NATIONAL URANIUM RESOURCE EVALUATION

AERIAL RADIOMETRIC AND MAGNETIC SURVEY

NATIONAL TOPOGRAPHIC MAP

BISMARCK

NORTH DAKOTA

FINAL REPORT

1981

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PREPARED FOR U.S. DEPARTMENT OF ENERGY

Grand Junction Office, Colorado

UNDER CONTRACT NO. DE-AC13-76 GJO 1664

AND BENDIX FIELD ENGINEERING CORPORATION SUBCONTRACT NO. 80-459-S

This report is a result of work performed by Geodata International, Inc., through a Bendix Field Engineering Corporation Subcontract, as part of the National Uranium Resource Evaluation. NURE is a program of the U.S. Department of Energy's Grand Junction, Colorado, Office to acquire and compile geologic and other information with which to assess the magnitude and distribution of uranium resources and to determine areas favorable for the occurrence of uranium in the United States.

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BISMARCK NATIONAL TOPOGRAPHIC MAP

NORTH DAKOTA

NEBRASKA-DAKOTAS PROJECT

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE
GRAND JUNCTION, COLORADO

UNDER BENDIX FIELD ENGINEERING SUBCONTRACT NO. 80-459-S
BY
GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

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ABSTRACT

The results of analyses of the airborne gamma radiation and total magnetic field survey flown for the region identified as the Bismarck National Topographic Map NL14-4 is presented in this report. The airborne data gathered is reduced by ground computer facilities to yield profile plots of the basic uranium, thorium and potassium equivalent gamma radiation intensities, ratios of these intensities, aircraft altitude above the earth's surface, total gamma ray and earth's magnetic field intensity, correlated as a function of geologic units. The distribution of data within each geologic unit, for all surveyed map lines and tie lines, has been calculated and is included. Two sets of profiled data for each line are included, with one set displaying the above-cited data. The second set includes only flight line magnetic field, temperature, pressure, altitude data plus magnetic field data as measured at a base station. A general description of the area, including descriptions of the various geologic units and the corresponding airborne data, is included also.

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SECTION I.

INTRODUCTION

A. SURVEY AREA

Geodata International, Inc., Dallas, Texas, conducted an airborne gamma ray and total magnetic field survey for the Bismarck National Topographic Map Sheet as outlined in Figure I.1. This survey was performed from a fixed-wing aircraft, using a computer-controlled, large-volume radiation detector system to detect the gamma radiation flux emanating from the surface materials. Each map line was flown in an east-west direction with line lengths of 94.5 miles; each tie line was flown in a north-south direction with line lengths of 69.0 miles. Map lines and tie lines are located as shown in Figure II.1.

Sections I through IV of this report present information and results associated with this specific survey. Section V gives the data acquisition and the processing procedures which are generally applicable to any survey flown with the equipment described.

B. SUMMARY of MAP LOCATION, GEOLOGY and PHYSIOGRAPHY

The Bismarck map sheet area (Figure I.2) is located in southcentral North Dakota and bounded by longitudes $100^{0}00'$ to $102^{0}00'$ west, latitudes $46^{0}00'$ to $47^{0}00'$ north. The map region is included within two distinct sections of the Great Plains physiographic province; namely, the Glaciated Missouri Plateau section, and the Unglaciated Missouri Plateau section. The land surface is generally characterized as irregular and rolling. Elevations range from approximately 2,500 to 1,700 feet above sea level.

Deposition in the Bismarck map area has reportedly been affected by a synclinal basin, the Lemmon Syncline, since the Paleozoic Era. Fluctuations of the region with respect to sea level have been responsible for producing unconformable surfaces at the top of the Paleozoic sequence and elsewhere throughout the column. Most of the area was mantled with glacial detritus during the Pleistocene. Eolian and fluvial processes have continued to affect the region to the present time.

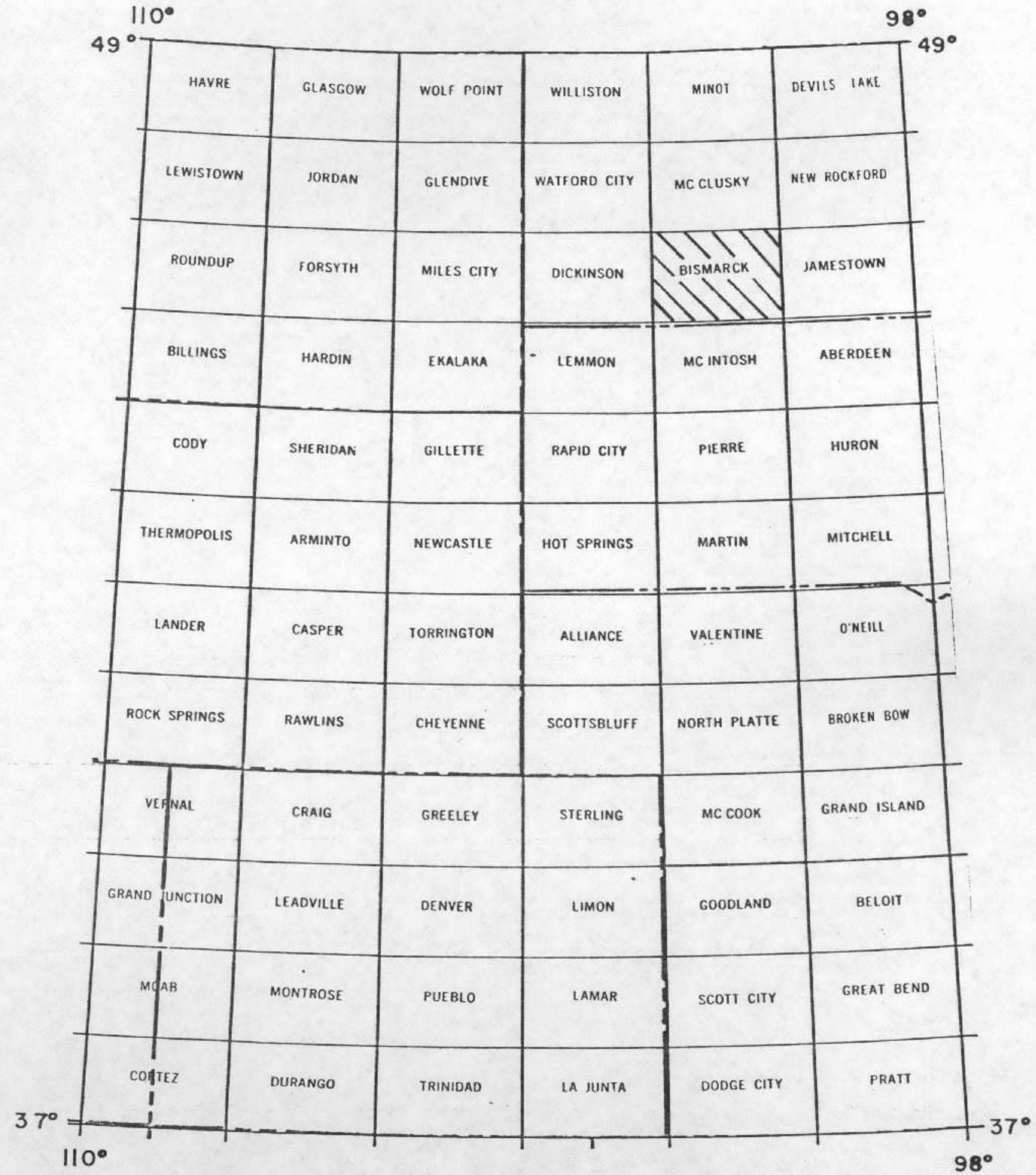

Figure I.1 Survey Index Map

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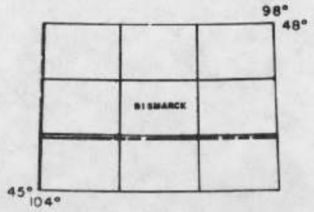
compiled by
Martel Laboratories, Inc.



GEOLOGY BASE
REF. NTMS, NL 14-4
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

N

5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 KILOMETERS

Bismarck, North Dakota

Figure I.2 Geologic Base Map

SECTION II

FLIGHT OPERATIONS

SECTION II.

FLIGHT OPERATIONS

A. SURVEY TIME SUMMARY

The Bismarck map sheet was flown between July 26 and July 28, 1980. A detailed list of dates flown and lines flown on those dates, as well as average altitude and speed for those dates, appears in Appendix I.A.

B. LINE COORDINATE LOCATION

Doppler navigation system data have been used to locate the positions of the flight lines. These lines are positioned and verified by point locations, determined by visual sighting by the navigator or photographic recovery, and corresponding record numbers displayed by the on-board computer. The data are then plotted as solid lines with ticks every ten records, circles every fifty records, and record numbers every one hundred records. Record numbers and circles also appear at the end of each line. The points used for location reference (at least every 10 miles) are marked with an "X". The flight base is then photographed with the geologic base map to produce the composite map in Figure II.1.

C. TEST LINES

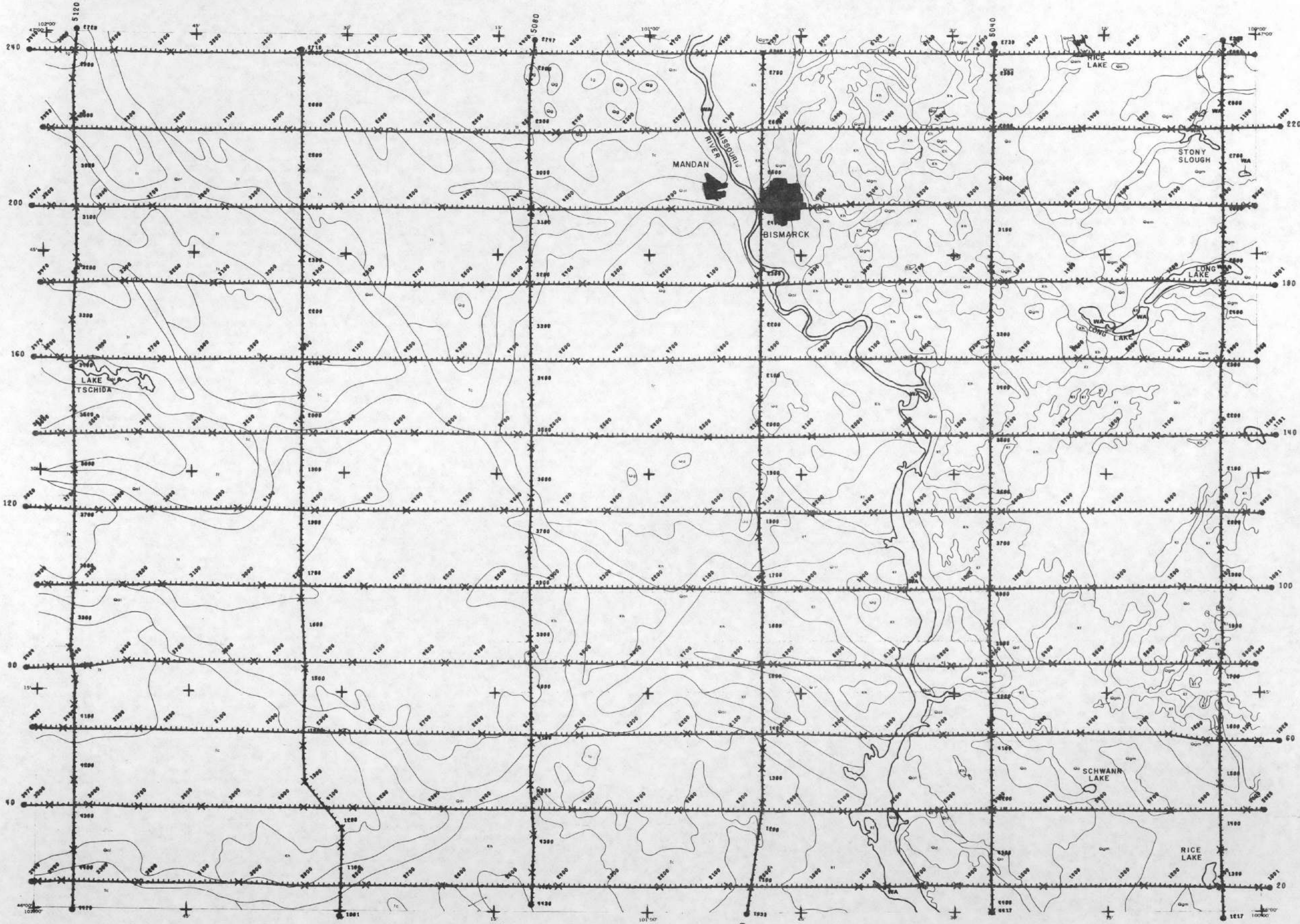
When conditions allow, two five-mile test lines are flown, one at the beginning of the day and one at the end of the day, over the same base. The data are used to check the repeatability of the system's measurements, and are presented in Appendix I.B.

D. MAGNETIC DIURNAL CORRECTION - BASE STATION

A base station magnetometer is set up in the area to acquire data pertaining to the diurnal changes in the magnetic field. These data are analyzed to evaluate a diurnal correction to the magnetic data obtained by the aircraft. A list of these corrections appears in Appendix I.C.

E. ALTITUDE AND GROUND SPEED SUMMARY

The average altitude and ground speed for each line is determined. A list by date appears in Appendix I.A, and is discussed in Section II.A. A list by flight line is given in Appendix I.E.



