LOGISTICS REPORT

FOR AN

AIRBORNE MAGNETIC & RADIOMETRIC SURVEY

OF

THE GRANITES, NORTHERN TERRITORY

FOR

THE NORTHERN TERRITORY

GEOLOGICAL SURVEY

BY

GEOTERREX PTY. LTD.

JOB NO. 1-390

JUNE 1989

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INTRODUCTION

In October/November 1988, Geoterrex Pty Ltd conducted an airborne magnetometer and spectrometer survey of The Granites area in the Northern Territory for the Northern Territory Geological Survey. This report summarises the logistics, survey parameters, calibration procedures and processing details of the survey.

This processed data was then merged with processed data which was acquired for North Flinders Exploration in 1985 and BHP Minerals Ltd. in 1982.

1 SURVEY OPERATIONS SUMMARY

Base of Operations:	The Granites, NT	
Airstrip:	The Granites	
Aircraft:	Rockwell Shrike Commander 500S, (VH-EXE)	
Field Personnel:	Pilot/Project Manager;	M. Howell
	Electronics Technicians;	R. Rivers F. Corriveau
	Data Compiler;	M. Drewitt
Data Processing Manager:	M. Schneider	
Supervising Geophysicist:	G. Nader	

TABLE 1: Survey Progress

Mobilisation:	15 October 1988
Flight 1:	16 October. Compensation flight and production. Fine, 40C
Flight 2:	17 October. Production, but poor Syledis. Fine, 40C
Flight 3:	19 October. Production. Fine, 40C
Flight 4:	20 October. Compensation flight Fine, 41C
Flight 5:	21 October. Some production lost due to base station failure. Fine, 42C
Flight 6:	22 October. Some production lost due to base station failure. Fine.
Flight 7:	23 October. Production, but RMS failure. Fine.

Flight 8:	24 October. Production. Hot and windy.
Flight 9:	25 October. Production. Hot and turbulent.
Flight 10:	28 October. Production. Hot, 40C
Flight 11:	29 October. Production. Hot, 41C
Flight 12:	30 October. Production. Fine, 40C
Flight 13:	31 October. Production. Fine, 40C
Flight 14:	1 November. Production. Turbulent, 40C
Flight 15:	6 November. Production. Hot.
Flight 16:	8 November. Production. Stormy, 40C
Flight 17:	9 November. Some production lost due to diurnal problems. Hot, 41C
Flight 18:	10 November. Production. Hot, 40C
Flight 19:	11 November. Aborted due to RMS failure. Hot, 42C
Flight 20:	13 November. Production. Cooler and overcast.
Flight 21:	14 November. Production. Overcast.
Flight 22:	15 November. Production. Overcast.
Flight 23:	16 November. Production. Windy, 30C
Flight 24:	17 November. Production. Overcast.
Flight 25:	18 November. Production. Fine and mild.

2 DATA ACQUISITION PARAMETERS

2.1 AREA

The survey area is depicted on the Location Map, Figure 1.

2.2 SURVEY PARAMETERS

Type of survey:	Magnetic and radiometric
Survey size:	23734 kilometres
Traverse line direction:	North-South
Traverse line spacing:	500 metres
Tie line direction:	Orthogonal to traverse lines
Tie line spacing:	5000 metres
Average line length:	54.8 kilometres
Nominal aircraft terrain clearance:	90 metres
Nominal aircraft speed:	125 knots

2.3 AERIAL PHOTOGRAPHY

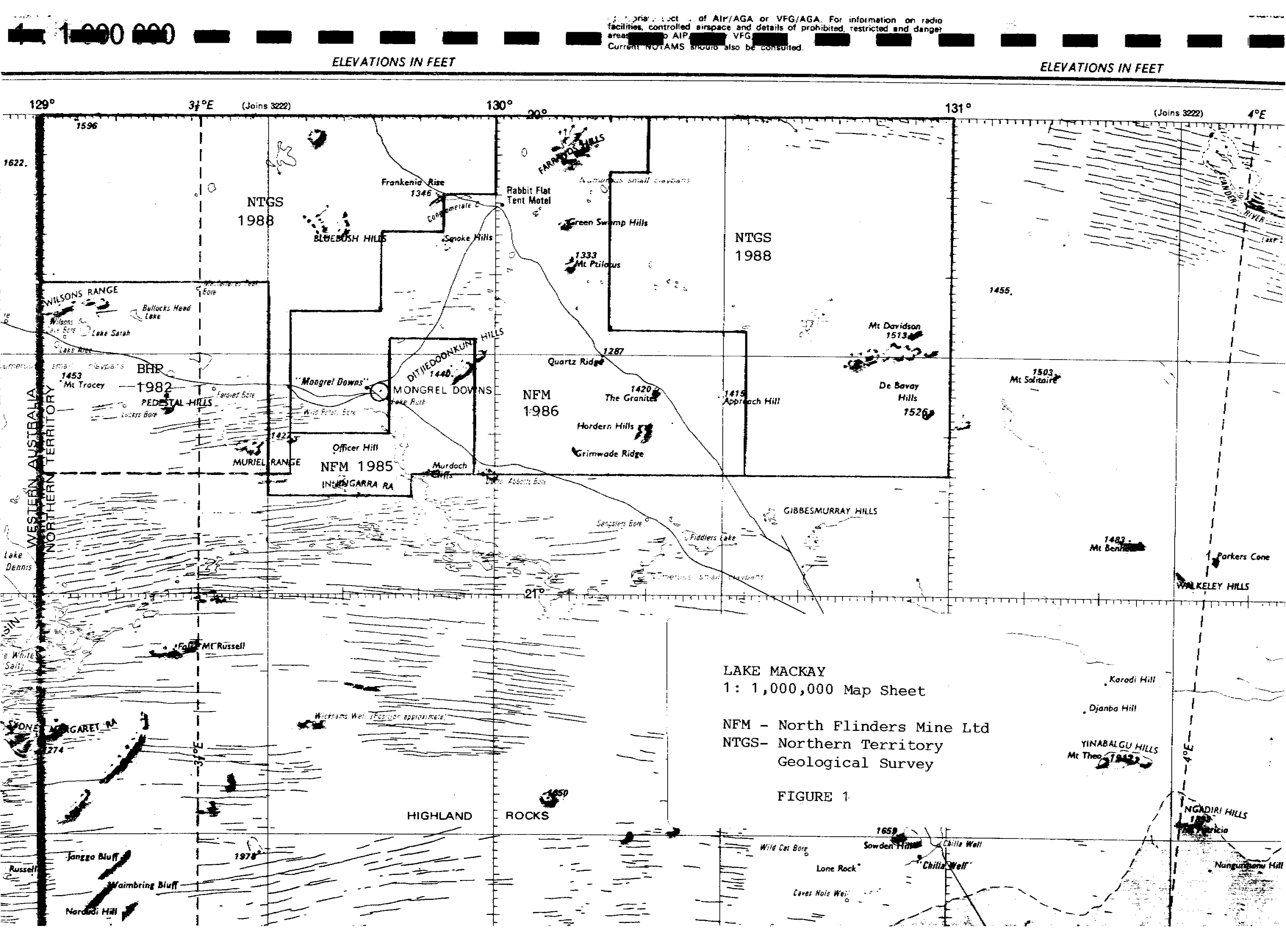
No photography was used other than that necessary for testing the Syledis navigation system.

2.4 SYLEDIS CHAIN

Syledis beacons and power supplies were initially established in the vicinity of the survey area by GEOMETRA PTY LTD at locations such that the survey area could be adequately covered, and were then relocated by Geoterrex staff when necessary.

2.5 FLIGHT PATH VERIFICATION

The Syledis position was recorded in AMG co-ordinates onto 9-track magnetic field tapes. The flight path as determined from the Syledis navigation system was plotted after each flight using a Compaq field computer processing system to determine if any relights were necessary.



LAKE MACKAY
1: 1,000,000 Map Sheet

NFM - North Flinders Mine Ltd
NTGS- Northern Territory Geological Survey

FIGURE 1

3 EQUIPMENT AND SPECIFICATIONS

3.1 AIRCRAFT

Model: Rockwell Shrike Commander 500S

Registration: VH-EXE

3.2 MAGNETOMETER

Model: Scintrex cesium vapour optical absorption magnetometer

Mounting: Tail stinger

Sample interval 0.5 seconds

Sensitivity: 0.01 nT

Average noise for the survey data is calculated from the fourth difference monitor using the equation:

Fourth difference noise envelope/16 = Average Data Noise

Figure of Merit = sum of noise envelopes produced by ten degree roll, pitch and yaw manoeuvres heading N,S,E and W.
= 1.98 nT (average of 0.16 nT per manoeuvre).

System Parallax: Less than one sample interval (see Sec.4).

3.3 SPECTROMETER

Model: Nuclear Data ADC/ND-560

Detectors: 8 Harshaw all viewing 4 pi NaI(Tl) crystals, totalling 33.5 litres. Crystals, photomultiplier tubes and preamplifiers are all mounted in temperature controlled, insulated compartments.

Sample interval: 1 second

Number of channels: 256

Synchronisation: The spectrometer sample is allocated to the time recorded at the end of the sample interval.

Window definitions:	Total Count	- Channel 68 to 255
	Potassium	- Channel 116 to 133
	Uranium	- Channel 141 to 158
	Thorium	- Channel 206 to 240
	Cosmic	- Channel 0
Nominal Window MeV Ranges:	Total Count	- 0.4 to 3.0 MeV
	Potassium	- 1.36 to 1.56 MeV (K40, 1.46 MeV)
	Uranium	- 1.66 to 1.86 MeV (Bi214, 1.76 MeV)
	Thorium	- 2.42 to 2.82 MeV (T1208, 2.615 MeV)
	Cosmic	- above 3.0 MeV

3.4 DATA ACQUISITION SYSTEM

Model: Geoterrex Pty. Ltd. MADACS

Program: ULMS1

The MADACS is a computer based software system using an Interdata 6/16 processor with 32K of memory. The processor is linked to a Digi-Data Model 1600 magnetic tape drive. This tape drive has a feature which allows checking of the recording process as many times as the particular application permits. The checking procedure includes elimination of errors due to bad tape spots. Multiple buffers permit recording, processing, and acquisition of data to be carried out simultaneously with no dead time. The system uses a Cybernex alpha numeric keyboard and VDU for operator-system communication.

The key feature of this system is that all data collection, verification, buffering, and recording is software-controlled. Therefore, the acquisition system may be economically altered to fit almost any requirement. Critical parameters are automatically monitored during flight, with visual and aural alarms provided for the operator.

Survey parameters are displayed during flight in their correct physical units, making operator comparisons simple. The survey program operates on a request-response basis, with the system pre-empting the operator and rejecting all illegal responses.

The MADACS is used to control and command the operations of all the ancillary equipment. This includes the magnetometer, spectrometer, camera, altimeter, tape drive, and analogue chart recorder.

The system is based on a precision clock. Time is digitally recorded as a six-figure number called a "fiducial". A fiducial number equals the real time in tenths of seconds after midnight, for example, 000000 corresponds to midnight and 360000 corresponds to 10:00 am. Fiducials are generated on digital tape, film and analogue charts at ten second intervals. The fiducial numbers do not increment by units, they are calculated from the clock time by the computer. This system does not require digital recording of line numbers, part numbers and line direction, thus avoiding a source of digital recording errors. These are recorded on the flight log by the operator.

Technical Specifications

Precision clock: The system is controlled by a precision clock which allows data to be collected at any multiple of 0.1 seconds.

Computer: The system is based on an Interdata 6/16 mini-computer with 32 kilobytes of core memory. The computer has the following interfaces:

- **Digital Input/Output Bus**
  This bus is capable of recording from, writing to, testing and controlling 16 external digital devices.
- **Analogue Input Module**
  This module has 16 analogue inputs with 12 bit resolution.
- **Analogue Output Module**
  This module has 12 analogue outputs with 12 bit resolution.
- **Magnetic Tape Controller**
  This interface/controller is capable of handling four 9-track NRZI tape transports. Tapes are written in an IBM compatible binary format with full parity, cyclic redundancy and longitudinal check characteristics.
- **Magnetometer Interface**
  This interface converts the signal from the high sensitivity cesium vapour magnetometer into a format acceptable to the MADACS.
- **Camera Controller**
  This interface allows the MADACS to control and monitor all aspects of the tracking camera's operation.
- **Operator's Console**
  This is a Cybernex alpha numeric keyboard and VDU, via which the operator communicates with the system. While on line during survey, all parameters are continuously displayed on the monitor unless the system senses an abnormal condition in which case a diagnostic message and the time sensed are displayed. The message remains until acknowledged by the operator.

Recorded Digital Data

Each second:	Flight number
	Time
	Altitude
	Spectrometer windows
	232 channels of radiometric data
	Cosmic count
	Live time
Each 0.5 seconds:	Total magnetic field

(See Field Tape Format, Appendix C)

3.5 TRACKING CAMERA

Model: Geocam 75 SF

The tracking camera is a 35 mm continuous strip camera equipped with a 17 mm wide-angle lens. The 35 mm film is synchronised with the geophysical record by means of fiducial marks printed every second and fiducial numbers recorded on the film every ten seconds. The ten second fiducial mark is the large dot between the ten thousand and one thousand digits. Times are not recorded from an incrementing counter, they are recorded from the digital information provided by the MADACS system. The tracking camera was in operation only during initial testing of the Syledis navigation system.

3.6 ALTIMETER

Model:	Sperry Stars AA200 radio altimeter system
Sample interval:	1.0 second
Accuracy:	+/- 1.5% (+/- 1 m at 60 m)
Synchronisation:	The average of the output of the altimeter over each second is calculated and assigned to the time recorded at the end of each sample.

3.7 ANALOGUE RECORDER

Model:	RMS GR33 Thermal Dot Matrix Printer
Chart Speed:	10 cm/minute; time increases from left to right
Chart width:	12 inches
Event marks:	10 second marks are recorded on both sides of the chart with the associated fiducial numbers being printed at the base of the chart.

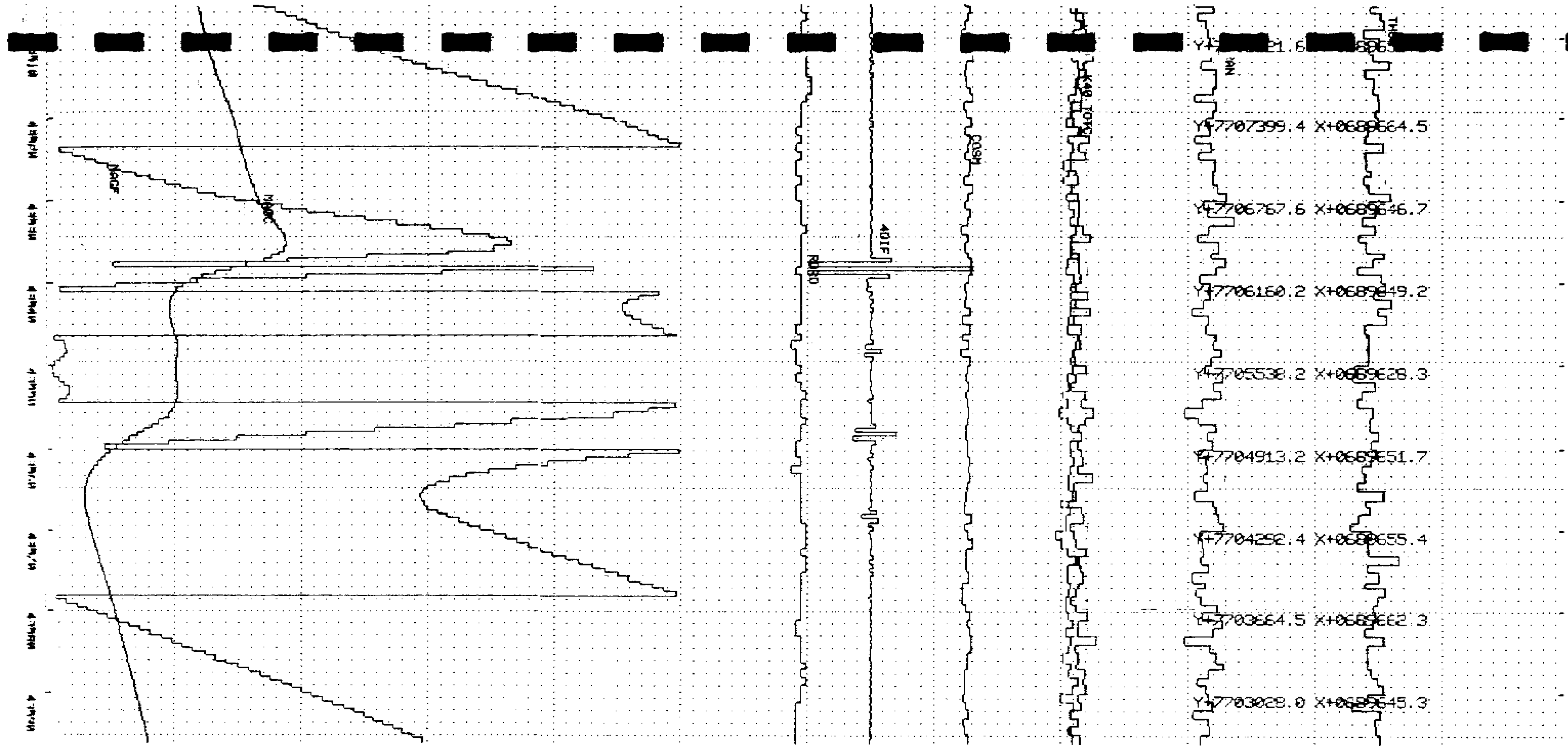
Channels recorded & full-scale values:

Total magnetic field	
Fine scale	- 200 nT
Coarse scale	- 2000 nT
Magnetic field fourth difference	- +/-20 nT
Terrain clearance	- 500 metres
Total Count	- 2000 counts/sec
Potassium	- 500 counts/sec
Uranium	- 200 counts/sec

Thorium	- 200 counts/sec
Cosmic	- 500 counts/sec All fields increase in value towards the top of the chart. A sample analogue record is shown in Figure 2.
Zero Positions:	These zero positions are annotated on the analogue sample. The zero position of each radiometric channel is calibrated automatically at the start of each line. Between lines each trace resides in its mid-range position.
Sychronisation:	No lags occur between traces, other than that which occurs between the magnetic field and its fourth difference.
Compton Effect Corrections:	The analogue radiometric channels have been Compton corrected using: Alpha (Thorium into Uranium) - 0.29 Beta (Thorium into Potassium) - 0.37 Gamma (Uranium into Potassium) - 0.72 The radiometric data recorded on the field tapes has not been corrected.
Cosmic Background Correction:	The analogue radiometric channels have been corrected, in real time, for aircraft and cosmic background using the equations set out in Section 4. The erroneous potassium background value of 37 counts is displayed on the analogues, however the correct value of 27 counts is being used to correct the data.

