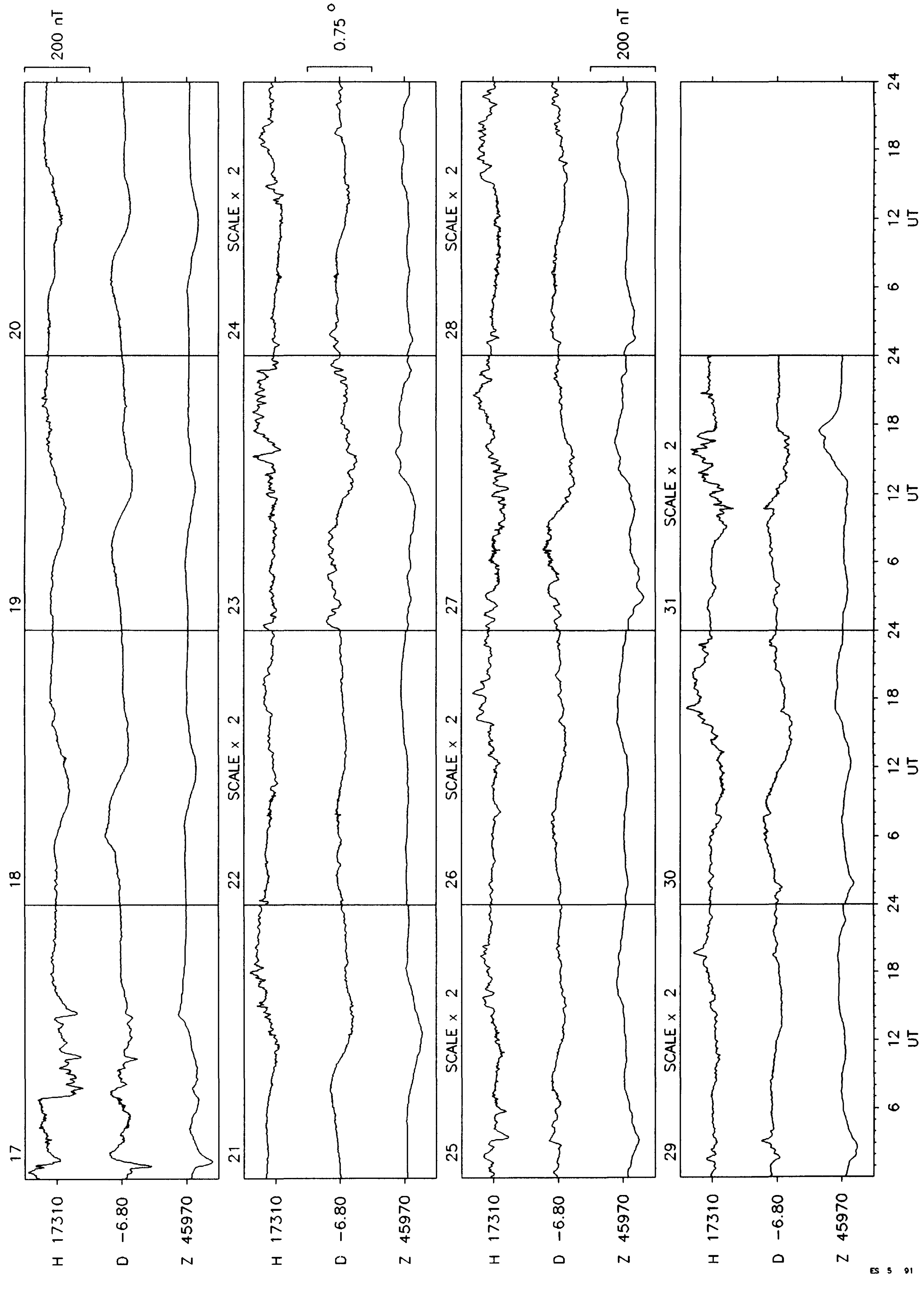
UT


200 nT
0.75 °
200 nT
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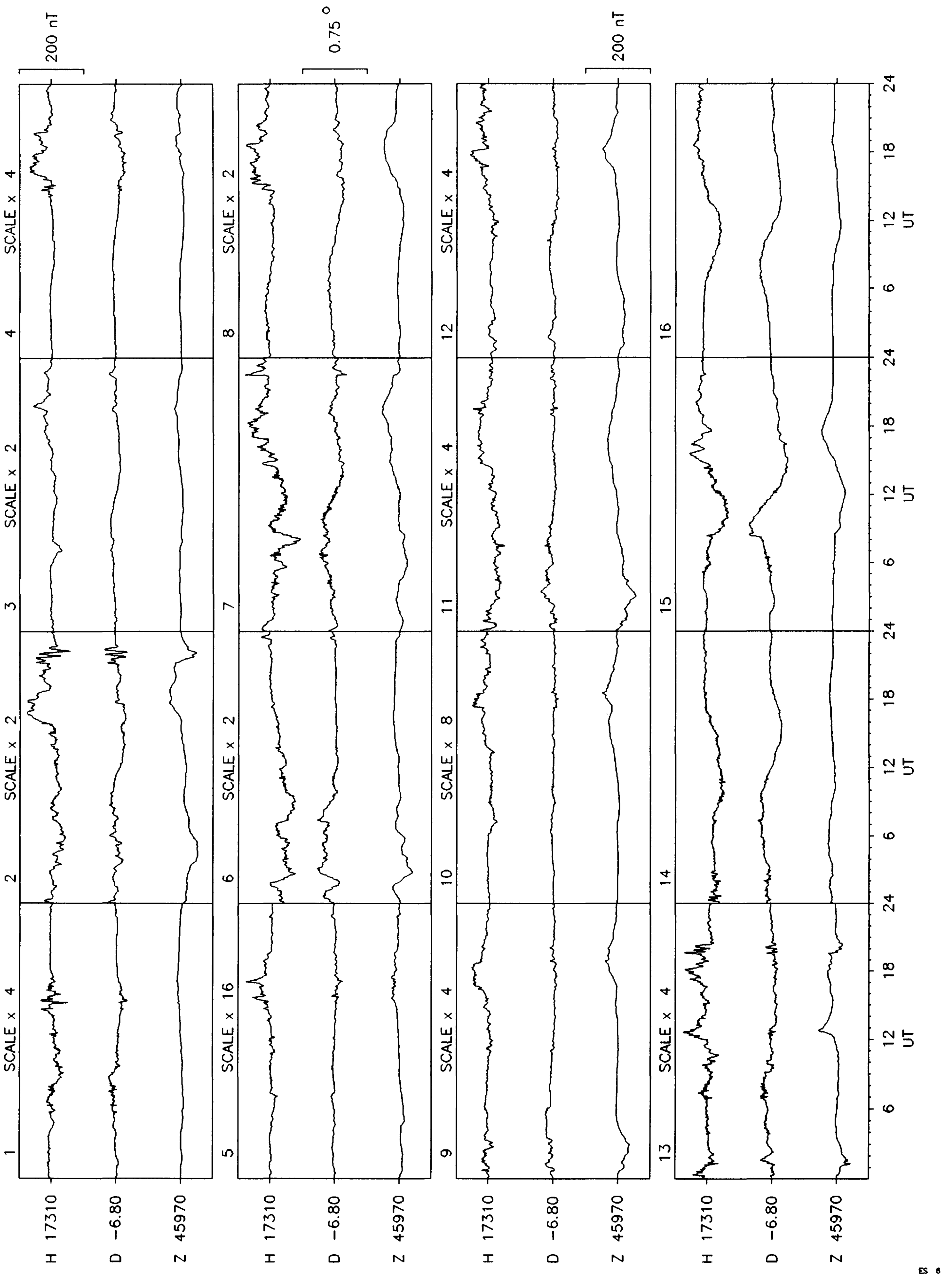
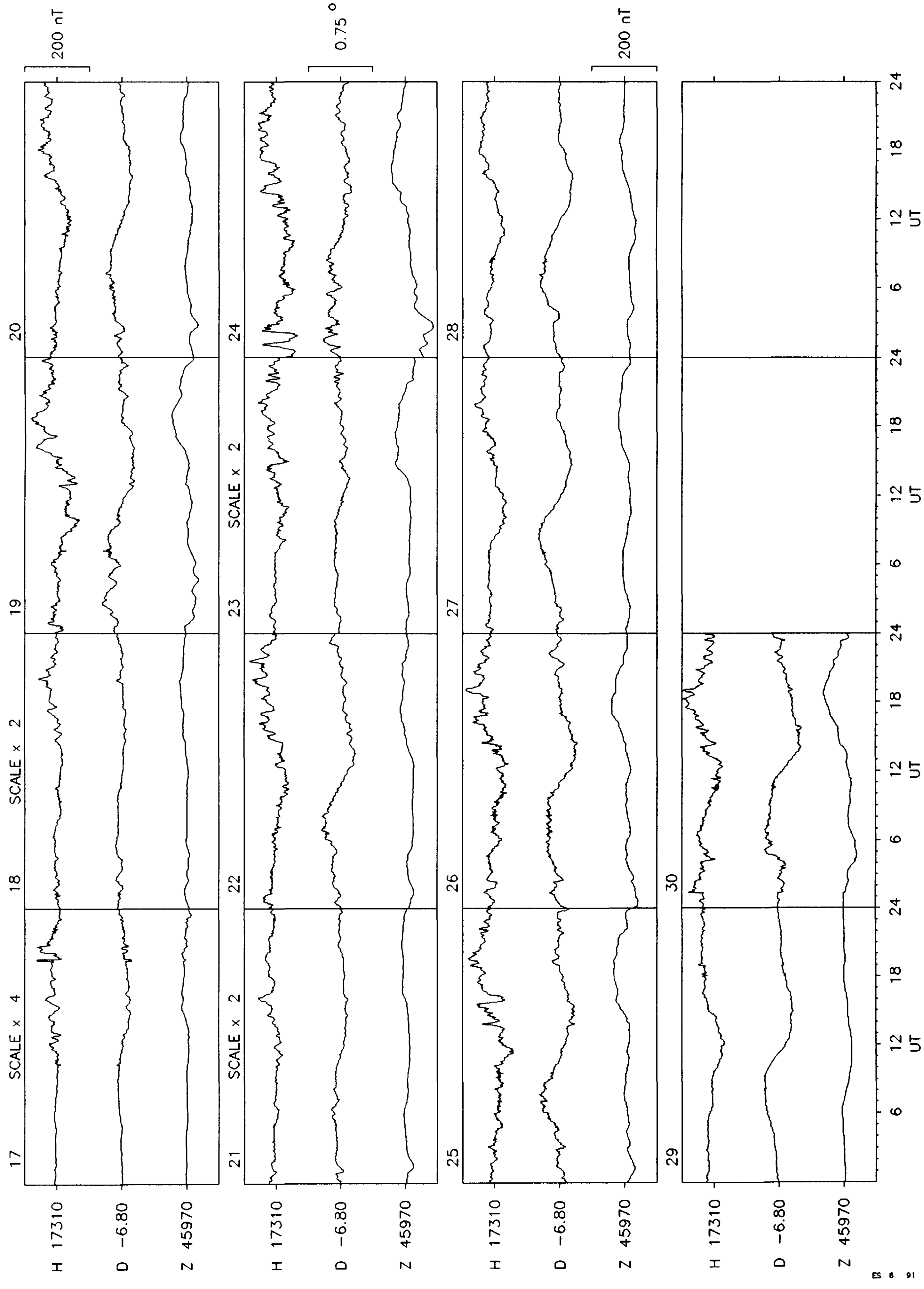
30
31
H 17310
D −6.80
Z 45970
SCALE x 2
UT
6
12
18
24
ES 5 91


200 nT
0.75 °
200 nT
1
SCALE x 4
2
SCALE x 2
3
SCALE x 2
4
SCALE x 4
5
SCALE x 16
6
SCALE x 2
7
8
SCALE x 2
9
SCALE x 4
10
SCALE x 8
11
SCALE x 4
12
SCALE x 4
13
SCALE x 4
14
15
16
H 17310
D -6.80
Z 45970
6
12
18
24
UT
ES 6



200 nT
0.75 °
200 nT
SCALE x 4
SCALE x 2
SCALE x 2
SCALE x 2
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30
H 17310
D -6.80
Z 45970
6
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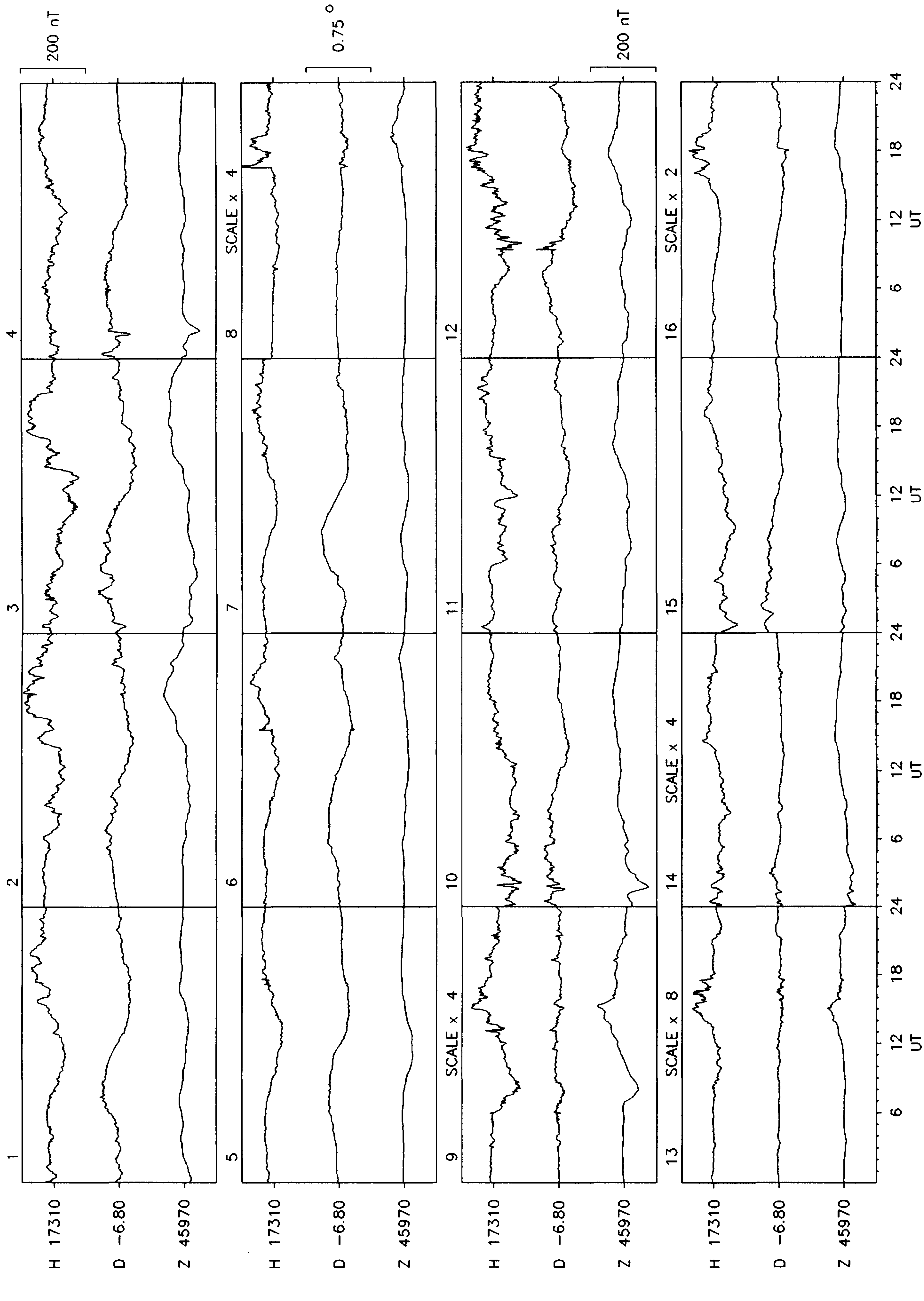
24
UT
ES 8 91


200 nT
0.75 °
200 nT
H 17310
D -6.80
Z 45970
SCALE x 4
SCALE x 8
SCALE x 2
UT
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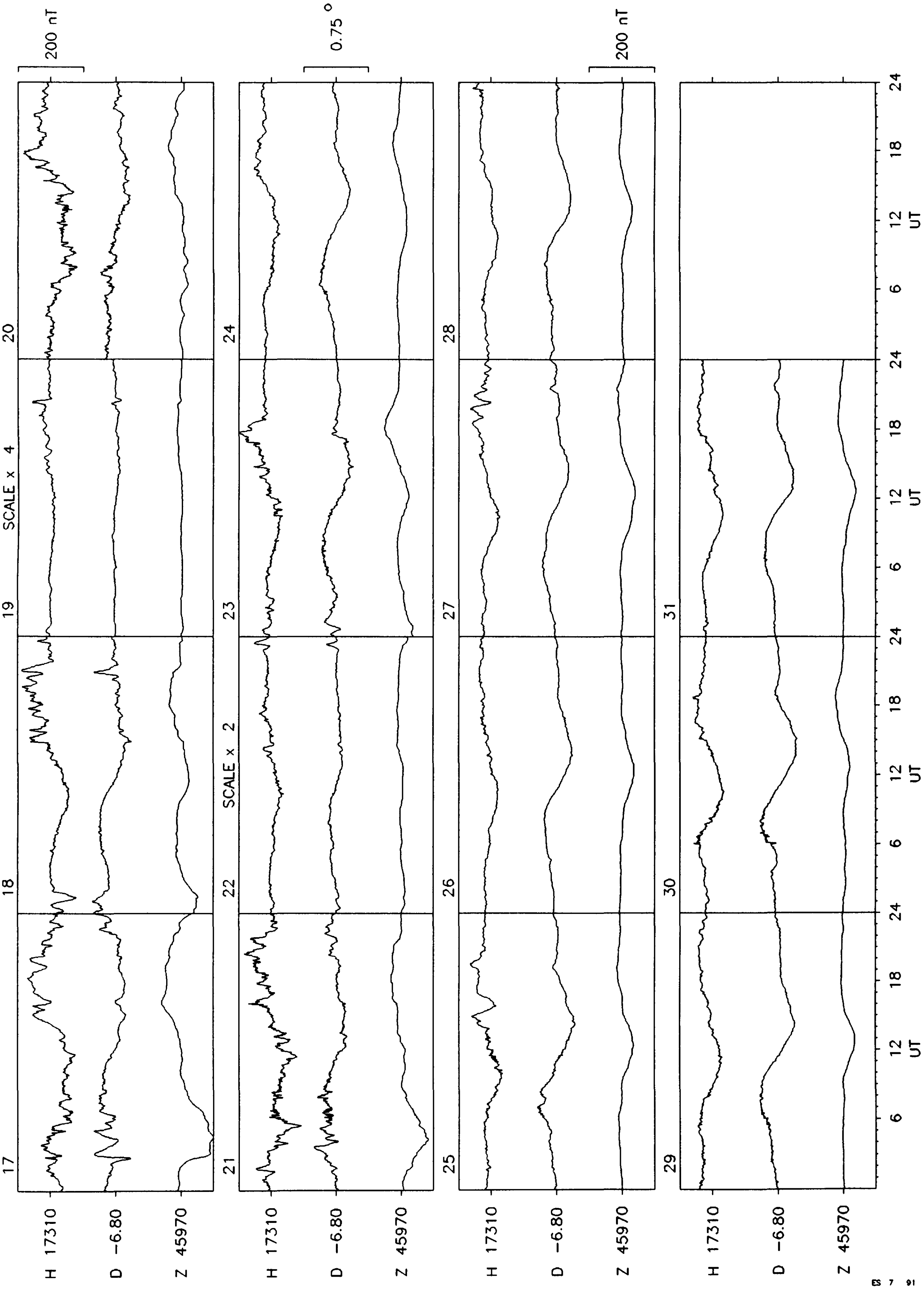
200 nT
0.75 °
200 nT
SCALE x 4
SCALE x 2
17
18
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22
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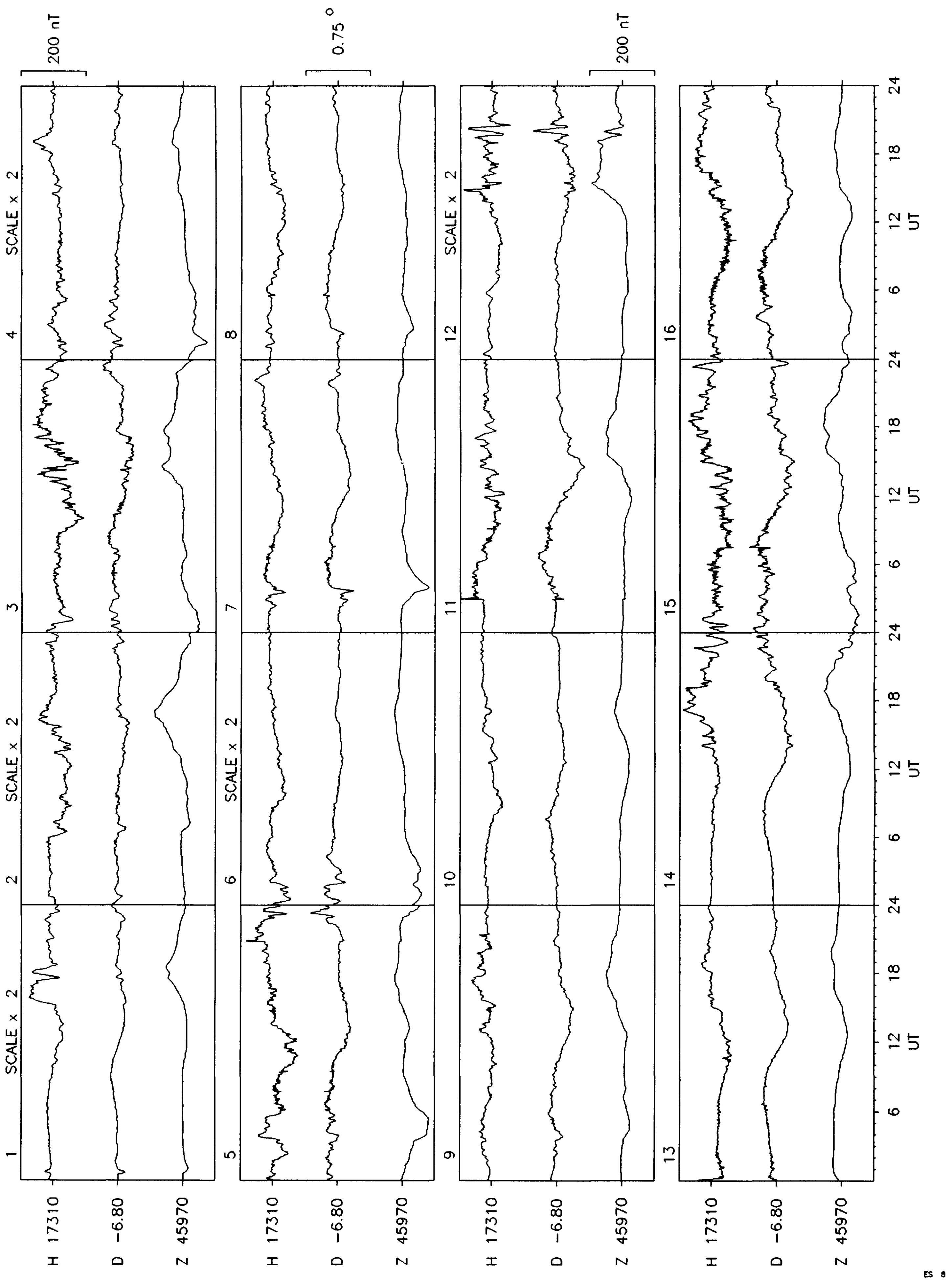
24
25
26
27
28
29
30
31
H 17310
D −6.80
Z 45970
6
12
18
24
UT


200 nT
0.75 °
200 nT
SCALE x 2
H 17310
D -6.80
Z 45970
1
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12
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16
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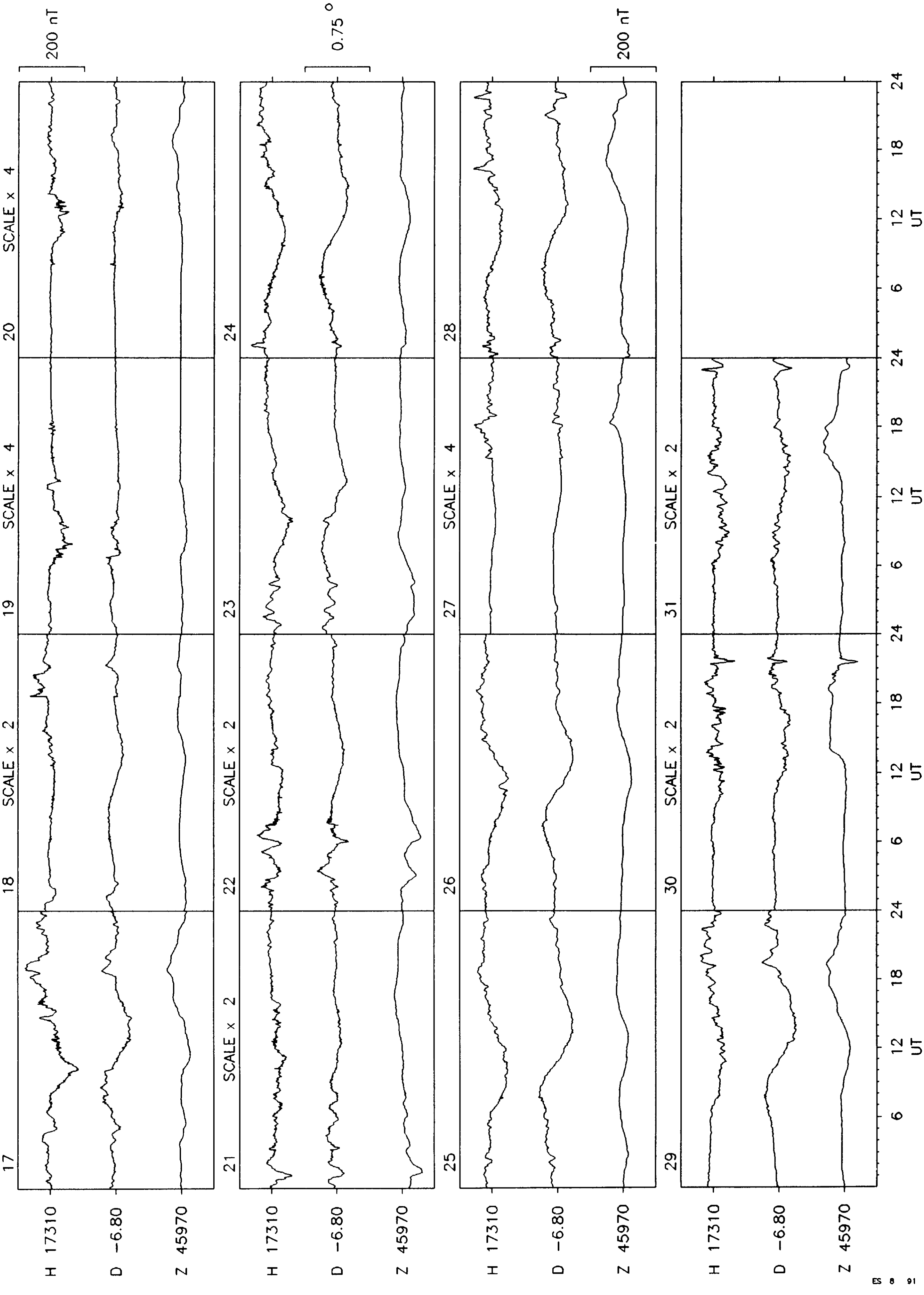
12
18
24
UT
ES 8