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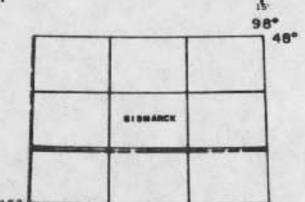
"X" INDICATES FILM VERIFIED POINTS



FLIGHT LINE BASE
REF. NTMS, NL 14-4
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

N

5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 KILOMETERS

Bismarck, North Dakota

Figure II.1 NTMS Showing Flight Line Location

SECTION III

GEOLOGY OF THE SURVEYED AREA

SECTION III.

GEOLOGY of the SURVEYED AREA

A. LOCATION and GENERAL PHYSIOGRAPHY

The aerial radiometric and magnetic survey was conducted over a portion of southcentral North Dakota. The Bismarck National Topographic Map Sheet area (N.T.M.S., 1954) is bounded by longitudes 100°00' to 102°00' west and latitudes 46°00' to 47°00' north. The map region includes all or part of the following counties in North Dakota: Burleigh, Emmons, Grant, Kidder, Morton, and Sioux. A portion of the Standing Rock Indian Reservation is also included in the map sheet area.

The Bismarck Quadrangle lies mainly within the Glaciated Missouri Plateau section of the Great Plains province. The Unglaciated Missouri Plateau section of the map lies southwest of the Cannonball River. The northeastern corner of the area is described by Fenneman (1928) as the Coteau du Missouri, a morainal shelf of ancient, glacial-lake deposits.

Drainage in the Bismarck map area is accomplished chiefly by the Missouri River, which dissects the eastern two-thirds of the area and trends generally to the north. Flowing into the Missouri River from the west is the Cedar Creek River. A smaller stream, the Heart River, drains the northern half of the map sheet area into the Missouri Basin.

The land surface west of the Missouri River is irregular and rolling; it increases in elevation very gradually into the butte and mini-badlands area east of the Little Missouri River. It is deeply cut by the entrenched streams flowing from the west. Relatively flatter areas of land are used for agricultural purposes. Buttes and hills extend up to the escarpment west of the Missouri River. East of the river, however, the terrain flattens out considerably into a morainal plain with very rich soil. There are many lakes and dry lake beds present, remnants of glacial action.

The total relief in the map sheet area is approximately 800 feet. Elevations range from approximately 2,500 feet above sea level in the southwest to 1,700 feet in elevation in the eastern lake country.

B. GEOLOGY

The structural and depositional events of the Bismarck, North Dakota Quadrangle and surrounding regions are described by Darton (1909), Hancock (1922), Wilson et.al. (1951), Lemke (1960), Carlson

and Anderson (1965), and Frye (1969). These data are summarized as follows:

Paleozoic Era

There are no exposures of Paleozoic rock units in the Bismarck area, although much subsurface information has been collected from deep-well data. Since the inception of the Paleozoic Era, the map sheet area has been part of a synclinal depositional basin, the Lemmon Syncline. This basin is a subelement of a larger, deeper basin to the northwest, the Williston Basin.

Logs from wells drilled in the map sheet area record Cambrian rock at approximately 13,500 feet. The depositional basin began filling with clastics during the Ordovician, producing the Deadwood Formation beds. A predominantly carbonate sequence followed through the Mississippian Period.

In the map sheet area, the top of the Pennsylvanian is marked by an unconformable surface. Evaporites and clastics were deposited during the Permian. A major unconformity truncates the Paleozoic units (Walker, 1963).

Mesozoic Era

Slight subsidence of the map sheet area is reported by Hancock (1922) to have occurred during the Triassic. Predominantly marine rock units of the Jurassic and Lower to Middle Cretaceous are representative of eastward extensions of the Cordilleran seas.

Late Cretaceous deposition was affected by minor tectonic movements. The Pierre and Fox Hills formations of the Montana Group were deposited during this time. These two formations are the oldest units exposed in the map sheet area.

Cenozoic Era

The beginning of the Cenozoic Era in the map region is marked by the transitional, lignite-bearing Fort Union Group of which the Cannonball, Tongue River and Sentinel Butte formations are members. The group was thinly overlain by a member of the White River Group, the Golden Valley Formation.

Several advances of ice sheets from Canada during the Pleistocene were responsible for producing a relatively thick mantle of glacial detritus in the map area. Eolian and fluvial processes have continued to the present.

C. DESCRIPTION of the GEOLOGICAL MAP UNITS

A brief description of the outcropping geologic units of the Bismarck, North Dakota map sheet area (Figure I.2) is given, based on the map compiled by Martel Laboratories, Inc. (1980), and data reported by Hancock (1922), Wilson, et.al. (1951), Lemke (1960), Finch (1967), Frye (1969) and Randich (1979).

Cenozoic Era

Quaternary

Holocene-Recent

Qal: Alluvium

Gravel, sand, silt, shale and clay, generally stratified, very permeable. Up to 150 feet in thickness at lower levels of the stream beds.

Qd: Dune Sand

In dune topography, fine, windblown, unconsolidated sand in spotty drifts and blowouts.

Pleistocene

Qo: Outwash-Channel Deposits

Gently undulating to nearly flat accumulations of stratified glacio-fluvial sand, clay, gravel and silt in generally elongated deposits.

Qem: End Moraines

Gently rolling to hummocky accumulations of drift, chiefly till, with moderate to high relief displaying linear patterns in places. Mostly till, small gravel, and sand.

Qgm: Ground Moraine

Moderately irregular deposits of small boulders, gravel, sand, stony clay till and humus, relatively impermeable; mantles part of the surface in the eastern and northeastern portion of map sheet area. 75 to 100 feet thick.

Qlb: Lacustrine Deposits

Very minor, isolated, irregular, glacial-lake deposits composed of sand, silts and clays. Generally stratified, with limited permeability.

Qg: Glacial Deposits

Isolated remnants of pre-Wisconsin glacial drift. The deposits are comprised of sand, gravel, cobbles and many boulders, granitic and gneissic. Up to 80 feet thick.

Tertiary

Eocene

Tg: Golden Valley Formation

A very small outlier exposure of sandy, soft, permeable clay and sandstone. The unit is a member of the upper Fort Union Group. Pinches out in the far northwestern corner of the map. From 0 to 30 feet thick.

Paleocene

Ts: Sentinel Butte Formation

The deposit is comprised of interbedded fine sandstone, siltstone, claystone, shale and lignite. Light-colored sandstone and dark shales alternate with carbonaceous seams and lignites of different color and composition. Ranges up to 185 feet in thickness, thickening westward.

Tt: Tongue River Formation

The unit is well-exposed in the northwestern one-third of the map sheet area; interbedded very fine- to medium-grained sandstone, siltstone, claystone, limestone, shale and lignite. The basal sandstone portion of the Tongue River Formation is the most extensively exposed and contains abundances of petrified wood locally. Thin lenses of limestone (4 inches or less) are present in the siltstone and claystone beds.

Tc: Cannonball Formation

Widely exposed in the central portion of the map sheet area. The unit is comprised in part of glauconitic, friable, sandstone that is non-calcareous except for large concretions with calcium carbonate cement in matrix. The Cannonball Formation generally consists of siltstone, claystone and shale (largely carbonaceous). Lignite seams outcrop extensively in the lower part of the formation all along the northside of Cedar Creek and both banks of the Cannonball River. These seams are up to 11 feet thick.

Mesozoic Era

Cretaceous

Kh: Hell Creek Formation

Predominantly sandstone (3 horizons) with unconsolidated fine clastics (quartzose) siltstone, shale and thin beds of lignite.

The sandstone contains much manganese minerals, siderite nodules and magnetite grains. The basal sandstone grades into lignitic and bentonitic shale with petrified wood. Average thickness is 290 feet (Randich, 1979).

Kf: Fox Hills Formation

Fine- to medium-grained sandstone, siltstone and shale. A relatively resistant sandstone bed at the top of the unit is responsible for producing benches and promontories. The bed comprises approximately one-third of the total formation thickness (maximum 390 feet). The remainder of the formation is composed of interbedded siltstone, fossilized shale with limonite concretions and a volcanic ash bed associated with a very dense bentonitic shale (Randich, 1979).

Kp: Pierre Shale

A very minor low-level exposure (approximately 100 feet thick) at the bottom of the Missouri River trench as it flows south out of the map sheet area. Contact between the overlying Fox Hills is transitional for 80 to 90 feet in most places and consists of a bentonitic shale. The formation itself is predominantly greyish-black shale with occasional fossils.

UNK: Unlabeled Geologic Unit

An unlabeled surface outcrop in the Bismarck map sheet area, of indeterminate age.

D. RADIOACTIVE MINERAL PROSPECTS in the SURVEYED AREA

Radioactive mineral-bearing ores are well distributed in several areas of southern and western North Dakota, adjoining the Crook County, Wyoming, and Black Hills outlier deposits. U_3O_8 mineralization occurs in association with carbonaceous material in these units (Zeller and Schopf, 1959, and Vine, 1962). There are no reports of significant concentrations of uranium directly within the Bismarck map sheet area, however.

SECTION IV

RESULTS OF DATA ANALYSIS

SECTION IV.

RESULTS OF DATA ANALYSIS

A. DESCRIPTION OF STACKED DATA PROFILES

1. Multivariable Radiometric Stacked Data Profiles

These profiles are presented at a horizontal scale of 1:500,000. The vertical scales are:

Altitude: 100 feet/div.; aircraft altitude above the surface

ETH(^{208}Tℓ)*	1.0 ppm/div;	7.15 c/s = 1 ppm/eTh
EU (^{214}Bi)*	.50 ppm/div;	13.52 c/s = 1 ppm/eU
K (^{40}K)*	.25 %/div;	98.06 c/s = 1%K
BiAir	5.0 c/s/div.	50.0 seconds averaged

Residual Magnetic Field 50.0 gammas/div. (See Sec.V.B.1)

GC (Count from 400 keV to 3.0 MeV) 400 c/s/div.

EU/ETH	.05 /div.
EU/K	.20 /div.
ETH/K	.50 /div.

Geology Strip: An approximate six-mile width of the geology map, containing each line, is displayed above the profiles.

* 7-second average weighted 1:2:3:4:3:2:1 is used and plotted at center.

2. Residual Magnetic Field Profiles

Altitude:	100 feet/div.
Temperature:	1.0 ^{o}C/div.
Pressure:	3.0 mm of Hg/div.
Base Magnetic Field:	20.0 gammas/div.
Residual Magnetic Field:	10.0 gammas/div.

Geology Strip: An approximate six-mile width of the geology map, containing each line, is displayed above the profiles.

All profiles appear in Section IV.H.

B. SINGLE AND AVERAGE RECORD LISTINGS

Single and average record listings are provided on microfiche. Samples of each type are presented in Appendix III.

C. STATISTICAL PRESENTATION OF DATA BY GEOLOGIC TYPE

Tables IV.(1-6) contain the average value of each variable as a function of line number and geologic type. The tables are in order eTh, eU, K, eU/eTh, eU/K, eTh/K.

D. FREQUENCY DISTRIBUTON OF DATA FOR EACH GEOLOGIC TYPE

Table IV.7 contains the mean, standard deviation, and number of events for each geologic type encountered over the entire map sheet. Histograms for these data appear in Section IV.H.2.

E. DATA INTERPRETATION

1. Analysis of Geologic Histograms

The radioactivity data is shown in histogram form with parts per million or percent plotted against number of events (Appendix I). The histograms for eTh and K were examined for conformity to a Gaussian curve. It is generally assumed that a geologic map unit, which encompasses a fairly homogeneous lithology, would have a unimodal distribution. Where map units vary significantly from a unimodal distribution, a further subdivision into more homogeneous lithologic types may be recommended. Table IV.8 shows the map units, which vary from a unimodal model, and for which separation of two or more distributions is feasible. Only units with excess of 200 events are considered.

2. Discussion of Anomalies

Introduction

The eTh , eU , and eU/eTh (ratio) data were examined for anomalous values. An anomaly is defined by a minimum of two adjacent, two-standard deviation values, or a single, three-standard deviation value. The anomalies were listed by flight line in Table IV.9; by geologic map unit in Table IV.10; Table IV.10 is statistically summarized in Table IV.11. Only positive anomalies were examined for eTh and eU , but both positive and negative values were studied for the ratio anomaly.