3.8 GROUND MAGNETOMETER BASE STATION

Sensor:	Proton
Magnetometer:	Geometrics G856
Sample interval:	4 seconds
Sensitivity:	0.1 nT
Location:	The Granites
Digital Recording:	G856



0--------------------COARSE MAG--------------------1000

0--------RADAR------0200

-20 4TH D +20

0--------------------FINE MAG--------------------0100

0----TOTAL COUNT---2000

0 COSMIC 0500

0-----POTASSIUM----0500

0------URANIUM-----0200

0----THORIUM----0200

COMPTON CORRECTIONS (PARTS/1000):ALPHA= 290 BETA= 370 GAMMA= 720
COSMIC CORRECTIONS (PARTS/1000):TC= 456 THOR= 050 URA= 040 K40= 049
HEIGHT CORRECTIONS (PPM) TC= 5940 THOR= 6490 URA= 7300 K40 7810
BACKGROUNDS (COUNTS) TC= 110 THOR= 004 URA= 014 K40= 037

DATE 15/11/88 FLIGHT NO. 0022

JOB NO. 1/390 LINE NO. 502.15.

AREA THE GRANITES

GEOTERREX AUSTRALIA PTY. LTD.

ULTRAMAG ULMS1.

FIGURE 2

4 CALIBRATION PROCEDURES AND RESULTS

4.1 MAGNETOMETER

The following calibration tests were carried out on the magnetometer.

Manoeuvre test to determine Figure of Merit (F.O.M.)

This test was carried out on 16 October 1988 over The Granites and is considered the most important of the magnetometer tests. The settings of the compensation coils determined from this test remain fixed during the heading effect test and during the survey. The Figure of Merit for this test was: F.O.M. = 1.98 nT. The Figure of Merit test analogues (Figures A1-A12) and Table of Results (Table A1) can be found in Appendix A.

Parallax

This test was carried out on 18 November 1988. The aircraft was flown in opposite directions over a sharp magnetic anomaly with the tracking camera and magnetometer operating. The time lag between the magnetic source being recorded on the tracking film and its anomaly being recorded was determined as below:

	EAST HEADING FIDUCIAL	WEST HEADING FIDUCIAL
Magnetic Low	40707.5	40590.5
Camera	40707.5	40590.5
Difference	E1 = 0.0	W1 = 0.0

Copies of the parallax test analogues can be found in Appendix A, Figures A13 - A14.

Heading Effect Test

This test was conducted on the 20th of October 1988 over The Granites following a
compensation coil F.O.M. test. Test lines were flown, one each with bearings of 0, 90, 180, and 270 degrees over a common point. These lines were flown, in a low gradient area, while the ground station was running and synchronised. It is necessary to use a low gradient area so that slight deviations in the test line navigation do not significantly affect the results of this test. The results of this heading test can be found in Appendix A (Table A2 and Figure A15).

4.2 SPECTROMETER

The following checks and determinations were carried out for the radiometric data.

Pre and Post-flight Source Check Procedures

- Pre and post-flight U and Th source checks with samples in a standard position relative to the crystals and the aircraft in a standard parking position - recorded for 100 seconds.

- Pre and post-flight test line recorded at survey altitude.

The results of the pre and post-flight uranium and thorium source checks can be found in Appendix B, Table B1. An annotated sample of the spectra plotted with each uranium and thorium source check is presented in Appendix B, Figures B1 and B2. The two figures combined form the output of one source check.

Compton Stripping Coefficients

These coefficients have been most recently determined from 46 source checks conducted during September 1987. They are:-

Alpha - 0.325 +/- 0.011
Beta - 0.373 +/- 0.014
Gamma - 0.769 +/- 0.015
Delta - 0.036 +/- 0.007

Background Determination

This test was carried out in April 1988 to determine the relationship between cosmic events (energies greater than 3.0 MeV) and counts recorded in other channels. The test was flown overland with the spectrometer system correctly calibrated as for survey work. Data was recorded at eight high altitudes: 5000 feet, 6000 ft, 7000 ft, 8000 ft, 9000 ft, 10000 ft, 11000 ft and 12000 feet A.S.L.

The best fit linear equations for these tests are:-

Th	background	=	0.056 x Cosmic + 0.0
U	background	=	0.052 x Cosmic + 0.8
K	background	=	0.066 x Cosmic + 12.7
TC	background	=	0.555 x Cosmic + 56.0

where

cosmic = counts of energies greater than 3.0 MeV stored in channel 0.
x background = counts to be subtracted from window x.

Graphs of these equations are presented in Appendix B (Figures B3-B6).

Height Attenuation Coefficients

In May 1988 linear height attenuation coefficients were determined using the procedure outlined below:

a) An area with "homogeneous" radioactivity, high count rates and relatively flat terrain was selected.

b) An easily repeatable line was flown over this area at eight different altitudes: 200 feet, 250 ft, 300 ft, 400 ft, 500 ft, 600 ft, 700 ft, 800 feet. The spectrometer was correctly calibrated for this test flight.

c) Sections of each line sharing the most constant terrain clearance and count rate were selected for data processing.

d) The altitude data for each line section was corrected using the altitude calibrations recorded on the same flight, and averaged.

e) The radiometric data for each line section was background corrected using a height correction for alpha. The resultant data was averaged.

f) The resulting count rates in each channel were plotted and attenuation coefficients suitable for an air temperature of 18C were determined.

Graphs of the results can be found in Appendix B, (Figures B7-B10).

The coefficients are:

Total count	0.00592 per metre
Potassium count	0.00708 per metre
Uranium count	0.00435 per metre
Thorium count	0.00588 per metre

Note: The value calculated for the Uranium window was affected by excessive scatter in the data caused by low count rates. It is suggested that a value of 0.0073 per metre be used. This value was calculated by interpolation from a suite of previous calibration data and the data from this calibration.

During all spectrometer tests the data used is the window data recorded on field tapes. The widths of these windows are specified in Section 3.

Resolution

The resolution of the spectrometer is defined as the full width of the Thorium peak at its half peak height position, expressed as a percentage of the peak MeV value. The spectrometer resolution was checked ~~during~~ BEFORE and after the survey and it was found to be 5.8% and 6.8% respectively. (see Figures B11 and B12, Appendix B).

4.3 ALTIMETER

The Sperry radio altimeter is a high quality instrument whose output is factory calibrated. It is fitted with a test function which checks the calibration of a terrain clearance of 100 feet and altitudes which are multiples of 100 feet. Calibration of the recorded terrain clearance, both analogue and digital, with respect to the altimeter reading is carried out using a potentiometer to vary the reading while recording the altimeter's output. The results of a recent altimeter calibration carried out in October 1988 are presented in Table 2.

TABLE 2: ALTIMETER CALIBRATION RESULTS

INDICATED ALT.(metres)	RECORDED ALT.(metres)
60	59
100	91
150	140
200	168
300	265

5 DATA PROCESSING

On receipt of all the data in Sydney, path recovery, analogue records and flight logs were checked for consistency of line numbering. The magnetic and radiometric data were processed by Geoterrex Limited in Ottawa, Canada.

5.1 FIELD TAPES

These are recorded in binary format, (see Appendix C for detailed description) and are compacted and reformatted in BINARY code. The following information is retained on file as the Compacted Field Tape (C.F.T.).

- flight number
- magnetic reading (0.1 nT)
- thorium count
- uranium count
- potassium count
- total count
- altimeter (feet)
- fiducial (time in tenth seconds after midnight)
- spectrometer live time (milliseconds)
- cosmic count
- syledis easting coordinate
- syledis northing coordinate

The 256 channels of radiometric data are not selected from the field tape unless there is some indication in the thorium and cesium peak positions that the radiometric channels have drifted away from the normal window settings. If it is necessary to re-construct radiometric data due to channel drift, summed spectral plots are produced for each survey line. These are examined to determine at what stage the drift began and which new channel positions define the principal radiometric windows.

Due to the difference in the sample interval between the magnetic and the radiometric data, the radiometric values are repeated for each 0.5 second reading between the 1.0 second readings. This gives both magnetic and radiometric readings for each 0.5 second interval. All channels are checked and edited for single reading spikes and recording gaps; any single reading spikes are removed manually.

5.2 FLIGHT PATH

The Syledis positioning information collected during the survey was read from the magnetic field tapes into the data base. A speed report of the Syledis flight path was then checked for erroneous points by comparing the average aircraft speed between adjacent fixes (being real time values in seconds) and the average speed for the whole line. Significant speed changes over short intervals were noted ad the Syledis data was checked for errors and corrected where necessary.

The final Syledis flight path was then plotted at 1:100,000 scale.

5.3 MAGNETICS

Levelling

The aeromagnetic data is tie line levelled. The base station record is used as a storm monitor only. No attempt is made to subtract the base station values from the airborne values. The tie lines are levelled to a common datum first and then the traverse lines are levelled to the tie line network. The method involves the fitting of polynomials to the observed flight line/tie line intersection errors along each traverse line in the survey. These intersection locations are adjusted to give minimum intersection errors. The aircraft heading effect is eliminated by the levelling process and therefore is not subtracted as a separate process before levelling.

Parallax

The results from the parallax test indicated that no parallax correction was required.

Australian Geomagnetic Reference Field

The Australian Geomagnetic Reference Field known as AGRF (1985) was subtracted from the data and a datum of 2000 nanoteslas added to ensure that there were no negative magnetic values before contouring.

Gridding and Contouring

Grid mesh size:	150 x 150 metres
Residual magnetic contour maps:	Horizontal scale - 1:100,000 & 1:250,000 Contour interval - 10, 100, & 1000 nT

The magnetic data was contoured at 1:50,000 scale and photographically reduced to 1:100,000 scale for presentation as final map sheets. The 1:100,000 scale sheets were mosaiced and further reduced to 1:250,000 scale for presentation as a final composite map.

Stacked Magnetic Profiles

The levelled magnetic data with the AGRF (1985) removed were also pesented as two sets of stacked profiles. One set was plotted at a horizontal scale of 1:100,000 and a vertical scale of 200 nT/cm. A constant base level of 2000 nT was used for each map sheet. The base level is a straight line joining the ends of the flight path at its intersections with the sheet boundaries. The second set was plotted at a horizontal scale of 1:100,000 and a vertical scale of 100 nT/cm, using every 4th flight line.

5.4 RADIOMETRICS

Corrections

The radiometric data was corrected for:

- **Spectrometer dead time**
  "Dead time" is the fraction of 1 second when the spectrometer is actually counting the energy levels and not registering the incoming counts. A typical "dead time" is 15 milliseconds in a 1 second sample period.

- **Cosmic effect and aircraft background**
  Through test flying outlined in Section 4, Geoterrex Pty Ltd has established the coefficients for the linear relationship between the incoming cosmic counts (energies greater than 3 MeV) and their contribution to the background in each window.

- **Changes in ambient air temperatures**
  The effects of changing air temperature are incorporated in the notion of a temperature corrected altitude that will be used in other calculations. The field operator records the outside temperature at regular intervals throughout each flight while at survey altitudes.

- **Compton scattering**
  These coefficients were determined from the calibration procedures outlined in Section 4. It should be noted that alpha coefficient is height dependent under the linear relation:

  true alpha = ground + 0.02 + 0.00025 x height

- **Height attenuation**
  The survey data was exponentially height attenuated to a common datum of 90 metres, which was the nominal survey altitude, using the coefficients determined in Section 4.

5.5 ALTIMETER

The altimeter data was presented as stacked profiles at a horizontal scale of 1:100,000 and vertical scale of 100 metres/cm. A constant base level of 90 metres was used for each map sheet. The base level is a straight line joining the ends of the flight path at its intersections with the sheet boundaries.

5.6 MERGED DATA

Following the processing of the data acquired in 1988 over The Granites, this data set was merged with two older data sets in order to produce a complete set of maps over this area. Areas B and C were surveyed by Geoterrex Pty Ltd in 1985 for North Flinders Exploration and Area D was surveyed by Geometrics Int. Corp. in 1982 for BHP Minerals Limited.

The specifications for these earlier surveys are as follows:

	Areas B & C	Area D
Aircraft	Rockwell Shrike Commander	Britten Norman Islander
Magnetometer	Cesium vapour optical absorption	Geometrics G813
Resolution	0.04nT	0.5nT
Cycle rate	0.2 second	0.73 second (approx)
Sample Interval	13 metres	45 metres (approx)
Spectrometer	Nuclear Data 256 channel ADC	Exploranium GR800D
Window ranges	Total Count = 0.80 - 3.00 MeV	0.20 - 3.00 MeV
	K40 = 1.36 - 1.56 MeV	1.36 - 1.56 MeV
	Bi214 = 1.66 - 1.86 MeV	1.66 - 1.86 MeV
	T1208 = 2.42 - 2.82 MeV	2.42 - 2.82 MeV
Volume	33.5 litres	16.8 litres
Cycle rate	1 second	0.73 second (approx)
Sample Interval	60 metres	45 metres (approx)
Data Acquisition	Geoterrex MADACS Acquisition System	Geometrics Digital Acquisition System
Flight Line Spacing	Traverse lines: 500 metres	Traverse Lines: 500 metres
	Tie lines: 5000 metres	Tie Lines: 5000 metres
Flight Line Direction	Traverse lines: Area B - 180-360 degrees 090-270 degrees Area C - 180-360 degrees	Traverse Lines: 180 - 360 degrees
	Tie lines: Area B: 090-270 degrees 180-360 degrees Area C: 090-270 degrees	Tie lines: 090-270 degrees
Survey Height	90 metres M.T.C.	100 metres M.T.C.
Flight Path Navigation	Visual from 1:25,000 Black and White photos	Combined Doppler/Visual from 1:25,000 photos

Flight Path Record	Geocam 35mm continuous tracking camera	35mm tracking camera

The magnetic data for all blocks were tied to the 1982 Geometerics data set by applying the following datum changes:

1985 Granites survey data -267nT
1986 Grimwade survey data (Southern area) -369nT
1986 Grimwade survey data (Northern area) -360nT
1988 NTGS Granites survey data (Area 1) -244nT
1988 NTGS Granites survey data (Area 2) -225nT

Each survey was gridded individually and the 6 grids merged together.

5.7 DATA TAPES

Located Data Tape

A levelled located data tape, containing all traverse line and tie line data, was recorded in 9-track ASCII code at a density of 1600 bpi in a format described in Appendix C.

6 DELIVERABLE ITEMS

8 Residual Magnetic Contour Maps at 1:100,000 scale (ink on plastic)
1 Residual Magnetic Contour Map at 1:250,000 scale (ink on plastic)
8 Final Flight Path Maps at 1:100,000 scale (ink on plastic)
8 Stacked Profile Maps of Residual Magnetics at 1:100,000 scale (every line) (ink on plastic)
32 Stacked Profile Maps of Residual Magnetics at 1:100,000 scale (every 4th line) (ink on plastic)
8 Stacked Profile Maps of Altimeter Data at 1:100,000 scale (ink on plastic)
22 Located Data Tapes
1 Calibrated data tape
1 Recovered line listing
1 Mileage list
Flight logs
22 Folders of radiometric and magnetic analogue records
1 Logistics report

APPENDIX A: MAGNETOMETER CALIBRATION DATA

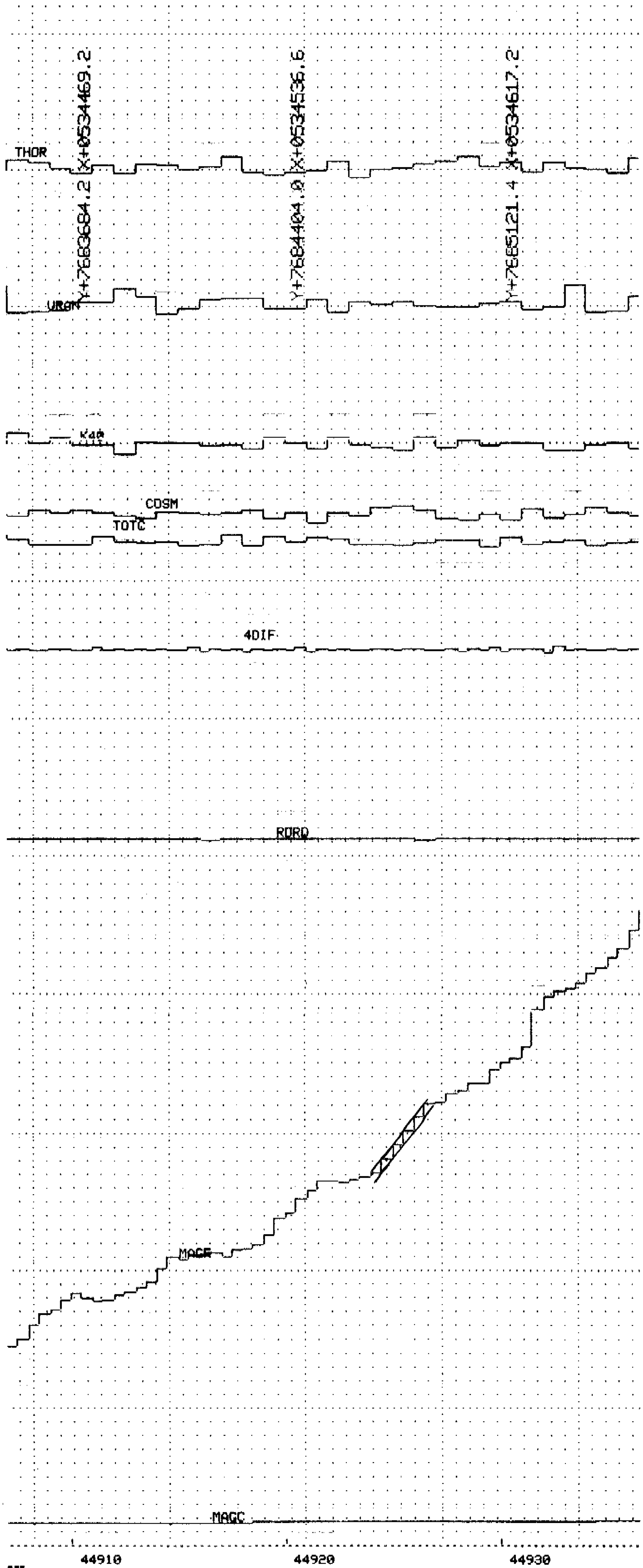
TABLE A1: FIGURE OF MERIT TEST RESULTS

16 October 1988

HEADING	ROLLS	PITCHES	YAWS	TOTAL
North	0.10 nT	0.30 nT	0.15 nT	0.55 nT
South	0.20 nT	0.20 nT	0.10 nT	0.50 nT
East	0.15 nT	0.15 nT	0.15 nT	0.45 nT
West	0.20 nT	0.08 nT	0.20 nT	0.48 nT
			F.O.M.	1.98 nT