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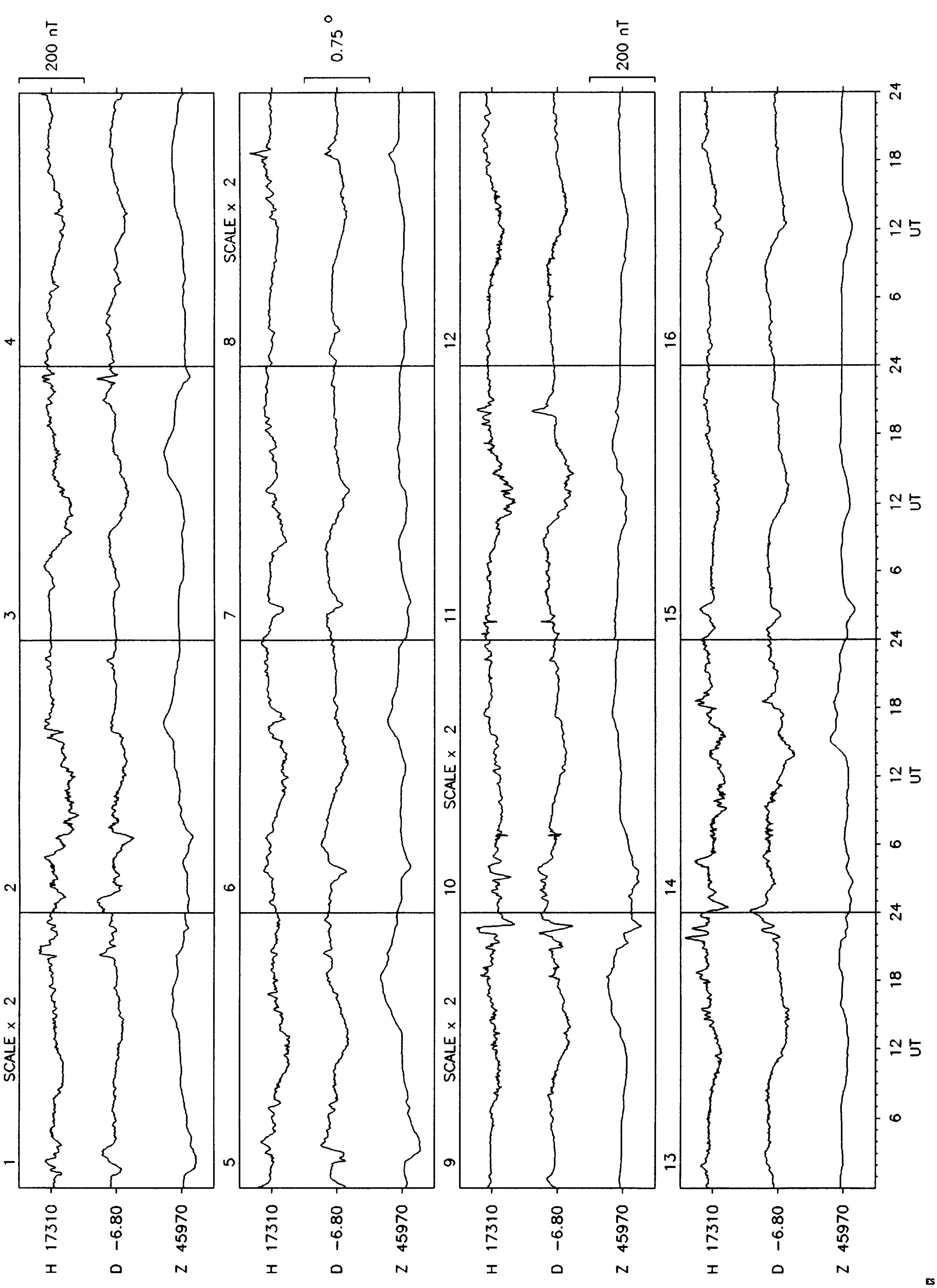
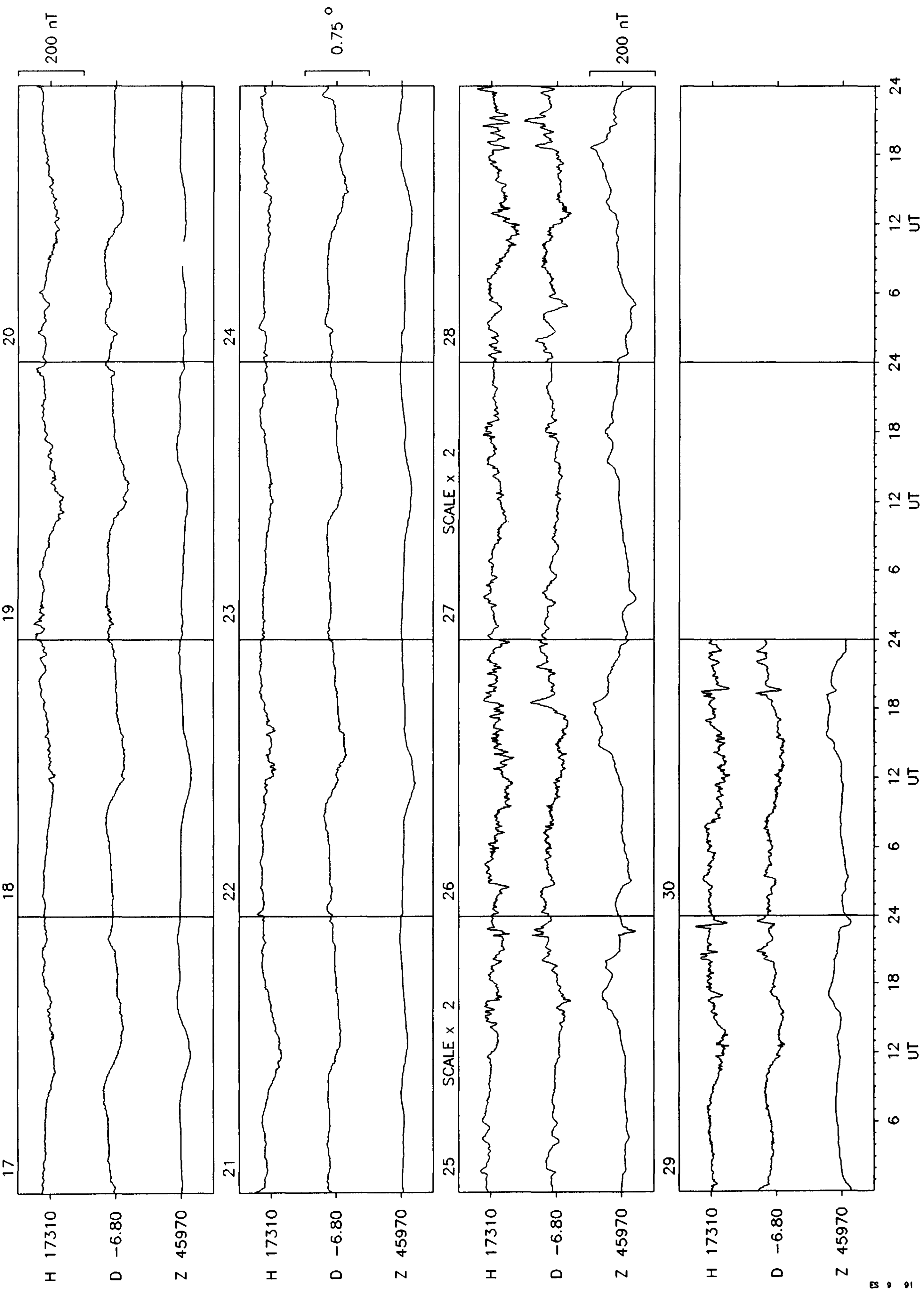
30
31
SCALE x 2
SCALE x 2
SCALE x 4
SCALE x 4
SCALE x 2
SCALE x 2
SCALE x 4
SCALE x 2
SCALE x 2
200 nT
0.75 °
200 nT
H 17310
D −6.80
Z 45970
6
12
18
24
UT
ES 8 91



200 nT
0.75 °
200 nT
SCALE x 2
H 17310
D −6.80
Z 45970
UT



200 nT
0.75 °
200 nT
17
18
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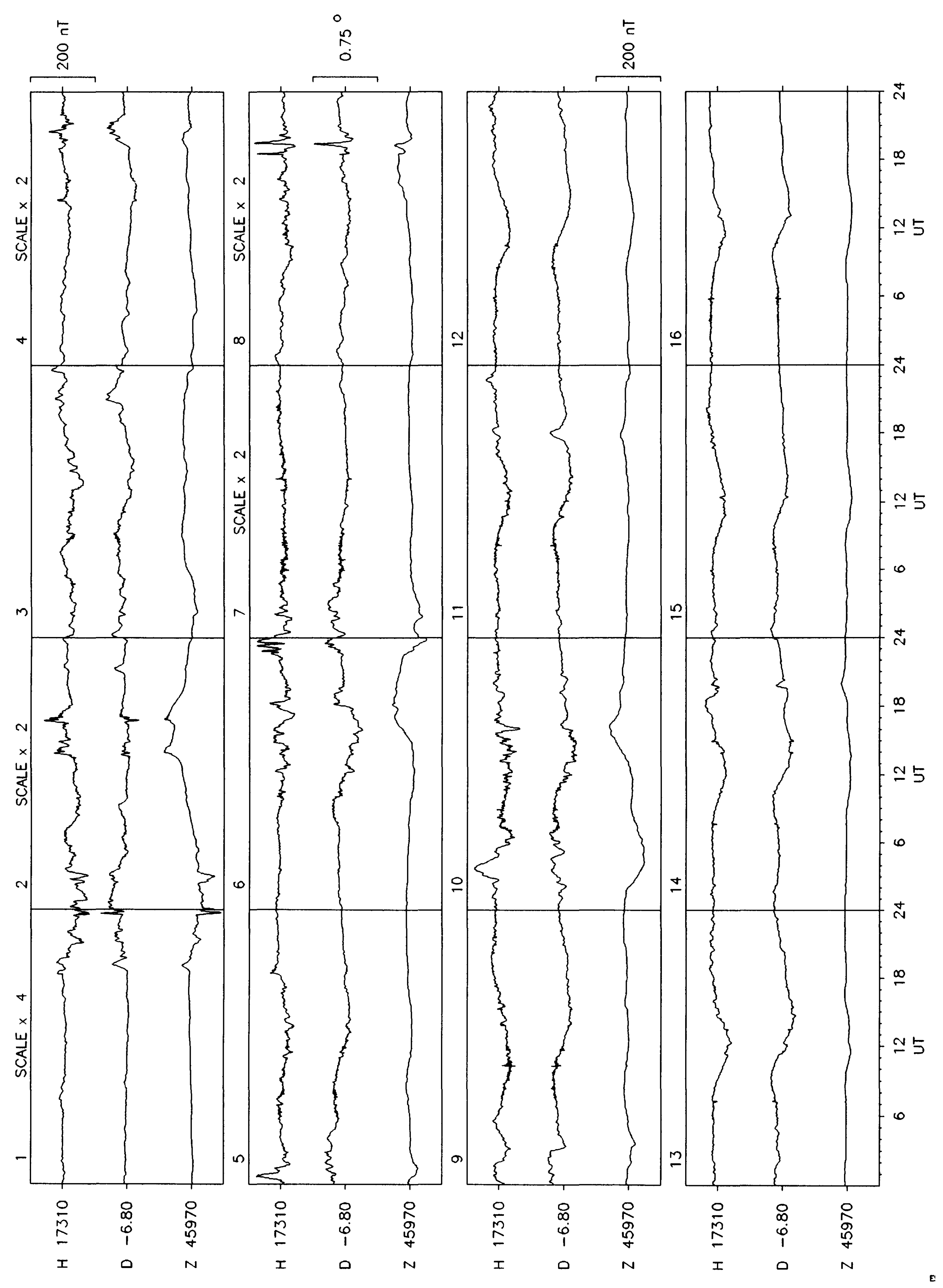
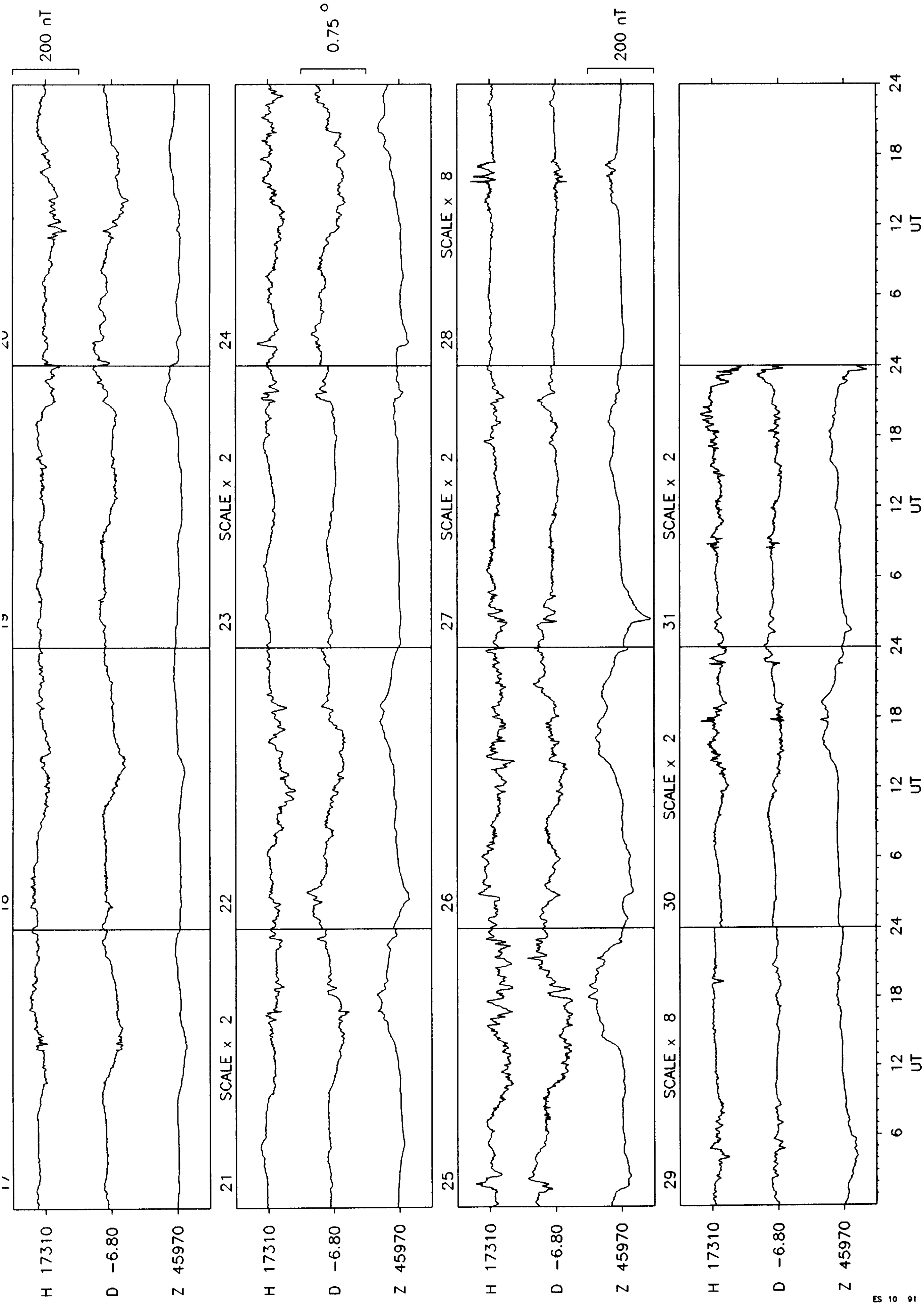
23
24
25
26
27
28
29
30
SCALE x 2
SCALE x 2
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
H 17310
D −6.80
Z 45970
6
12
18
24
UT



200 nT
0.75 °
200 nT
SCALE x 4
SCALE x 2
SCALE x 2
SCALE x 2
SCALE x 2
SCALE x 2
H 17310
D −6.80
Z 45970
UT


200 nT
0.75 °
200 nT
17
18
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24
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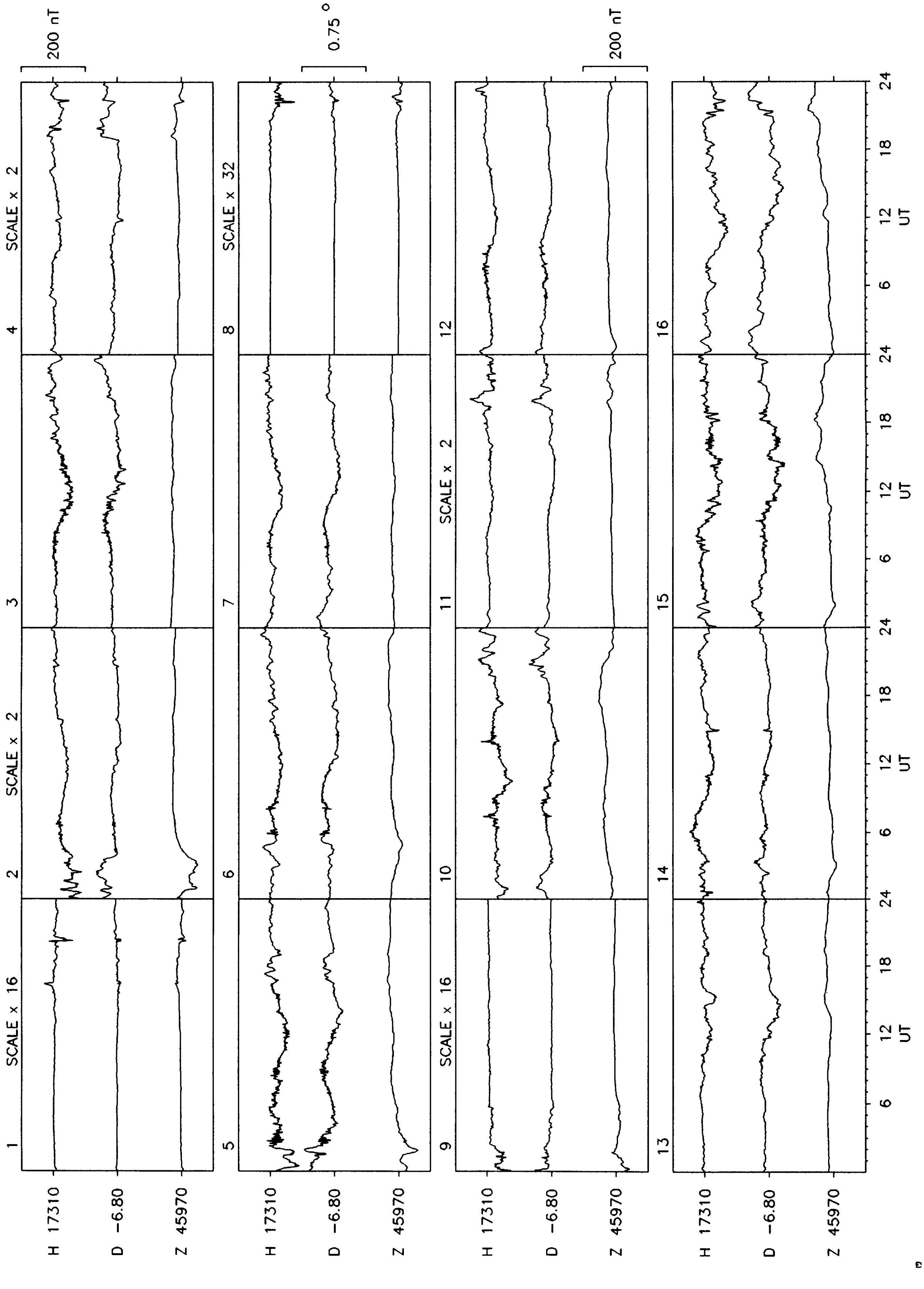
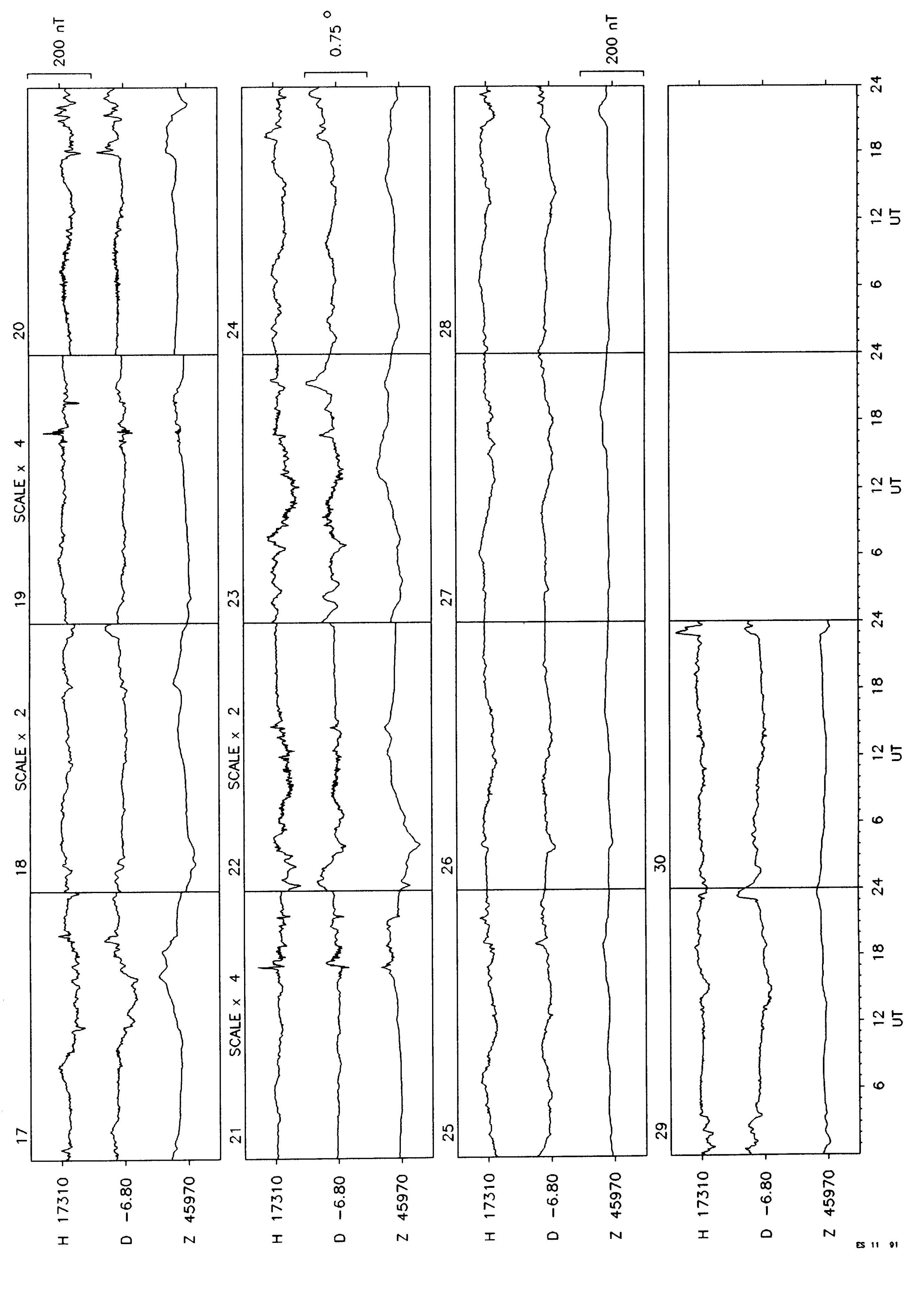
26
27
28
29
30
31
SCALE x 2
SCALE x 2
SCALE x 2
SCALE x 8
SCALE x 8
SCALE x 2
H 17310
D −6.80
Z 45970
UT
6
12
18
24
ES 10 91


200 nT
0.75 °
200 nT
SCALE x 16
SCALE x 2
SCALE x 2
SCALE x 32
SCALE x 16
SCALE x 2
H 17310
D -6.80
Z 45970
UT


200 nT
0.75 °
200 nT
SCALE x 2
SCALE x 4
SCALE x 2
SCALE x 4
17
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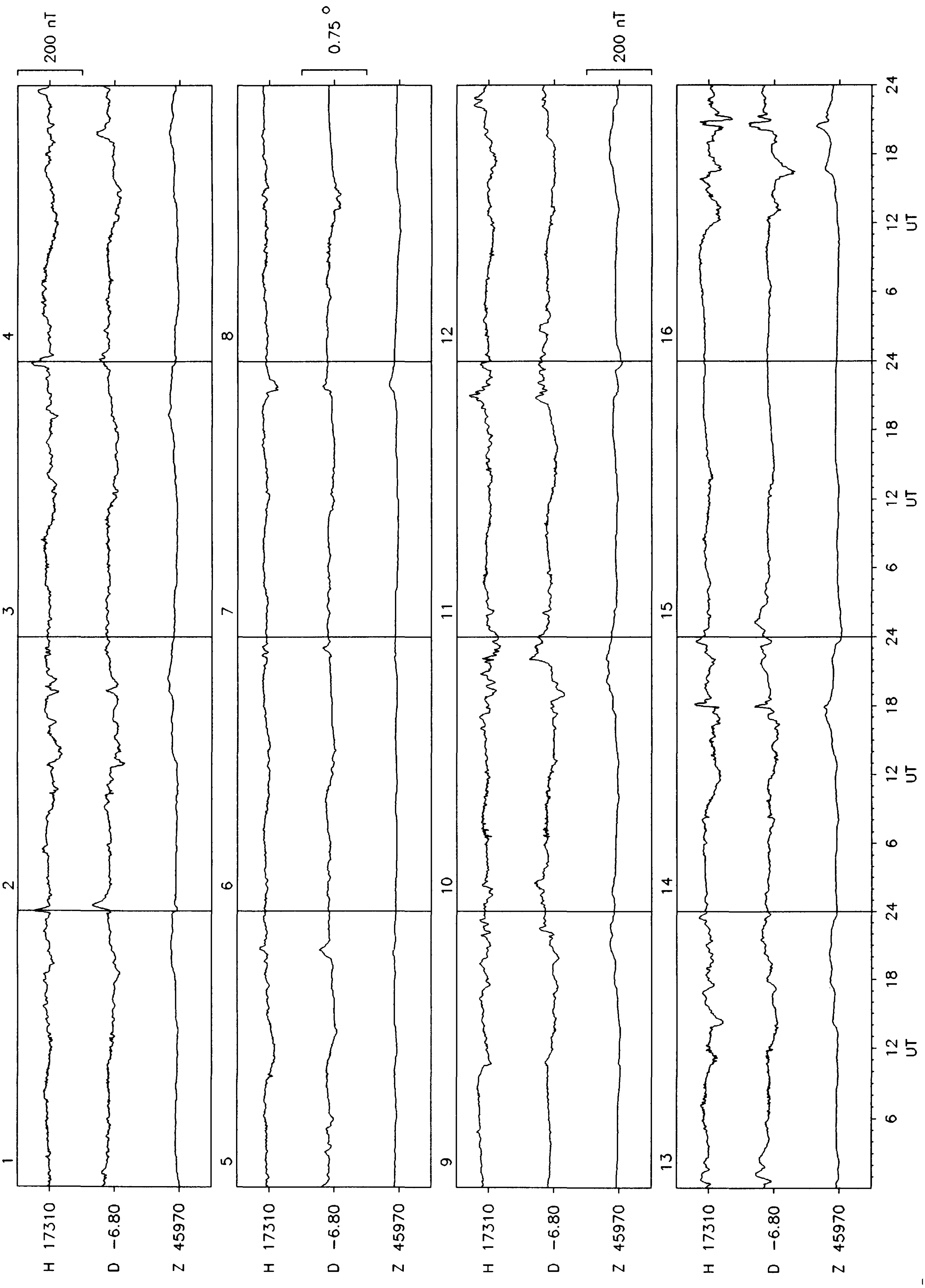
21
22
23
24
25
26
27
28
29
30
H 17310
D −6.80
Z 45970
UT