Table IV.1 Geologic Unit Average Value as a Function of Map Line for eTh (PPM Times 10)

UNIT: LINE	QAL	QD	QO	QEM	QGM	QLB	QG	TG	TS	TT	TC	KH	KF	KP	UNK
ML 240:	66		61	58	66			80	71	70	68	67			
ML 220:	67		58	59	66		71		70	69	67	70			
ML 200:	67		57	59	62	65	61		74	74	65	54			
ML 180:	64	43	41	59	55	53	69		74	71	66	55			
ML 160:	71	57	44	50	47	55				73	67	57	46		
ML 140:	59		64						74	66	68	64	68		64
ML 120:	66		70				67		77	61	63	70	66		74
ML 100:	67		67							76	69	64	69		70
ML 80:	64	58	65		70					74	72	62	71		
ML 60:	67		56		73					67	71	60	68		
ML 40:	57		66		71						75	63	69		
ML 20:	68		65		77						70	64	64	57	
TL 5020:			59	57	63								62		
TL 5040:		48	61		66	39						60	71		
TL 5060:	60		70				68				64	63	61		
TL 5080:	58						68			66	71	62			
TL 5100:	65								71	67	66	66			
TL 5120:	66							79	73	71	67				

Table IV.2 Geologic Unit Average Value as a Function of Map Line for eU (PPM Times 10)

UNIT: LINE	QAL	QD	QO	QEM	QGM	QLB	QG	TG	TS	TT	TC	KH	KF	KP	UNK
ML 240:	16		16	15	16			23	18	17	15	18			
ML 220:	15		15	14	17		18		18	17	17	17			
ML 200:	18		16	14	17	15	19		19	20	15	13			
ML 180:	16	12	12	15	13	14	18		19	18	18	15			
ML 160:	18	16	9	13	13	13				19	16	15	12		
ML 140:	14		16						16	17	16	16	16		15
ML 120:	16		19				15		17	17	16	17	18		21
ML 100:	17		17							20	16	16	17		21
ML 80:	17	12	17		19					17	17	17	19		
ML 60:	19		16		19					20	17	18	18		
ML 40:	17		17		16						19	16	19		
ML 20:	18		15		22						18	18	17	12	
TL 5020:			14	12	15								15		
TL 5040:		11	14		17	8						15	18		
TL 5060:	16		16				15				15	17	18		
TL 5080:	15						17			17	17	17			
TL 5100:	16								17	17	16	18			
TL 5120:	18							21	19	18	17				

Table IV.3 Geologic Unit Average Value as a Function of Map Line for K (PC Times 100)

UNIT: / LINE	QAL	QD	QO	QEM	QGM	QLB	QG	TG	TS	TT	TC	KH	KF	KP	UNK
ML 240:	151		144	135	142			169	156	155	152	146			
ML 220:	159		143	138	147		164		157	153	149	156			
ML 200:	156		143	138	148	150	139		162	161	150	127			
ML 180:	150	140	111	140	136	144	155		164	156	150	149			
ML 160:	158	148	142	142	139	149				170	160	145	140		
ML 140:	150		148						170	166	155	147	152		149
ML 120:	159		159				164		162	160	157	157	154		159
ML 100:	155		158							172	163	157	155		155
ML 80:	158	169	158		160					171	164	157	156		
ML 60:	153		160		158					172	163	154	162		
ML 40:	146		155		163						171	154	157		
ML 20:	163		148		164						162	150	156	143	
TL 5020:			145	141	146								156		
TL 5040:		148	158		155	139						149	164		
TL 5060:	137		154				160				157	152	151		
TL 5080:	153						157			153	161	153			
TL 5100:	160								160	163	165	152			
TL 5120:	165							177	166	169	179				

Table IV.4 Geologic Unit Average Value as a Function of Map Line for eU/eTh (Times 100)

UNIT: / LINE	QAL	QD	QO	QEM	QGM	QLB	QG	TG	TS	TT	TC	KH	KF	KP	UNK
ML 240:	25		27	27	25			29	25	25	22	27			
ML 220:	23		26	25	27		25		27	25	26	25			
ML 200:	28		28	24	28	24	32		27	27	24	25			
ML 180:	25	28	32	25	24	26	26		26	26	27	27			
ML 160:	26	28	20	27	30	25				26	25	26	27		
ML 140:	24		25						22	26	24	25	24		23
ML 120:	24		28				22		23	28	26	25	28		29
ML 100:	26		25							27	24	25	25		31
ML 80:	26	20	26		27					23	24	27	27		
ML 60:	28		29		26					30	25	30	27		
ML 40:	30		25		22						26	26	28		
ML 20:	28		24		28						26	29	27	19	
TL 5020:			24	22	24								25		
TL 5040:		23	24		26	21						26	26		
TL 5060:	28		23				22				24	28	30		
TL 5080:	26						26			26	24	28			
TL 5100:	24								25	26	25	28			
TL 5120:	28							27	26	26	26				

Table IV.5 Geologic Unit Average Value as a Function of Map Line for eU/K (Times 1000)

LINE	QAL	QD	QO	QEM	QGM	QLB	QG	TG	TS	TT	TC	KH	KF	KP	UNK
ML 240:	1108		1166	1164	1192			1419	1170	1163	1000	1242			
ML 220:	1007		1092	1082	1222		1096		1206	1126	1181	1142			
ML 200:	1225		1155	1075	1214	1047	1416		1242	1284	1046	1128			
ML 180:	1129	878	1224	1081	1011	980	1187		1184	1218	1223	1025			
ML 160:	1184	1087	655	972	1008	926				1145	1066	1048	920		
ML 140:	982		1093						977	1062	1067	1103	1073		1022
ML 120:	1016		1231				927		1101	1076	1043	1143	1207		1362
ML 100:	1148		1100							1191	1040	1027	1156		1418
ML 80:	1074	726	1131		1207					1027	1082	1097	1236		
ML 60:	1254		1014		1226					1179	1092	1202	1178		
ML 40:	1223		1093		989						1143	1099	1266		
ML 20:	1166		1072		1349						1146	1256	1148	774	
TL 5020:			1020	880	1072								1001		
TL 5040:		757	941		1114	611						1062	1150		
TL 5060:	1229		1097				971				999	1177	1230		
TL 5080:	1018						1131			1152	1072	1152			
TL 5100:	1005								1125	1100	1017	1267			
TL 5120:	1130							1200	1178	1124	974				

Table IV.6 Geologic Unit Average Value as a Function of Map Line for eTh/K (Times 1000)

LINE	QAL	QD	QO	QEM	QGM	QLB	QG	TG	TS	TT	TC	KH	KF	KP	UNK
ML 240:	4400		4301	4336	4649			4754	4594	4571	4516	4608			
ML 220:	4226		4112	4303	4495		4339		4481	4521	4530	4517			
ML 200:	4334		4059	4359	4234	4342	4406		4576	4620	4381	4332			
ML 180:	4339	3098	3751	4232	4083	3706	4453		4529	4570	4449	3730			
ML 160:	4548	3844	3109	3582	3407	3684				4314	4226	3957	3320		
ML 140:	3990		4355						4369	3999	4434	4358	4515		4305
ML 120:	4198		4396				4077		4784	3804	4007	4492	4306		4651
ML 100:	4398		4279							4424	4299	4120	4491		4534
ML 80:	4078	3465	4158		4393					4373	4429	3953	4585		
ML 60:	4396		3494		4621					3944	4376	3947	4234		
ML 40:	4066		4289		4394						4412	4147	4396		
ML 20:	4194		4422		4750						4343	4298	4153	4375	
TL 5020:			4135	4040	4353								4017		
TL 5040:		3276	3899		4292	2814						4046	4332		
TL 5060:	4384		4564				4283				4135	4160	4095		
TL 5080:	3826						4319			4330	4408	4073			
TL 5100:	4114								4446	4158	4007	4364			
TL 5120:	4016							4458	4414	4219	3748				

eTh		eU		K		eU/eTh		eU/K		eTh/K		MAX. NO. EVENTS	GEOL. UNIT
σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$		
0.9723	6.6	0.3977	1.7	0.1851	1.6	0.0634	0.2686	0.2752	1.1297	0.5309	4.2299	3550.0	QAL
1.0036	4.8	0.4220	1.3	0.1188	1.5	0.0767	0.2691	0.2829	0.8905	0.5563	3.3138	370.0	QD
1.1329	6.2	0.4156	1.6	0.1884	1.5	0.0665	0.2615	0.2919	1.0705	0.5947	4.1192	3913.0	QO
0.6984	5.8	0.3236	1.5	0.0925	1.4	0.0623	0.2540	0.2497	1.0487	0.5524	4.1673	1384.0	QEM
0.8945	6.7	0.4138	1.8	0.1511	1.5	0.0575	0.2629	0.2571	1.1618	0.4630	4.4390	2430.0	QGM
1.0961	5.8	0.3556	1.4	0.1074	1.5	0.0546	0.2534	0.2378	0.9822	0.6637	3.9060	456.0	QLB
0.6517	6.8	0.2981	1.8	0.1225	1.5	0.0500	0.2670	0.2358	1.1699	0.4062	4.3855	482.0	QG
0.5819	8.0	0.2999	2.3	0.0948	1.7	0.0454	0.2893	0.2017	1.3368	0.4209	4.6433	122.0	TG
0.9334	7.3	0.3957	1.9	0.1481	1.6	0.0582	0.2602	0.2613	1.1650	0.5017	4.5025	3324.0	TS
0.9273	7.1	0.4009	1.9	0.1623	1.6	0.0608	0.2683	0.2587	1.1548	0.5109	4.3345	5139.0	TT
0.9140	6.9	0.3829	1.7	0.1429	1.6	0.0595	0.2526	0.2620	1.0754	0.5845	4.2872	8100.0	TC
0.8780	6.3	0.3769	1.7	0.1265	1.5	0.0641	0.2763	0.2634	1.1404	0.5521	4.1619	5559.0	KH
0.8804	6.8	0.4009	1.8	0.1246	1.6	0.0590	0.2728	0.2701	1.1776	0.5454	4.3327	3366.0	KF
1.8119	5.7	0.3054	1.2	0.4261	1.4	0.0413	0.1904	0.1474	0.7746	0.9852	4.3759	28.0	KP
0.7207	7.1	0.4224	2.0	0.1011	1.6	0.0551	0.2842	0.2640	1.2951	0.3733	4.5598	228.0	UNK

Table IV.7 Mean ($\bar{X}$) and Standard Deviation (σ) for Each Geologic Type.

TABLE IV.8 Geologic Units with Apparent Significant Variations from Unimodal Distributions, Based on the Analysis of the eTh Histograms*

Geologic Unit	No. Events	eTh Recommended Split (equivalent ppm)
Qal	3550	None
Qd	370	"
Qo	3913	"
Qem	1384	"
Qgm	2430	"
Qlb	456	"
Qg	482	"
Ts	3324	"
Kh	5558	"
Kf	3366	"
Unk	228	None

*Recommended Splits on the Histograms are Given Only Where Such Splits Appear to be Obvious.

TABLE IV.9 SUMMARY OF ANOMALIES
BISMARCK

	ETH		EU		EU/ETH	
ML240			TS	3760- 3765	TS	3760- 3765
				4045- 4050		3790
			QEM	5580- 5585		4045- 4050
						(4095- 4100)
					QAL	4615- 4620
					QO	4740
					QGM	5145
					QEM	5580- 5585
					QGM	(5790- 5795)
ML220					TT	(2535- 2540)
ML200			TT	3631- 3636	TT	3811
				3776- 3796	QG	4431- 4436
				3811		
			QAL	4586- 4591	QO	5106- 5111
ML180					QO	1086- 1091
						1111- 1116
						1206
					QLB	1486- 1491
					QD	1866- 1871
					TS	3316
ML160	TT	3626	QAL	3496- 3501	TC	4151- 4156
			TT	3931- 3936		4441- 4446
			TC	4501- 4516		4506
			QAL	5089- 5094	QEM	5696
ML140	TC	2816- 2831	TC	2831- 2836	TS	(3586- 3596)
		2966- 2971				
ML120	TS	3680	QO	5745- 5750	TT	3805
						4215- 4235
					TC	4255
						4265- 4270
					QO	6085
ML100	TC	2866- 2871	TT	3331- 3341	QAL	(2201)
	TT	3019- 3029				
ML80	KF	5554	QO	5454- 5459		
			KF	5489		
				5549- 5559		
			QO	5804- 5809		
ML60			KH	2523	KF	(1688- 1693)

(...) DENOTES NEGATIVE ANOMALY

(TABLE IV.9 CONT'D)

	ETH		EU		EU/ETH	
ML60			TT	3308- 3318	KF	1743- 1748
					KH	2068
						2403- 2413
					QAL	2433
					TT	3308- 3318
						3328
						3353
ML40	TC	3661- 3666	TC	3790- 3805	TC	3795- 3805
				4520- 4525		4520- 4530
			QO	5866- 5871		4820
				5880- 5885	QAL	5201
ML20	QGM	1386- 1391	QO	1221- 1226	KF	(1651)
			QGM	1401- 1416		1776
			KH	2376- 2381		1936- 1941
					TC	3356
TL5020						
TL5040	QD	4313- 4318			QO	3523- 3528
TL5060	KH	2548- 2553			KF	1433
					KH	1803- 1808
					TC	2173
TL5080						
TL5100			TC	1636- 1641	TC	1636- 1641
					TT	1841- 1846
					TC	2061
TL5120	TT	3844- 3854	TS	3029	TT	3824- 3834
			TT	3819- 3834		4049- 4054
			TC	4164- 4169		
				4234- 4244		

(...) DENOTES NEGATIVE ANOMALY

TABLE IV.10 Radioactivity Anomalies per Geologic Map Unit

Geologic Unit	eTh	eU	eU/eTh
Quaternary			
Qal	0	3	3(1)
Qd	1	0	1
Qo	0	6	7
Qem	0	1	2
Qgm	1	1	1(1)
Qlb	0	0	1
Qg	0	0	1
Tertiary			
Ts	1	3	4(2)
Tt	3	7	9(1)
Tc	4	7	12
Cretaceous			
Kh	1	2	3
Kf	1	2	4(2)

(...) denotes negative anomaly.

TABLE IV.11 Statistical Summary of Radioactivity Anomalies per Geologic Period(s)

Geologic Unit	eTh	eU	eU/eTh
Quaternary			
No. of Units w/ Anomalies	2	4	7
No. of Anomalies	2	11	16(2)
Tertiary			
No. of Units w/ Anomalies	3	3	3
No. Of Anomalies	8	17	25(3)
Cretaceous			
No. of Units w/ Anomalies	2	2	2
No. of Anomalies	2	4	7(2)
Total Sample			
No. of Units w/ Anomalies	7	9	12
No. of Anomalies	12	32	48(7)

(...) denotes negative anomaly.