→ noise level

1.98/12 = 0.17 nT



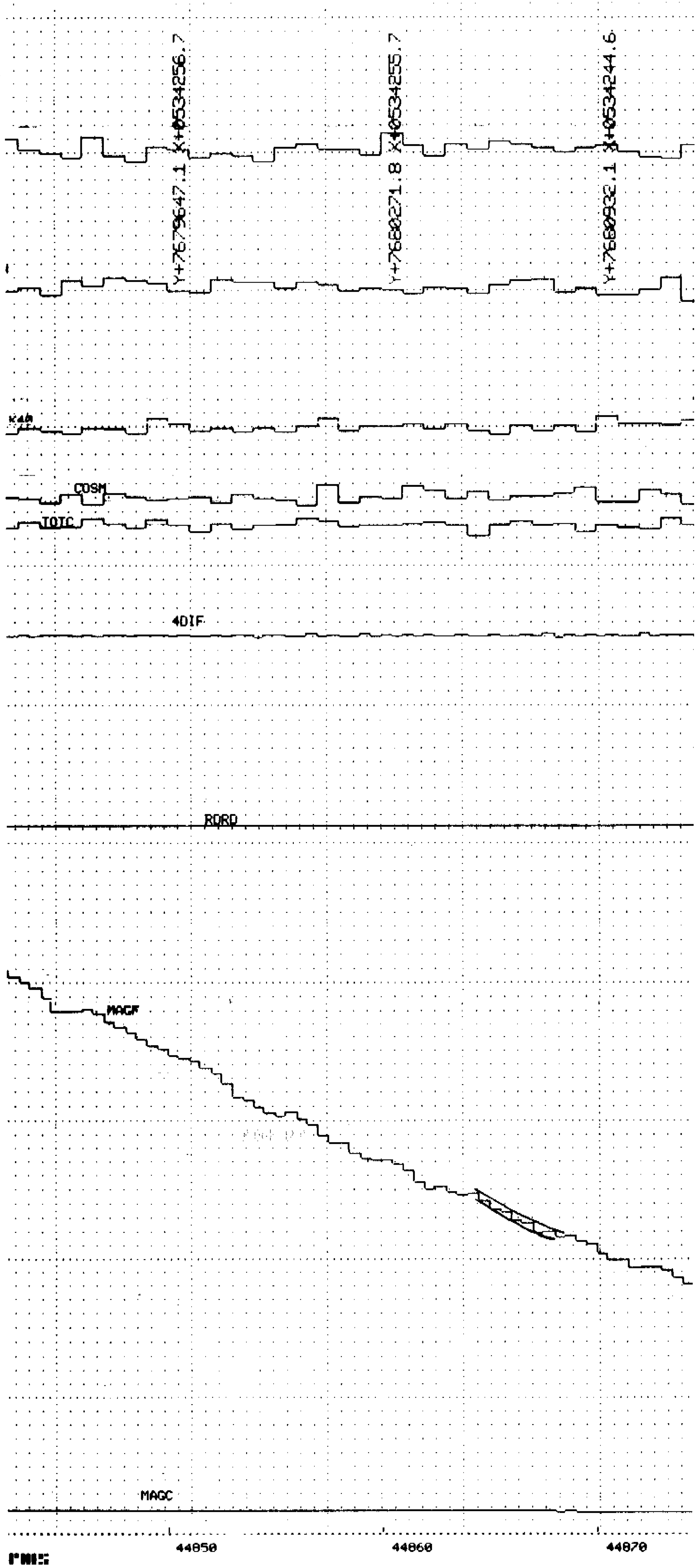
16th October 1988

North-Pitches

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A1



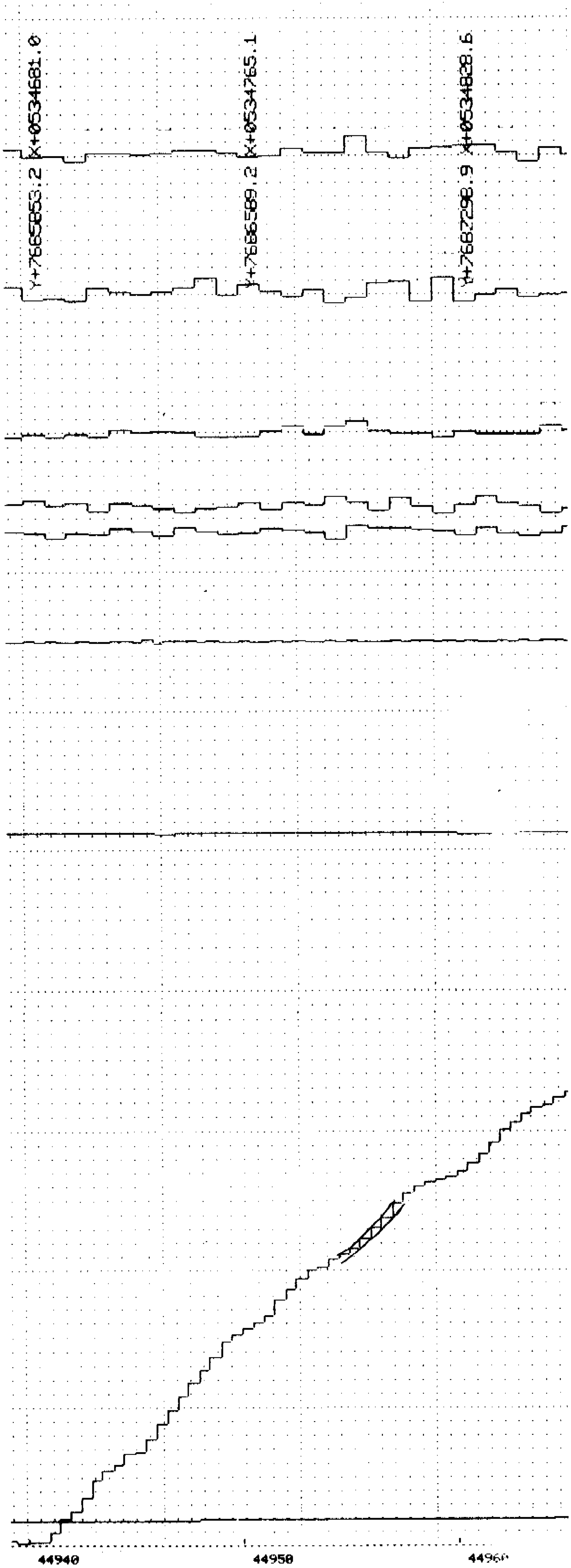
16th October 1988

North-Rolls

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A2



16th October 1988

North-Yaws

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A3

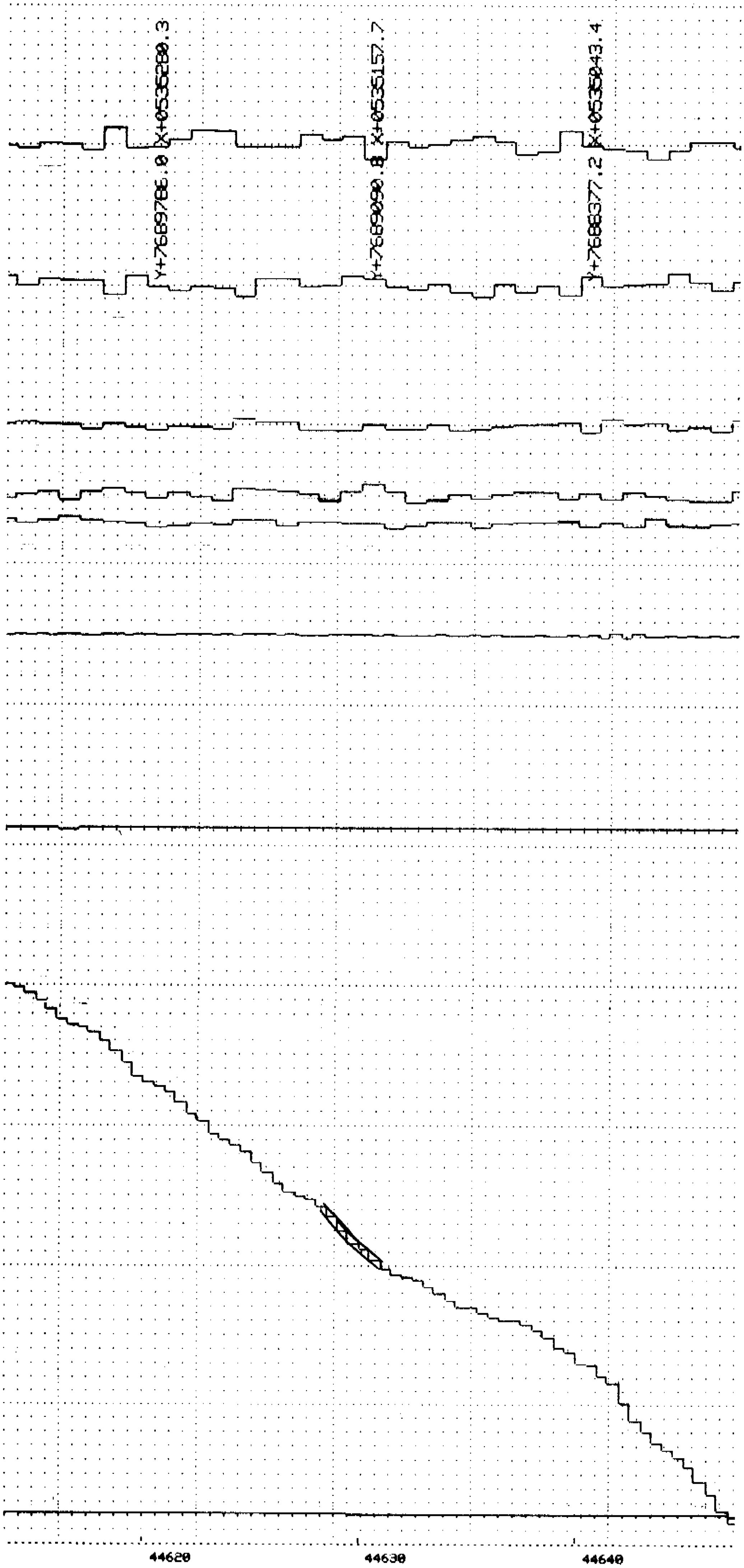
16th October 1988

South-Pitches

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A4



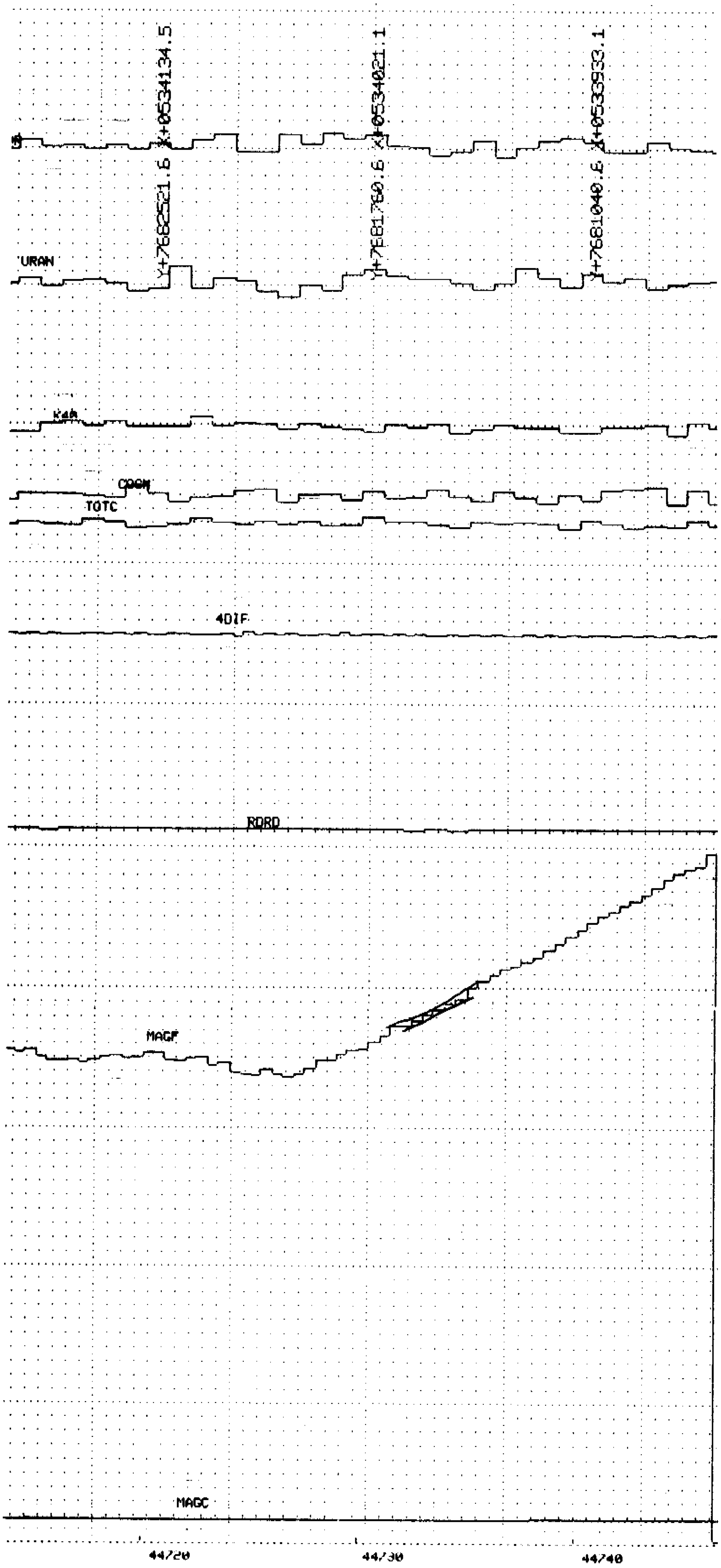
16th October 1988

South-Rolls

MAGNETOMETER

Fine Scale:10nt FSD

FIGURE A5



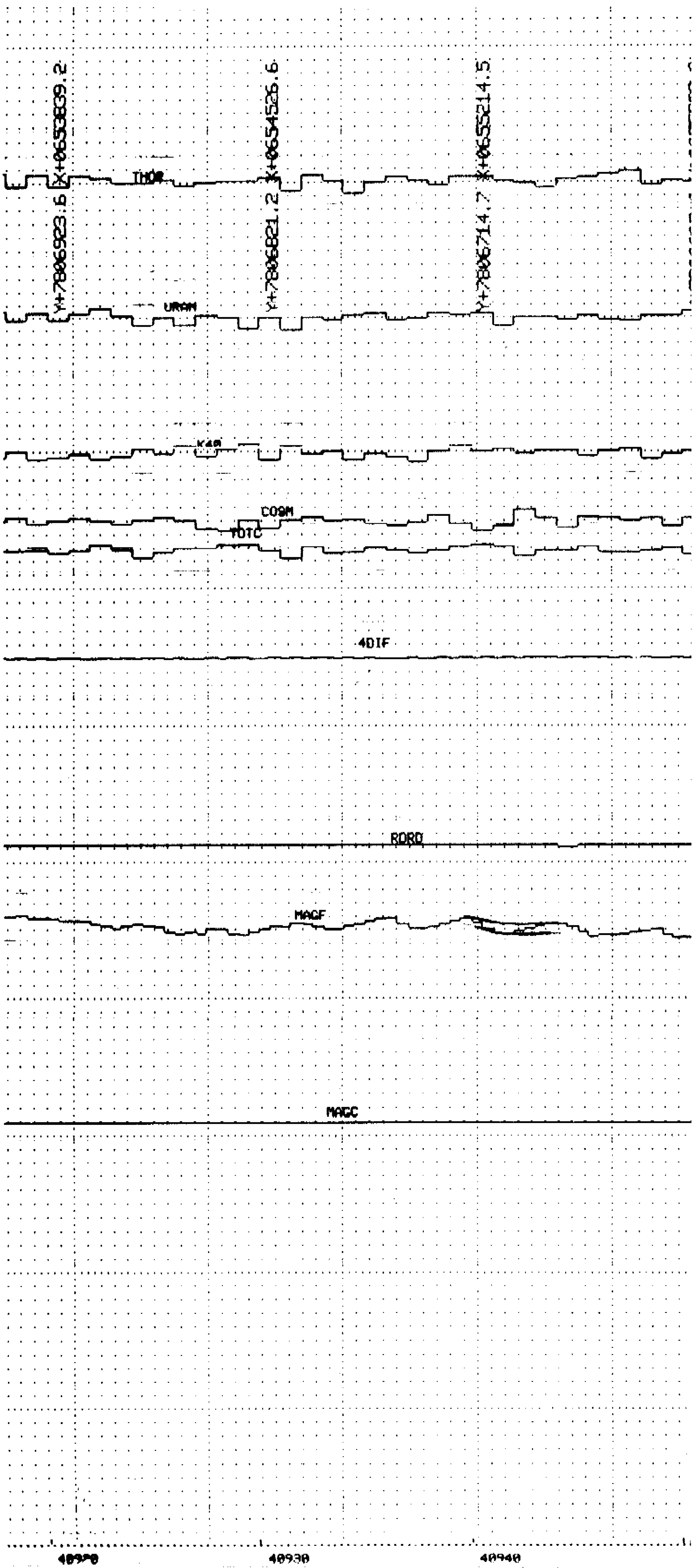
16th October 1988

South-Yaws

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A6



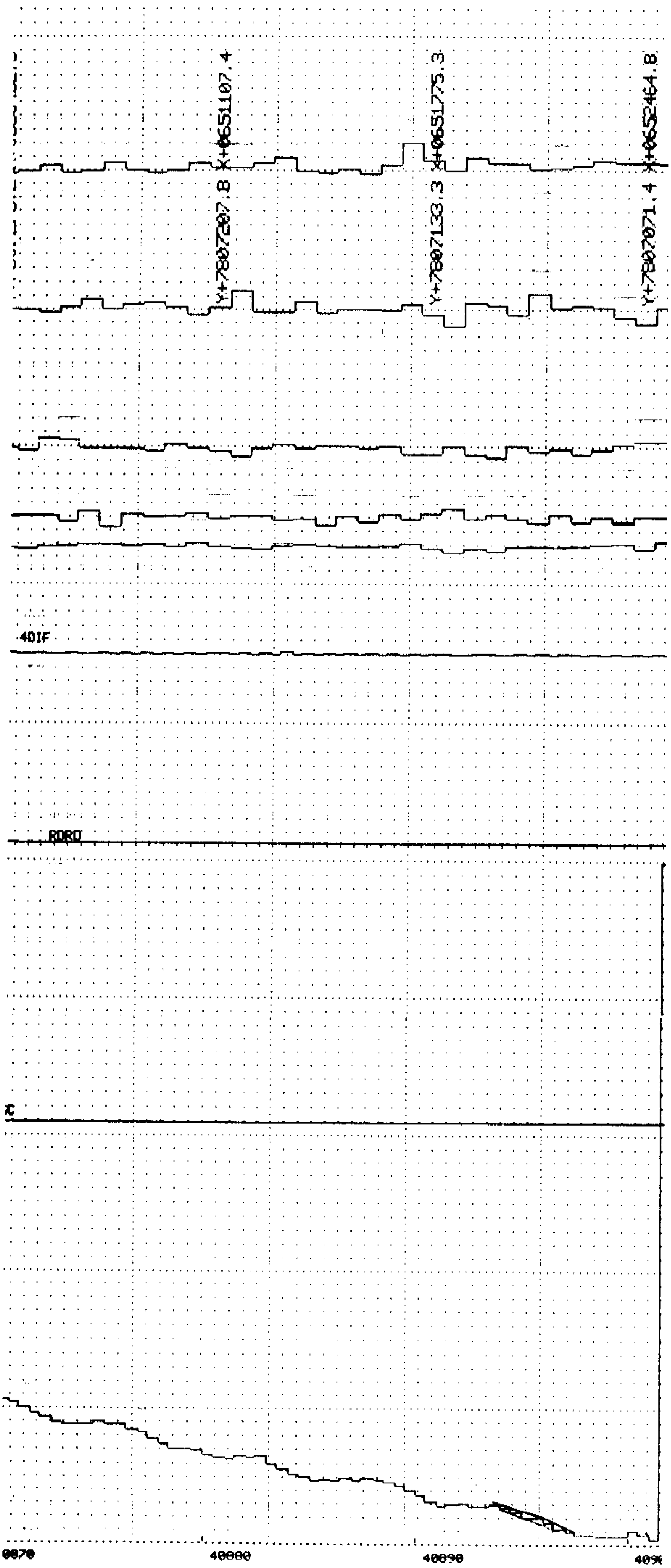
16th October 1988

East-Pitches

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A7



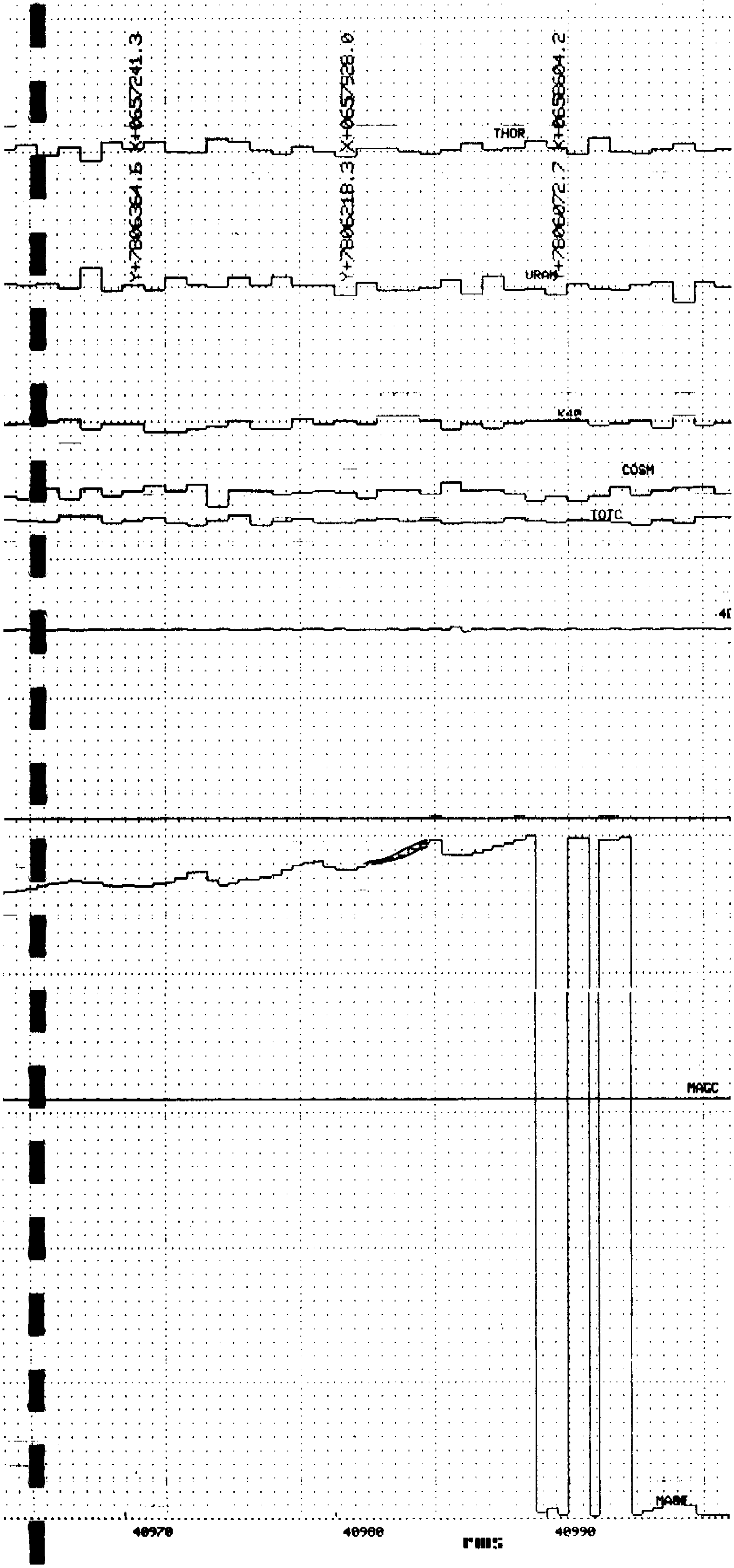
16th October 1988

East-Rolls

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A8



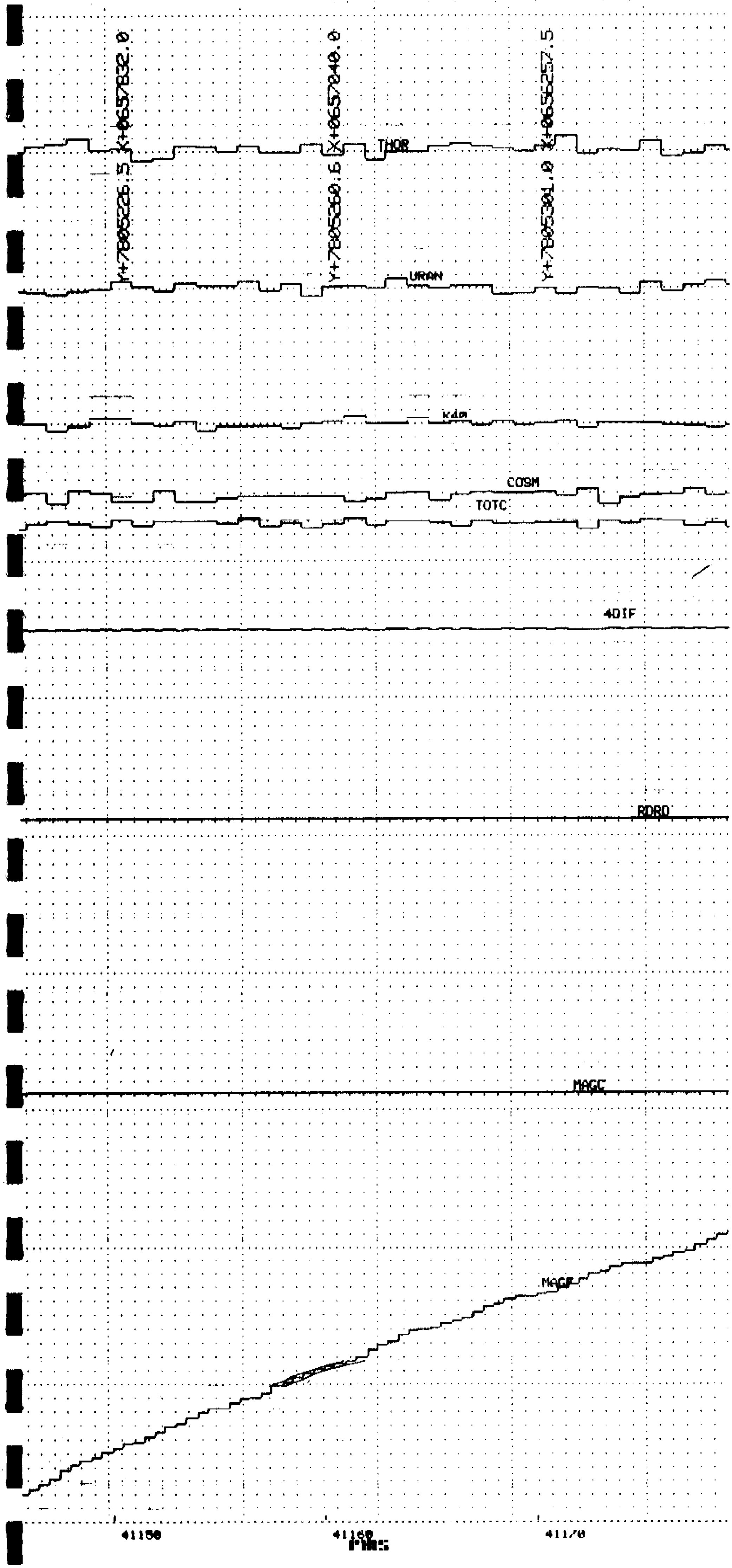
16th October 1988

East-Yaws

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A9



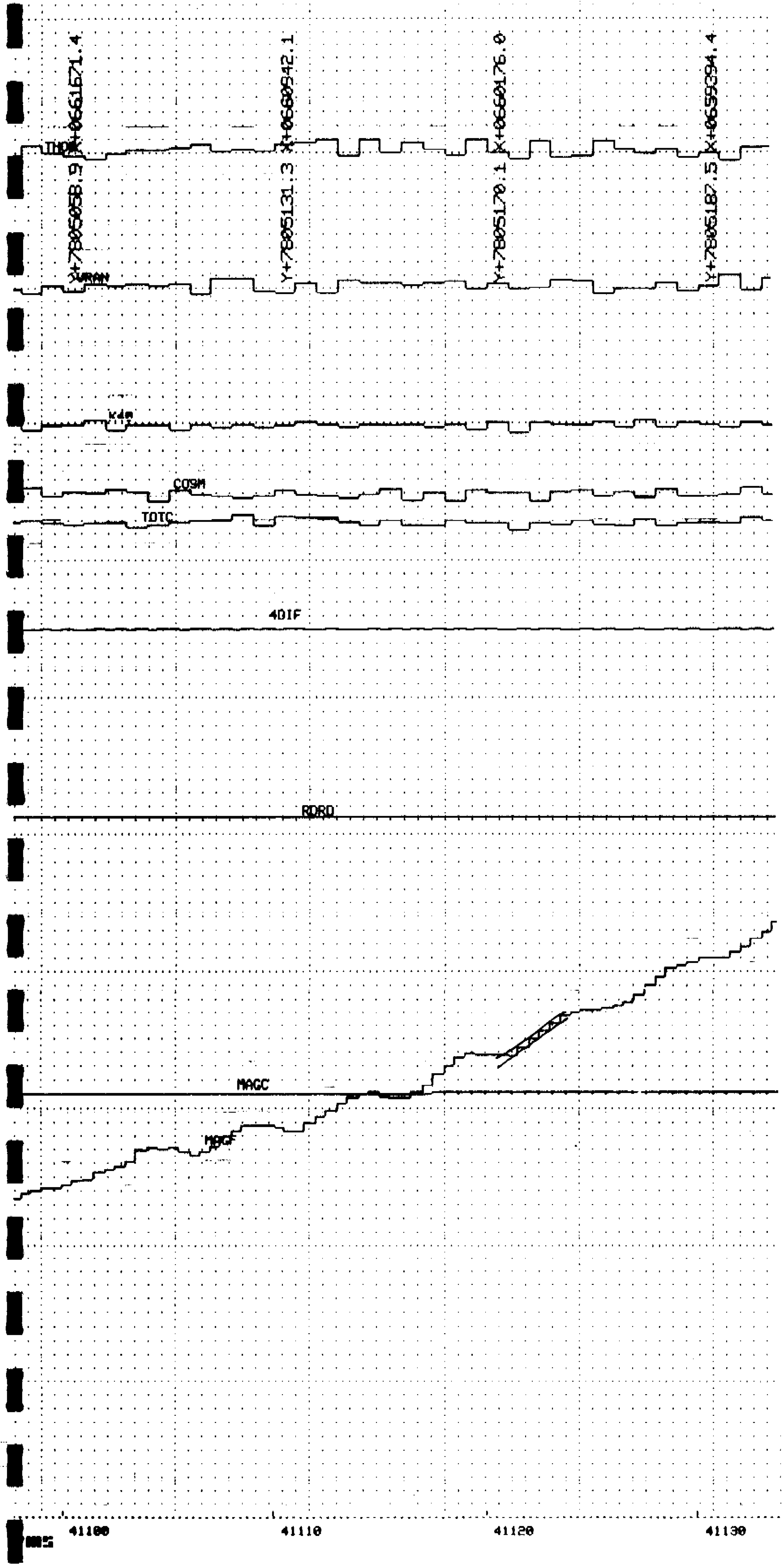
16th October 1988

West-Pitches

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A10



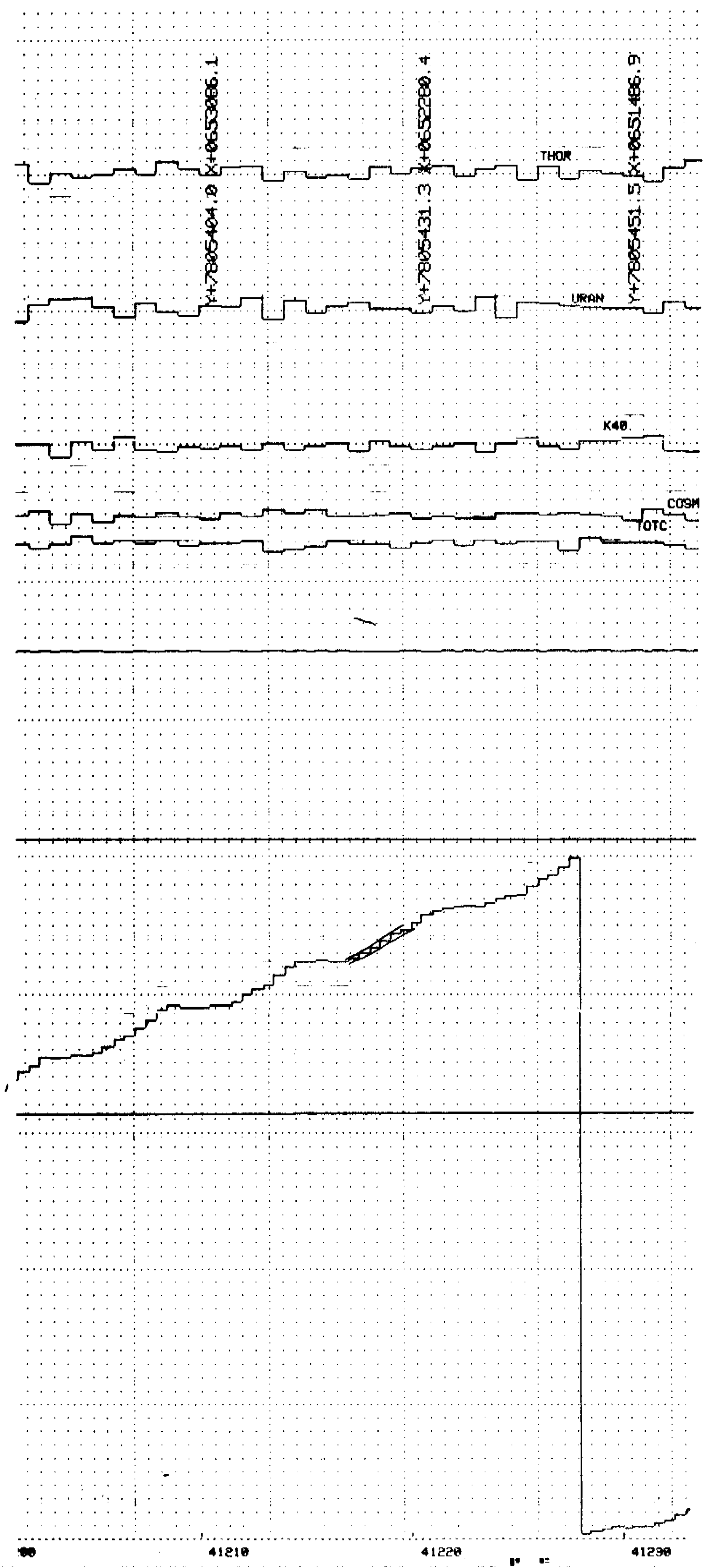
16th October 1988

West-Rolls

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A11



16th October 1988

West-Yaws

MAGNETOMETER

Fine Scale:10nT FSD

FIGURE A12

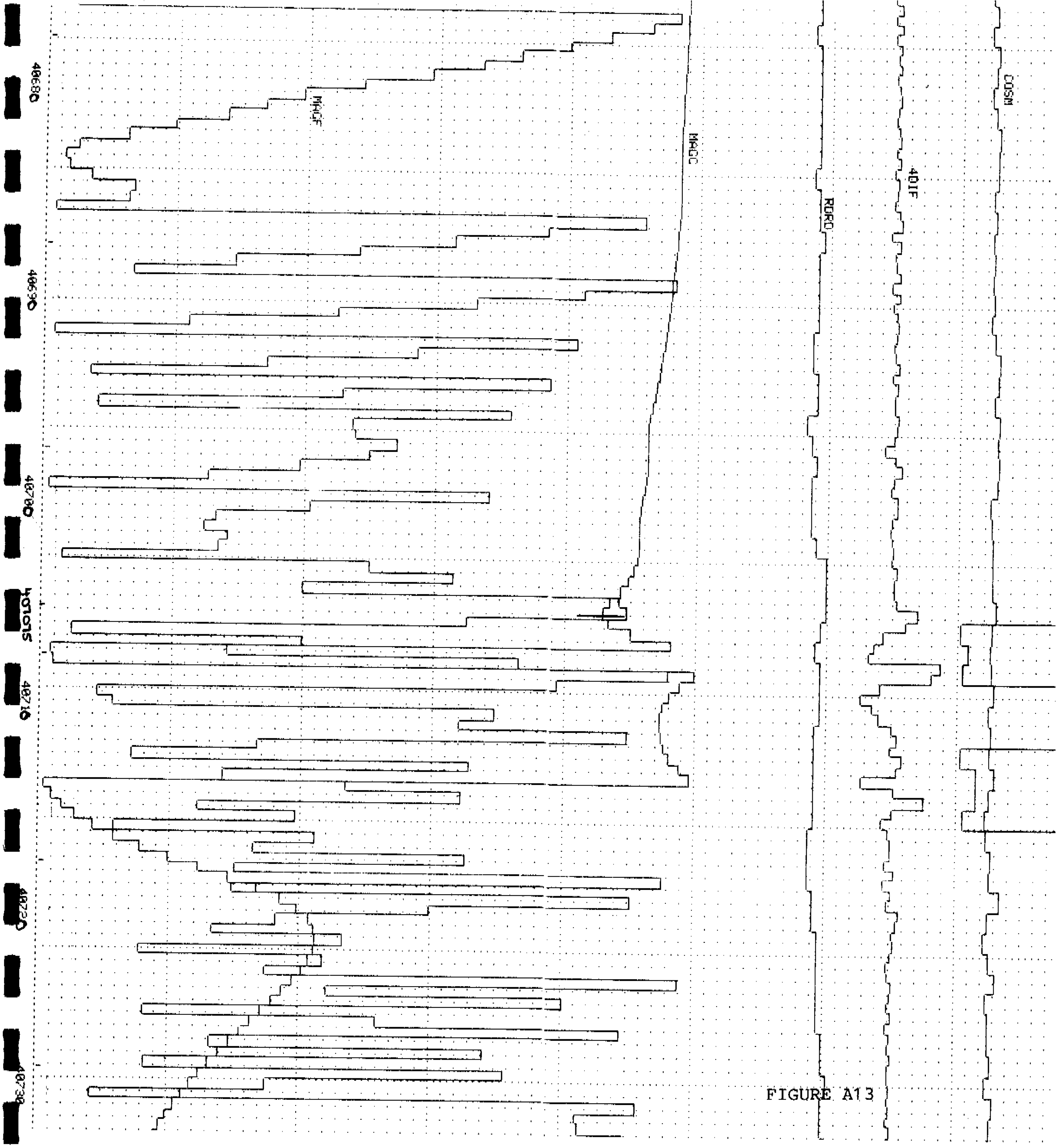


FIGURE A13

0----------------------COARSE MAG----------------------1000   0----TOTAL

0-------RADAR------0200

-20 4TH D +20

0----------------------FINE MAG----------------------0010   0 COSMIC

COMPTON CORRECTIONS (PARTS/1000):ALPHA= 290 BETA= 370 GAMMA= 720
COSMIC CORRECTIONS (PARTS/1000):TC= 456 THOR= 050 URA= 040 K40= 049
HEIGHT CORRECTIONS (PPM) TC= 5940 THOR= 6490 URA= 7300 K40 7810
BACKGROUNDS (COUNTS) TC= 110 THOR= 004 URA= 014 K40= 037