H 17310
D -6.80
Z 45970
200 nT
0.75 °
1
2
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4
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6
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8
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10
11
12
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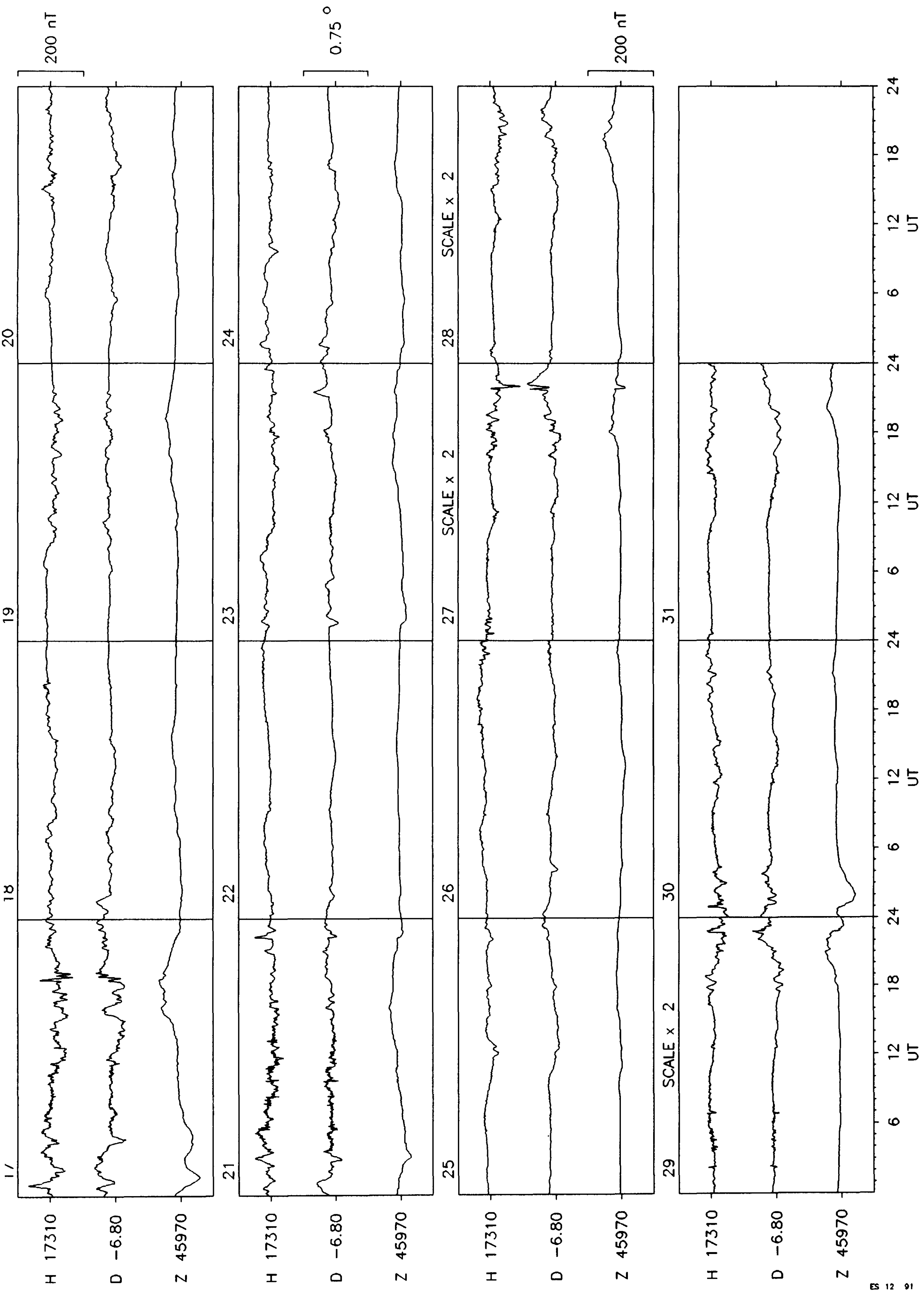
14
15
16
UT



200 nT
0.75 °
200 nT
H 17310
D −6.80
Z 45970
17
18
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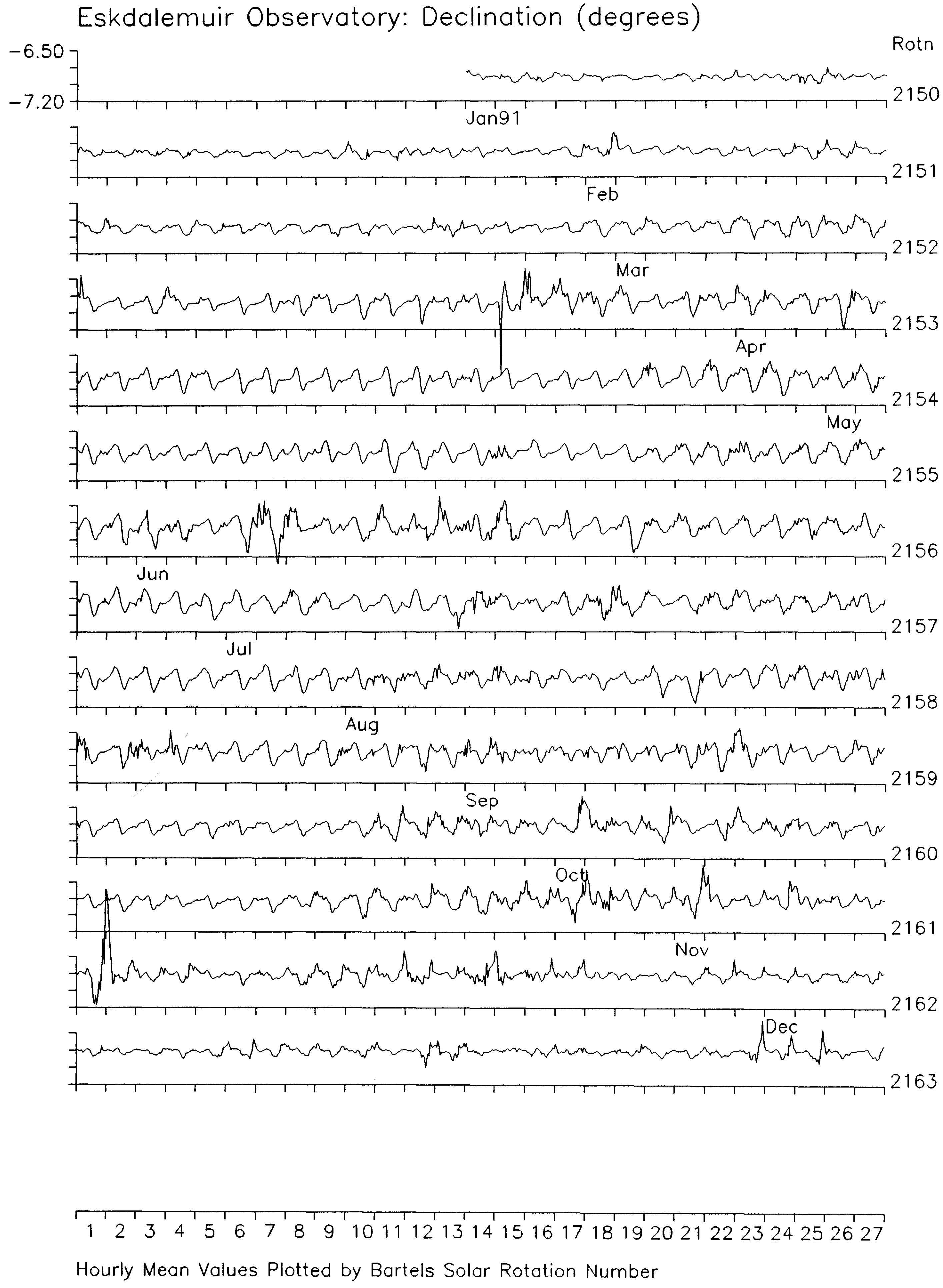
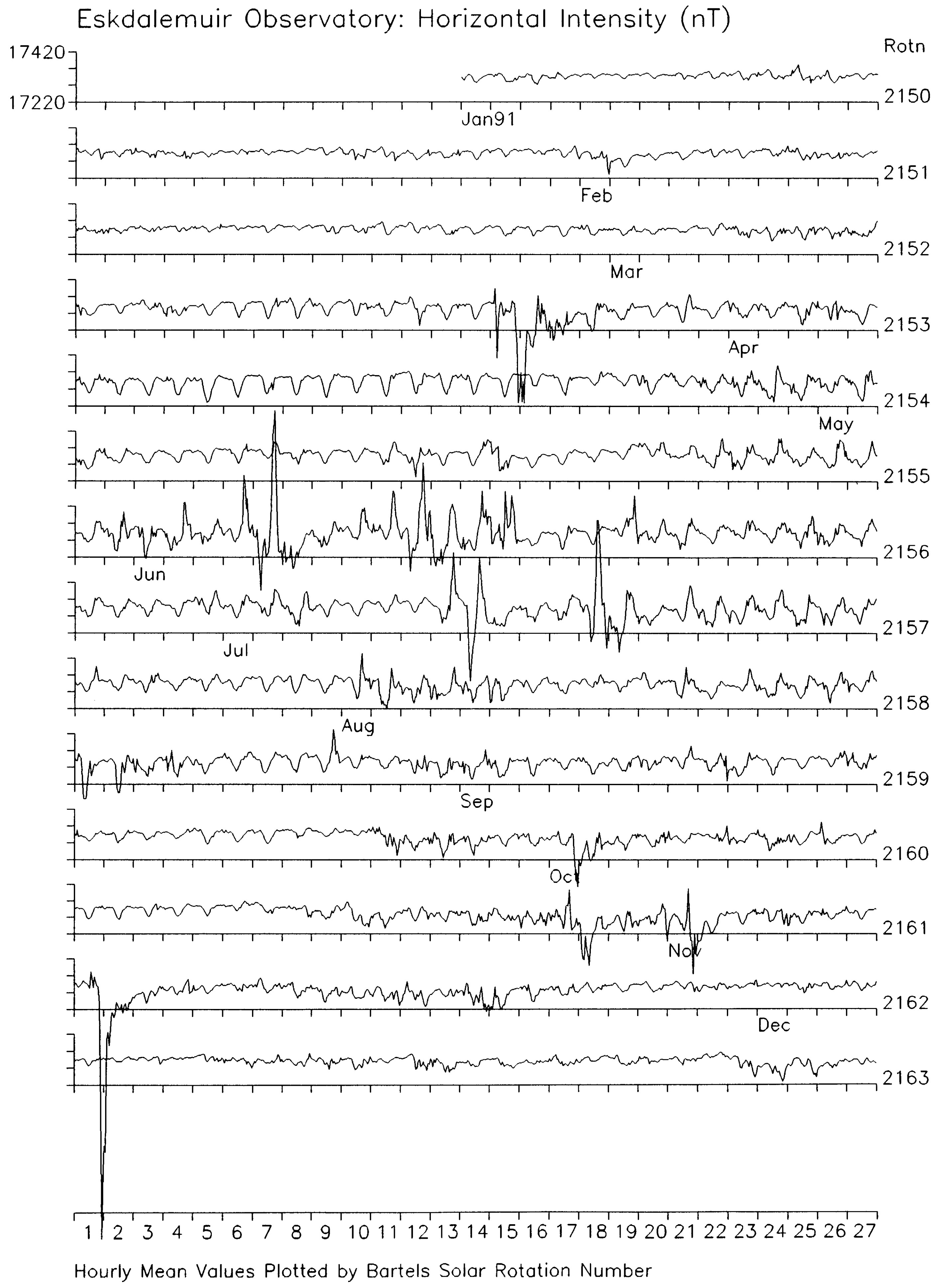
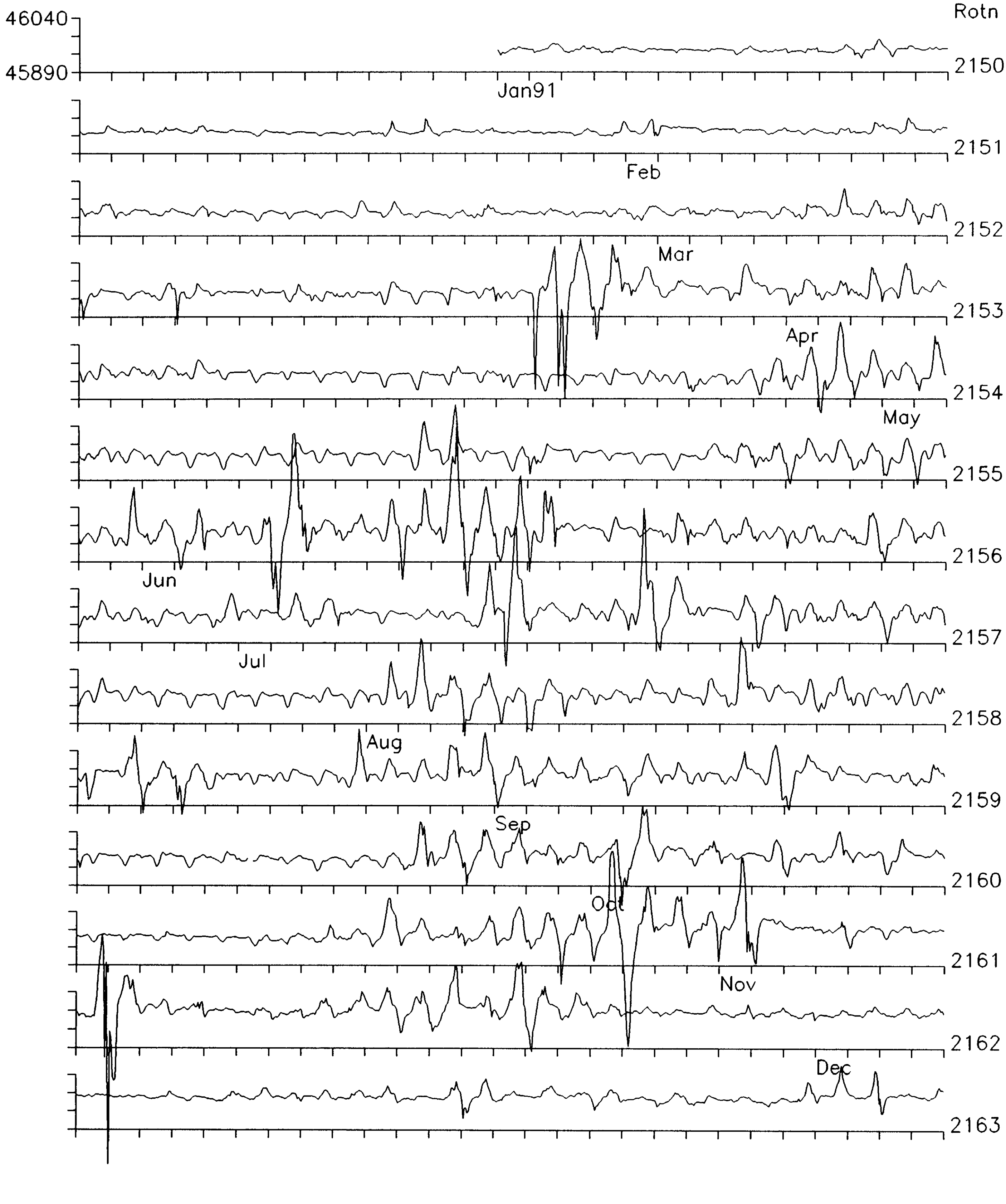
22
23
24
25
26
27
28
29
30
31
SCALE x 2
SCALE x 2
SCALE x 2
UT
6
12
18
24
ES 12 91

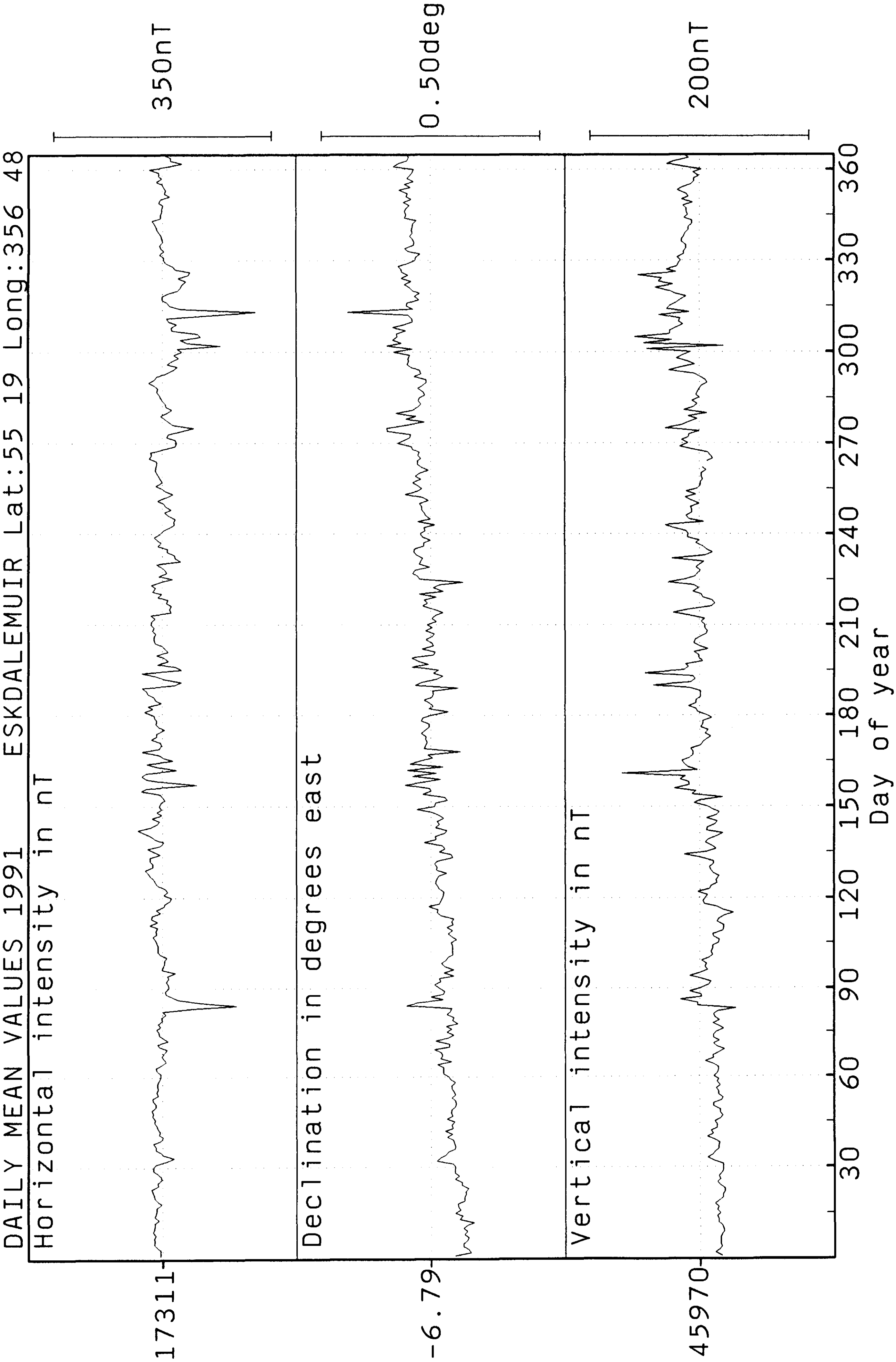

Eskdalemuir Observatory: Declination (degrees)
Rotn
-6.50
-7.20
2150
Jan91
2151
Feb
2152
Mar
2153
Apr
2154
May
2155
2156
Jun
2157
Jul
2158
Aug
2159
Sep
2160
Oct
2161
Nov
2162
Dec
2163
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Hourly Mean Values Plotted by Bartels Solar Rotation Number


Eskdalemuir Observatory: Horizontal Intensity (nT)
17420
17220
Rotn
2150
Jan91
2151
Feb
2152
Mar
2153
Apr
2154
May
2155
2156
Jun
2157
Jul
2158
Aug
2159
Sep
2160
Oct
2161
Nov
2162
Dec
2163
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)



Hourly Mean Values Plotted by Bartels Solar Rotation Number


DAILY MEAN VALUES 1991 ESKDALEMUIR Lat:55 19 Long:356 48
Horizontal intensity in nT
350nT
17311
Declination in degrees east
0.50deg
-6.79
Vertical intensity in nT
200nT
45970
30
60
90
120
150
180
210
240
270
300
330
360
Day of year

Monthly and annual mean values for Eskdalemuir 1991

Month	D	H	I	X	Y	Z	F
Jan	-6 51.9	17321	69 20.8	17197	-2070	45951	49107
Feb	-6 50.4	17319	69 21.0	17196	-2063	45955	49110
Mar	-6 49.3	17303	69 22.2	17181	-2055	45959	49108
Apr	-6 49.8	17314	69 21.4	17191	-2059	45959	49112
May	-6 48.7	17323	69 20.9	17201	-2055	45960	49116
Jun	-6 47.3	17319	69 21.5	17198	-2047	45975	49129
Jul	-6 47.5	17318	69 21.6	17196	-2048	45975	49129
Aug	-6 47.1	17309	69 22.2	17188	-2045	45975	49125
Sep	-6 45.9	17310	69 22.0	17189	-2039	45973	49124
Oct	-6 44.9	17299	69 22.9	17179	-2033	45979	49126
Nov	-6 44.2	17286	69 24.2	17167	-2028	45995	49136
Dec	-6 44.6	17312	69 22.1	17192	-2033	45982	49133
Annual	-6 47.6	17311	69 21.9	17189	-2048	45970	49121

D and I are given in degrees and decimal minutes
H, X, Y, Z and F are given in nanotesla

ESKDALEMUIR OBSERVATORY K INDICES 1991

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	3100 1000	3123 3455	2222 2243	4334 3234	4333 4434	3465 6723	3221 2332	4213 3655	5443 3354	3242 3367	5244 5896	2221 2233
2	2311 2222	4312 1101	3212 2322	3233 3324	4343 5454	4443 4646	1234 4443	4353 5534	4443 3313	5544 5534	5533 3333	4223 3332
3	2222 2102	0111 1101	2111 1022	2344 4344	3332 3333	2241 2353	4333 5433	4234 5544	1233 3334	3333 3244	2133 3334	2222 3234
4	2310 1112	2001 1013	2101 2333	2235 5454	3111 2422	1223 5764	4222 4221	5543 4454	3221 3223	3331 4355	3334 3355	3222 2243
5	1111 3022	2221 1122	2334 4423	4222 3322	2110 1212	6677 8976	1101 2221	4434 4345	3432 3332	4322 3230	4333 3332	2312 2131
6	0000 1001	1001 1022	3234 2454	3321 2342	1110 2212	5455 4324	1211 2333	5433 3332	3422 2312	1113 3444	2332 2322	1111 1102
7	1000 1001	1211 2323	3233 3344	3232 3332	2121 1220	3343 4444	3200 1222	3431 2223	4332 3221	5533 4333	3223 2232	1111 1123
8	2111 2122	2222 3323	2213 2334	2210 1122	2223 2341	3222 4553	2244 4764	3222 2212	3311 4452	3334 4463	2233 5679	1112 2110
9	1211 1113	4112 2444	3322 4324	3220 2232	2221 2443	5534 4653	4475 7655	2322 3433	4345 4446	3323 2221	9755 5444	0113 2333
10	3011 2213	2112 2111	4521 2210	2311 3212	1122 3323	4465 7776	4431 4321	1221 2212	4543 3434	3534 3432	3233 4344	3232 2334
11	1101 2221	3322 1334	0011 2212	1012 1121	1000 1200	6655 6464	3234 4433	4433 4431	4233 4343	2133 2433	3222 2354	3211 2244
12	4242 2332	3323 2211	1232 3344	3233 3411	0101 1221	4435 5665	3235 4434	3343 6564	1232 2222	1212 1112	3232 1113	3312 2323
13	3211 2231	2212 2222	5342 2310	1111 2211	1335 4442	7456 7674	4455 8846	4122 2231	2222 3334	2221 3221	1112 3322	3223 3323
14	0000 1110	1111 2233	3221 0110	0111 2222	0344 4534	3222 2211	6554 6453	0011 3445	4434 3333	2021 3332	3333 3223	1122 3434
15	3211 2043	4111 2223	1002 3200	1111 2210	3222 2210	1242 4422	3322 2131	4443 4444	3211 2222	2111 2220	4234 4333	3111 2000
16	1011 2113	1001 1211	0001 1341	0002 3321	1112 2353	0011 2222	2211 3554	3333 4433	2112 2121	1211 2110	3333 3334	0011 3444
17	3111 2323	1001 1101	2312 3334	1223 4431	5454 4310	2315 5676	5433 4434	2334 4443	1011 1212	1002 3222	3234 3443	5433 4443
18	2101 2333	0000 1112	3221 1110	1234 3223	1210 2200	3333 3443	4211 4444	4122 3354	1001 2113	3212 3222	4323 3345	3232 1220
19	0001 1111	1002 2331	0212 3343	2333 2222	0100 1221	3443 4433	4343 5463	4466 5442	3212 3223	2312 2343	5444 3764	1023 2321
20	2101 1220	0011 1232	2322 2221	0001 1111	1111 2100	3222 2433	2344 3533	2245 6444	3321 1202	3223 4323	1223 2444	1211 3322
21	0201 1102	3212 1220	0123 5433	1112 2221	0112 2331	3333 4533	3534 4444	5444 3423	3101 1101	2312 3444	2444 4755	4433 3324
22	1100 1001	1233 2224	2333 3224	3122 3320	4333 3332	3233 3334	3333 4434	4653 4333	2112 3211	3433 3332	5544 5323	2111 0001
23	1001 1123	2233 3344	3212 3221	0103 1423	3323 3434	3244 5554	3322 3441	3313 2111	1101 1111	3322 2345	3343 3434	3322 2233
24	4323 2433	1221 1123	2976 4489	3111 2134	4332 5443	5433 4433	1222 2221	3321 3333	2201 2223	4333 3344	3321 2333	3213 2210
25	1112 2353	2113 3222	7844 6646	4422 2122	4544 4443	3433 4433	2223 4431	3221 2222	4433 4555	4333 3454	3121 2233	0001 3212
26	2322 2114	1222 2221	7555 7544	3411 2224	3333 4553	3333 4343	0111 2221	2223 3232	4333 4344	4333 4344	0322 2110	2211 1223
27	0101 1124	0013 2222	3333 5434	4422 3333	3333 3333	3222 2333	2111 1243	3221 2664	4443 4543	5433 3455	2111 2221	3224 3446
28	1111 1102	3333 3223	3332 3331	3432 4444	4333 2444	2421 2322	1110 1213	3221 2434	4434 4354	4444 6845	2010 2233	3212 4344
29	1001 1002		0010 0113	5434 6534	5423 3343	1111 3221	2221 2112	0012 2344	3113 3344	6765 4565	3311 3324	3432 2345
30	0000 2211		1233 4444	4443 5433	3122 3433	3422 4443	1341 2331	2223 5445	3333 3343	2124 5545	3222 2124	4312 2232
31	2221 2323		3211 1113		3345 5542		2110 2322	2354 5535		4244 4456		2001 2232