Quaternary Geologic Units: Qal, Qd, Qo, Qem, Qgm, Qlb, Qg

eTh Anomalies

Approximately seventeen percent of the eTh anomalies reported from the Bismarck map sheet area are present in the units Qd and Qgm. The Quaternary units are exposed over roughly thirty percent of the map surface. Given the fact that the thorium ion is relatively insoluble and does not readily concentrate in surface waters, the anomalies are not considered to be significant.

eU and eU/eTh Anomalies

Thirty-four percent of the eU anomalies and thirty-three percent of the positive eU/eTh anomalies are recorded over the Quaternary units. Of these anomalies, well over one-third (54% and 44%, respectively) occur in the unit Qo. Twenty-eight percent of the negative ratio anomalies are present. There is one point of geographical coincidence between the Quaternary eU and eU/eTh anomalies; namely, ML240, stations 5580-5585 (Qem). The anomalies are probably not economically significant.

Tertiary Geologic Units: Ts, Tt, Tc

eTh Anomalies

Approximately sixty-seven percent of the eTh anomalies are found in the units Tc, Tt and, to a lesser extent, unit Ts. The Tertiary exposures comprise roughly forty percent of all outcrops in the Bismarck map area.

eU and eU/eTh Anomalies

Fifty-three percent of the eU anomalies and fifty-two percent of the positive eU/eTh anomalies are reported from the Tertiary units. Approximately forty-three percent of the negative ratio anomalies are found in the units. There are nine geographical coincidences of eU and eU/eTh anomalies: ML40, stations 3795-3805 and 4520-4525 (Tc); ML60, stations 3308-3318 (Tt); ML160, station 4506 (Tc); ML200, station 3811 (Tt); ML240, stations 3760-3765 and 4045-4050 (Ts); TL5100, stations 1636-1641 (Tc); and TL5120, stations 3824-3834 (Tt).

The loci of coincidental anomalies in these Fort Union Group members may yield significant cocentrations of uranium, especially where the anomalies are associated with organic deposits.

Cretaceous Geologic Units: Kh, Kf

eTh Anomalies

Approximately seventeen percent of the eTh anomalies are recorded from Cretaceous exposures which make up roughly thirty percent of the map surface area.

eU and eU/eTh Anomalies

Approximately twelve and one-half percent of the eU anomalies and fourteen and one-half percent of the positive ratio anomalies are reported from the Cretaceous units. Twenty-eight percent of the negative ratio anomalies are present in the unit Kf. There are no coincidental anomalies within the Cretaceous exposures. The anomalies are presumably not economically significant.

Relationship between Radioactivity Anomalies and Known Radioactive Mineral Deposits

There are no reported radioactive mineral deposits directly within the Bismarck map sheet area (see Section III.D).

Relationship of Radioactivity Data to Cultural Features

Cultural features in the Bismarck map sheet area which may produce an effect on radioactivity data include the towns of Bismarck, Driscoll, Elgin, Flasher, Fort Yates, Glen Ullin, Hazelton, Linton, Mandan, New Salem, Selfridge and Strasburg. Major bodies of water include the Missouri River, the Geneva, Long, Magnuson, Rice, Schwahn, and Tschida lakes, the Strong Slough, and the Oahe Reservoir, as well as numerous intermittent lakes.

Water may have had a slight causative effect on the positive ratio anomalies associated with Long Lake: ML180, stations 1111-1116 and 1206 (Qo), and the positive ratio anomaly in the vicinity of the Missouri River: ML240, station 4740 (Qo).

Trends

eTh Anomalies

The eTh anomalies in the Bismarck map sheet area are roughly delimited into two loose clusters. The first is located in the southeastern corner of the map, and the second lies along the westcentral edge of the map sheet. The eTh anomalies are relatively scant in the map region.

eU Anomalies

Except for a paucity of eU anomalies in the northeastern corner of the map, the anomalies are relatively randomly distributed across the map region.

eU/eTh Anomalies

The eU/eTh anomalies are fairly uniformly distributed throughout the Bismarck map region, with the exception of the extreme southeastern edge of the map. Their distribution appears to be independent of structure or topography.

3. Summary and Recommendations

Over one-half of all eTh, eU and eU/eTh anomalies reported from the Bismarck map sheet area are recorded in the units Ts, Tt and Tc. The presence of relatively many geographically coincident anomalies within these Fort Union Group members seems to concur with known radioactive mineral deposits occurring in the Fort Union due west of the map region. Further, more detailed surveying is suggested.

F. NATIONAL GAMMA RAY MAP SERIES (NGRMS)

The geologic base has been photographically screened to allow emphasis of the flight line locations and of the information regarding data analysis. These maps are used as the base for presenting statistical information on the six variables:

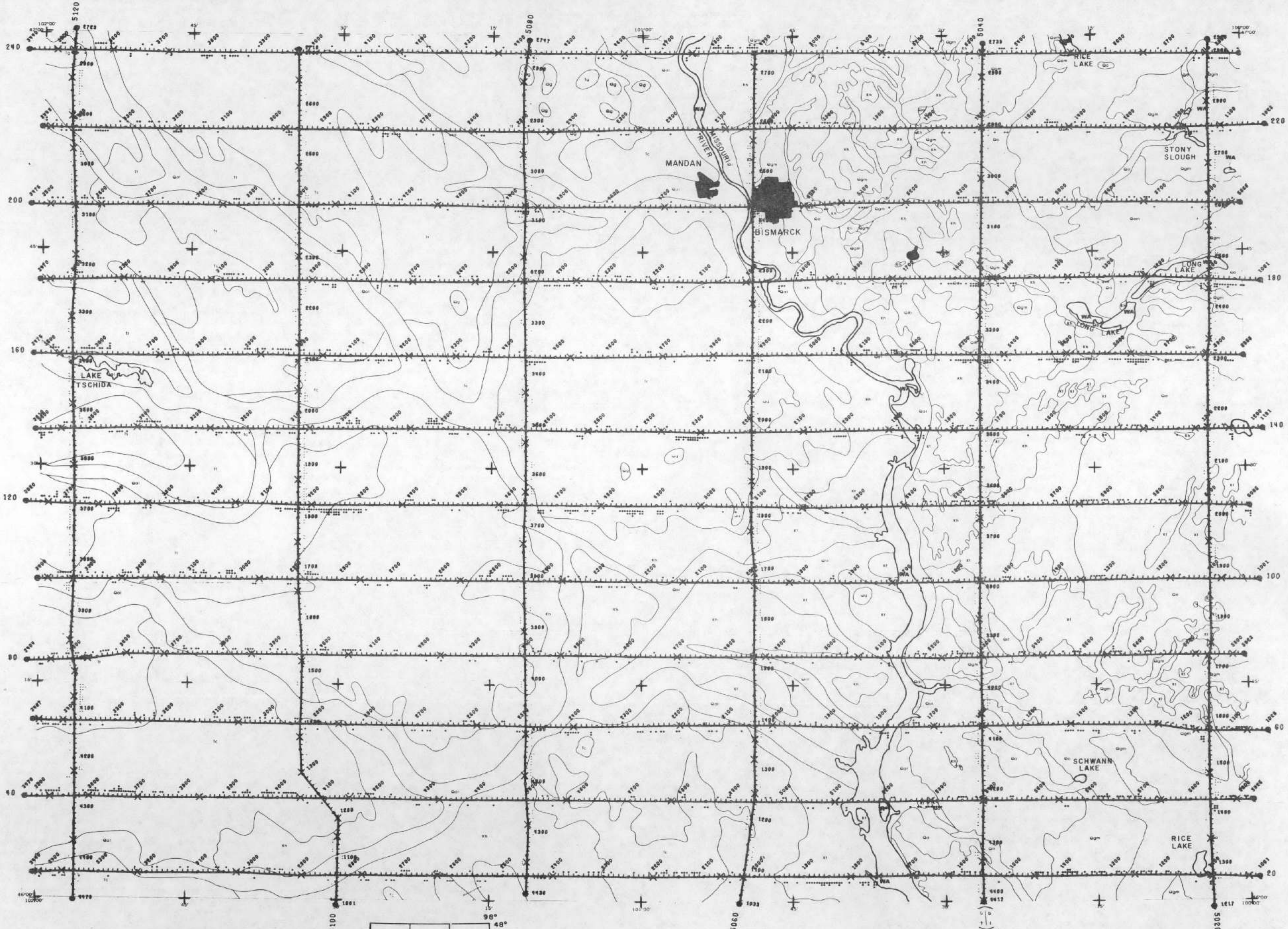
* eTh
* eU
* K
* eU/eTh Ratio
* eU/K Ratio
* eTh/K Ratio

The six NGRMS sheets are presented in Figures IV. (1-6) of this report at a scale of 1:500,000 and as separate sheets at a scale of 1:250,000.

The statistical information is summarized on these maps through the utilization of one, two or three dots above or below the flight line at every fifth data point. One dot above the line indicates that the variable value at that point is between 1σ and 2σ greater than the mean value for that geologic type where σ values are determined for each geologic type based on all flight line data from the area, as is discussed further in Section V.B.4. Two dots indicate values between 2σ and 3σ, and three dots show values greater than 3σ. Dots below the line indicate the variable values which are less than the mean value by 1, 2 or 3σ in the same manner.

G. LINE PRINTER CONTOURS

Printer contours have been generated at a 1:500,000 scale for seven variables (eTh, eU, K, eU/eTh, eU/K, eTh/K, and RMag, respectively). They appear in Appendix IV. Note that every alternate contour interval is composed of blanks to help delineate contour boundaries. Dots are used where the denominator value for a ratio is approaching zero, and to denote non-data areas.



GEODATA INTERNATIONAL, INC.
7035 John W. Carpenter Frwy., Dallas, Texas 75247

NATIONAL GAMMA RAY MAP SERIES

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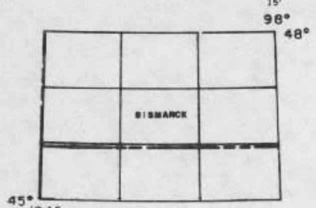
Martel Laboratories, Inc.



ETH ± STANDARD DEVIATIONS
REF. NTMS, NL 14-4

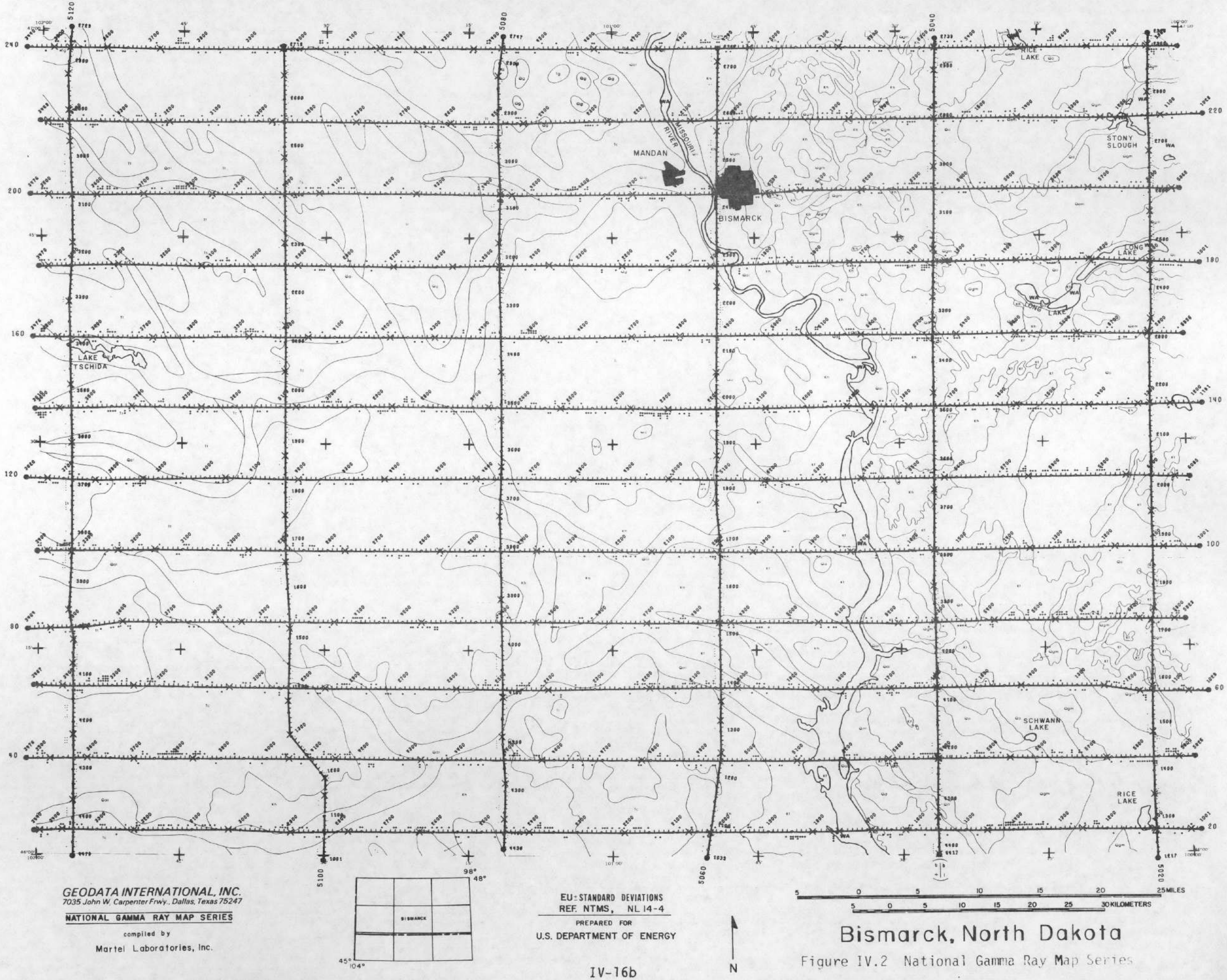
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