DATE 18/11/88 FLIGHT NO. 0024

JOB NO. 1/390 LINE NO...........

AREA............

GEOTERREX AUSTRALIA PTY. LTD.

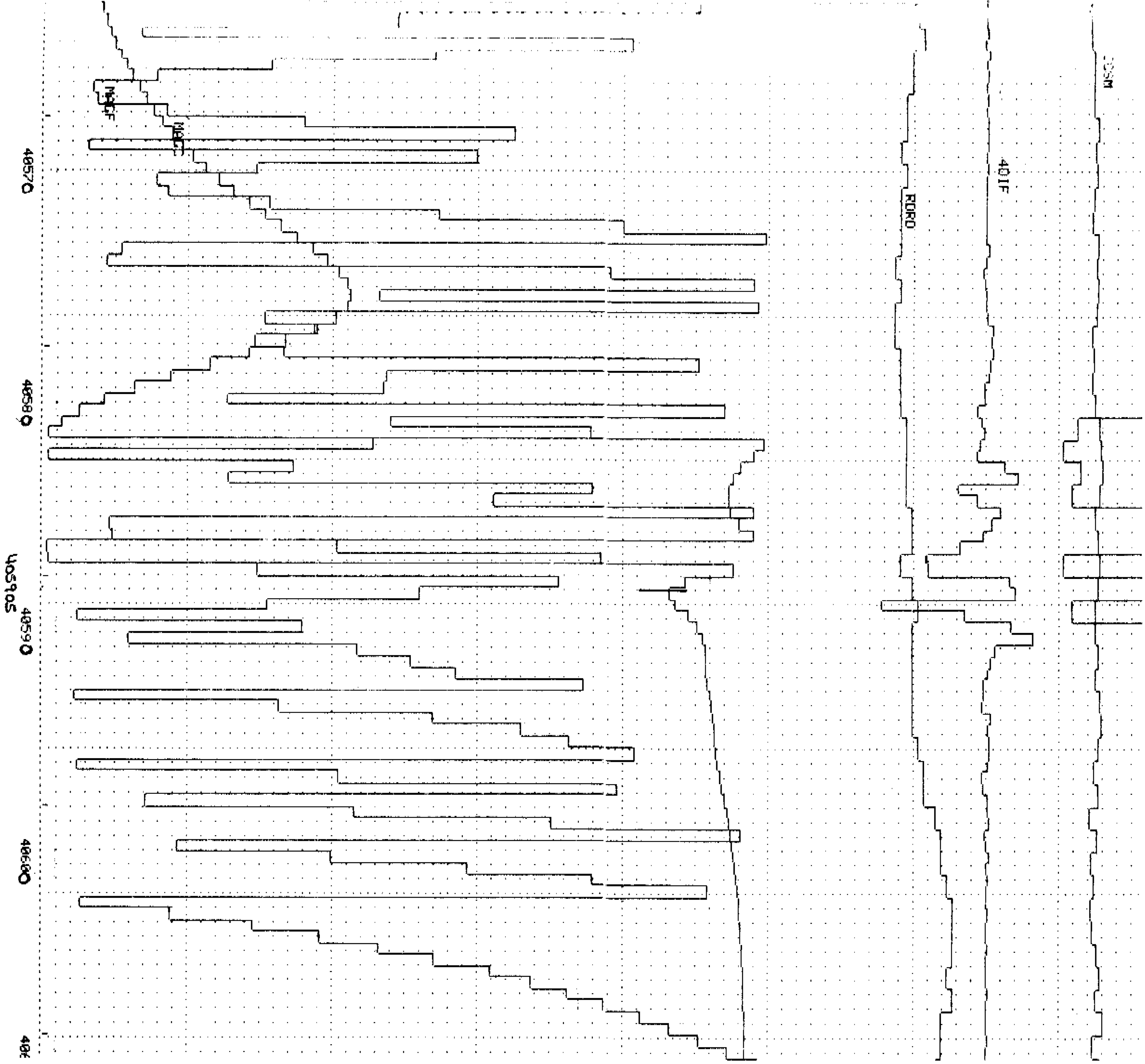


FIGURE A14

0--------------------COARSE MAG--------------------1000 0----TO
0-------RADAR------0200
-20 4TH D +20
0--------------------FINE MAG--------------------0010 0 COSMI

COMPTON CORRECTIONS (PARTS/1000):ALPHA= 290 BETA= 370 GAMMA= 720
COSMIC CORRECTIONS (PARTS/1000):TC= 456 THOR= 050 URA= 040 K40= 049
HEIGHT CORRECTIONS (PPM) TC= 5940 THOR= 6490 URA= 7300 K40 7810
BACKGROUNDS (COUNTS) TC= 110 THOR= 004 URA= 014 K40= 037

DATE 18/11/88 FLIGHT NO. 0024

JOB NO. 1/390 LINE NO...........

AREA............

GEOTERREX AUSTRALIA PTY. LTD.

ULTRAMAG ULMS1.

TABLE A2: CLOVERLEAF/HEADING TEST

20 October 1988

HEADING	FIDUCIAL	MAGNETIC VALUE (nT)	DIURNAL CORRECTION(nT)	CORRECTED MAG VALUE(nT)
000	42935	3.1	0.0	3.1
180	43186	2.8	0.4	3.2
090	43116	1.7	0.5	2.2
270	42859	2.3	0.0	2.3

HEADING TEST

AIRCRAFT :- VH-EXE
DATE :- 20/10/88
AREA :- THE GRANITES
MAGNETOMETER :- **Optically pumped cesium vapour magnetometer**
SENSITIVITY :- **0·01 nT**
SAMPLING INTERVAL :- 0.5 **seconds**

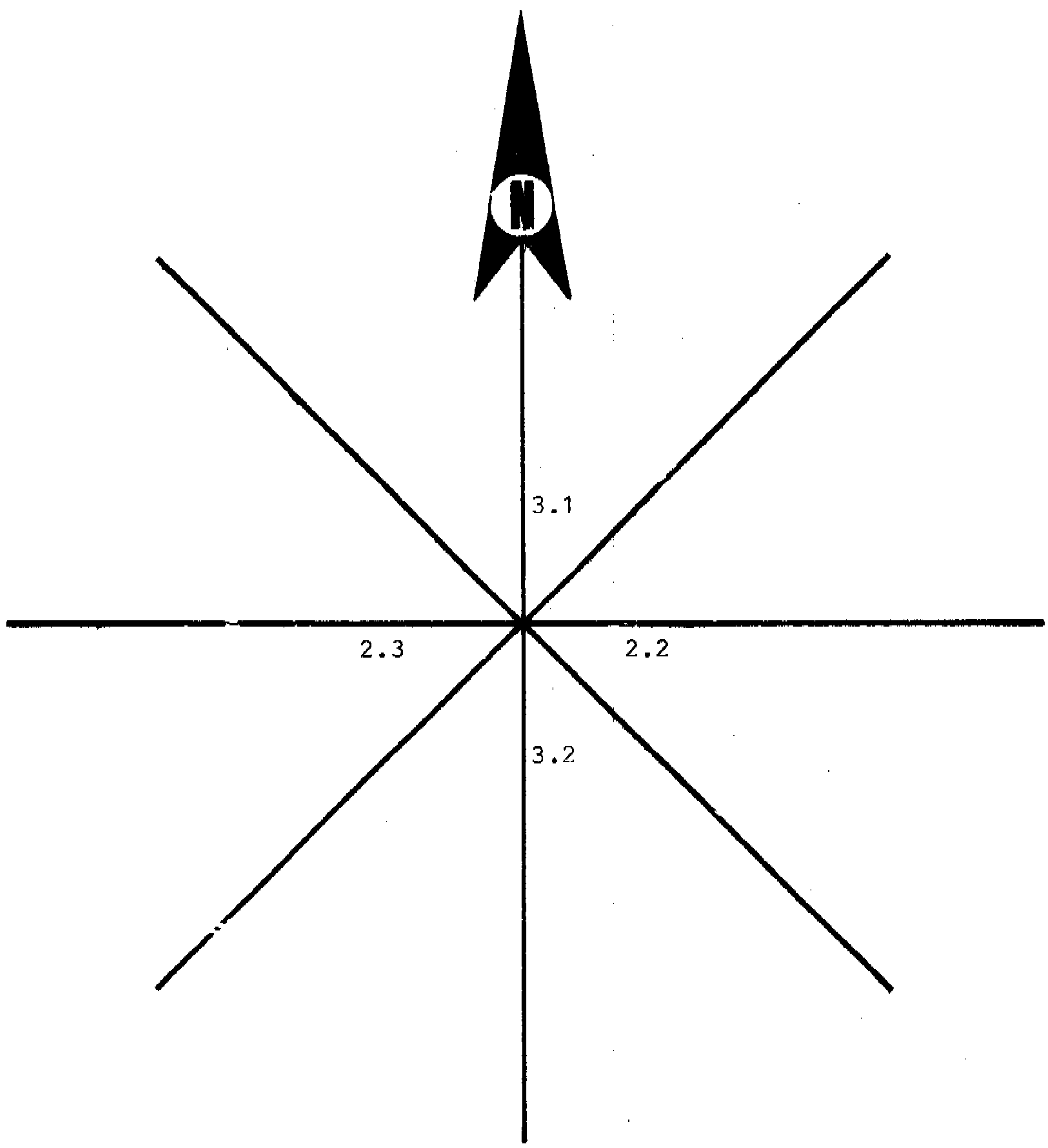


FIGURE A15

(MAGNETIC READINGS HAVE BEEN CORRECTED FOR DIURNAL VARIATION)

APPENDIX B: SPECTROMETER CALIBRATION DATA

TABLE B1: **URANIUM AND THORIUM SOURCE CHECK DATA**
(UNITS - COUNTS)
(SAMPLE PERIOD - 100 SECONDS)

FLIGHT	CHANNEL	PRE-FLIGHT U Source	PRE-FLIGHT Th Source	POST-FLIGHT U Source	POST-FLIGHT Th Source
1	Th	322	22729	-	22657
	U	19911	7372	20064	7599
	K	17603	9911	17225	9874
	TC	251923	298303	249937	298019
2	Th	217	22402	447	22102
	U	20132	7316	20349	6826
	K	16610	9589	17680	9876
	TC	247768	296234	251645	292094
3	Th	-	22113	53	22770
	U	19174	7297	19536	7496
	K	16998	9019	15602	8503
	TC	243232	279879	240821	281032
5	Th	380	22586	89	22537
	U	19480	7023	19423	7136
	K	16193	8632	16102	8493
	TC	247546	281219	241794	281413
6	Th	493	22322	344	22164
	U	20200	7174	19748	7163
	K	15903	8600	15394	8320
	TC	247827	280413	243253	273877