SIs and SSCs

Day	Month	UT		Type	Quality	H(nT)	D(min)	Z(nT)
12	1	01	52	SSC	C	28	-2.8	-5
1	2	18	42	SI	B	55	4.0	-7
4	2	22	14	SSC*	B	26	-1.9	-3
4	3	16	18	SSC*	B	30	-3.0	
9	3	22	45	SSC	B	68	-1.9	-10
24	3	03	41	SSC	A	347	-34.6	-30
4	4	11	22	SSC	B	21	8.0	-14
19	4	10	55	SI*	B	42	-1.9	-6
13	5	08	56	SSC*	B	-23	10.2	-6
16	5	20	41	SSC	A	103	-4.0	-12
21	5	12	27	SSC*	C	23	-2.4	-2
31	5	10	38	SSC*	B	-84	12.4	3
7	6	22	28	SI	B	64	-6.8	-10
9	6	00	40	SI*	C	87	-10.1	-21
12	6	10	12	SSC	B	-11	11.7	-4
17	6	10	18	SSC*	A	-51	8.5	-4
30	6	01	15	SSC*	B	46	-3.8	-6
6	7	15	26	SI*	C	44	-2.8	
8	7	16	35	SSC*	A	343	-10.0	-23
12	7	09	23	SSC*	B	-39	13.9	2
5	8	20	46	SI	B	55	-1.0	-4
11	8	02	53	SSC*	A	70	-8.2	-8
18	8	18	33	SSC*	A	109	-5.5	-8
20	8	08	01	SI*	B	-54	13.3	
27	8	15	14	SSC*	A	88	-9.1	-6
10	9	06	47	SI*	B	-49	13.6	-5
11	9	01	30	SI*	B	-41	8.9	3
1	10	18	14	SSC*	A	68	-2.1	-4
8	10	18	26	SSC*	B	157	-9.9	-4
17	10	13	30	SSC*	B	25	-4.3	-3
28	10	10	53	SSC*	B	-43	7.2	4
1	11	11	41	SSC*	C	11	-9.0	
8	11	06	47	SSC*	B	-25	-3.8	
8	11	13	12	SSC*	B	49	-9.3	-5
11	11	17	50	SSC*	B	23	-2.1	
19	11	04	21	SSC	B	21	-6.4	

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		Maximum		End		H(nT)	D(min)	Z(nT)
23	3	12	30	12	35	12	46	35	-2.8	-3
11	4	11	14	11	17	11	25	-14		5
15	6	08	12	08	20	08	35	17	8.6	

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

Annual Values of Geomagnetic Elements

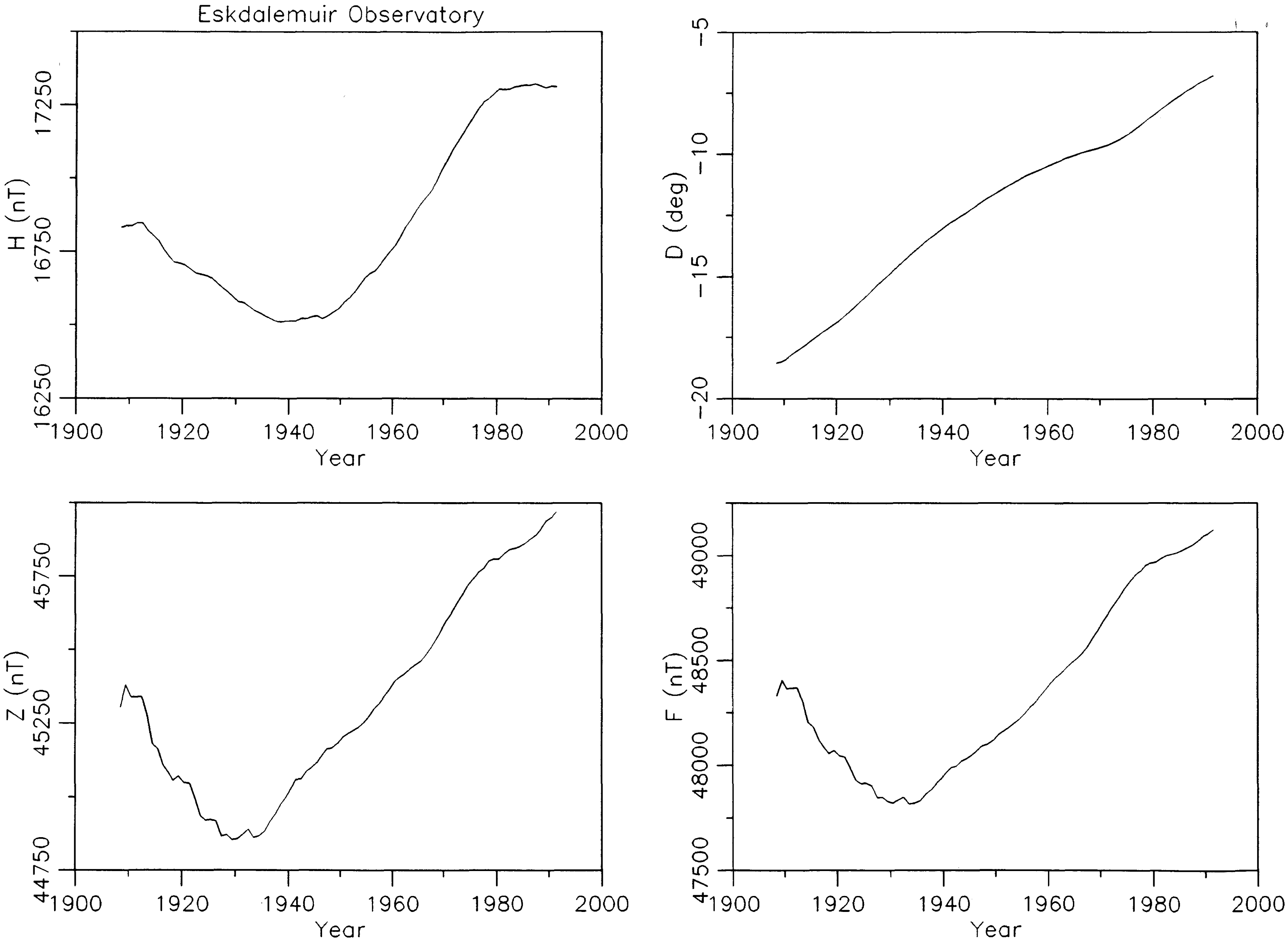
Eskdalemuir

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

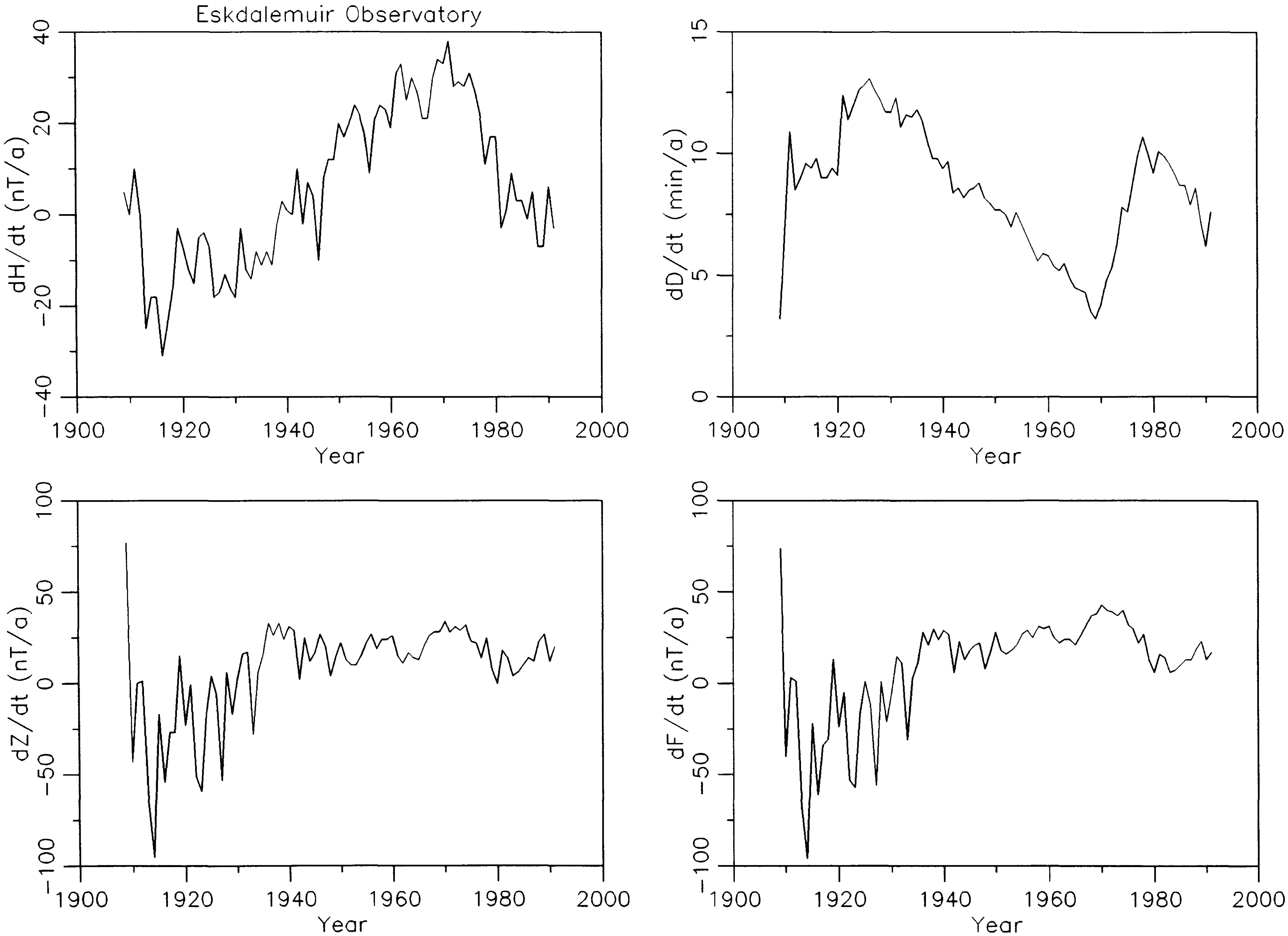
	Year	D		H	I		X	Y	Z	F
	1970.5	-9	41.6	17046	69	29.6	16803	-2870	45576	48659
	1971.5	-9	36.8	17084	69	27.8	16844	-2853	45604	48699
	1972.5	-9	31.5	17112	69	26.7	16876	-2832	45635	48738
	1973.5	-9	25.2	17141	69	25.5	16910	-2805	45664	48775
	1974.5	-9	17.4	17169	69	24.5	16944	-2772	45696	48815
	1975.5	-9	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	1.4	17297	69	21.5	17167	-2115	45916	49066
Note 1		0	0.0	11	0	-0.2	11	-1	22	25
	1990.5	-6	55.2	17314	69	21.2	17188	-2086	45950	49104
	1991.5	-6	47.6	17311	69	21.9	17189	-2048	45970	49121

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

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

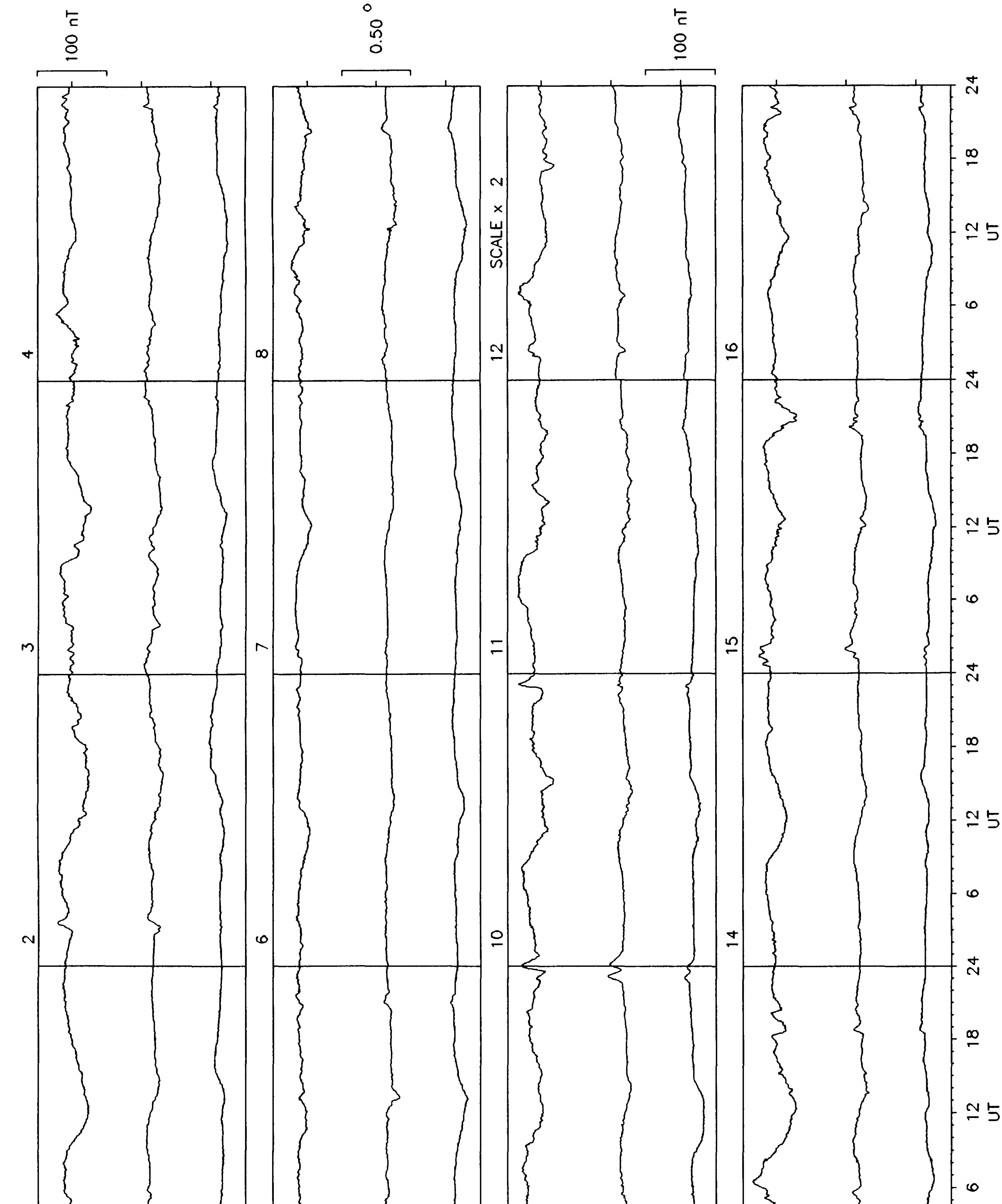


Annual mean values of H, D, Z & F at Eskdalemuir



Rate of change of annual mean values for H, D, Z & F at Eskdalemuir

Hartland 1991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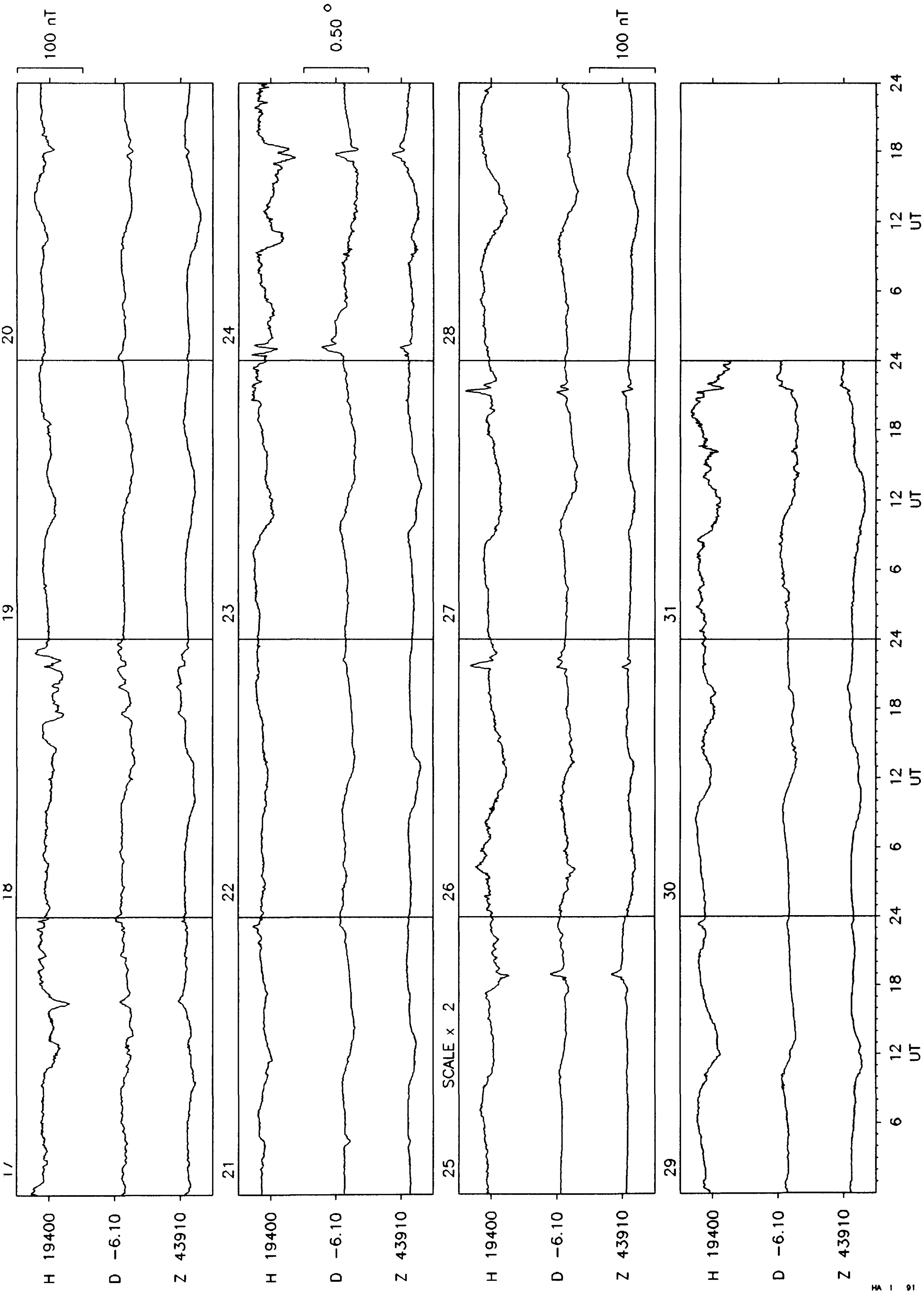
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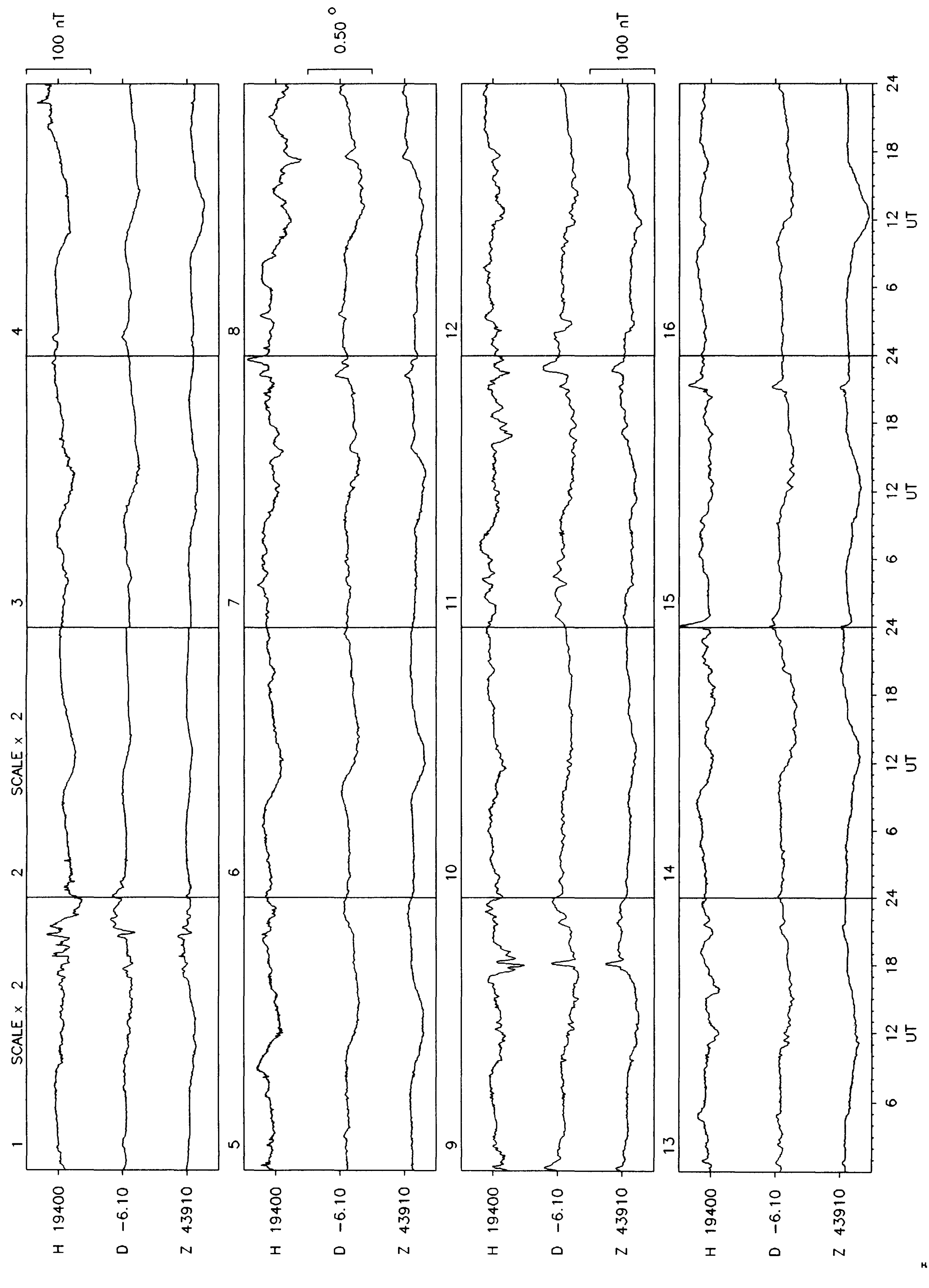