N

5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 KILOMETERS

Bismarck, North Dakota

Figure IV.1 National Gamma Ray Map Series



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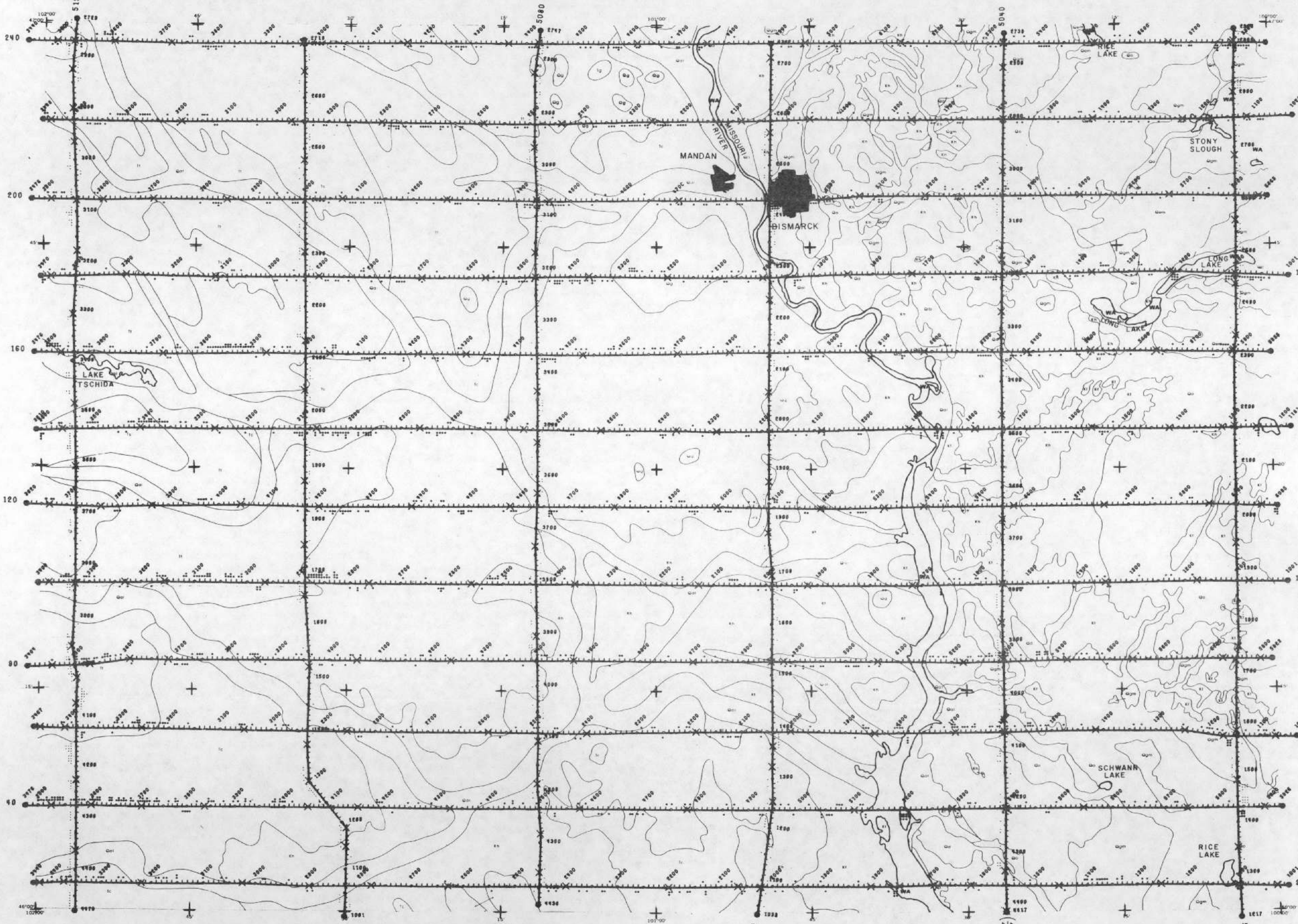
Bismarck, North Dakota

Figure IV.2 National Gamma Ray Map Series



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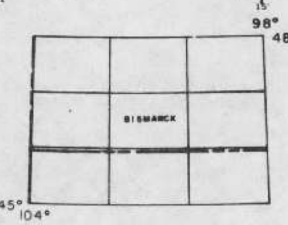


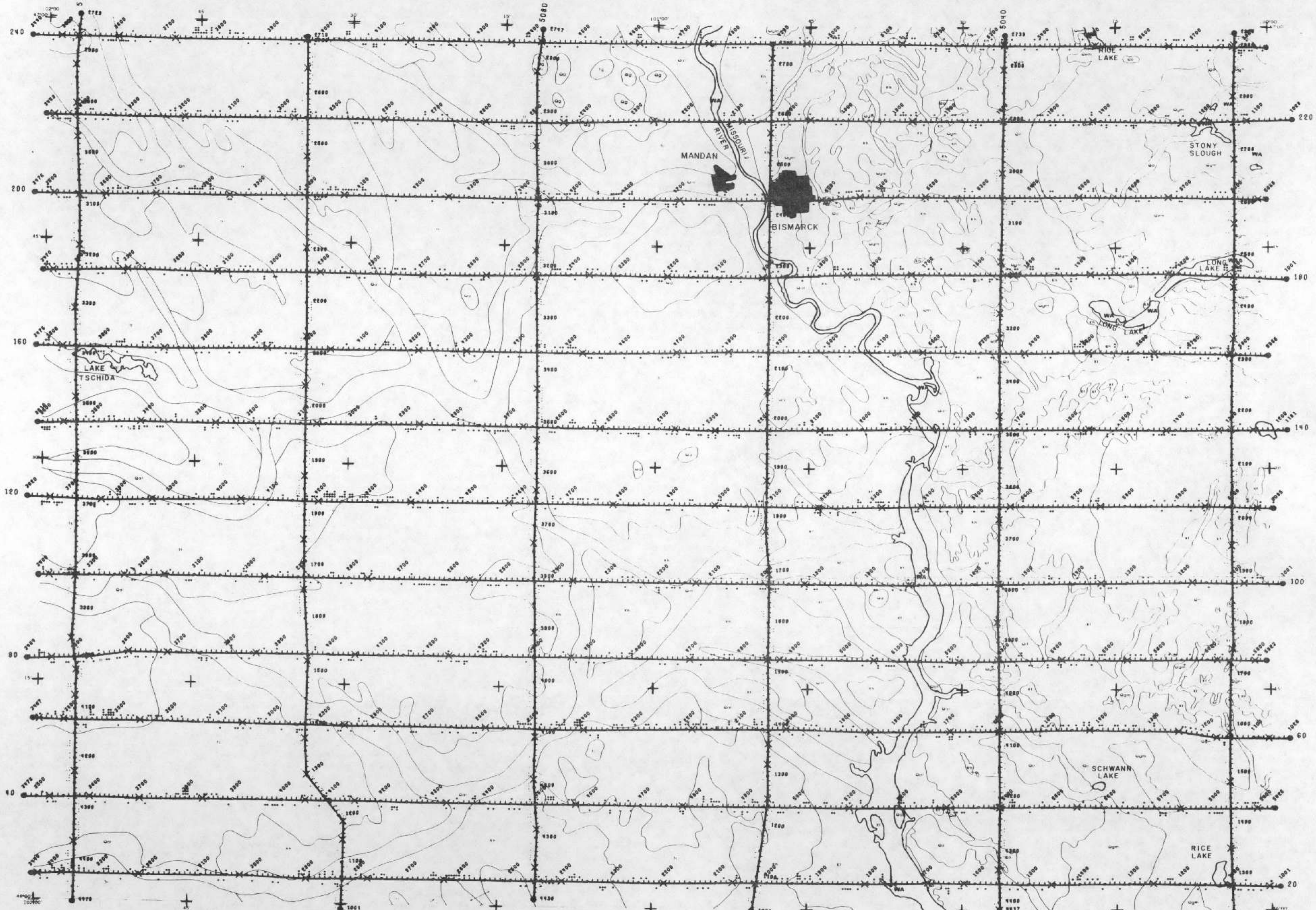
K ± STANDARD DEVIATIONS
REF. NTMS, NL 14-4
PREPARED FOR
U.S. DEPARTMENT OF ENERGY

N

5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 KILOMETERS

Bismarck, North Dakota

Figure IV.3 National Gamma Ray Map Series



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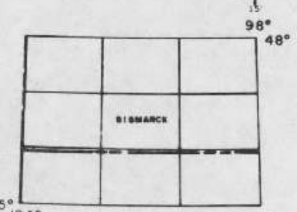

EU/ETH : STANDARD DEVIATIONS
REF. NTMS, NL 14-4

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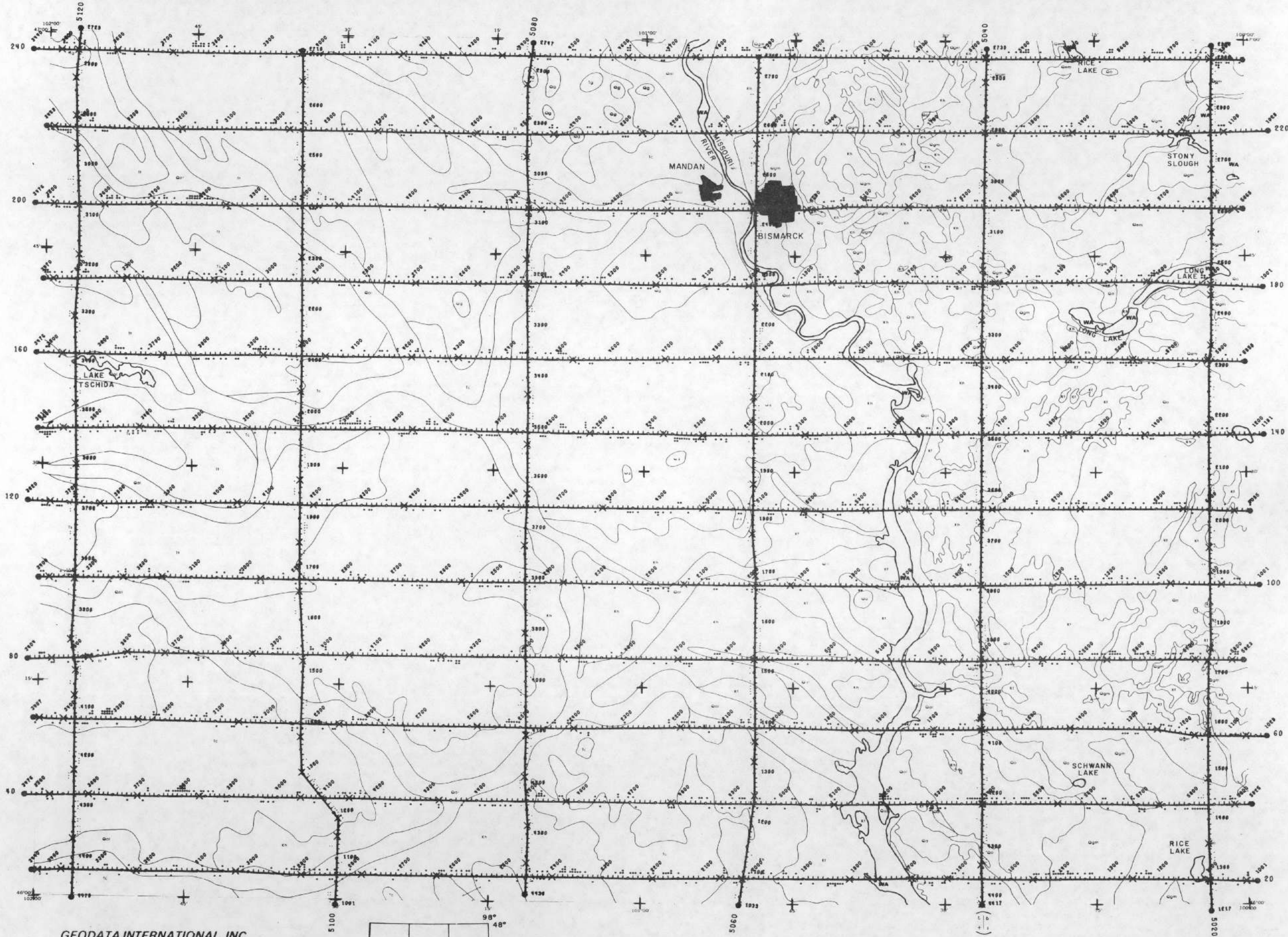
N

5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 KILOMETERS

Bismarck, North Dakota

Figure IV.4 National Gamma Ray Map Series



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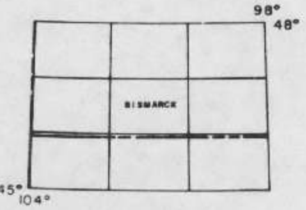