7	Th	266	22744	223	22598
	U	20128	7700	19820	6997
	K	16183	8327	15848	8378
	TC	246283	284046	247269	282883
8	Th	-	21692	470	22602
	U	20171	6744	19852	6606
	K	16691	8903	15763	8245
	TC	247812	279799	245786	275322
9	Th	153	22486	68	22297
	U	19691	6847	19934	6986
	K	15948	8437	15597	8850
	TC	244151	280027	243042	279144

10	Th	392	22927	369	23145
	U	20179	7330	20058	6647
	K	16680	8309	15632	8343
	TC	251749	282588	247415	279978
11	Th	755	22971	–	22378
	U	20359	7597	20216	7044
	K	16174	7876	16156	9050
	TC	248968	282189	249893	278933
12	Th	217	22818	32	22052
	U	20078	7427	19915	7128
	K	15899	8511	15501	8896
	TC	249094	282841	242112	280646
13	Th	532	22276	338	22093
	U	19845	7128	20017	7124
	K	16559	8572	16536	8485
	TC	246984	281648	247045	274083
14	Th	633	22932	–	22292
	U	19728	6747	19503	7073
	K	15860	8678	15387	8499
	TC	247481	279761	238981	280983
15	Th	432	22038	–	21701
	U	19847	7808	19357	7259
	K	16373	8541	15873	9009
	TC	250830	281864	243490	281872
16	Th	–	22348	536	22571
	U	19580	7207	20376	7278
	K	16507	8569	16487	8663
	TC	245310	277235	244018	277121
17	Th	153	22644	583	23401
	U	20318	7324	20303	6698
	K	16365	8419	16160	8720
	TC	249302	282026	249295	280862
18	Th	530	22791	588	22671
	U	19196	7294	17986	7051
	K	16092	8676	14084	8385
	TC	243427	280895	223355	278066
19	Th	363	21859		23082
	U	19129	7238	20500	
	K	15421	8427		
	TC	242374	277850	254830	286347

20	Th	166	22435		22427
	U	20064	7165	19820	
	K	16352	8504		
	TC	248318	279843	247480	282649
21	Th	343	22028	197	22301
	U	19929	7217	19521	7011
	K	16217	8303	15772	8427
	TC	248476	277715	241741	277524
22	Th	–	21764	–	22542
	U	20339	6889	20096	6788
	K	16363	8643	16746	9042
	TC	247230	277765	248293	281662
23	Th	428	22539	255	22312
	U	20072	6861	20231	7270
	K	16224	8203	16299	8633
	TC	249193	282868	250987	283860
24	Th	397	22872	–	22030
	U	19596	6905	20152	6696
	K	16176	8493	16121	8710
	TC	249066	283217	245639	273737
25	Th	256	22572	317	23366
	U	20178	7136	20260	7423
	K	16273	7886	15974	8388
	TC	252450	278800	244486	282753