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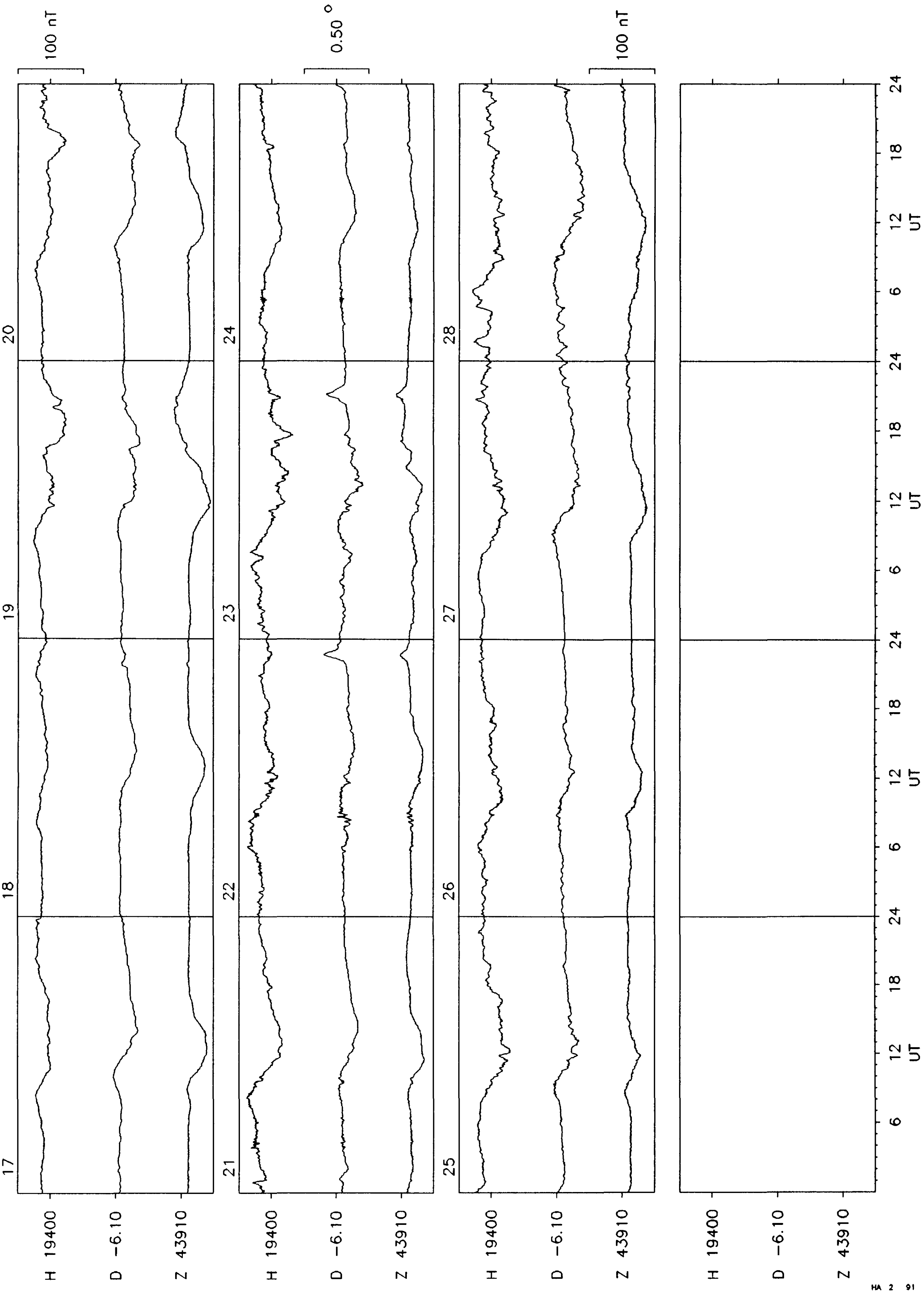
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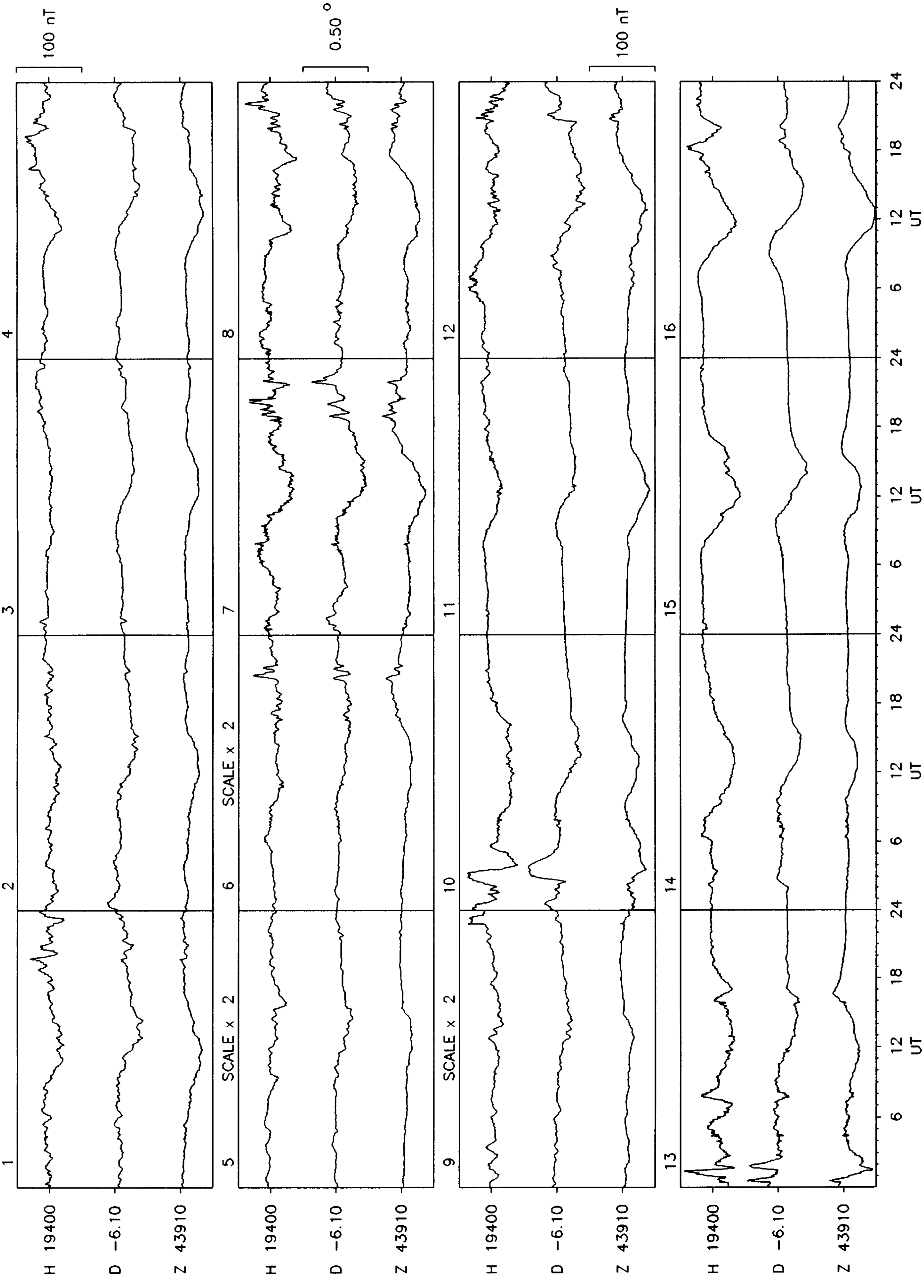
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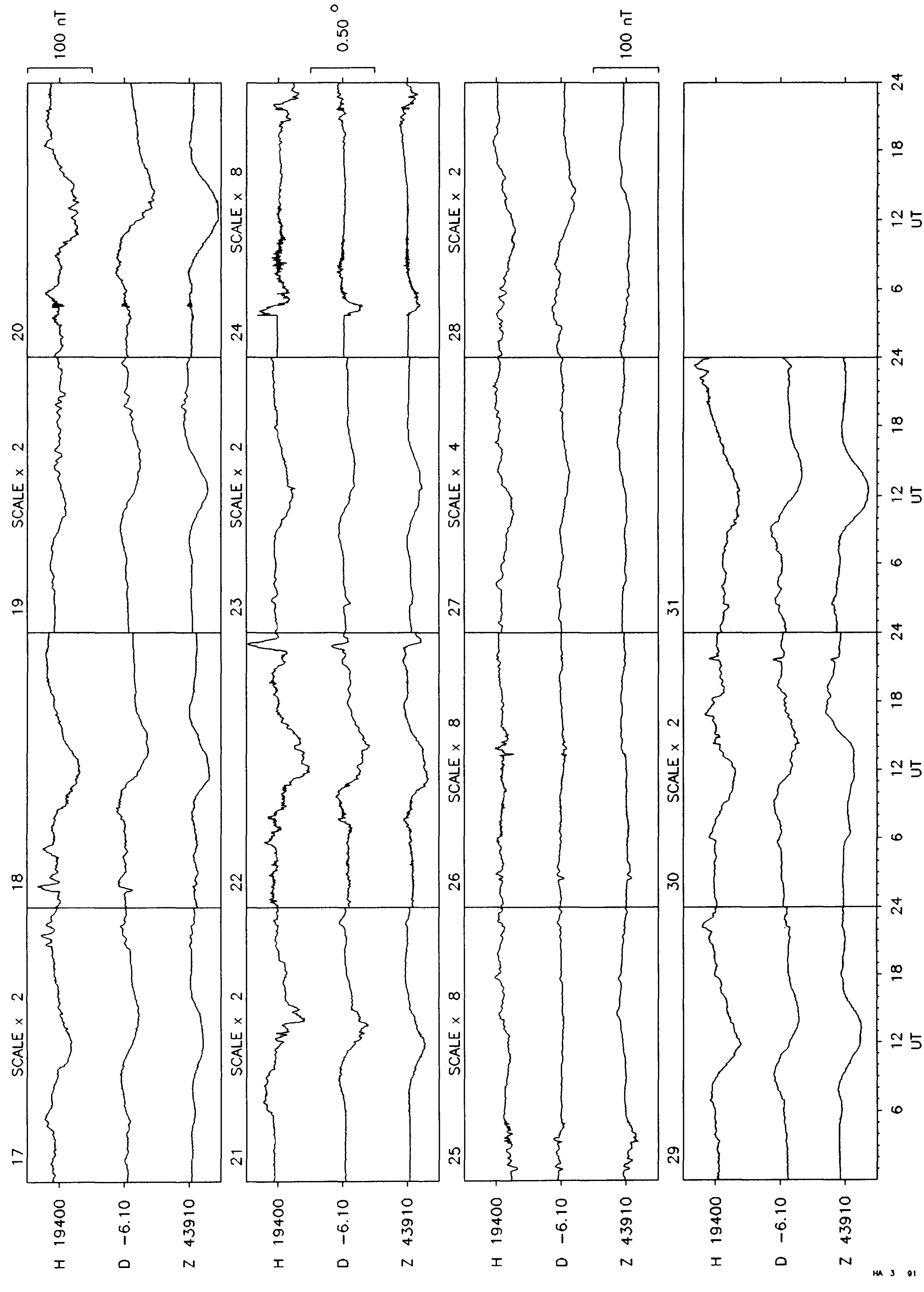
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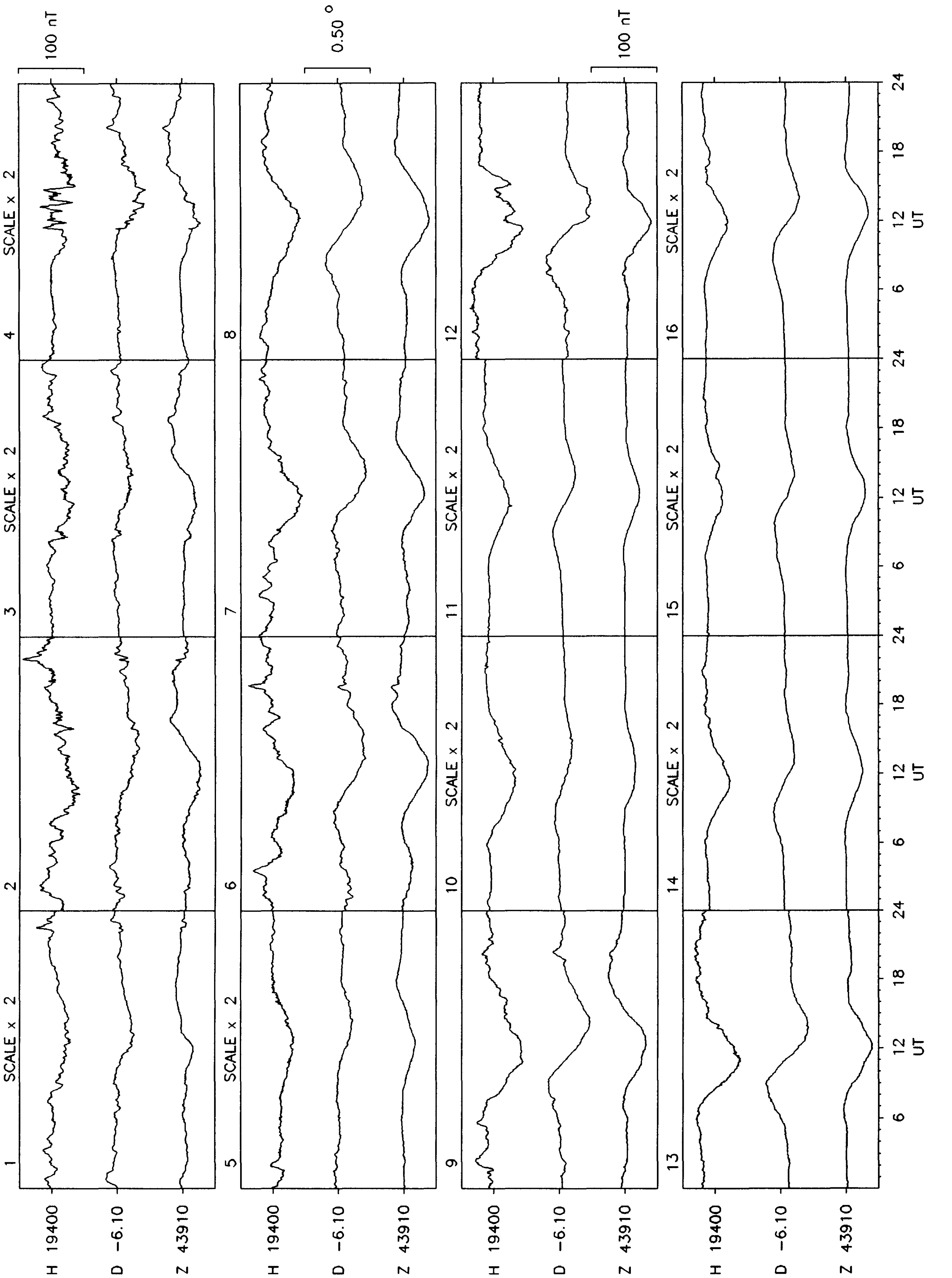
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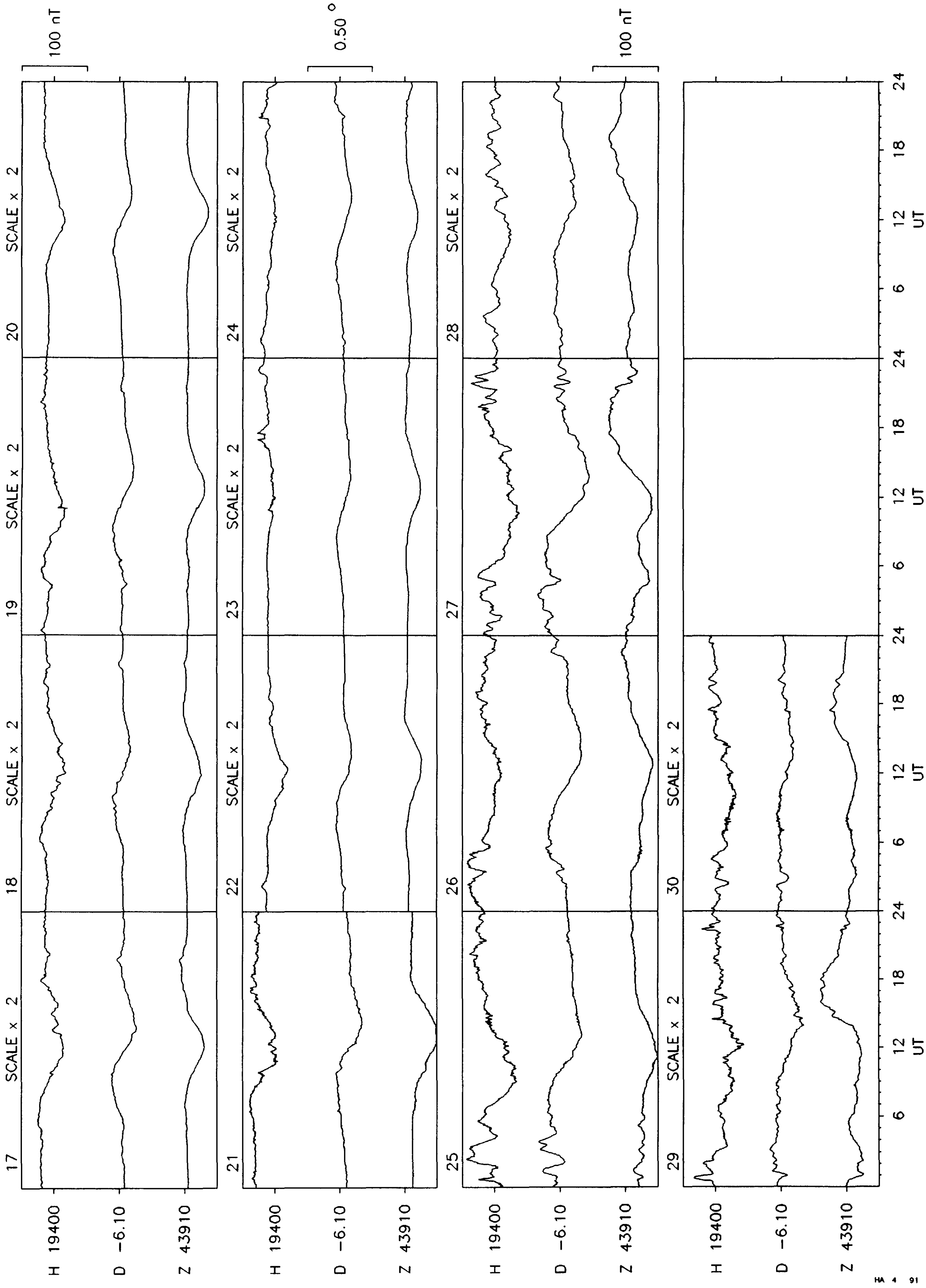
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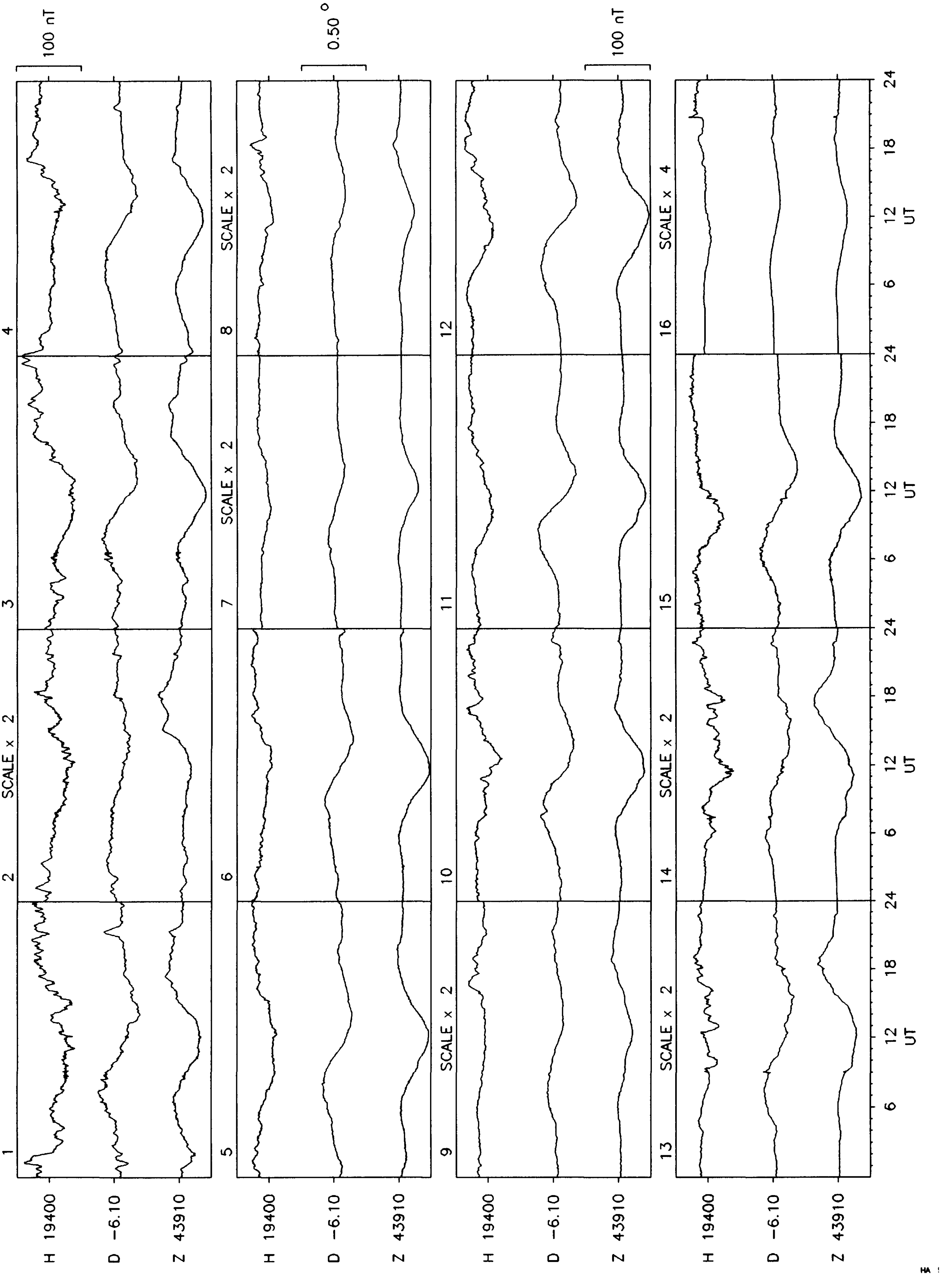
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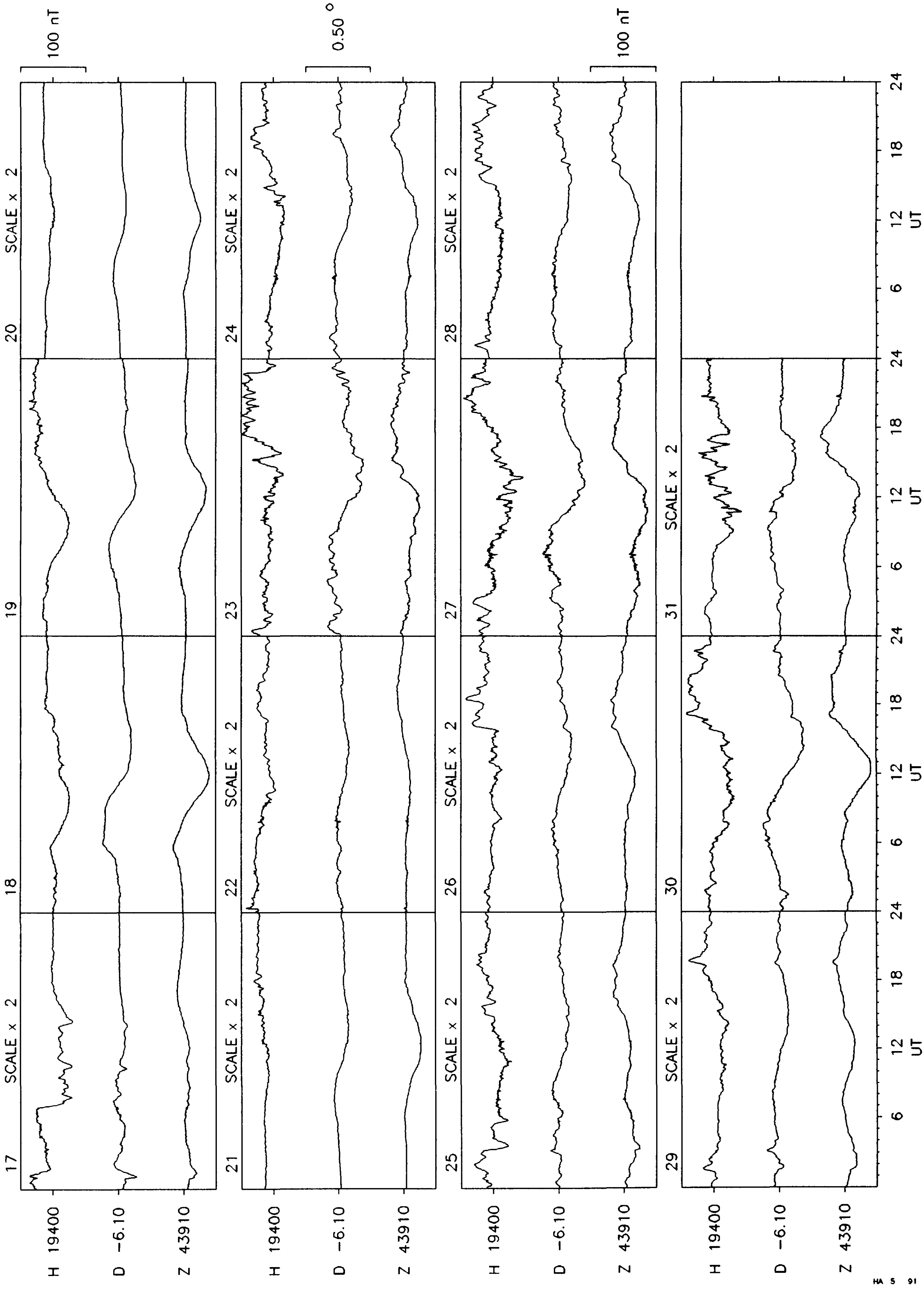
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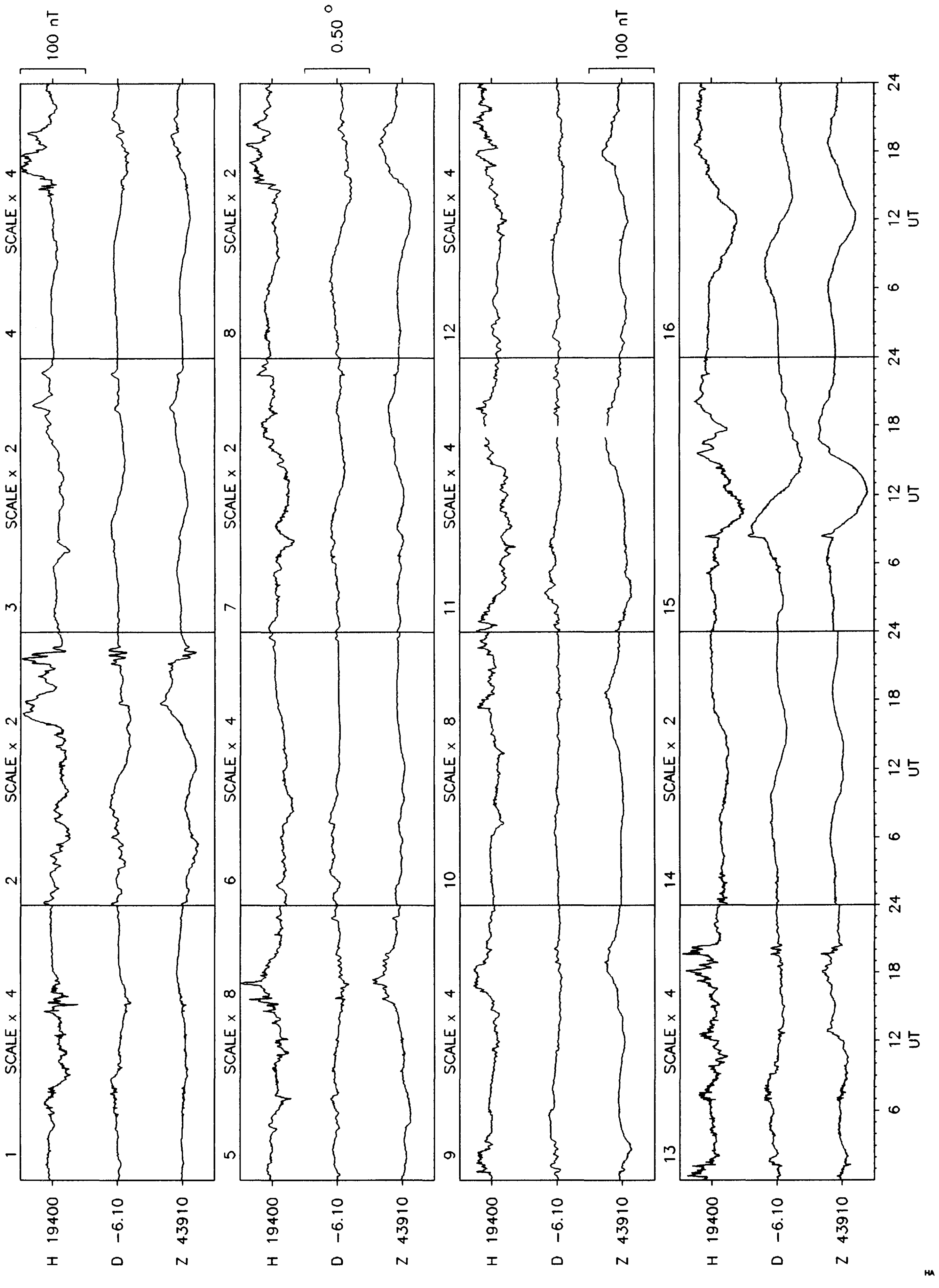
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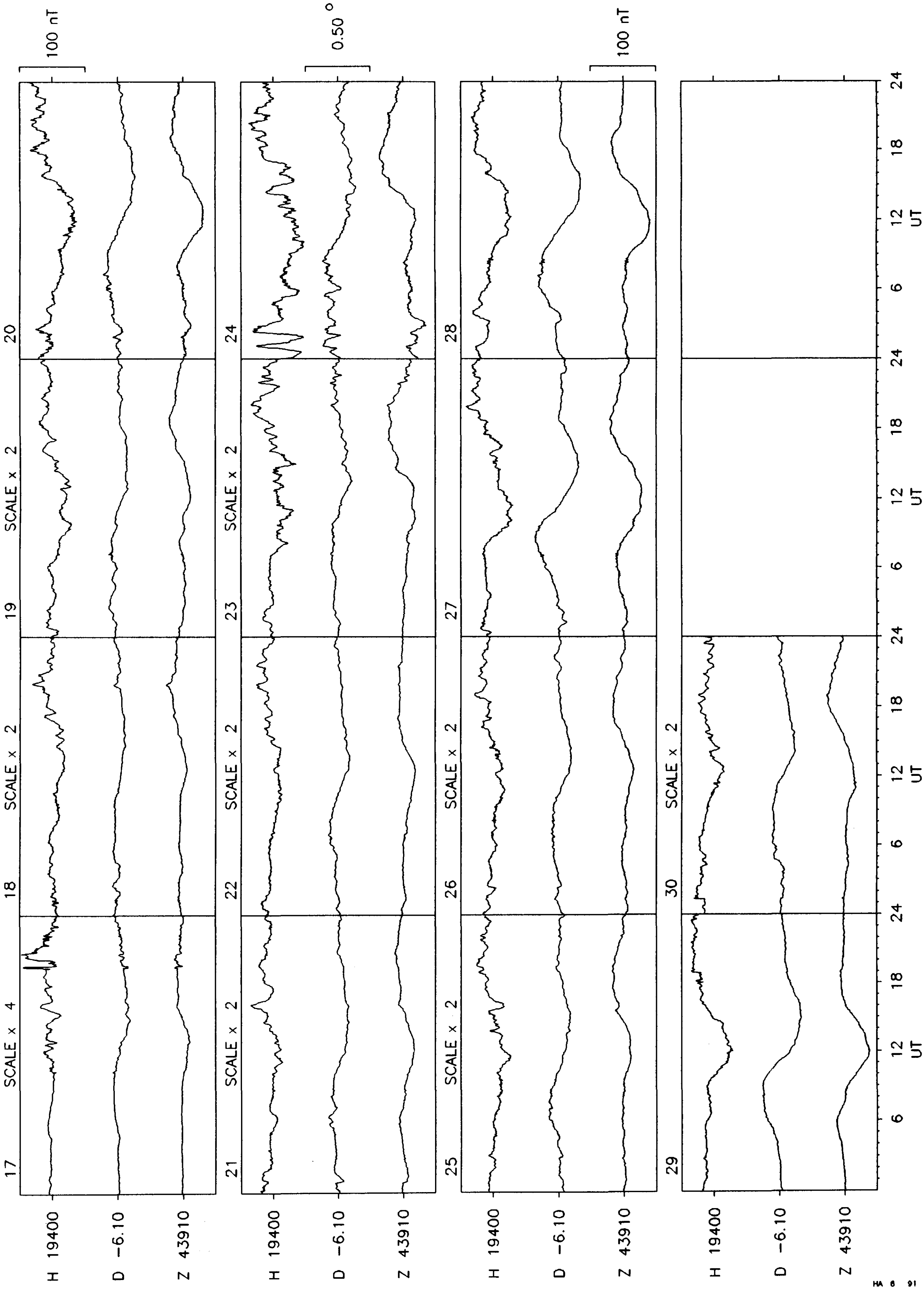