EU/K ± STANDARD DEVIATIONS
REF. NTMS, NL 14-4

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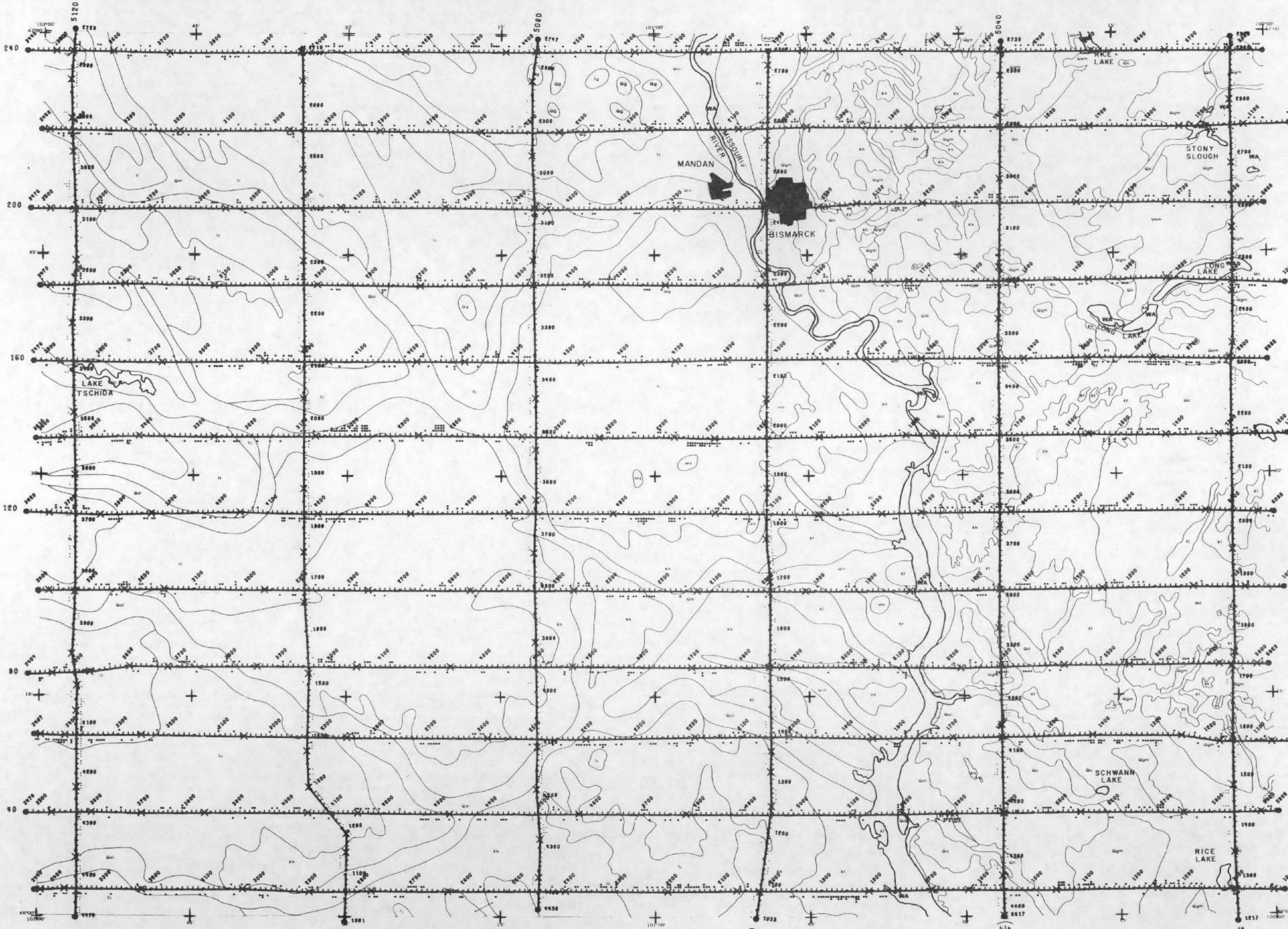
5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 KILOMETERS

N

Bismarck, North Dakota

Figure IV.5 National Gamma Ray Map Series



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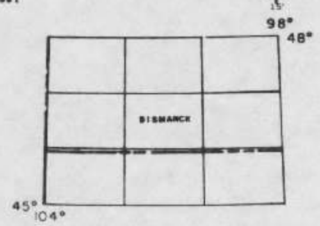


ETH/K ± STANDARD DEVIATIONS
REF. NTMS, NL 14-4

PREPARED FOR
U.S. DEPARTMENT OF ENERGY

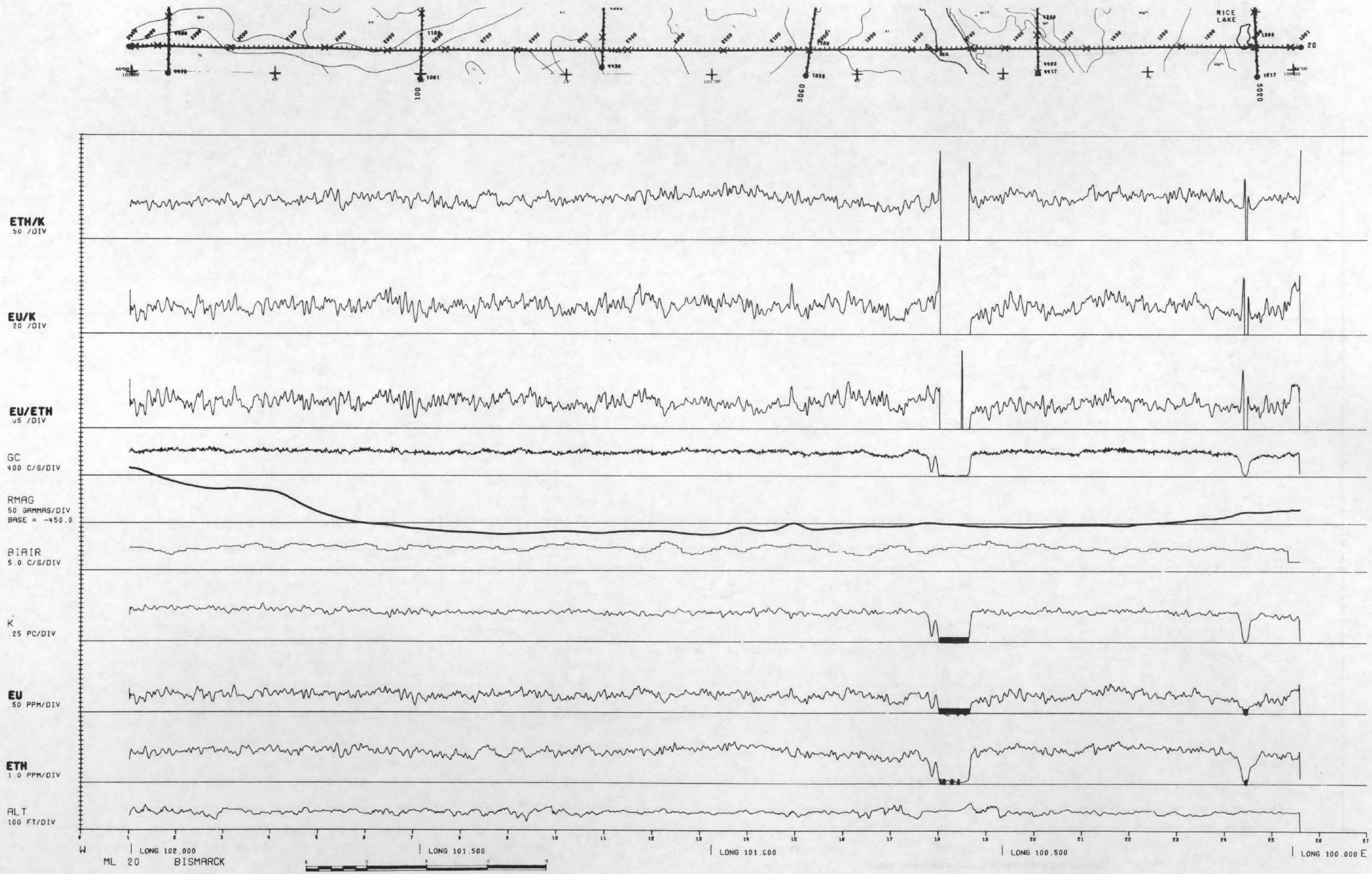
N

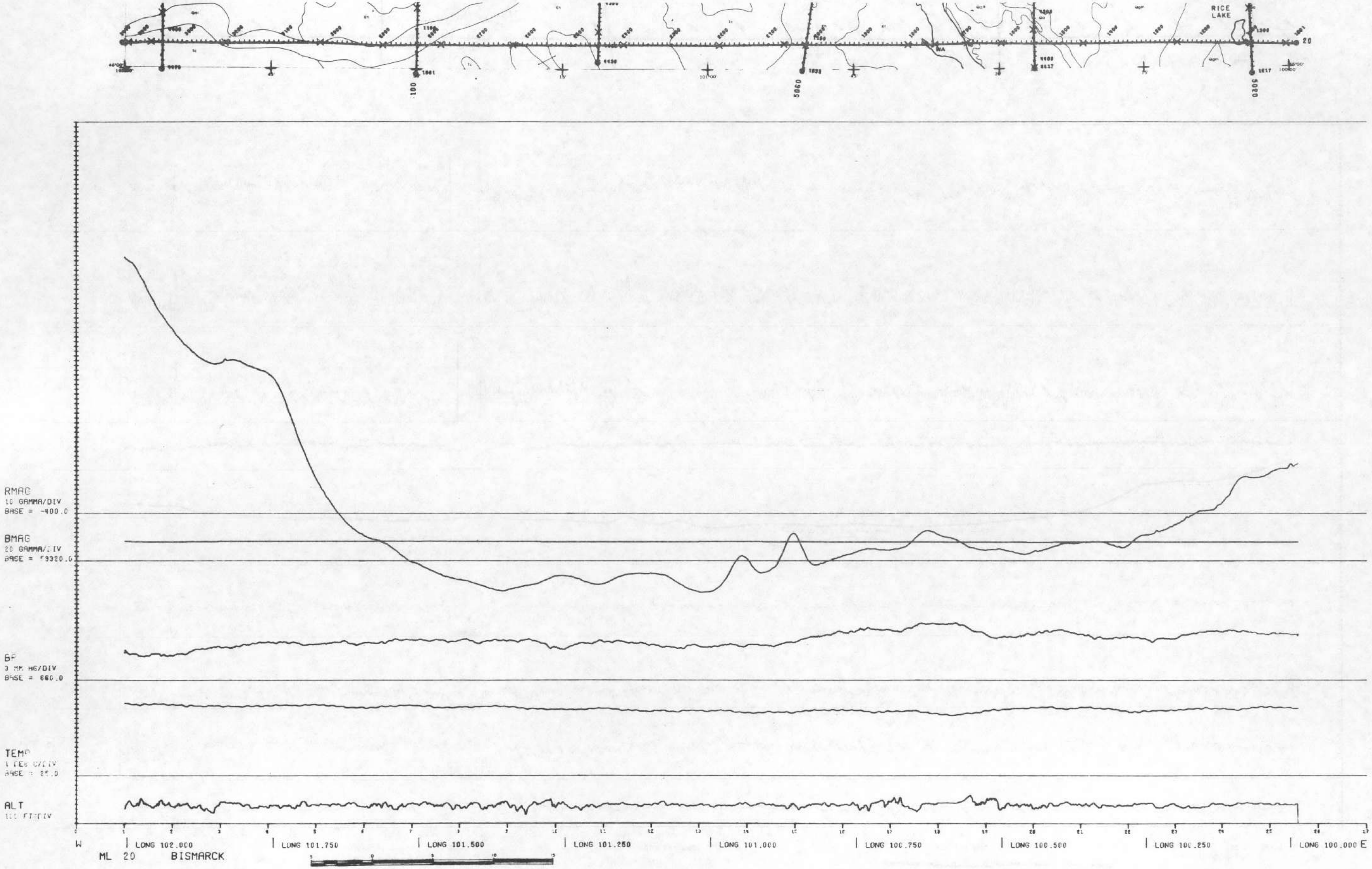
5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 KILOMETERS