SOURCE TEST PERIOD 00000120 SECONDS
RESULTS IN COUNTS

THORIUM	WINDOW & UR SOURCE	00020847
URANIUM	WINDOW & UR SOURCE	00025598
K40	WINDOW & UR SOURCE	00016692
TOTAL	WINDOW & UR SOURCE	00139908
THORIUM	WINDOW & TH SOURCE	00021125
URANIUM	WINDOW & TH SOURCE	00006370
K40	WINDOW & TH SOURCE	00006654
TOTAL	WINDOW & TH SOURCE	00125396

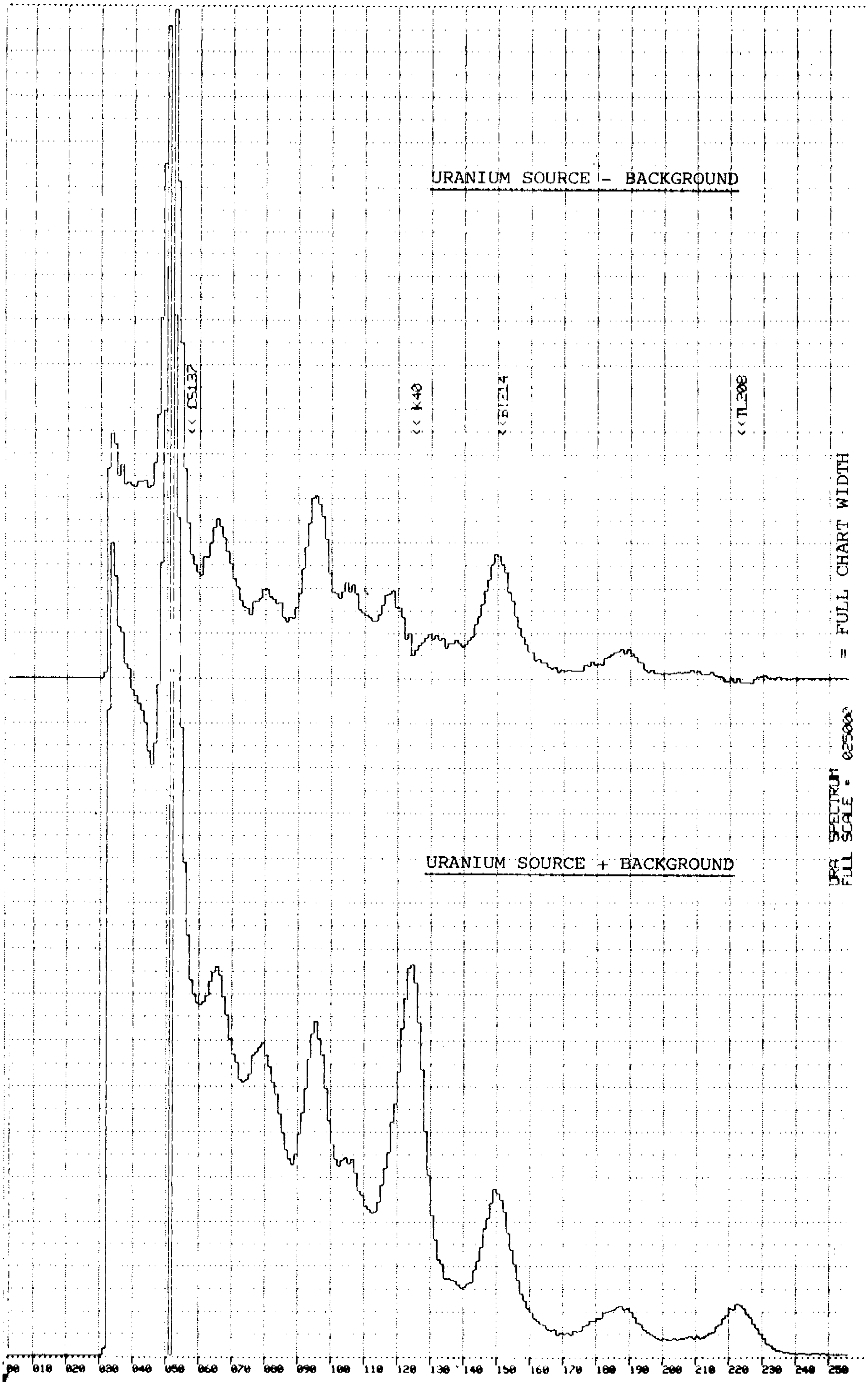


FIGURE B1

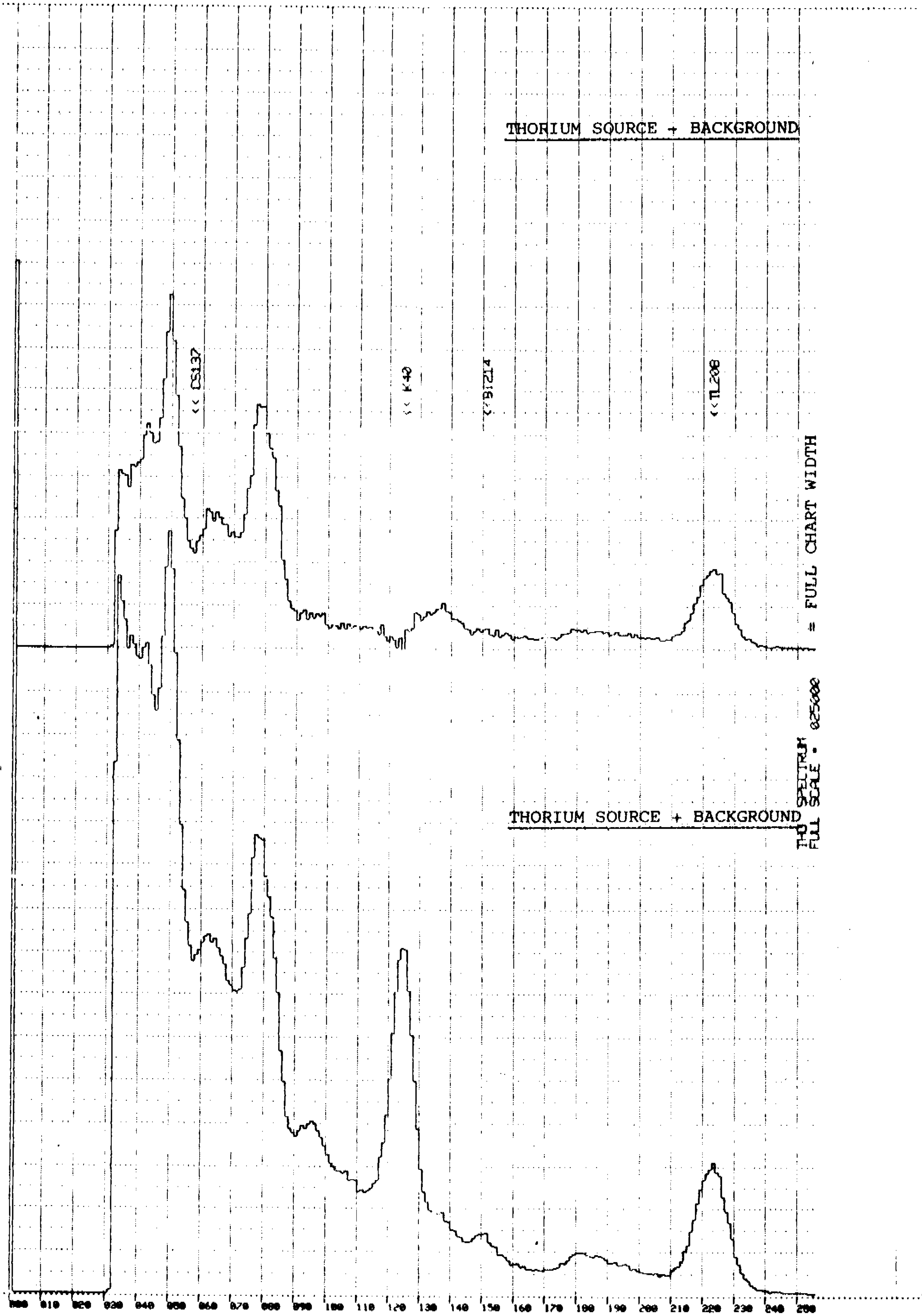

THORIUM SOURCE + BACKGROUND
<< CS137
<< K40
<< BI214
<< TL208
THORIUM SOURCE + BACKGROUND
THO SPECTRUM
FULL SCALE = 025000 = FULL CHART WIDTH
000 010 020 030 040 050 060 070 080 090 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250

FIGURE B2

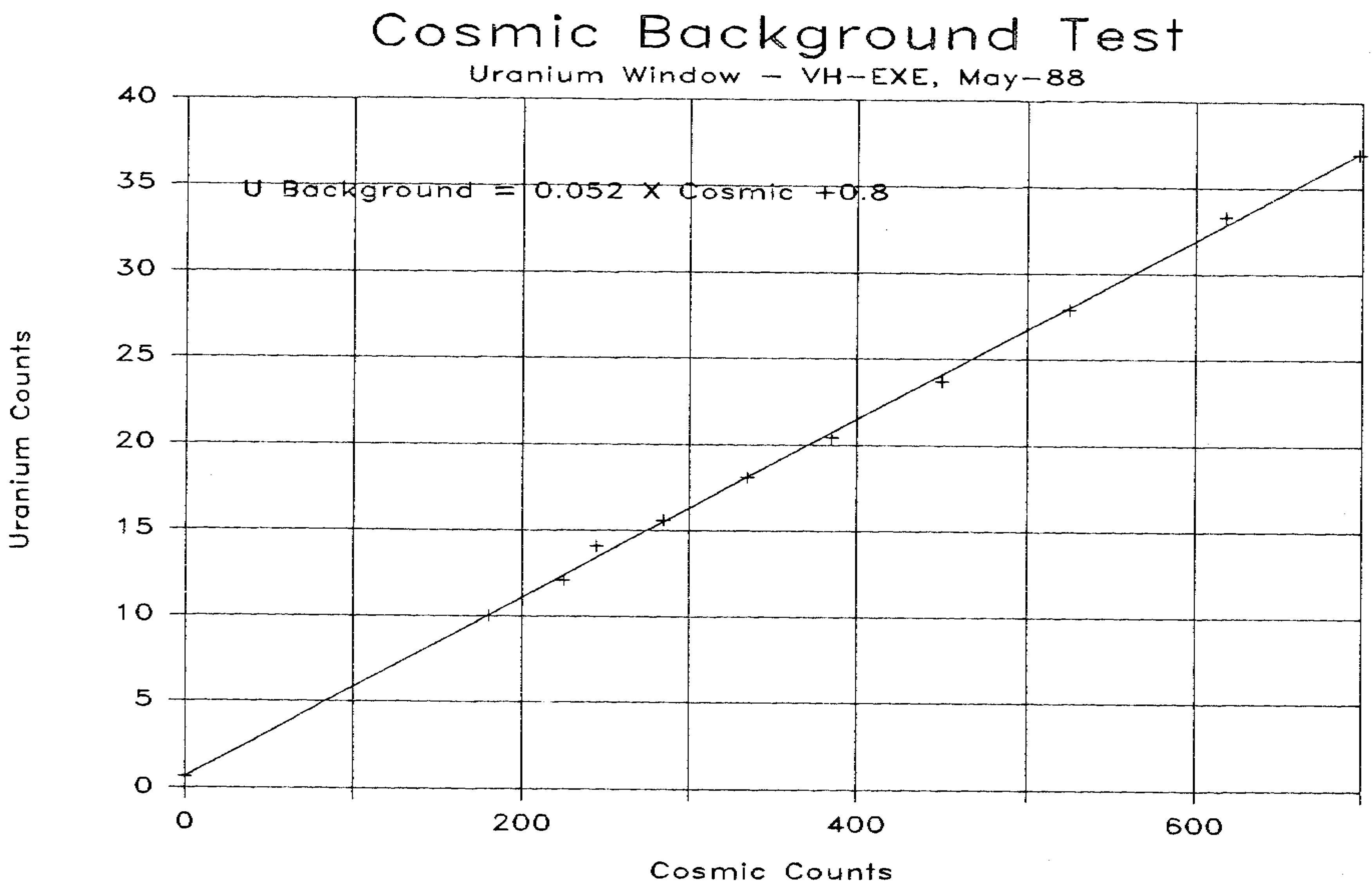
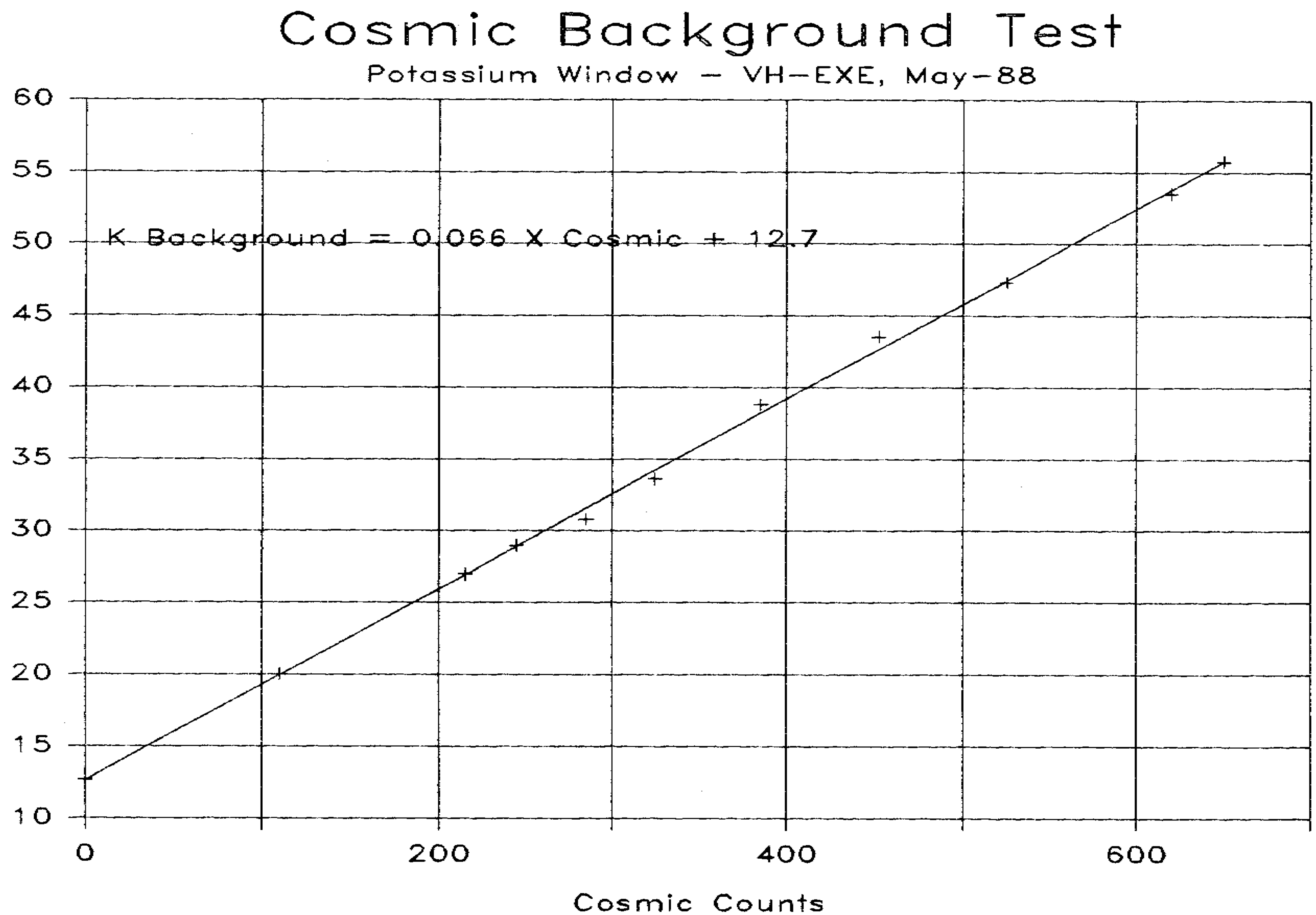

Cosmic Background Test
Uranium Window - VH-EXE, May-88
U Background = 0.052 X Cosmic +0.8
Uranium Counts
Cosmic Counts
0
5
10
15
20
25
30
35
40
0
200
400
600

FIGURE B3



Cosmic Background Test
Potassium Window - VH-EXE, May-88
K Background = 0.066 X Cosmic + 12.7
Potassium Counts
Cosmic Counts
60
55
50
45
40
35
30
25
20
15
10
0
200
400
600