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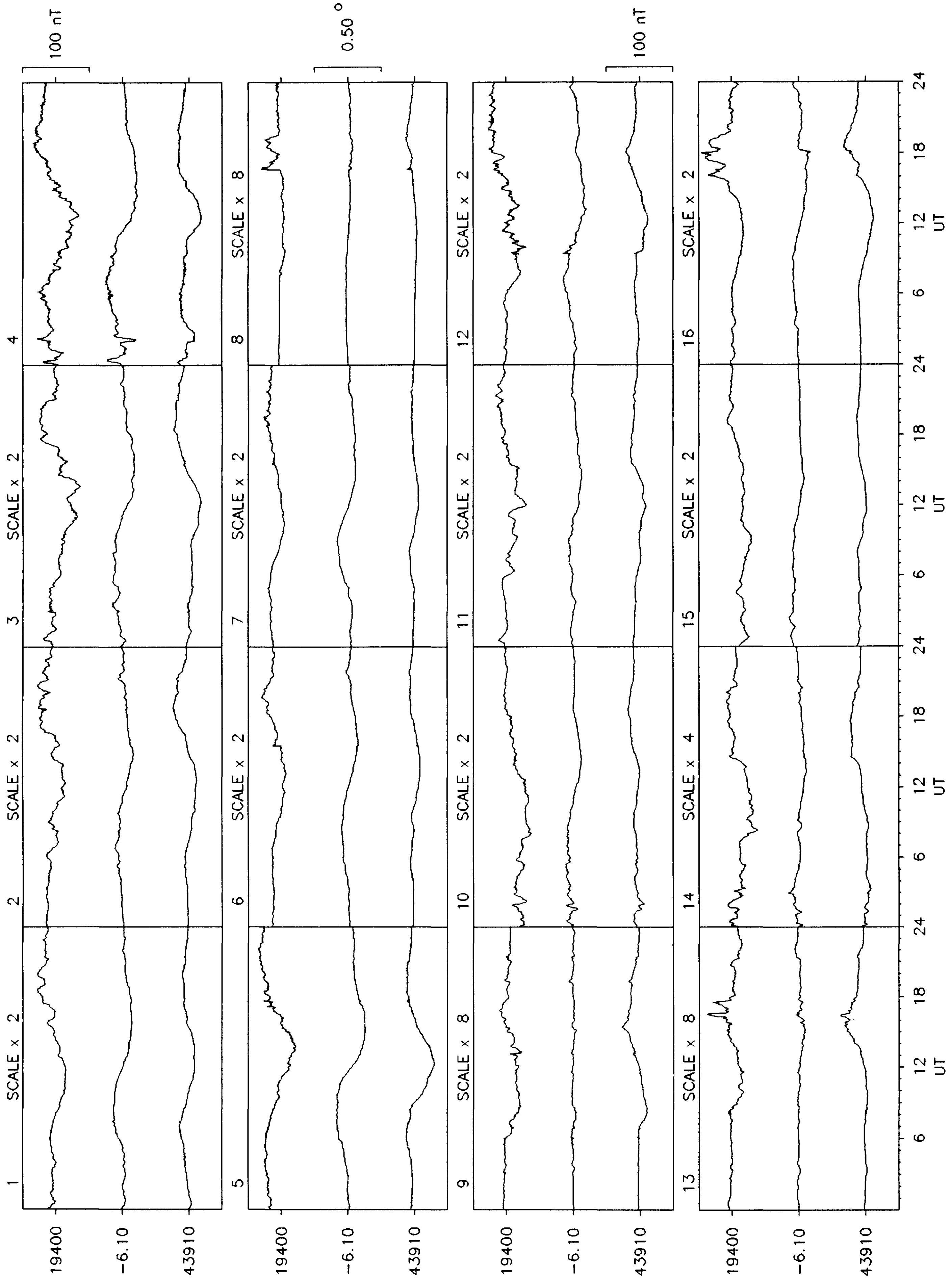
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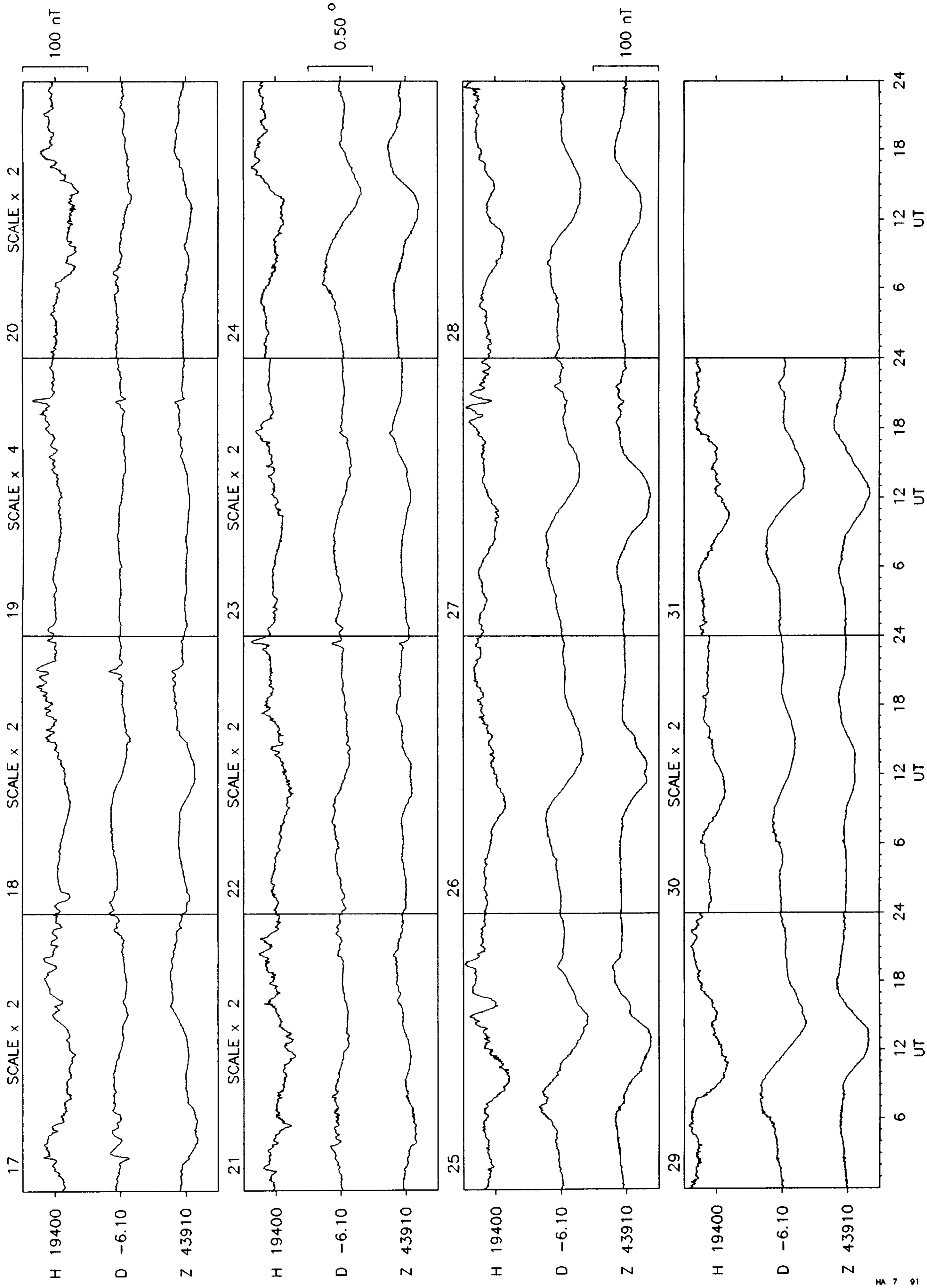
SCALE x 4
UT



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D −6.10
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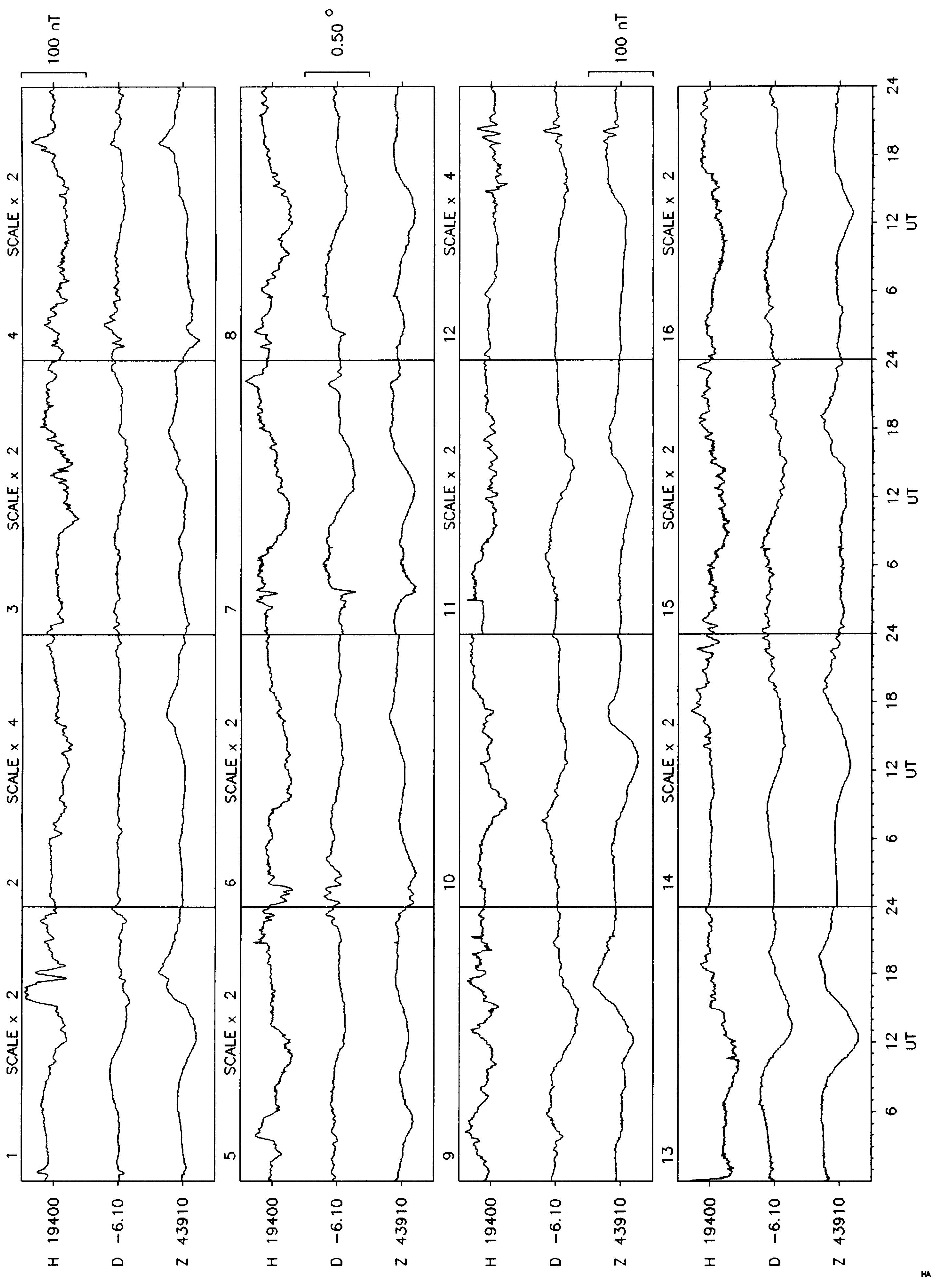
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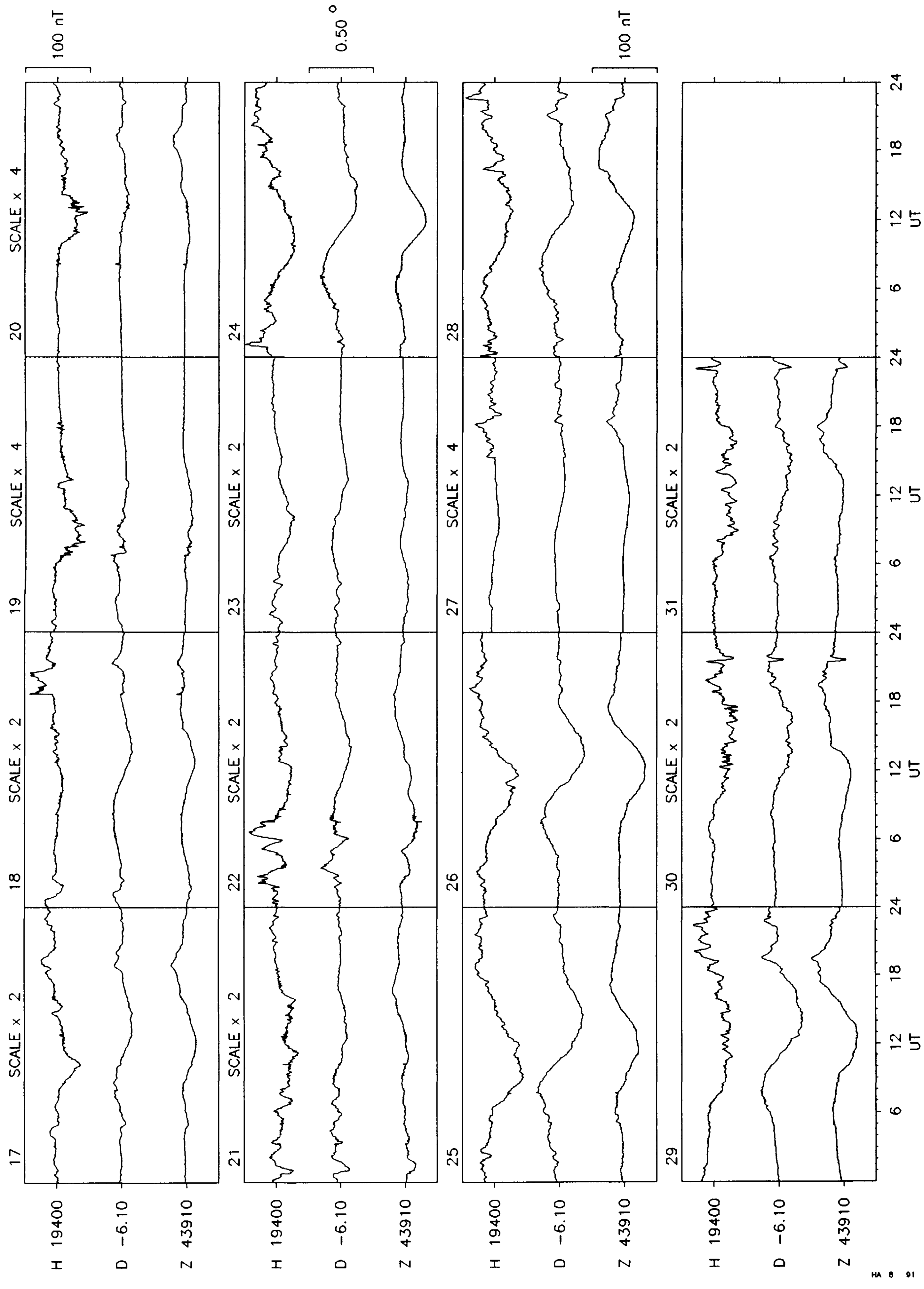
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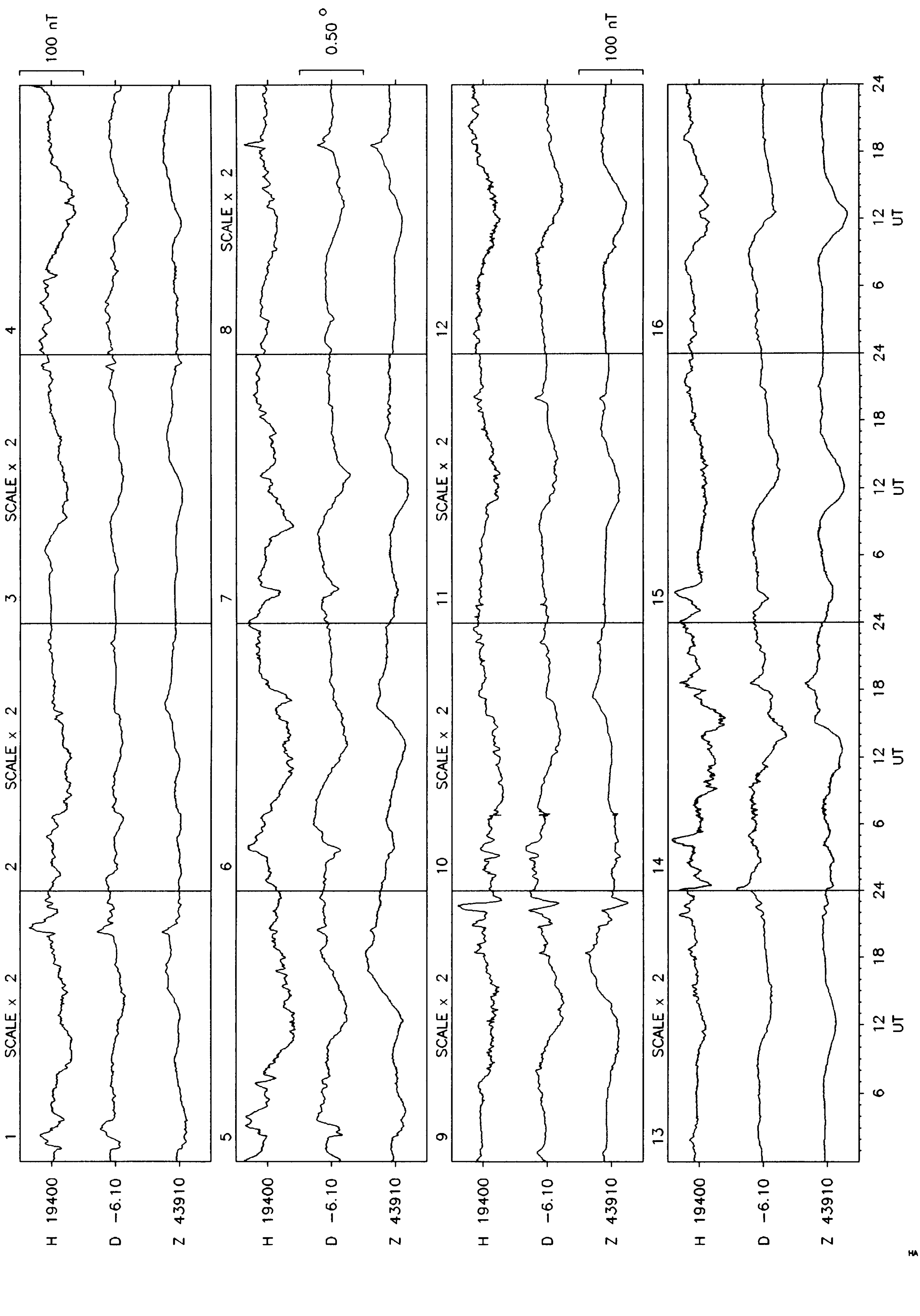
H 19400
D −6.10
Z 43910
H 19400
D −6.10
Z 43910
H 19400
D −6.10
Z 43910
6
12
18
24
UT
HA 8 91


100 nT
0.50 °
100 nT
H 19400
D −6.10
Z 43910
SCALE x 2
1
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14
15
16
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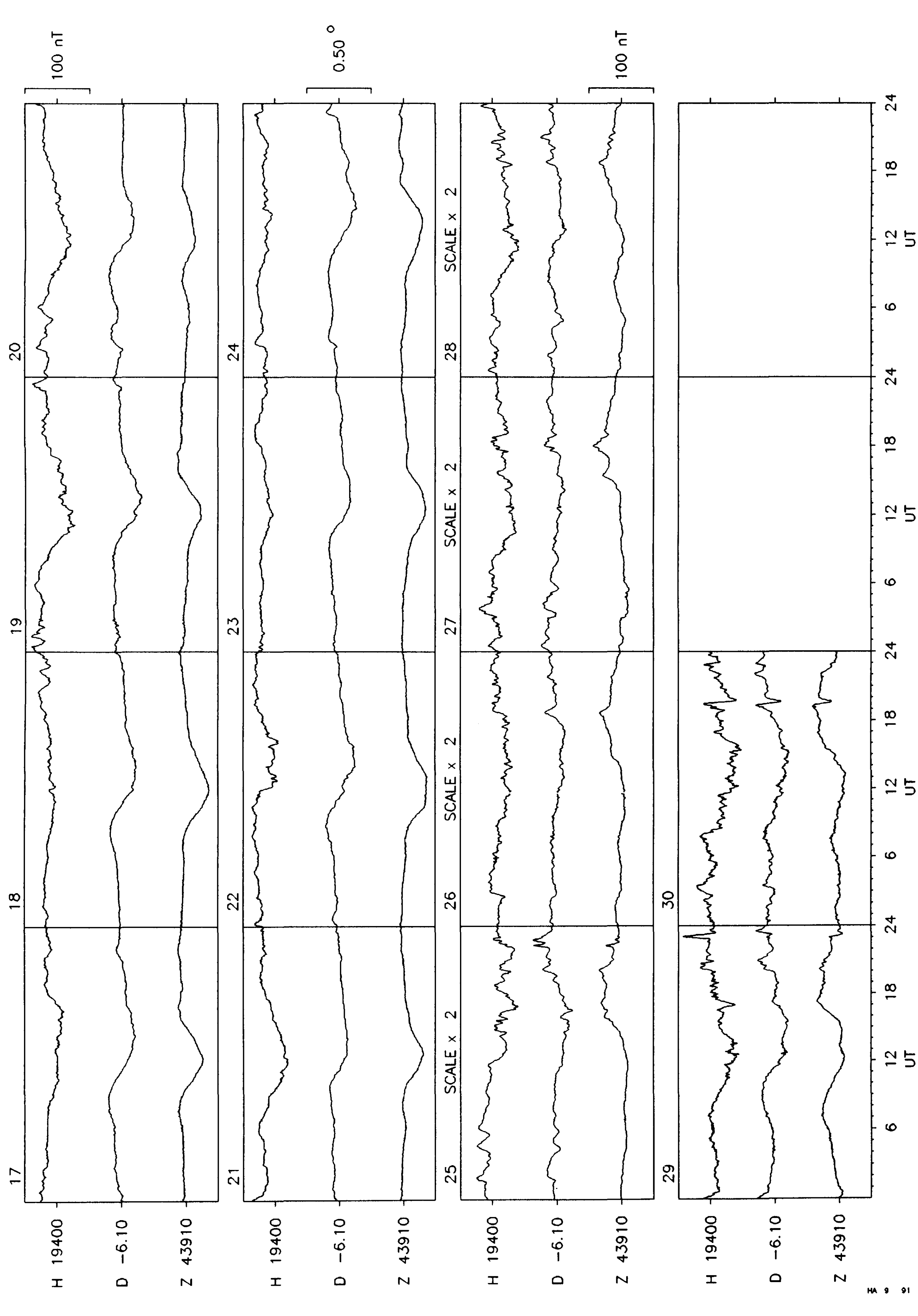
12
18
24
UT