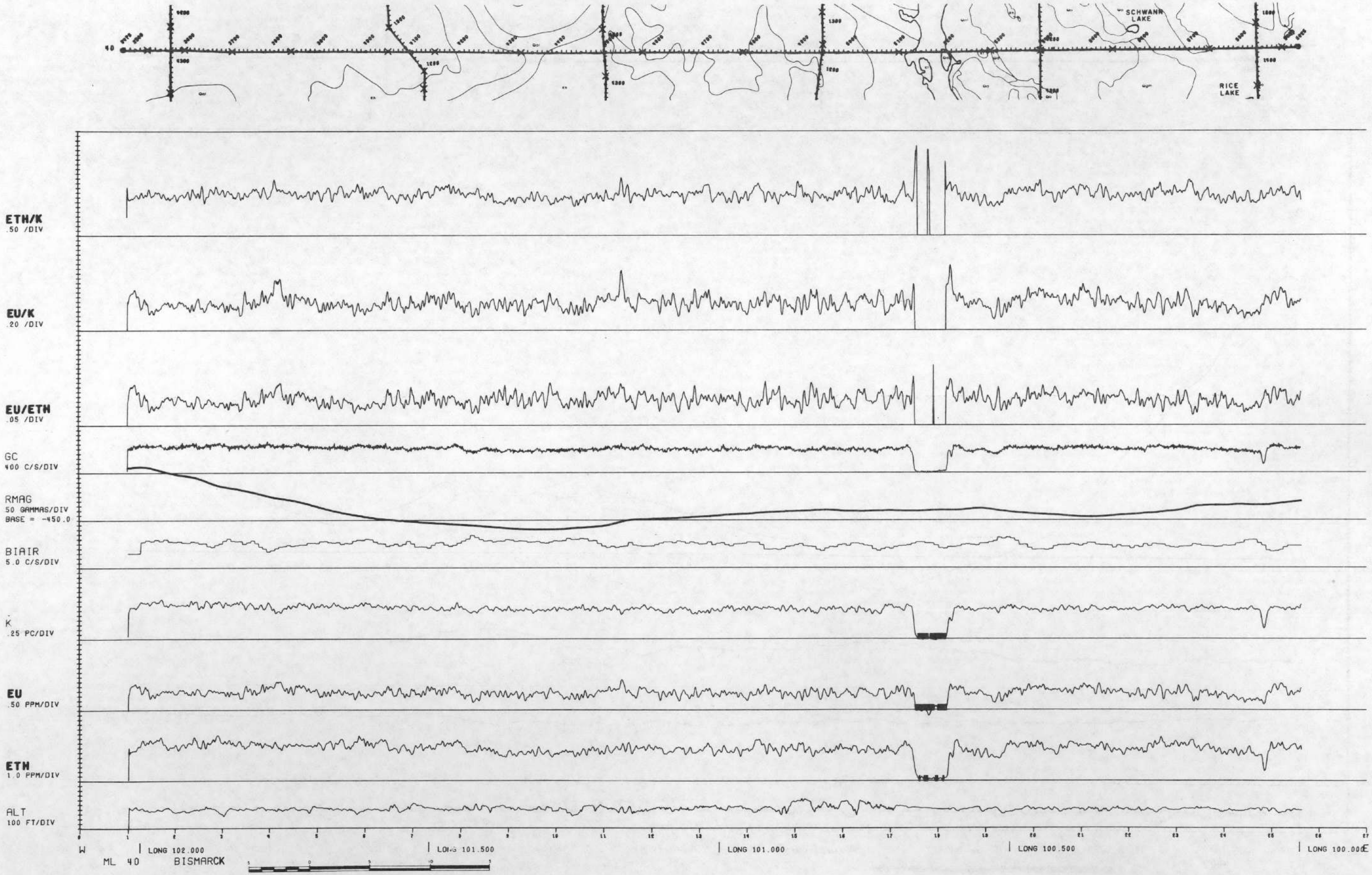
Bismarck, North Dakota

Figure IV.6 National Gamma Ray Map Series

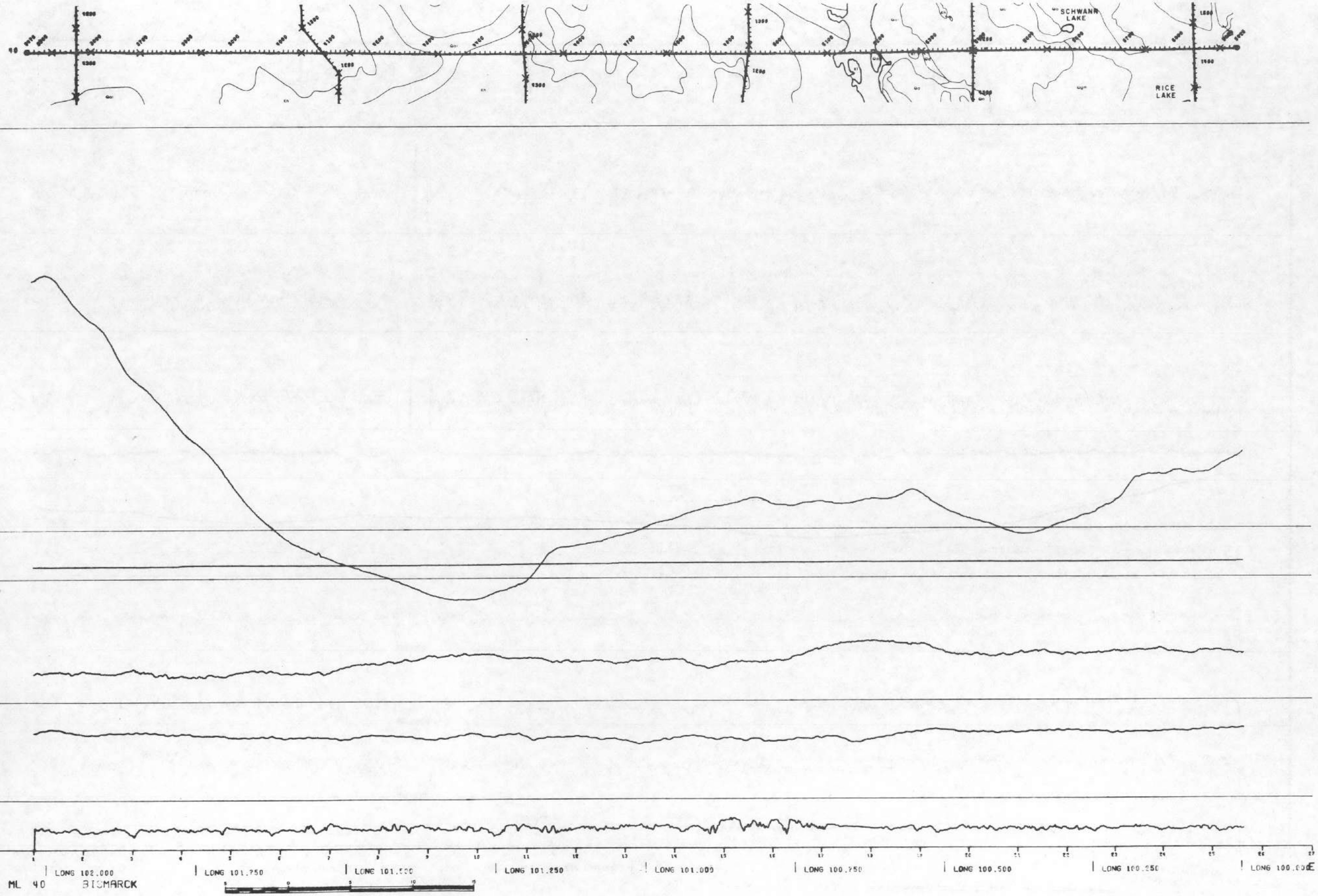
H. STACKED DATA PROFILES AND GEOLOGIC HISTOGRAMS


RICE LAKE
ETH/K
.50 /DIV
EU/K
.20 /DIV
EU/ETH
.05 /DIV
GC
400 C/S/DIV
RMAG
50 GAMMAS/DIV
BASE = -450.0
BIAIR
5.0 C/S/DIV
K
.25 PC/DIV
EU
.50 PPM/DIV
ETH
1.0 PPM/DIV
ALT
100 FT/DIV
W
LONG 102.000
LONG 101.500
LONG 101.000
LONG 100.500
LONG 100.000 E
ML 20 BISMARCK

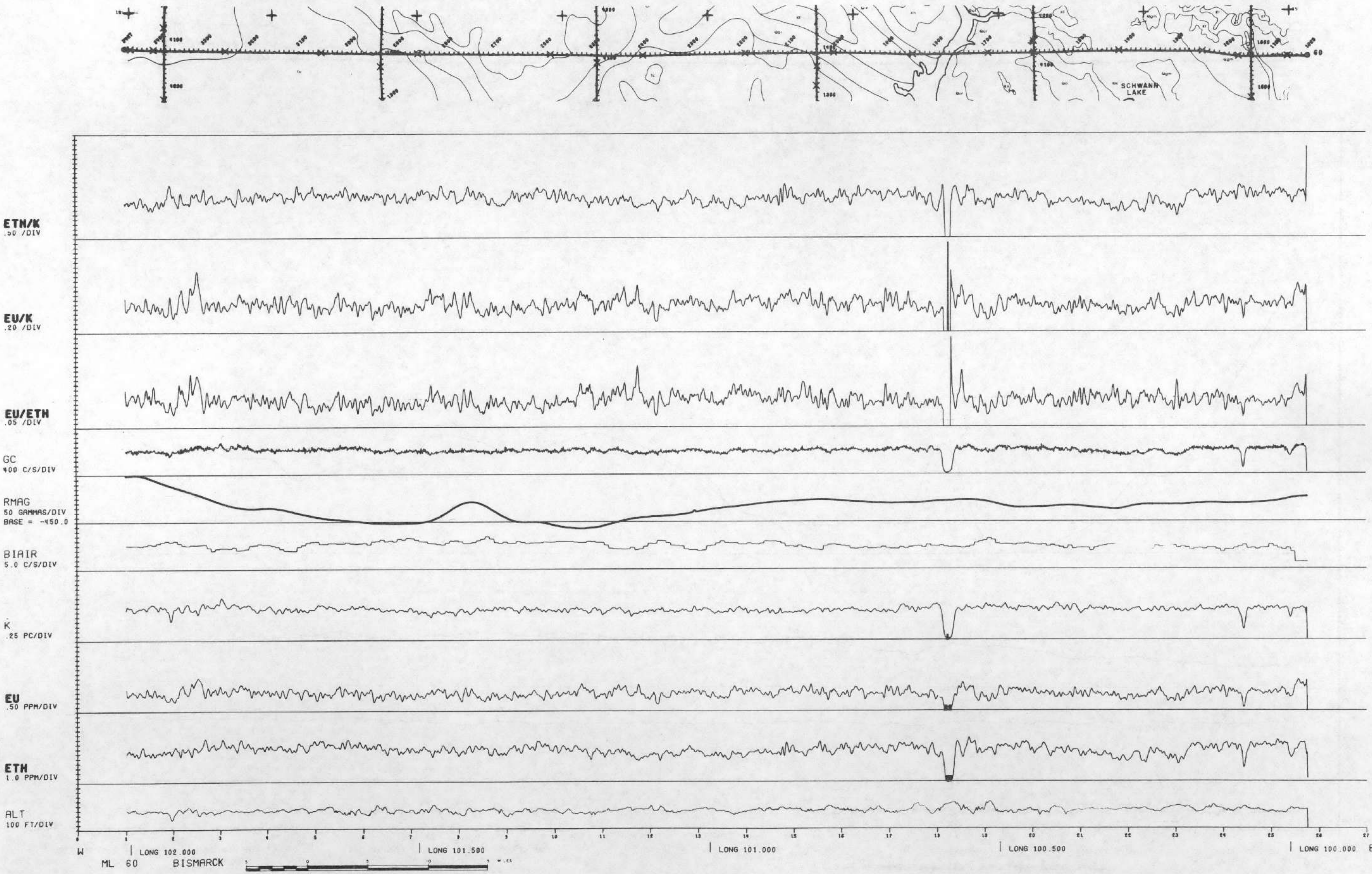

RICE LAKE
RMAG
10 GAMMA/DIV
BASE = -400.0
BMAG
20 GAMMA/DIV
BASE = 59320.0
BF
3 MM HG/DIV
BASE = 660.0
TEMP
BASE = 25.0
ALT
W
LONG 102.000
LONG 101.750
LONG 101.500
LONG 101.250
LONG 101.000
LONG 100.750
LONG 100.500
LONG 100.250
LONG 100.000
E
ML 20 BISMARCK



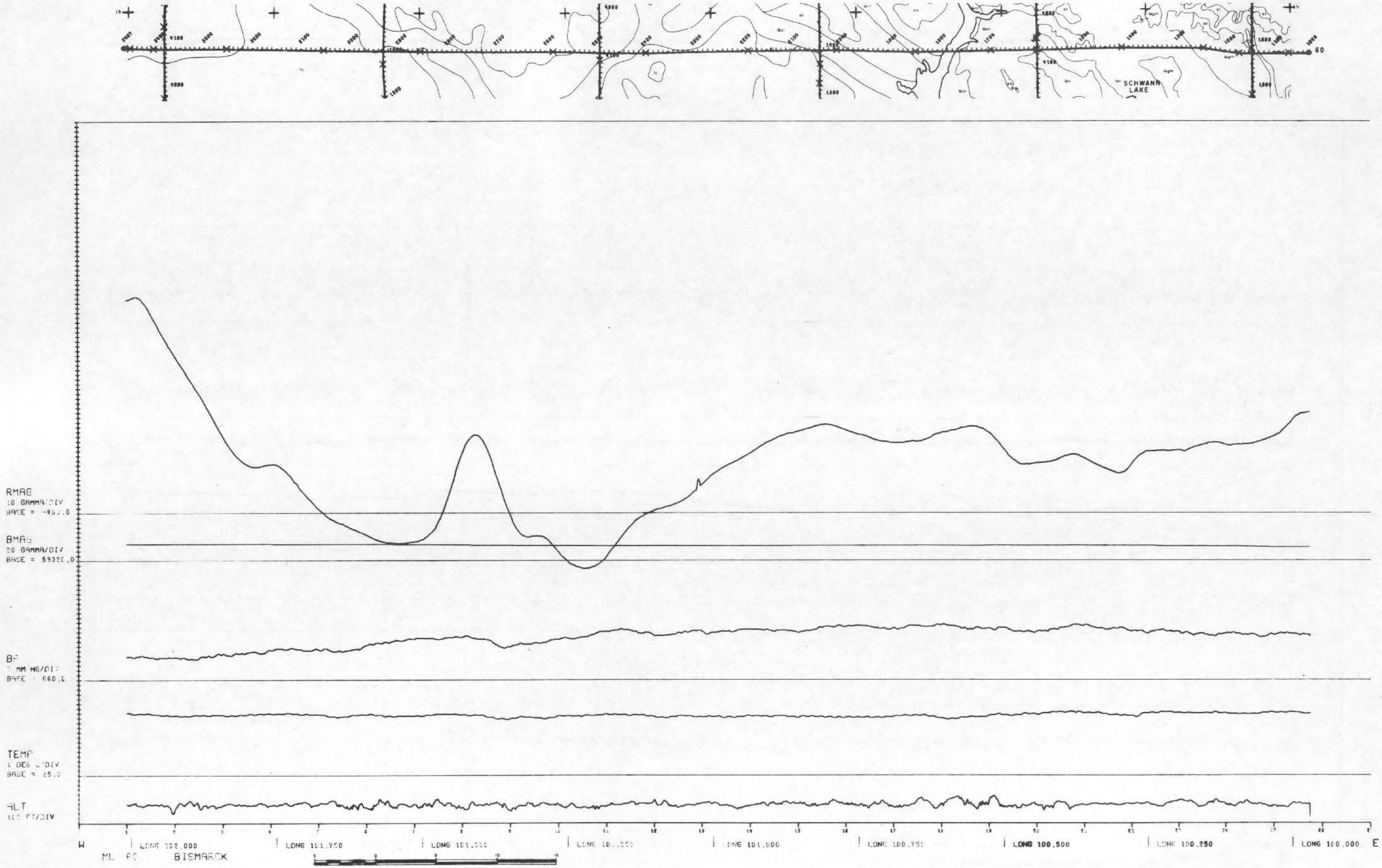
SCHWANN LAKE
RICE LAKE
ETH/K
.50 /DIV
EU/K
.20 /DIV
EU/ETH
.05 /DIV
GC
400 C/S/DIV
RMAG
50 GAMMAS/DIV
BASE = -450.0
BIAIR
5.0 C/S/DIV
K
.25 PC/DIV
EU
.50 PPM/DIV
ETH
1.0 PPM/DIV
ALT
100 FT/DIV
W
LONG 102.000
LONG 101.500
LONG 101.000
LONG 100.500
LONG 100.000
E
ML 40
BISMARCK