FIGURE B4

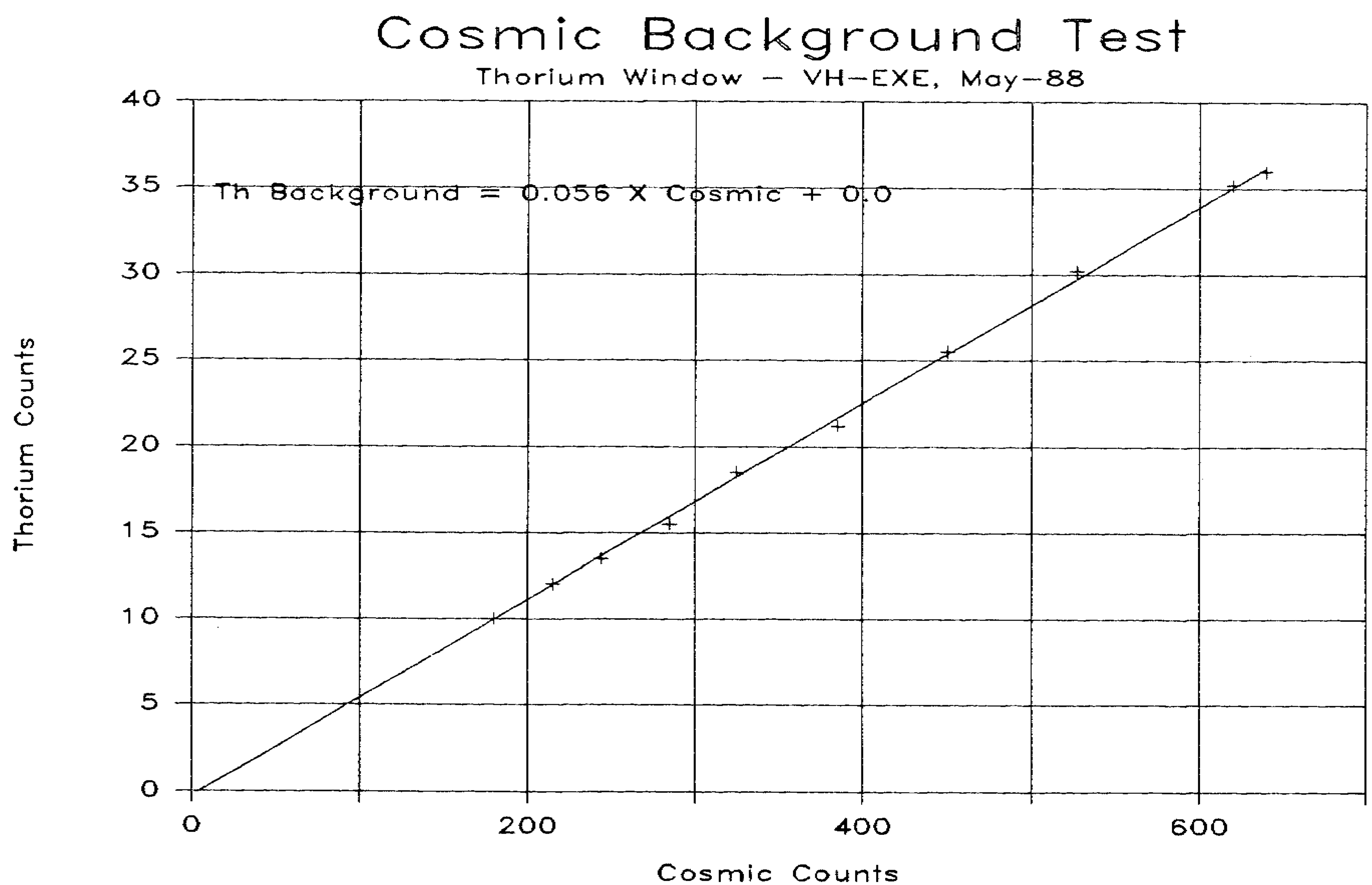

Cosmic Background Test
Thorium Window – VH–EXE, May–88
Th Background = 0.056 X Cosmic + 0.0
Thorium Counts
Cosmic Counts
0
5
10
15
20
25
30
35
40
0
200
400
600

FIGURE B5

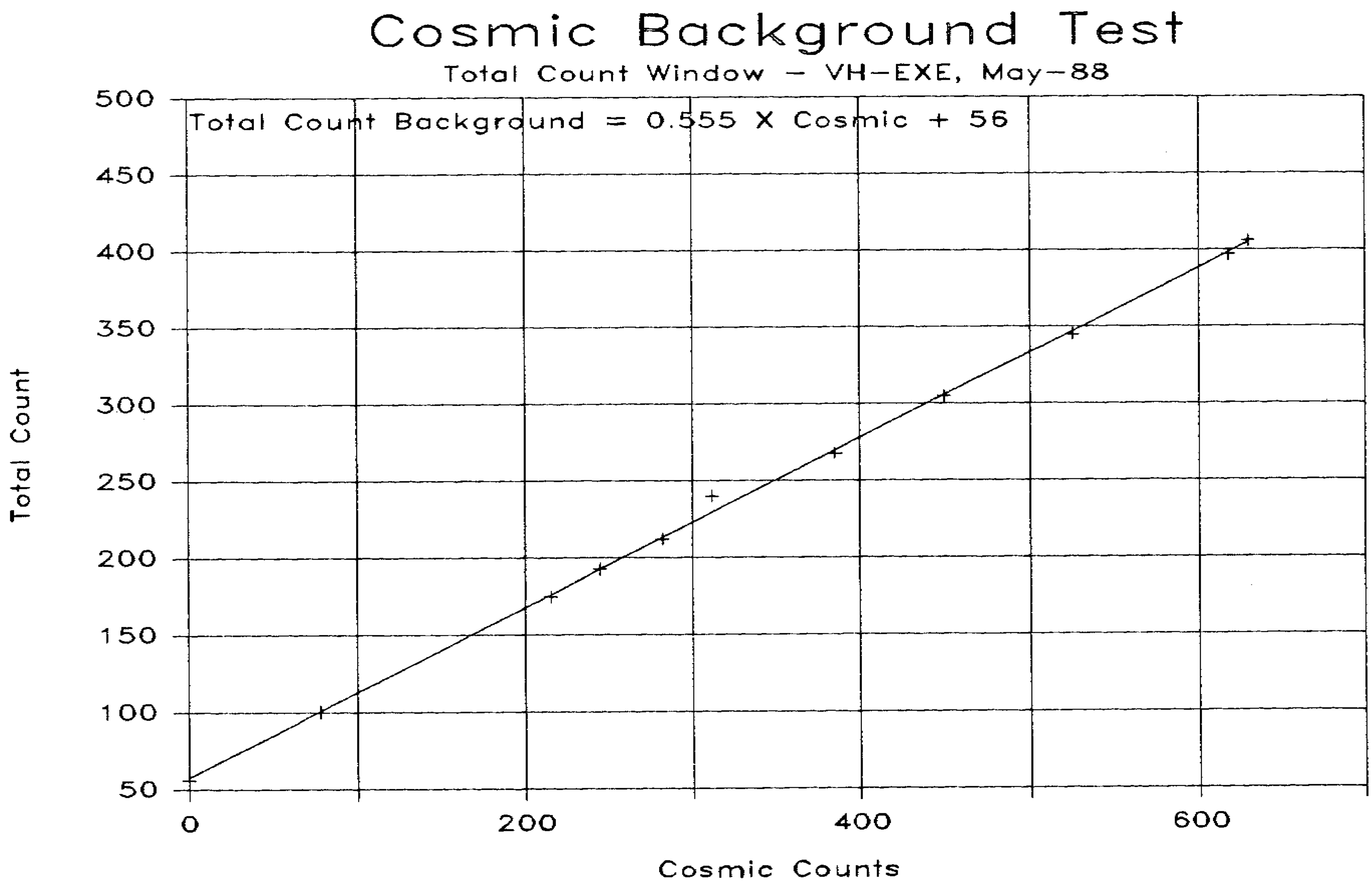
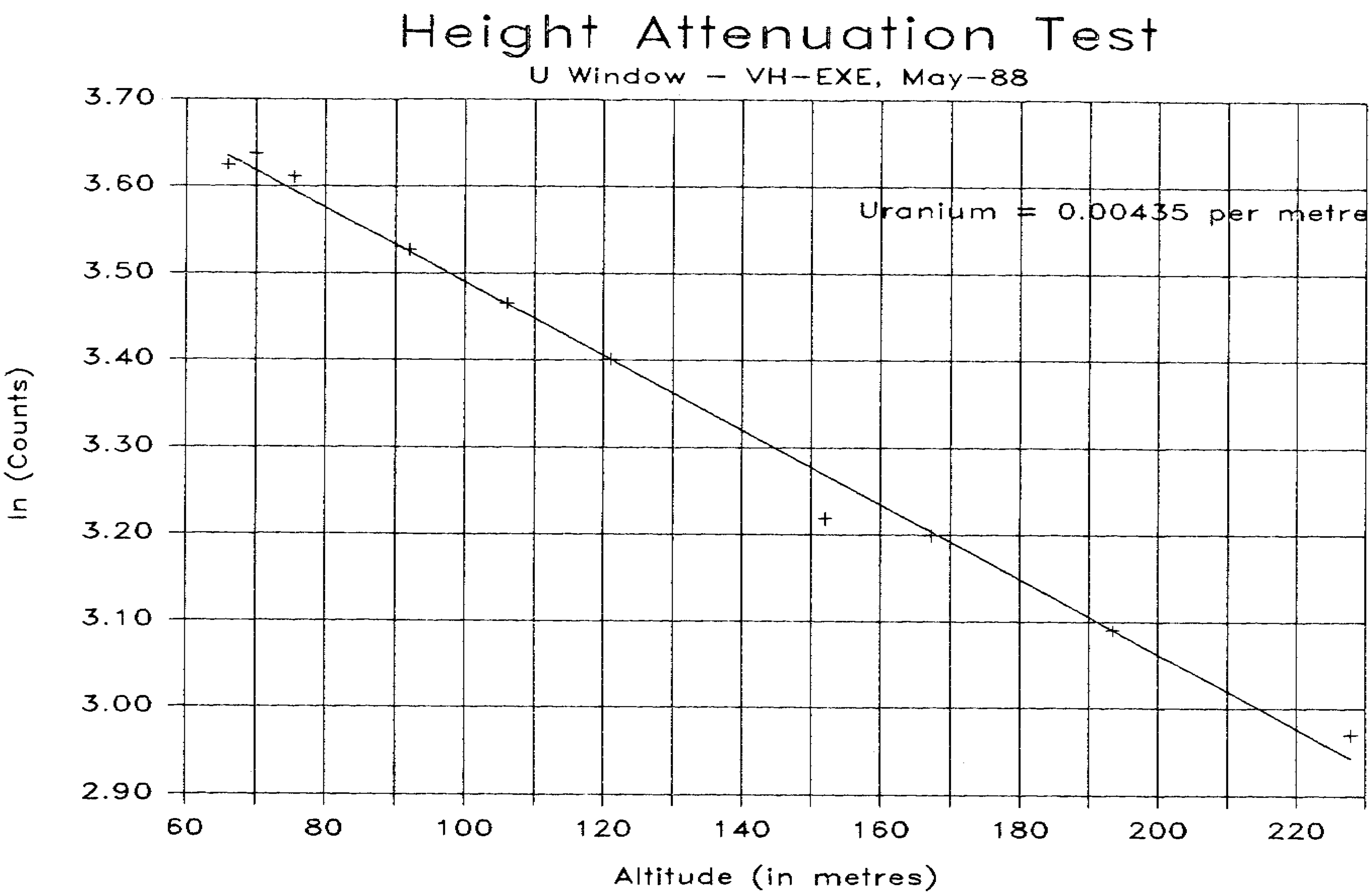

Cosmic Background Test
Total Count Window - VH-EXE, May-88
Total Count Background = 0.555 X Cosmic + 56
Total Count
Cosmic Counts
500
450
400
350
300
250
200
150
100
50
0
200
400
600

FIGURE B6



Height Attenuation Test
U Window - VH-EXE, May-88
Uranium = 0.00435 per metre
ln (Counts)
3.70
3.60
3.50
3.40
3.30
3.20
3.10
3.00
2.90
60
80
100
120
140
160
180
200
220
Altitude (in metres)

FIGURE B7

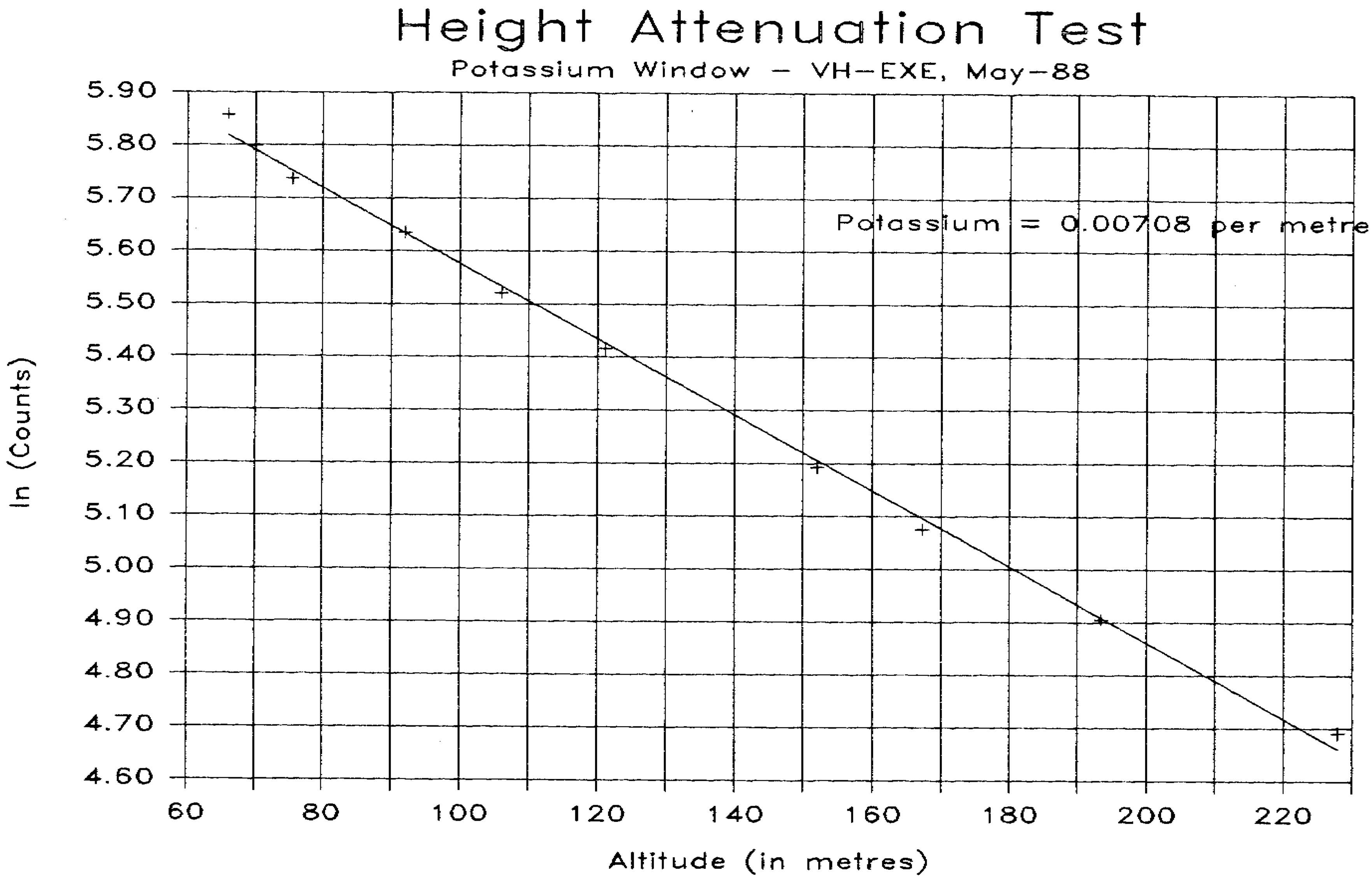

Height Attenuation Test
Potassium Window - VH-EXE, May-88
Potassium = 0.00708 per metre
ln (Counts)
5.90
5.80
5.70
5.60
5.50
5.40
5.30
5.20
5.10
5.00
4.90
4.80
4.70
4.60
60
80
100
120
140
160
180
200
220
Altitude (in metres)

FIGURE B8

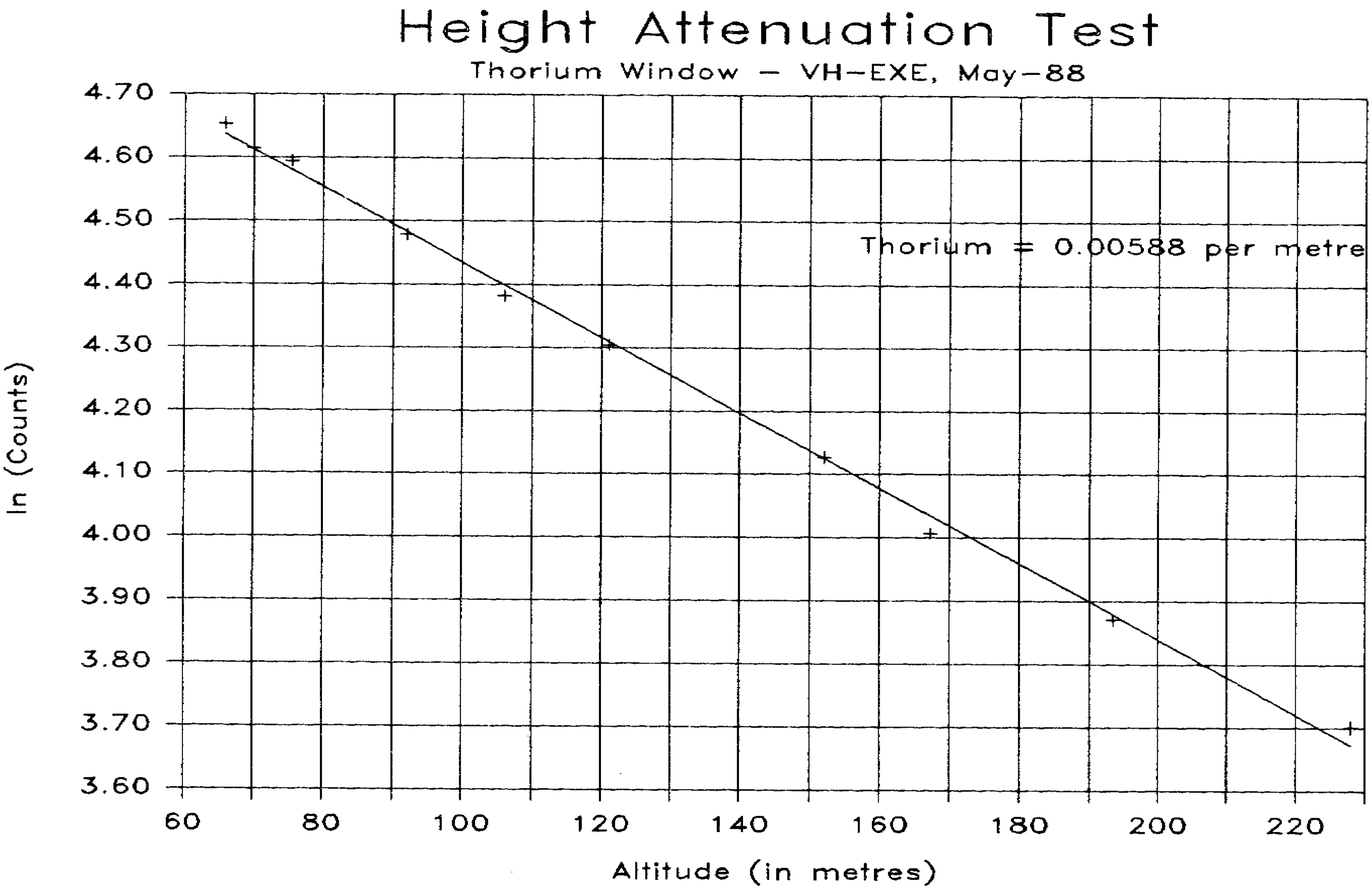

Height Attenuation Test
Thorium Window – VH–EXE, May–88
Thorium = 0.00588 per metre
ln (Counts)
Altitude (in metres)
4.70
4.60
4.50
4.40
4.30
4.20
4.10
4.00
3.90
3.80
3.70
3.60
60
80
100
120
140
160
180
200
220