100 nT
0.50 °
100 nT
17
18
19
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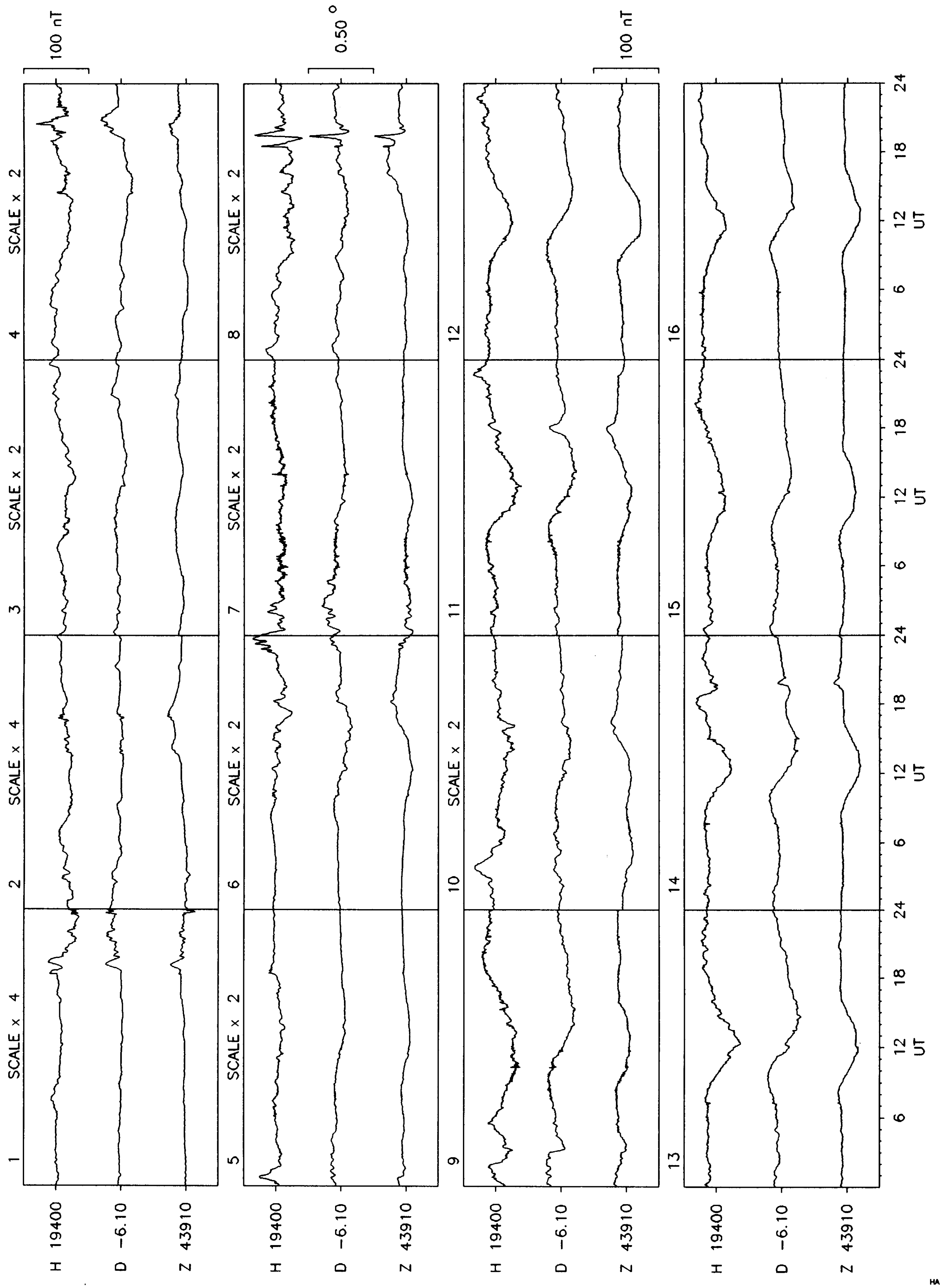
30
SCALE x 2
SCALE x 2
SCALE x 2
SCALE x 2
H 19400
D −6.10
Z 43910
H 19400
D −6.10
Z 43910
H 19400
D −6.10
Z 43910
H 19400
D −6.10
Z 43910
6
12
18
24
UT


100 nT
0.50 °
100 nT
H 19400
D −6.10
Z 43910
SCALE x 4
SCALE x 2
1
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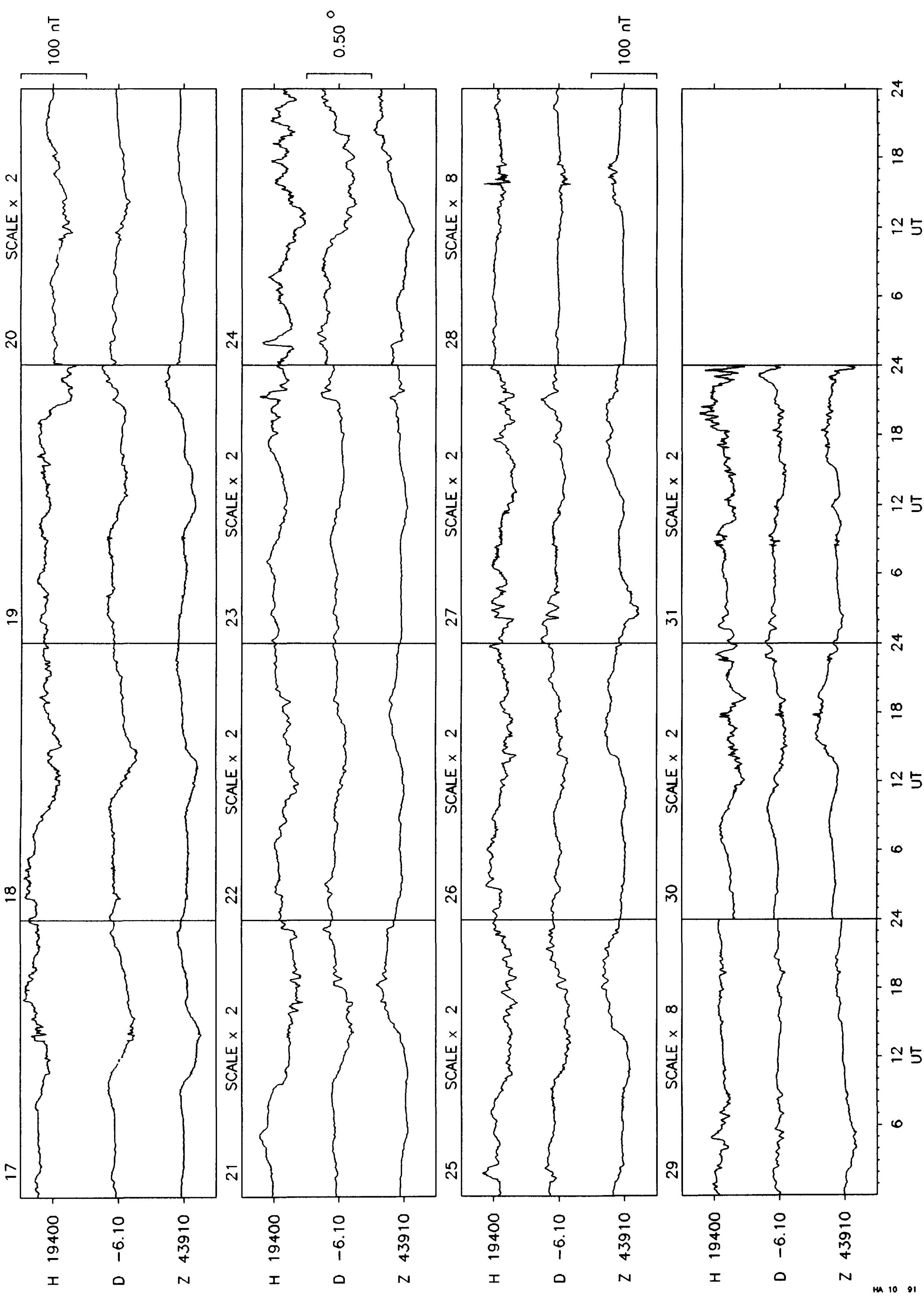
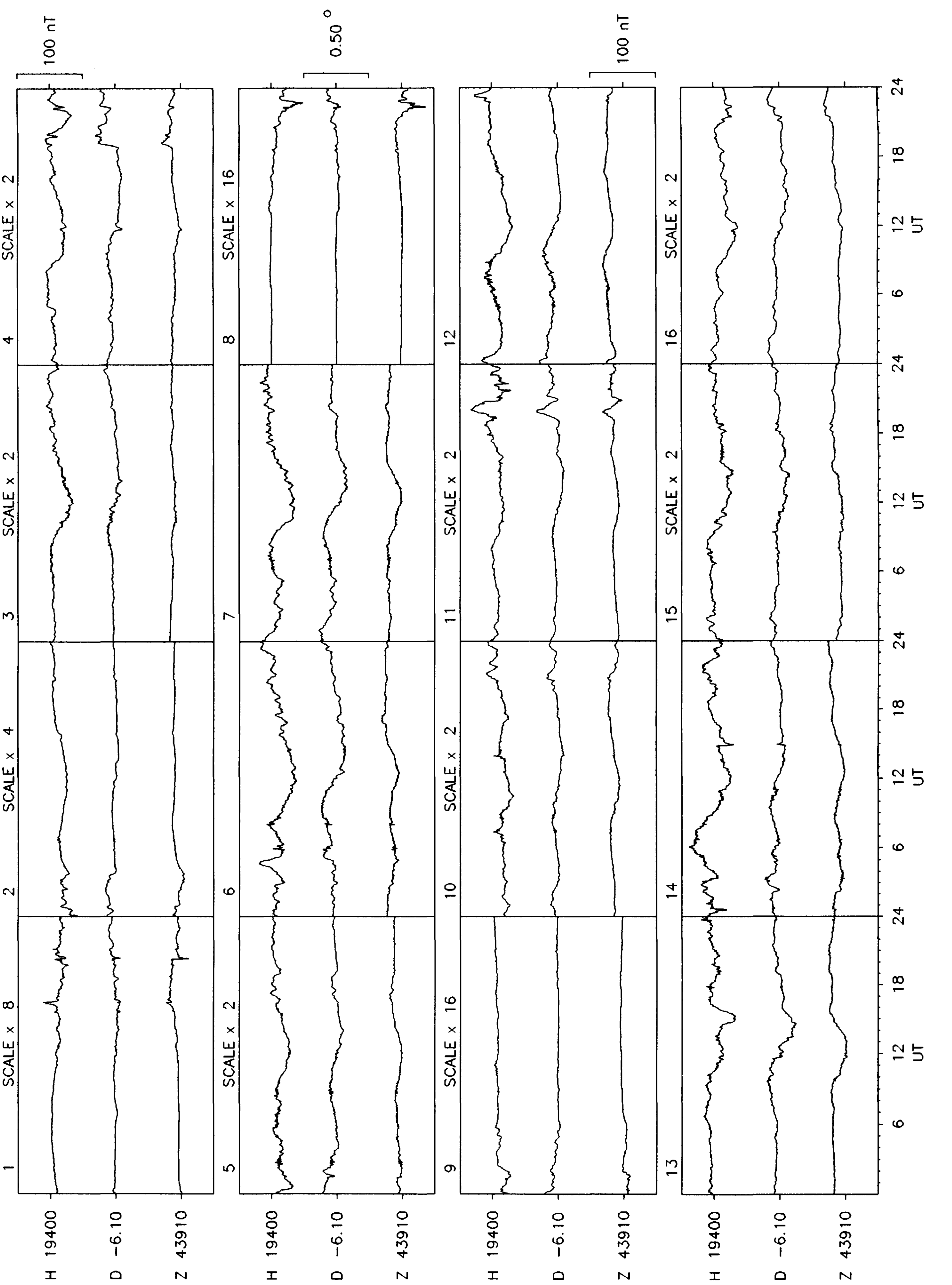
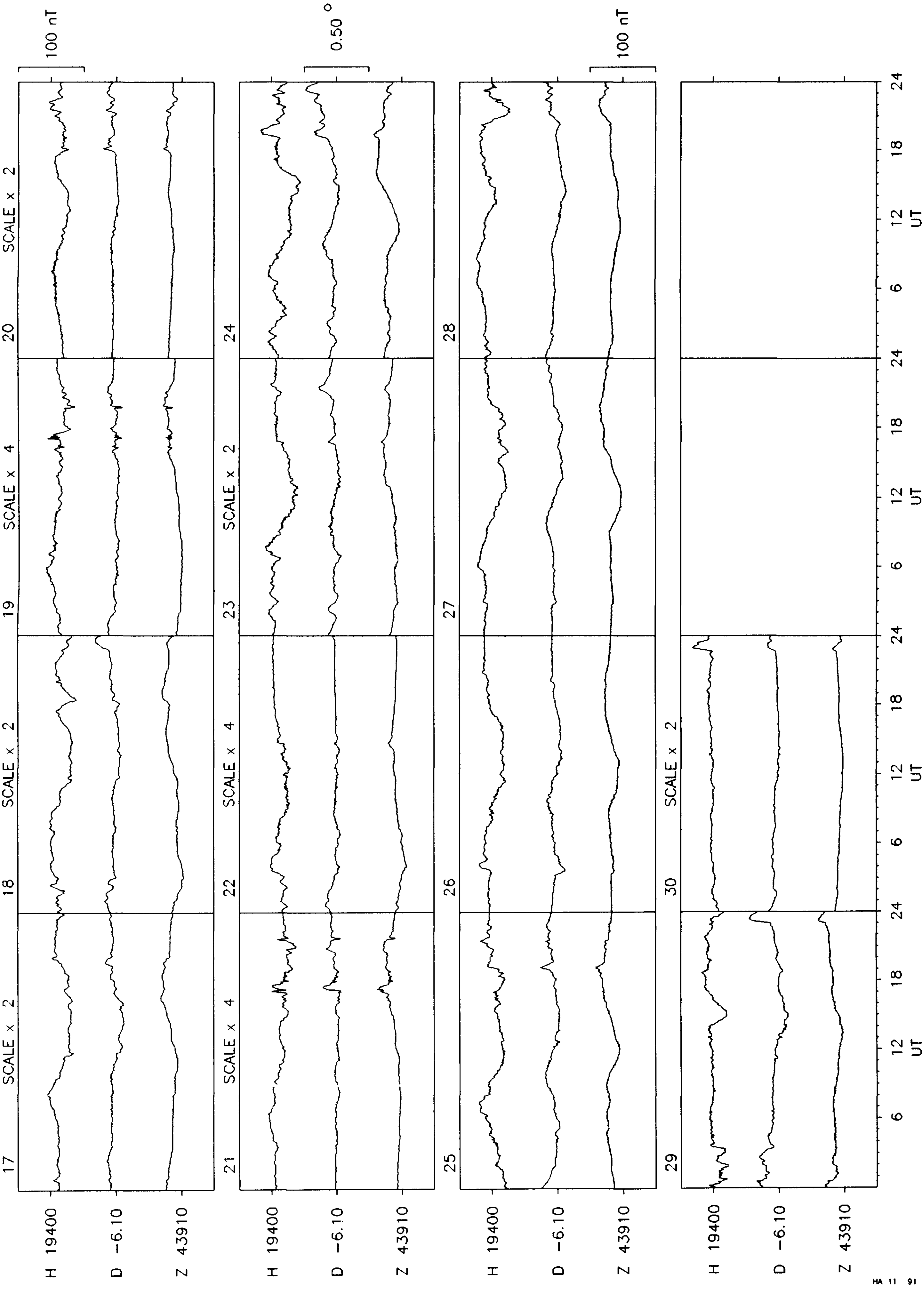
UT


100 nT
0.50 °
100 nT
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
SCALE x 2
SCALE x 8
H 19400
D −6.10
Z 43910
6
12
18
24
UT
HA 10 91


100 nT
0.50 °
100 nT
H 19400
D −6.10
Z 43910
SCALE x 8
SCALE x 4
SCALE x 2
SCALE x 16
UT
HA 11


100 nT
0.50 °
100 nT
SCALE x 2
SCALE x 4
SCALE x 2
SCALE x 2
SCALE x 4
SCALE x 4
SCALE x 2
SCALE x 2
17
18
19
20
21
22
23
24
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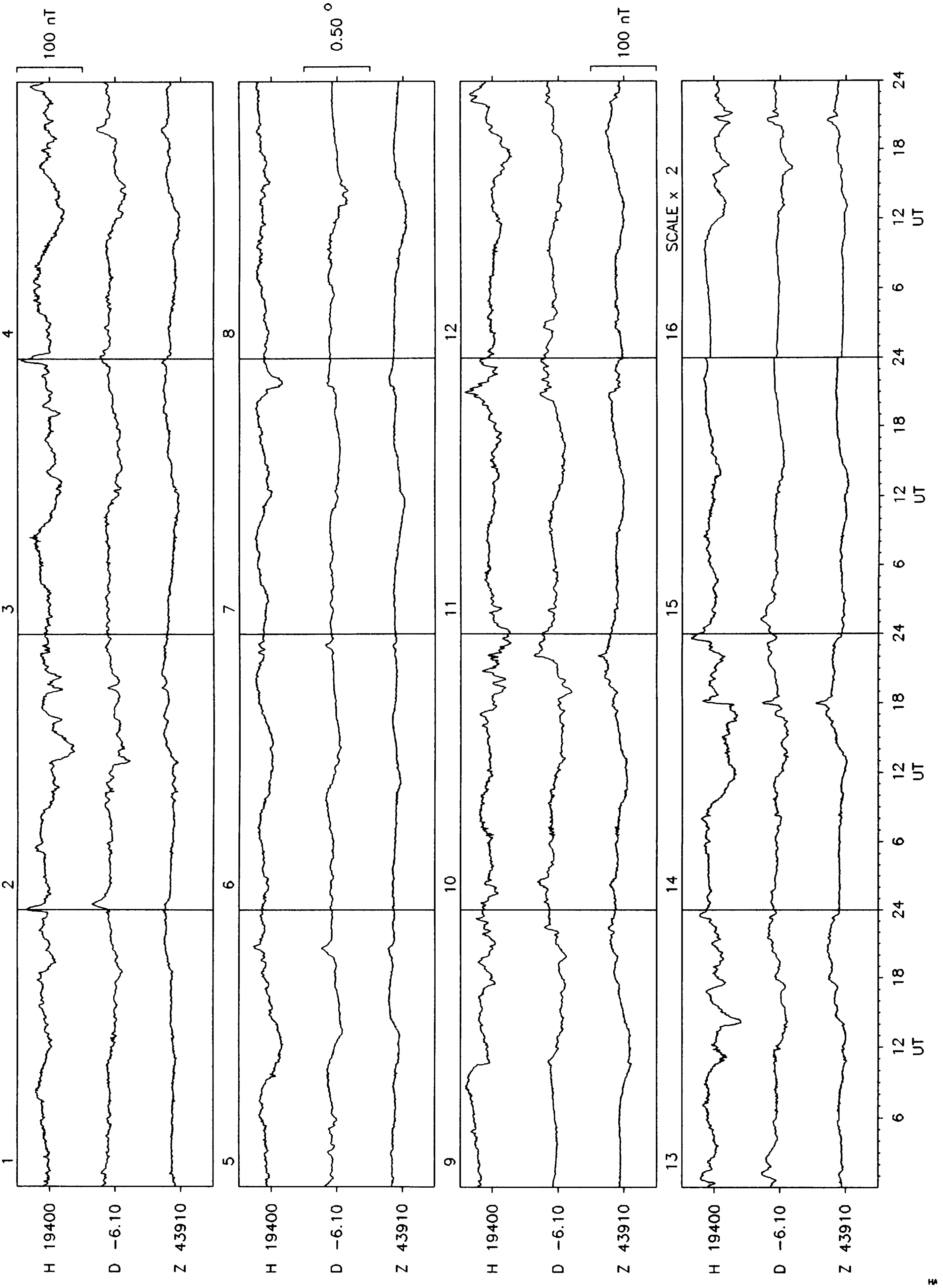
27
28
29
30
H 19400
D −6.10
Z 43910
UT
6
12
18
24
HA 11 91


100 nT
0.50 °
100 nT
H 19400
D −6.10
Z 43910
1
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16
SCALE x 2
6
12
18
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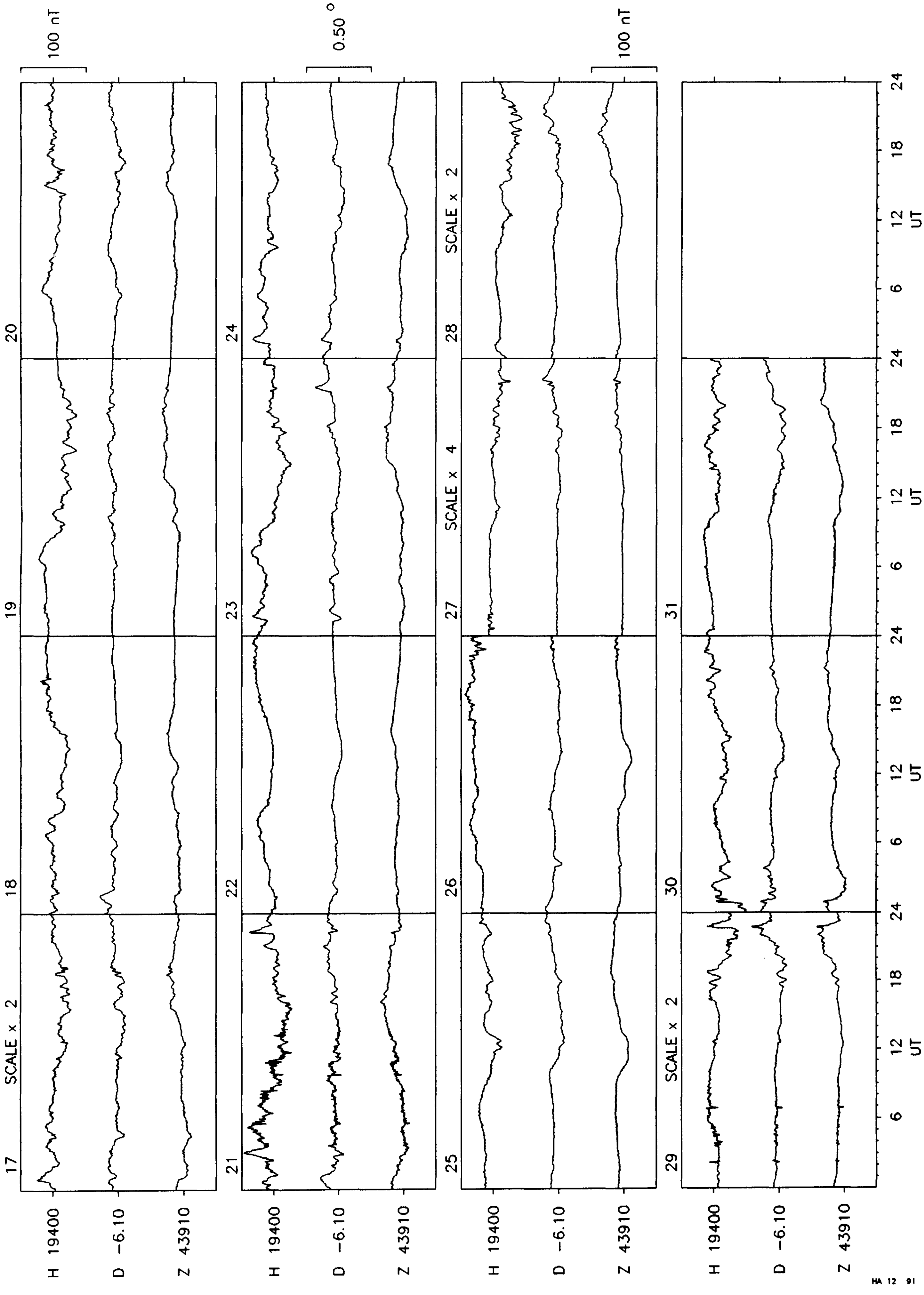
UT


100 nT
0.50 °
100 nT
17
18
19
20
21
22
23
24
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26
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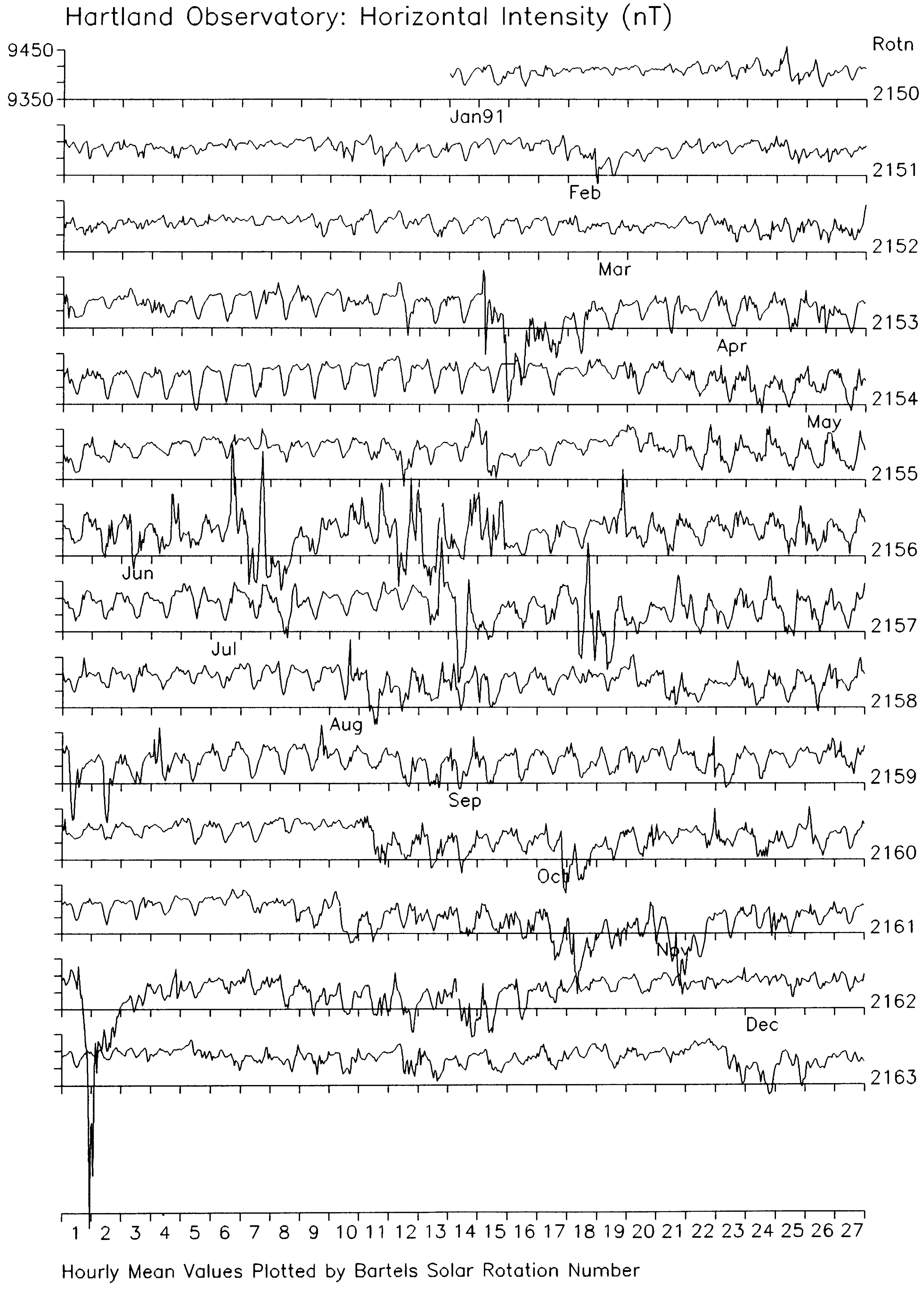
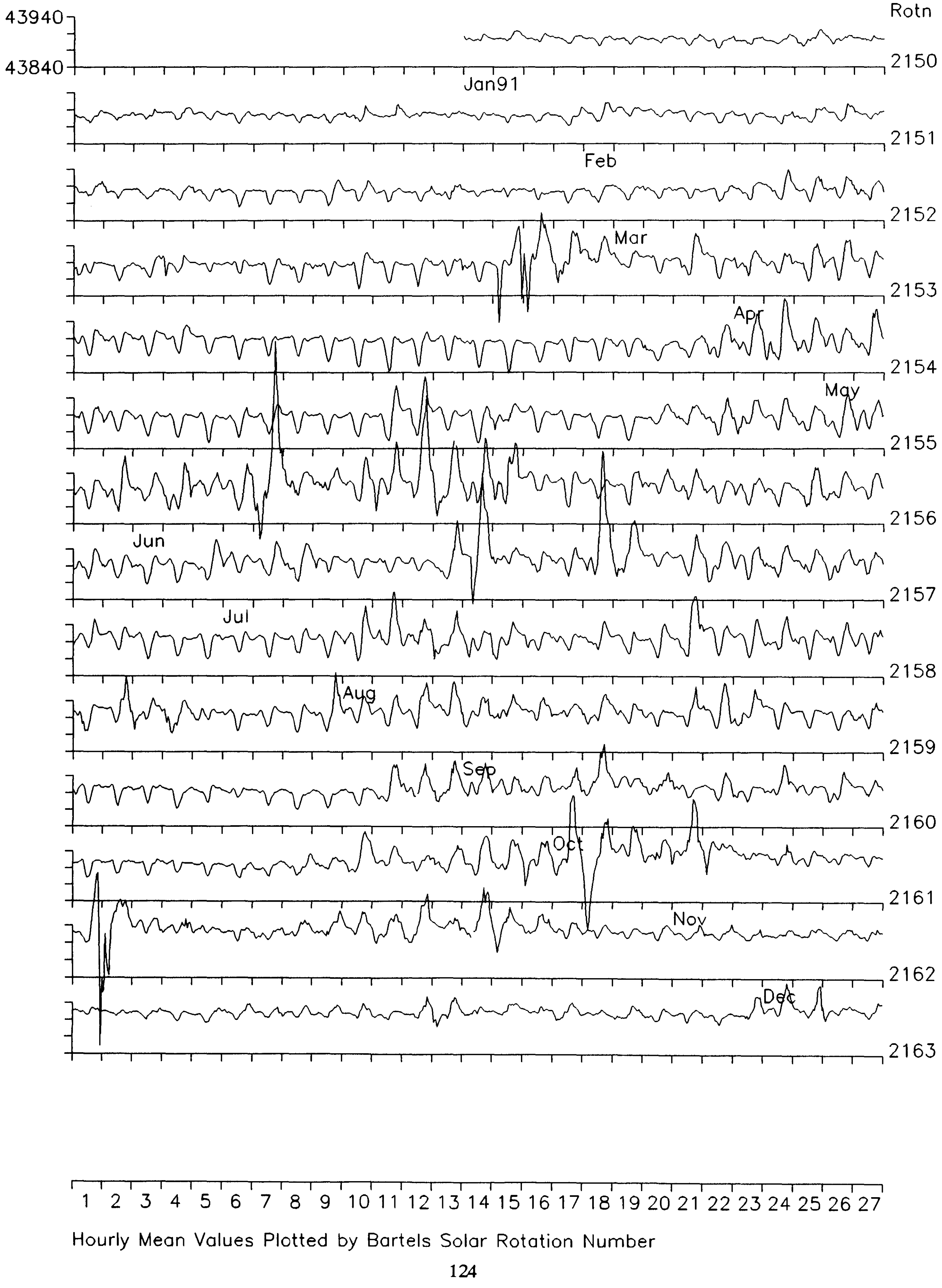
28
29
30
31
SCALE x 2
SCALE x 4
SCALE x 2
SCALE x 2
H 19400
D −6.10
Z 43910
6
12
18
24
UT
HA 12 91