FIGURE B9

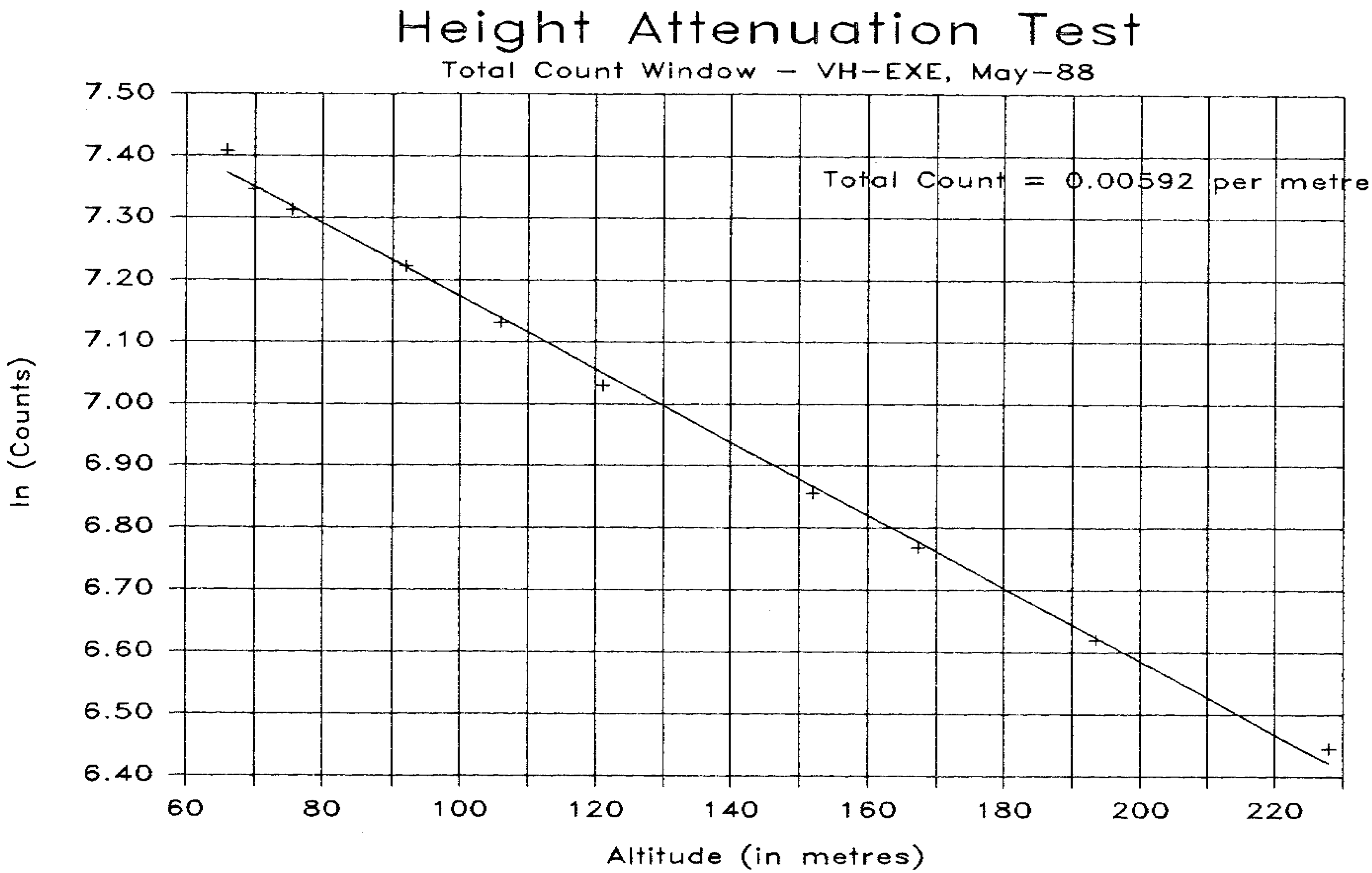

Height Attenuation Test
Total Count Window - VH-EXE, May-88
Total Count = 0.00592 per metre
ln (Counts)
Altitude (in metres)
7.50
7.40
7.30
7.20
7.10
7.00
6.90
6.80
6.70
6.60
6.50
6.40
60
80
100
120
140
160
180
200
220

FIGURE B10

16th October 1988

1/2 Peak Full Width=13Channels

Thorium Peak Position=224

Spectrometer Resolution=(13/224)*100

=5.8%

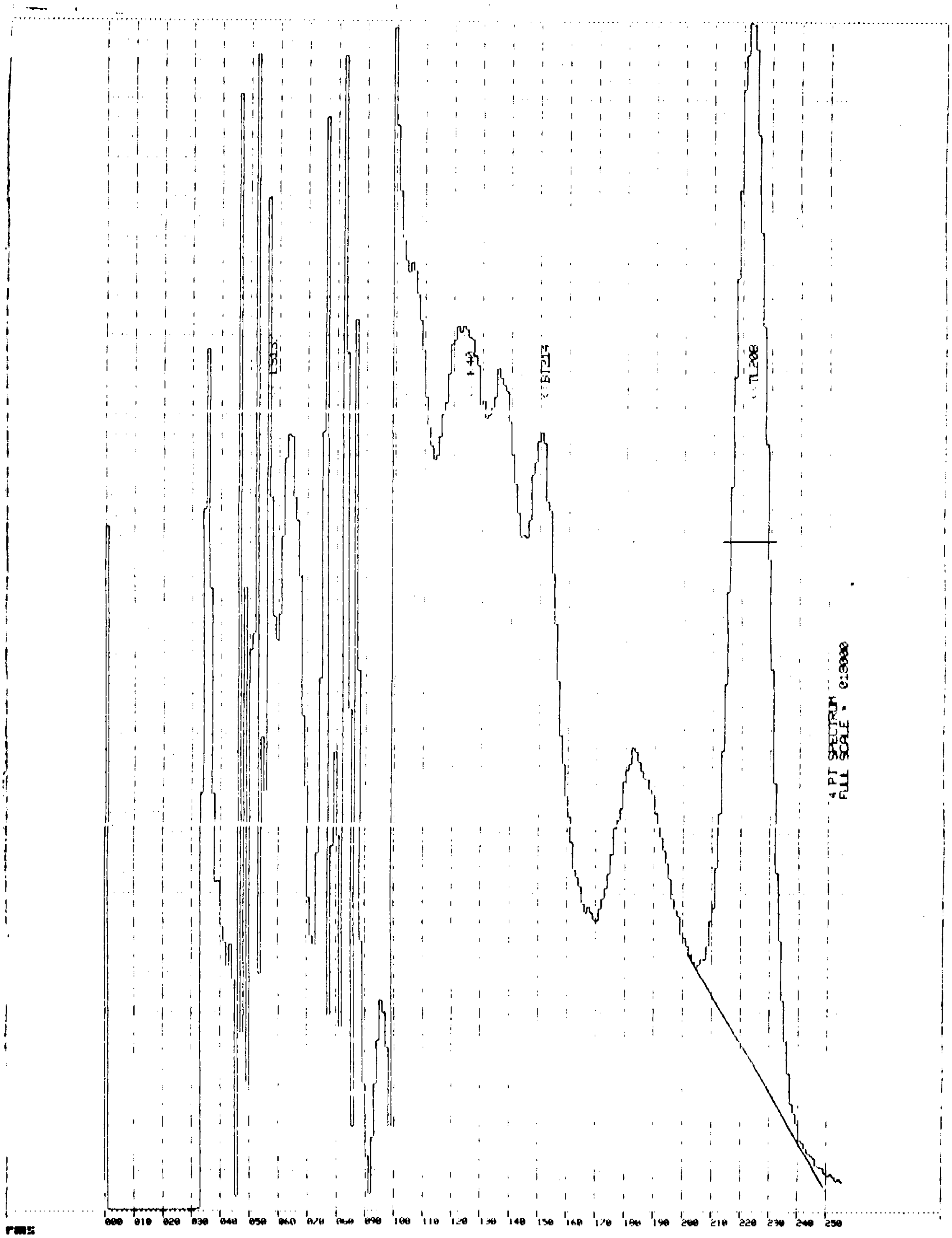
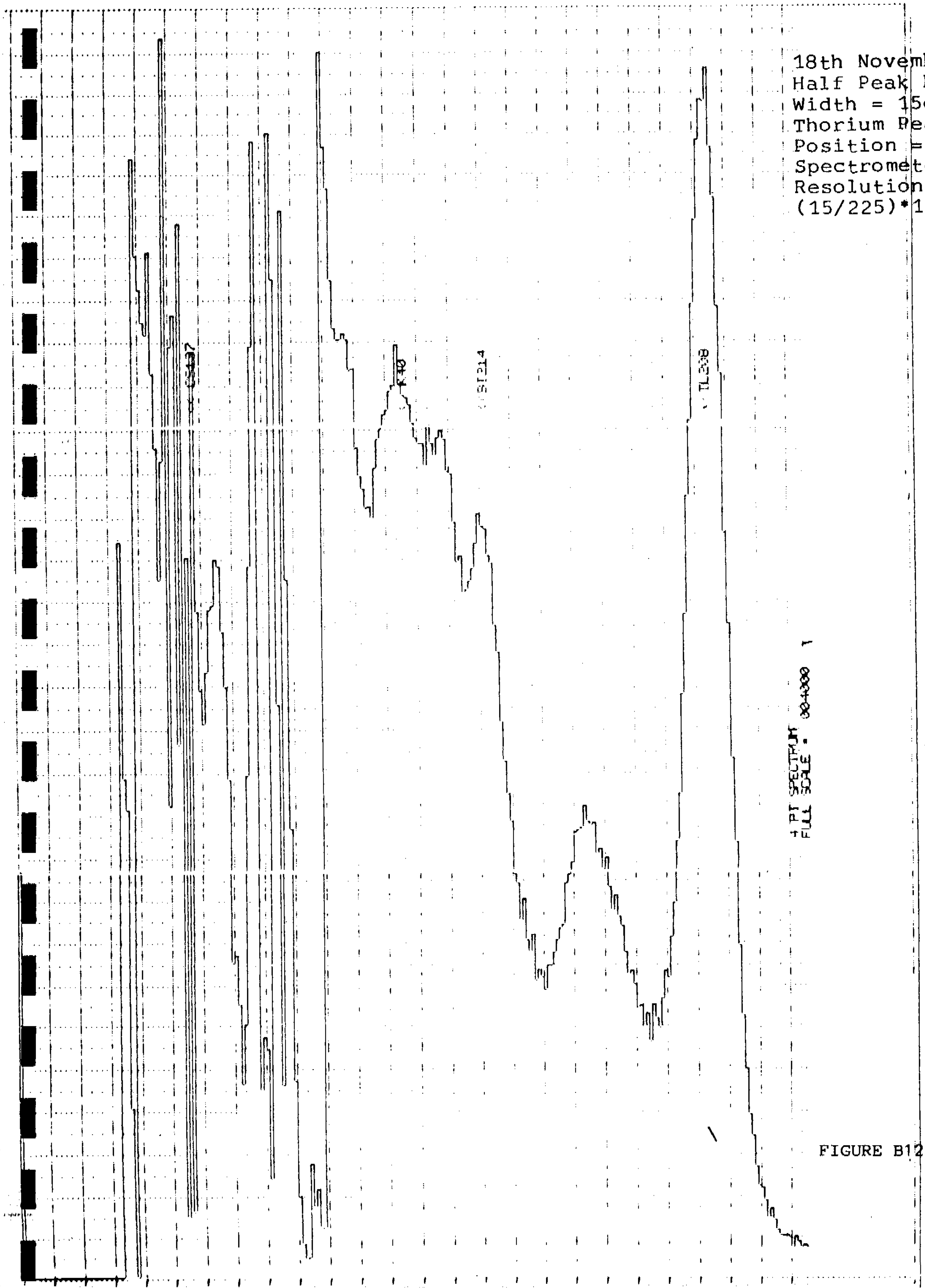


FIGURE B11



18th November 1988
Half Peak Full
Width = 15ch
Thorium Peak
Position = 225
Spectrometer
Resolution =
(15/225)*100
= 6.8%

FIGURE B12

APPENDIX C: MAGNETIC DATA TAPE FORMATS

FIELD DATA TAPE FORMAT

Geoterrex 9-track field tapes are recorded in binary code at 800 bpi. The format for each one second record is:-

Byte Position	Number of Bytes	Description
0 - 1	2	Flight Number
2 - 5	4	Fiducial Number
6 - 9	4	Magnetometer @ T-0.0 seconds
10 - 13 *	4	Magnetometer @ T-0.1 seconds
14 - 17 *	4	Magnetometer @ T-0.2 seconds
18 - 21 *	4	Magnetometer @ T-0.3 seconds
22 - 25 *	4	Magnetometer @ T-0.4 seconds
26 - 29	4	Magnetometer @ T-0.5 seconds
30 - 33 *	4	Magnetometer @ T-0.6 seconds
34 - 37 *	4	Magnetometer @ T-0.7 seconds
38 - 41 *	4	Magnetometer @ T-0.8 seconds
42 - 45 *	4	Magnetometer @ T-0.9 seconds
46 - 47	2	Radar Altimeter
48 - 49 *	2	Pressure Alt. or Pressure
50 - 51 *	2	Temperature
52 - 53 *	2	Relative Humidity
54 - 55 *	2	For VLF Analogue Input
56 - 57 *	2	For 2nd VLF Analogue Input
58 - 63 *	6	Doppler Northing
64 - 69 *	6	Doppler Easting
70 - 75 *	6	For Zone Data
76 - 81 *	6	For ID Square Data
82 - 87 *	6	Doppler Ground Speed
88 - 93 *	6	For Drift Velocity Data
94 - 99 *	6	For Heading Velocity Data
100 - 103	4	;STR4 Data Logged Time
104 - 113	10	;STR4 Y-Coordinate
114 - 123	10	;STR4 X-Coordinate
124 - 132	9	;STR4 Course and Speed
133 - 141	9	;STR4 Quality of Fix
142 - 145	4	;STR4 Measurement to Data Delay
146 - 165	20	;STR4 Left/Right Info
166 - 167	2	Thorium
168 - 169	2	Uranium
170 - 171	2	Potassium
172 - 173	2	Total Count
174 - 175	2	Cosmic Count
176 - 177	2	Live Time
178 - 409	232	For Chans 24-255 Inc. 1 Byte Each

* Positions not used in this survey.

RECORD SIZE - 410 Bytes
BLOCK SIZE - 4100 Bytes
RECORDING MODE - binary (IBM compatible)
PROGRAM - ULMS1

THE NORTHERN TERRITORY GEOLOGICAL SURVEY
THE GRANITES
AEROMAGNETIC SURVEY
LOCATED DATA TAPE FORMAT

POSITION	DESCRIPTION
1-2	FLIGHT NUMBER
3-6	LINE NUMBER ✓
7-8	SEGMENT NUMBER ✓
9-16	DATE (DDMMYY)
17-24	TIME (SECONDS)
25-32	FIDUCIAL (TENTHS OF SECONDS)
33-40	AMG ZONE 52 EASTING (METRES)
41-48	AMG ZONE 52 NORTHING (METRES)
49-56	RAW MAGNETICS
57-64	LEVELLED MAGNETICS
65-72	TOTAL COUNT (CORRECTED CPS)
73-80	POTASSIUM (CORRECTED CPS)
81-88	URANIUM (CORRECTED CPS)
89-96	THORIUM (CORRECTED CPS)
97-104	RADAR ALTITUDE (METRES)

RECORD LENGTH = 128 BYTES
BLOCK SIZE = 13312 BYTES
DENSITY = 1600 BPI
MODE = 9 TRACK ASCII

APPENDIX D: RMS THERMAL PAPER STORAGE INSTRUCTIONS

2.5 PAPER STORAGE AND HANDLING, RMS2030 THERMAL PAPER

STORAGE:

Ambient Temperature:	Less than 25°C	Under these conditions, the paper should retain its characteristics and the printed images will remain legible for at least five years, although in the case of blue image paper, there may be some slight fading.
Relative Humidity:	Less than 65%	
Storage Location:	In darkness, before and after exposure.	

TO ELIMINATE PREMATURE PAPER DEVELOPMENT:

- Careful attention must be paid to ambient temperature and relative humidity for long term storage of RMS2030 Thermal Paper. Colour development begins at temperatures between 70 to 100°C, and reaches saturation density between 80 to 120°C. Premature development of the paper may occur at lower temperatures, and particularly if the humidity is greater than 65%:

  e.g. Ambient Temperature - if the paper is stored for 24 hours at a temperature of 60°C, some development may occur

  Ambient Temperature and Relative Humidity - if the paper is stored for 24 hours at a temperature of 45°C when the relative humidity is 90%, development may also occur.

- Avoid use of solvent-type adhesives. Adhesives containing volatile organic solvents such as alcohol, ester, ketone, etc. causes colour formation and therefore rubber-type adhesives etc. should not be used. Starch, PVA and CMC type adhesives are recommended.

- Frictional heat generated by rubbing a finger nail or sharp object over the surface will cause images to develop.

- Thermal paper will develop colour if brought into contact with freshly processed Diazo copying paper.

TO ELIMINATE PAPER FADING:

- File exposed paper in the dark immediately after exposure. Thermal paper will turn yellow, and blue printed images will tend to fade if exposed to direct sunlight or to fluorescent lighting for long periods. Do not store paper near windows.

- Prolonged contact with PVC film containing plasticizers such as ester phtalate will reduce the image forming ability of the paper and cause printed images to fade. We recommend that files made of polythylene, polypropylene, polyester, etc. be used.

- Self-adhesive cellophane tapes containing an alcohol type plasticizer will cause the image to fade. Double-sided adhesive tape is recommended for use instead of paste.

- Handling thermal paper with dirty or sweaty fingers might cause images to fade.

- Do not store developed paper with the sensitized surfaces touching as images might be transferred from one sheet to another.