Hartland Observatory: Declination (degrees)

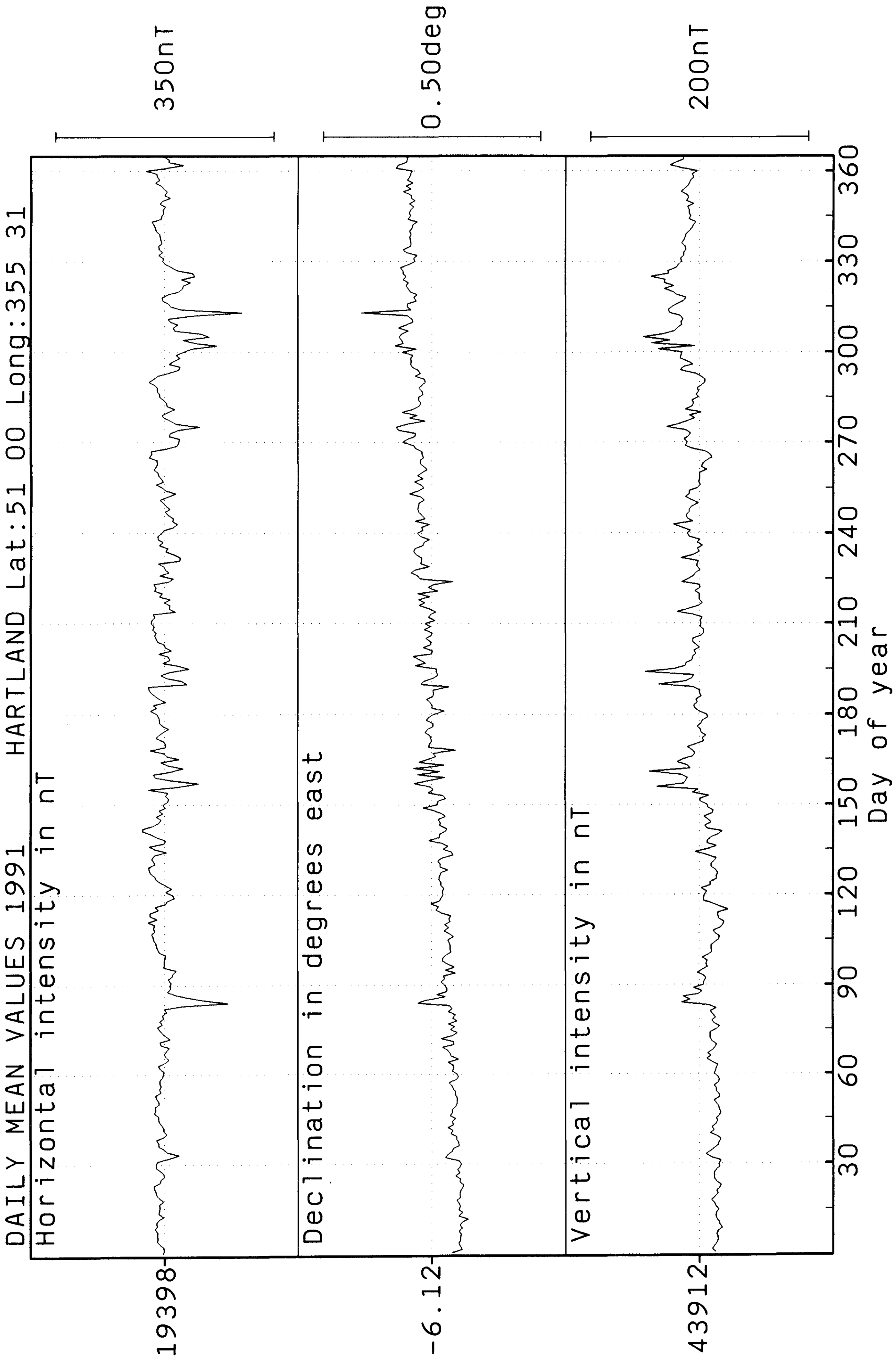
Hourly Mean Values Plotted by Bartels Solar Rotation Number


Hartland Observatory: Horizontal Intensity (nT)
9450
9350
Rotn
2150
Jan91
2151
Feb
2152
Mar
2153
Apr
2154
May
2155
2156
Jun
2157
Jul
2158
Aug
2159
Sep
2160
Oct
2161
Nov
2162
Dec
2163
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

Hartland Observatory: Vertical Intensity (nT)



Hourly Mean Values Plotted by Bartels Solar Rotation Number



DAILY MEAN VALUES 1991 HARTLAND Lat:51 00 Long:355 31
Horizontal intensity in nT
Declination in degrees east
Vertical intensity in nT
350nT
0.50deg
200nT
19398
-6.12
43912
30 60 90 120 150 180 210 240 270 300 330 360
Day of year

Monthly and annual mean values for Hartland 1991

Month	D		H	I		X	Y	Z	F
Jan	-6	11.0	19407	66	8.9	19294	-2090	43896	47995
Feb	-6	10.2	19404	66	9.1	19292	-2086	43896	47993
Mar	-6	9.4	19391	66	10.2	19279	-2080	43903	47995
Apr	-6	9.1	19404	66	9.3	19292	-2079	43900	47997
May	-6	8.4	19409	66	9.0	19298	-2076	43902	48001
Jun	-6	7.2	19398	66	10.2	19287	-2068	43918	48011
Jul	-6	6.8	19402	66	9.9	19292	-2066	43918	48013
Aug	-6	6.1	19396	66	10.3	19286	-2062	43917	48009
Sep	-6	5.3	19398	66	10.1	19289	-2057	43916	48009
Oct	-6	4.6	19386	66	11.1	19277	-2052	43923	48011
Nov	-6	3.6	19376	66	12.1	19268	-2046	43935	48018
Dec	-6	4.0	19403	66	10.0	19294	-2051	43923	48018
Annual	-6	7.1	19398	66	10.0	19288	-2067	43912	48006

D and I are given in degrees and decimal minutes
H, X, Y, Z and F are given in nanotesla

HARTLAND OBSERVATORY K INDICES 1991

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	3210 1100	3123 3455	2322 3244	4345 3234	4332 4434	4465 6624	3321 2332	4213 3655	5544 4455	3242 2365	4244 5776	2221 2233
2	2311 2222	5312 2111	3222 2322	3333 2334	4443 5444	4443 4656	1233 4433	4354 4534	4343 3323	5554 4544	5534 3433	4223 4332
3	2223 2112	1111 2211	2111 1122	2344 3344	3331 3333	2241 2343	4433 4533	4334 5544	1323 3334	3233 4244	2234 4334	2233 3234
4	3311 1112	3101 1123	2111 2333	3235 5554	4121 2422	1233 5765	5232 3221	5533 3454	2333 2213	3432 4465	3335 2365	3322 2343
5	2211 3122	3223 2222	2334 4424	4332 3433	2110 1222	6577 7876	1111 1221	3433 4345	4432 2232	5332 3231	4444 3332	2312 2131
6	1111 1001	1111 1122	3244 3454	3421 2333	1111 1212	5454 3314	1211 2333	5443 3332	3522 2322	1134 4445	3332 2323	2111 1113
7	1000 1101	1211 3324	3334 3345	3332 2332	2122 1111	3344 3444	3211 1232	3531 2223	4443 3221	5534 4333	3233 2332	1211 1123
8	2121 3132	2332 3333	3323 2434	2211 1122	2223 1341	3322 3553	2243 4764	3223 2212	4422 4452	4344 3473	2334 6679	1222 3210
9	1211 2113	4122 3443	3333 4324	3321 1232	2321 1443	5534 4653	2464 6654	2422 3432	4345 3456	3323 2222	8755 4555	1123 2333
10	3111 3313	2222 2121	5521 3210	2322 2211	1122 3323	4465 6667	4331 3221	1232 2322	4542 4434	3534 4432	3233 4344	3232 2334
11	1112 3221	3333 2334	0021 2212	1112 1121	1011 1111	6655 5454	3334 3433	4443 5432	4234 3342	2234 2443	3222 2454	3212 2344
12	4242 3432	4323 2222	2334 4344	3334 3421	1111 1221	5435 5665	3335 4434	3343 5564	2232 2222	2222 1122	3232 2123	3322 3333
13	3321 2231	2213 3332	5342 2310	1132 2111	2435 4442	6566 5674	4455 6756	4122 2231	2222 3335	2223 3221	1123 4433	3223 4333
14	1110 1120	3212 2233	3322 1211	1231 2222	1445 4544	3222 2211	6554 5443	1021 3444	4434 4433	2121 3332	3433 3223	2132 2444
15	3311 2144	4111 2223	1012 3210	1123 3221	3222 2111	1252 2442	3323 2231	4445 4434	4311 2222	2111 2121	4334 4343	3211 2101
16	2111 3123	1112 2212	0012 1341	1112 2321	1112 3354	1111 2222	2211 2554	3433 3434	2212 2122	1211 2211	3334 4335	0113 3454
17	3212 3333	1112 2201	3323 3334	1333 3431	6354 4311	2335 5676	5443 4445	2344 3443	2111 1212	2011 3223	3234 3443	4534 4453
18	3213 2333	1011 1112	3332 1110	2334 3223	1221 1210	4333 3443	4212 4454	4222 3354	1111 2223	3212 3222	4334 3445	3232 2321
19	0001 1121	1113 2332	1222 2343	3343 2132	1101 1221	4443 4433	4343 4563	5466 5432	3212 2223	2332 2244	5444 3665	1132 2331
20	2101 1230	1011 1232	2322 3221	1011 1111	1111 2210	3222 2433	3343 4533	3246 6444	3322 2212	3334 4333	1233 3444	1221 3322
21	0201 1102	3233 2111	1233 5433	1113 2221	1112 2331	4443 4543	4544 4444	5544 3433	3111 1101	2323 4444	2444 4666	4434 3323
22	1200 1101	2333 3224	2334 3234	3222 3320	4334 2333	3322 3334	3333 4434	4652 4333	2112 3212	3434 3442	5554 5323	2121 1101
23	1111 1123	2233 4344	3232 3221	1113 2423	3332 3434	4344 5554	3322 3442	4323 3221	1111 1111	3332 1345	4343 3445	3322 2234
24	4333 2443	1211 1123	2866 4467	2121 2234	4232 4443	5443 4433	1222 2221	4321 2333	2211 2323	4334 3344	3322 2444	3222 2211
25	1122 2353	3124 3222	6734 6645	4432 2222	4544 4433	3434 4433	2232 3332	2322 2222	4434 4555	4335 3454	3221 2233	1011 3222
26	3322 3214	2222 3221	6555 7544	3411 1234	3333 4553	4333 4343	1111 1222	2223 2222	4334 3444	4334 4454	1322 2220	2321 2223
27	1111 2124	1123 2233	3443 5434	3422 2334	3333 3243	3222 2332	1111 1243	3221 2564	4544 4543	5434 3455	2212 2221	4234 3456
28	1111 2312	3344 3234	3332 3331	3432 4444	4333 2444	2321 1222	2211 1213	3221 2344	4444 4355	4435 5745	2111 2234	3212 4454
29	2112 1002		0111 1113	5444 5434	5422 3443	1111 1122	2221 1212	0122 2344	4113 3444	6764 5575	3312 3325	3432 3356
30	0001 2321		1335 4444	4443 4343	3222 3423	3432 4433	1341 2221	2233 4455	3333 3443	2124 4444	4222 2224	4312 3233
31	2221 3334		3332 1113		3445 5553		2111 2322	3354 4535		4244 4456		2111 3332

DAILY aa INDICES

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	9	48	26	41	44	83	17	46	64	59	128	22
2	15	22	20	30	59	70	29	65	41	73	48	34
3	17	9	10	43	27	22	45	57	28	30	35	27
4	18	13	15	68	18	69	21	54	20	53	59	26
5	17	19	38	25	9	213	7	44	31	25	38	16
6	8	11	43	22	8	48	15	42	23	44	30	11
7	5	22	46	19	8	40	13	25	23	44	24	13
8	21	27	28	10	18	33	71	17	38	70	164	19
9	17	28	35	16	20	75	106	28	67	22	148	25
10	19	12	27	14	16	127	27	16	44	43	36	28
11	14	30	10	8	5	104	32	46	36	29	41	28
12	40	23	39	26	8	81	42	69	17	12	18	28
13	16	22	38	8	43	143	127	17	25	15	25	29
14	7	16	12	13	51	18	77	26	44	15	38	33
15	21	16	10	12	13	24	17	49	16	10	48	13
16	16	9	14	11	24	10	31	33	12	9	48	35
17	24	7	30	25	54	83	62	35	10	14	40	59
18	22	7	15	22	7	35	35	34	11	22	53	21
19	6	17	24	22	7	45	61	78	20	26	81	23
20	10	16	19	5	6	24	43	79	15	42	31	21
21	8	19	34	12	12	45	50	47	8	48	85	43
22	9	29	34	17	28	30	35	66	14	35	67	10
23	14	35	19	16	34	67	26	22	10	32	49	32
24	49	14	162	16	38	44	12	22	13	39	27	17
25	31	21	120	25	50	39	19	17	58	60	19	14
26	25	14	127	22	44	36	8	17	52	48	15	21
27	14	21	53	27	35	19	13	43	55	69	15	65
28	13	33	39	42	36	15	11	24	52	105	21	44
29	11		8	67	39	8	11	23	32	142	33	60
30	11		48	44	23	35	17	56	38	45	28	30
31	33		16		62		11	65		84		20
Monthly Mean Value	17.4	19.9	37.4	24.3	27.3	56.2	35.2	40.6	30.7	44.1	49.7	28.0

Annual Mean Value for 1991 = 34.3

SIs and SSCs

Day	Month	UT		Type	Quality	H(nT)	D(min)	Z(nT)
12	1	01	52	SSC	C	20	-1.6	-2
1	2	18	42	SI	B	47	3.5	17
4	2	22	14	SSC*	B	21	-0.8	4
4	3	16	18	SSC*	B	18	-1.7	-4
9	3	22	45	SSC	B	50		12
24	3	03	41	SSC*	A	238	-22.9	26
4	4	11	22	SSC	B	24	4.8	12
19	4	10	55	SI*	B	29		-5
13	5	08	56	SSC*	B	7	6.8	7
16	5	20	41	SSC*	A	82	-3.0	24
21	5	12	27	SSC*	C	15	-1.6	-5
31	5	10	38	SSC*	B	-45	5.4	-10
7	6	22	27	SI	B	50	-4.0	6
9	6	00	40	SI	B	85	-6.1	-28
12	6	10	13	SSC	A	12	7.1	14
17	6	10	18	SSC*	B	-24	4.0	-8
30	6	01	15	SSC	C	32	-1.9	7
6	7	15	26	SI*	C	26	-1.5	5
8	7	16	35	SSC*	A	228	-4.3	62
12	7	09	23	SSC*	B	-19	7.4	10
5	8	20	46	SSC	B	38	-2.7	10
11	8	02	53	SSC*	B	49	-4.3	8
20	8	08	01	SI*	C	-30	9.4	16
27	8	15	14	SSC*	A	55	-6.2	8
10	9	06	47	SI*	B	-23	7.4	13
11	9	01	30	SI*	B	-23	5.6	7
1	10	18	13	SSC*	A	49	0.8	14
8	10	18	26	SSC*	B	77	4.2	17
17	10	13	30	SSC*	B	17	-2.4	3
28	10	10	52	SSC*	B	-26	5.6	6
1	11	11	41	SSC*	C	16	2.7	-12
8	11	06	47	SSC*	B	-17	-2.7	-9
8	11	13	12	SSC*	B	25	-5.6	8
11	11	17	50	SSC*	B	21	-2.0	6
19	11	04	21	SSC	B	17	-4.3	-9

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		Maximum		End		H(nT)	D(min)	Z(nT)
23	3	12	30	12	35	12	46	24	-2.1	-9
11	4	11	14	11	17	11	23	-12	0.4	
15	6	08	13	08	20	08	37	21	7.8	18

Notes

The amplitudes given are for the first 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

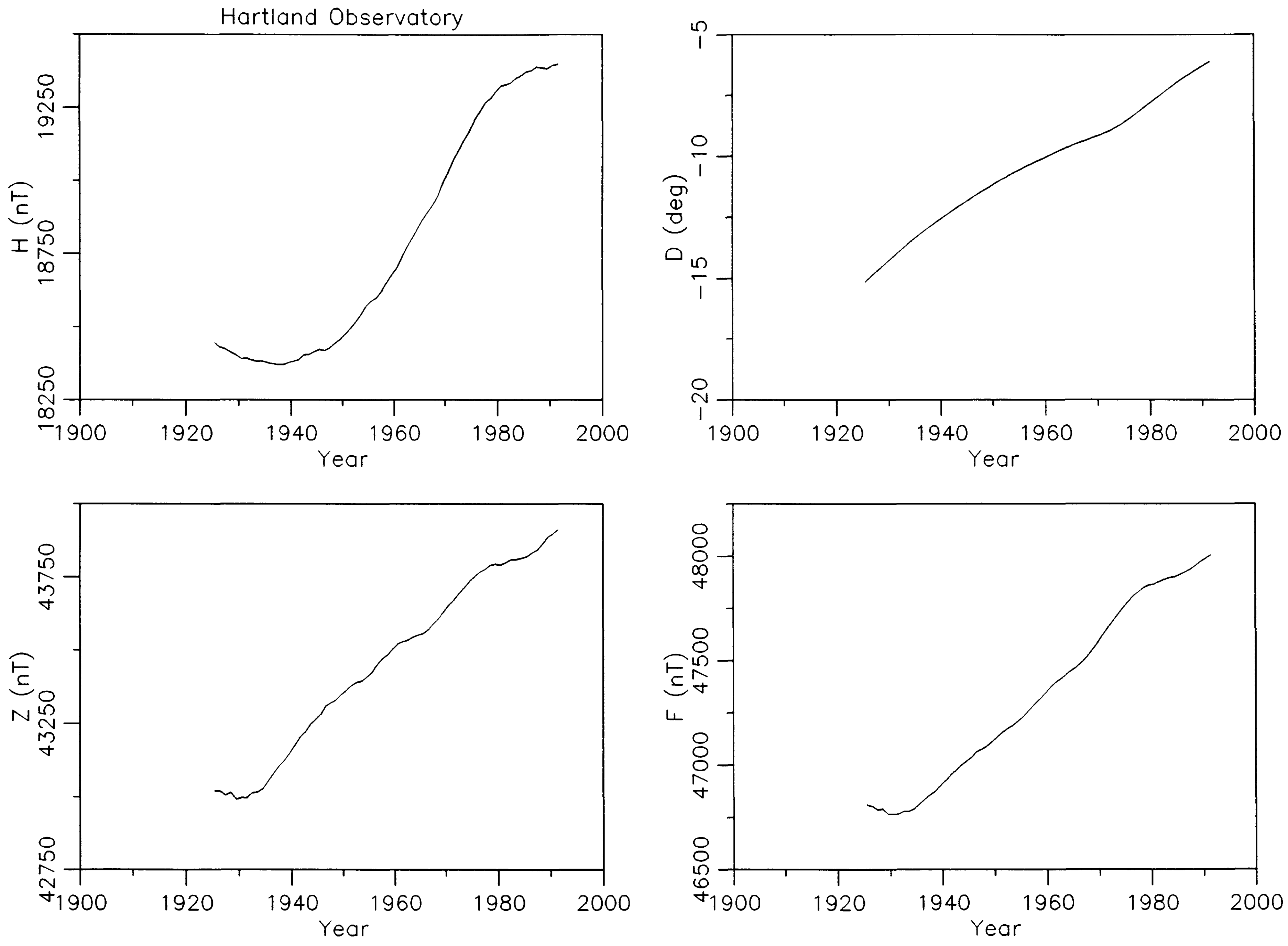
Hartland

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

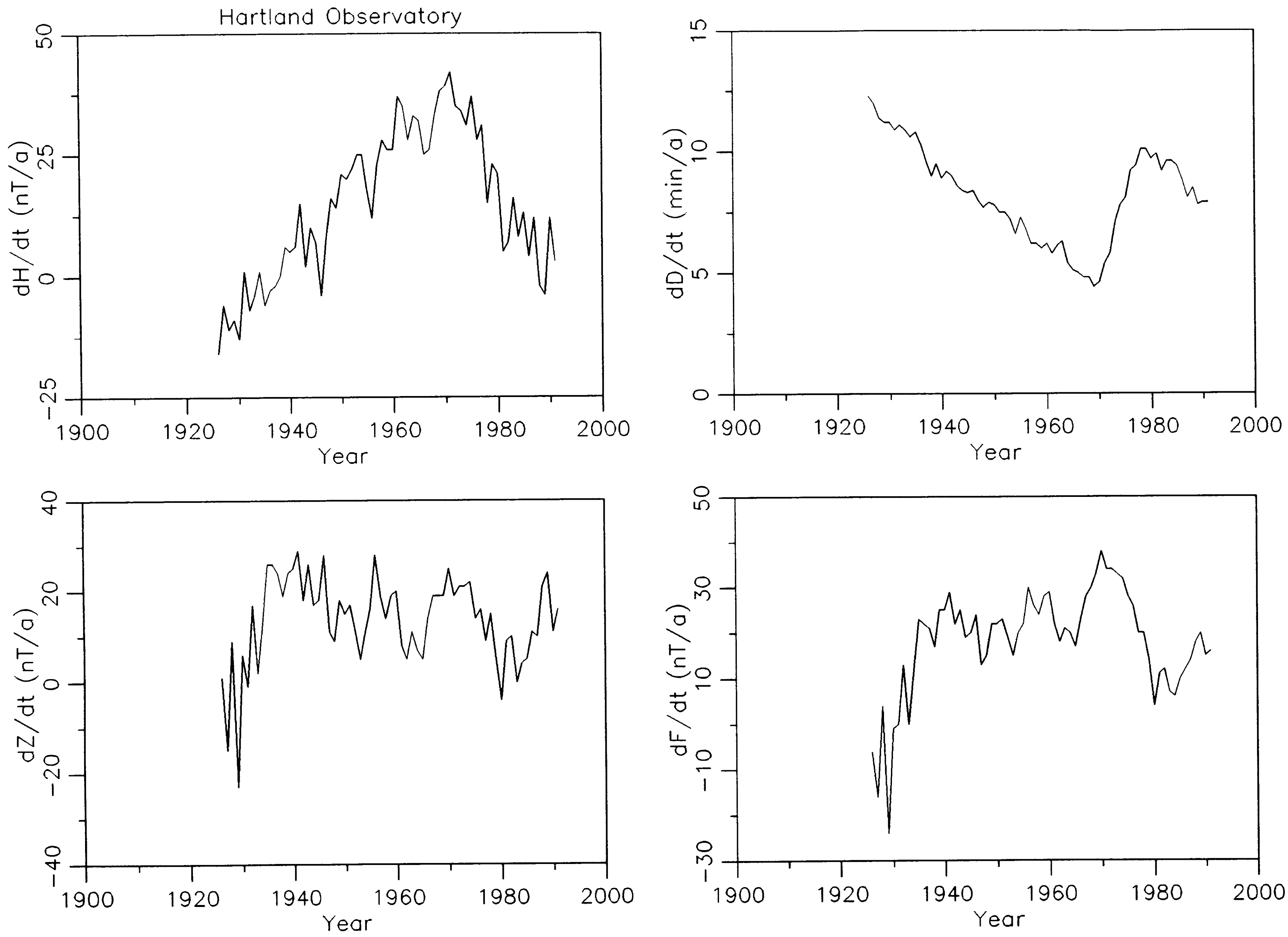
	Year	D	H	I	X	Y	Z	F
	1981.5	-7 33.9	19335	66 10.2	19167	-2546	43777	47857
	1982.5	-7 24.7	19342	66 10.1	19180	-2495	43787	47869
	1983.5	-7 15.1	19358	66 9.0	19203	-2443	43787	47876
	1984.5	-7 5.5	19366	66 8.6	19218	-2391	43791	47882
	1985.5	-6 56.1	19379	66 7.9	19237	-2340	43796	47892
	1986.5	-6 47.3	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

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 nanotesla



Annual mean values of H, D, Z & F at Hartland



Rate of change of annual mean values for H, D, Z & F at Hartland

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Cover photos

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Eskdalemuir observatory

Back
Magnetic observations being made using a fluxgate-theodolite

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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

8 Spherical harmonic models of the geomagnetic field

9 Magnetic results 1973–77. Eskdalemuir, Hartland and Lerwick observatories

10 Annual mean values of the geomagnetic elements

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12 A bibliographic guide to the production of local and regional magnetic charts

13 Magnetic results 1980. Eskdalemuir, Hartland and Lerwick observatories

14 Magnetic results 1981. Eskdalemuir, Hartland and Lerwick observatories

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19 Magnetic results 1987–89. Lerwick, Eskdalemuir and Hartland observatories

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