ML 40 BISMARCK



SCHWANN LAKE
60
ETH/K
.50 /DIV
EU/K
.20 /DIV
EU/ETH
.05 /DIV
GC
400 C/S/DIV
RMAG
50 GAMMAS/DIV
BASE = -450.0
BIAIR
5.0 C/S/DIV
K
.25 PC/DIV
EU
.50 PPM/DIV
ETH
1.0 PPM/DIV
ALT
100 FT/DIV
W
LONG 102.000
LONG 101.500
LONG 101.000
LONG 100.500
LONG 100.000
E
ML 60
BISMARCK



SCHWANN LAKE
RMAG
10 GAMMA/DIV
BASE = -400.0
BMAG
20 GAMMA/DIV
BASE = 59320.0
BP
MM HG/DIV
BASE = 660.0
TEMP
1 DEG C/DIV
BASE = 25.0
ALT
100 FT/DIV
W
LONG 102.000
LONG 101.750
LONG 101.500
LONG 101.250
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LONG 100.000
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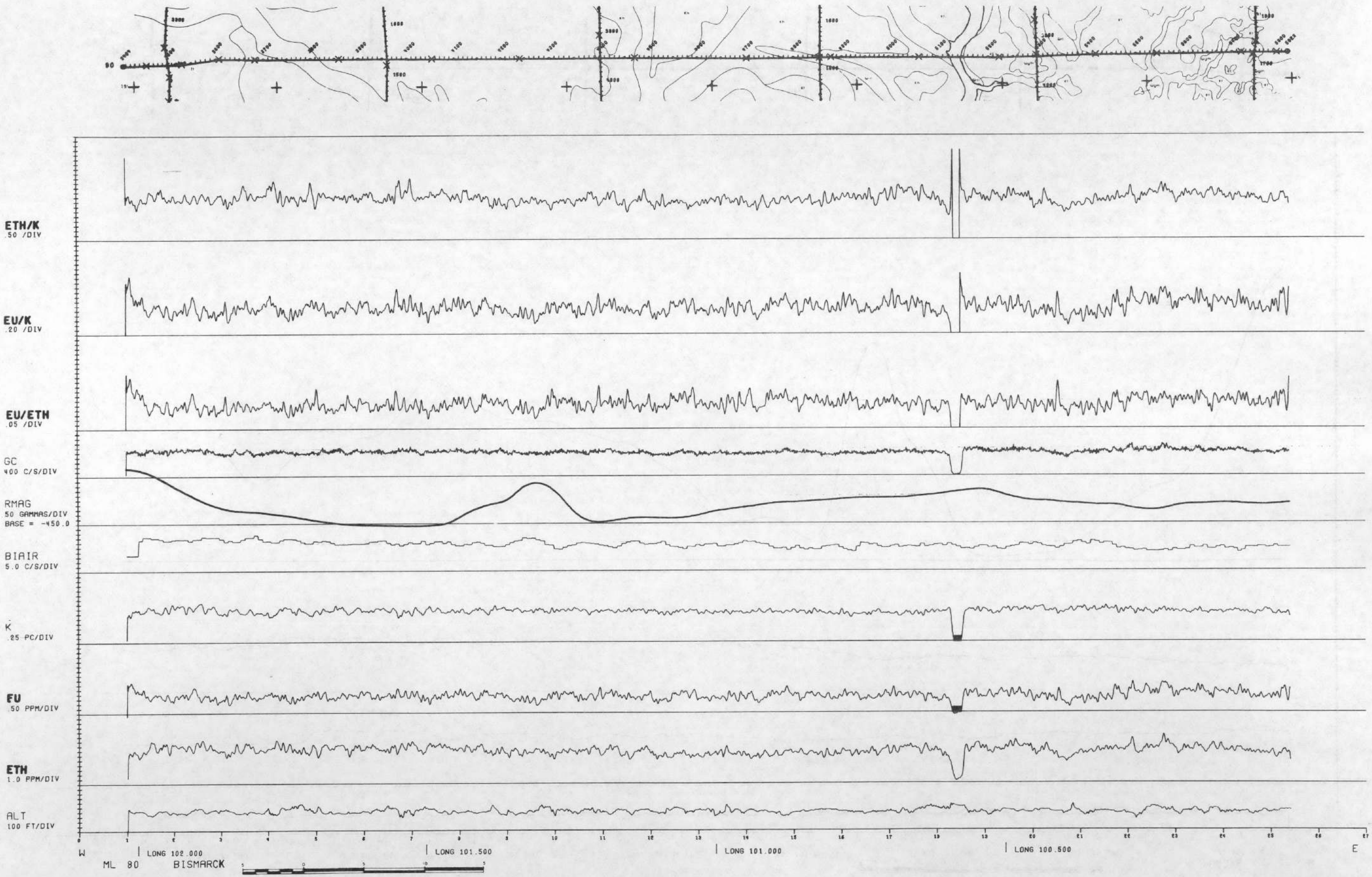
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5.0 C/S/DIV
K
.25 PC/DIV
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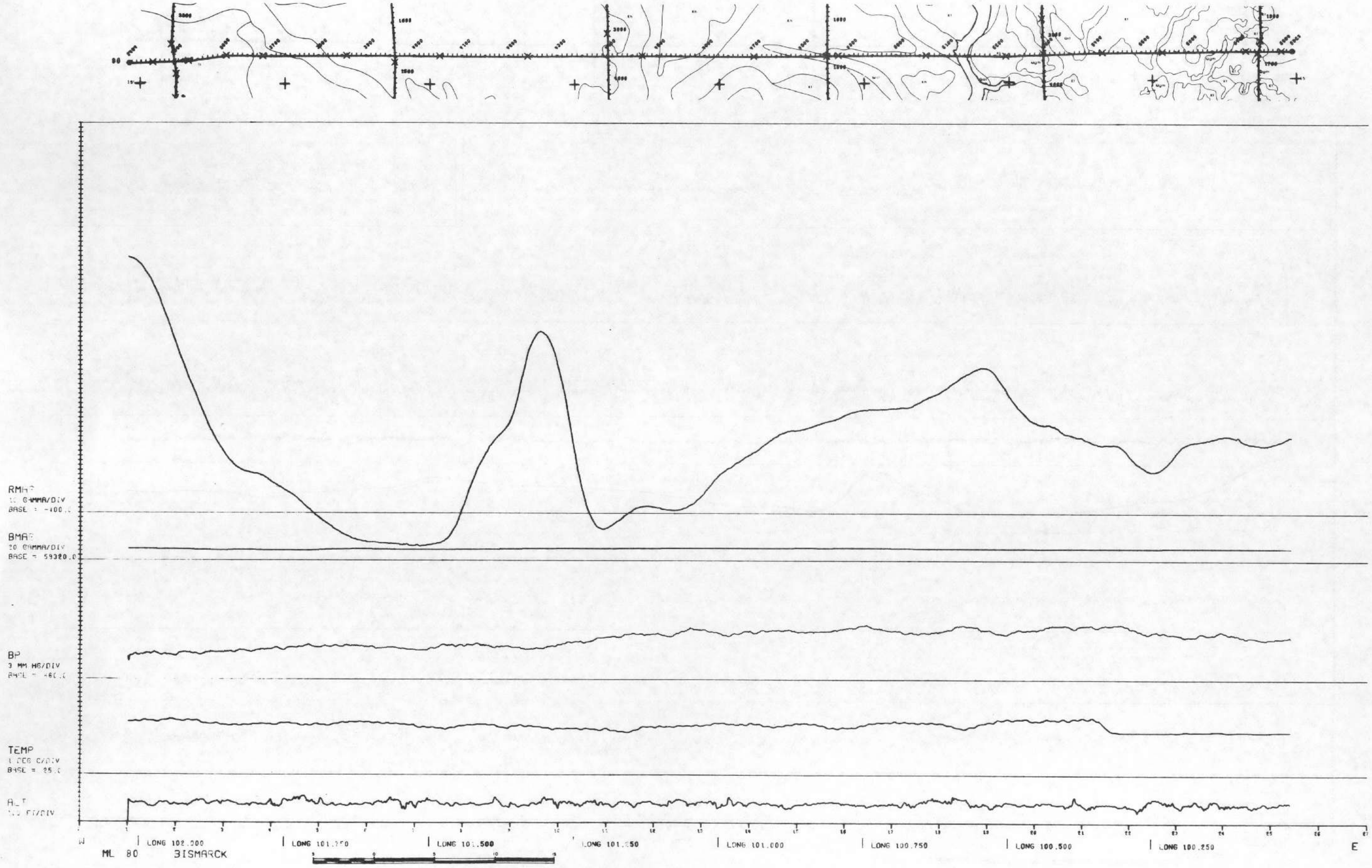
BISMARCK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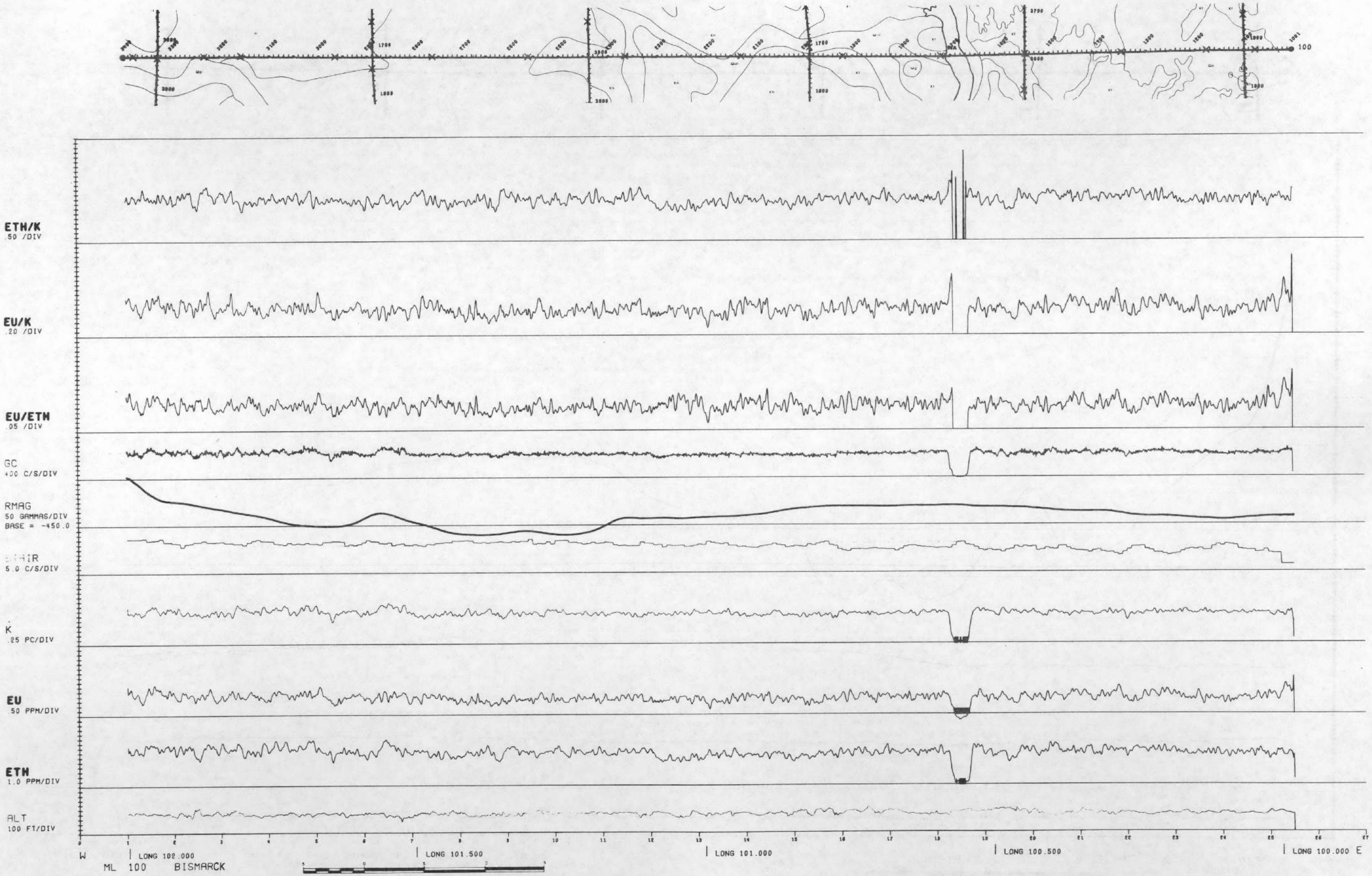

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EU
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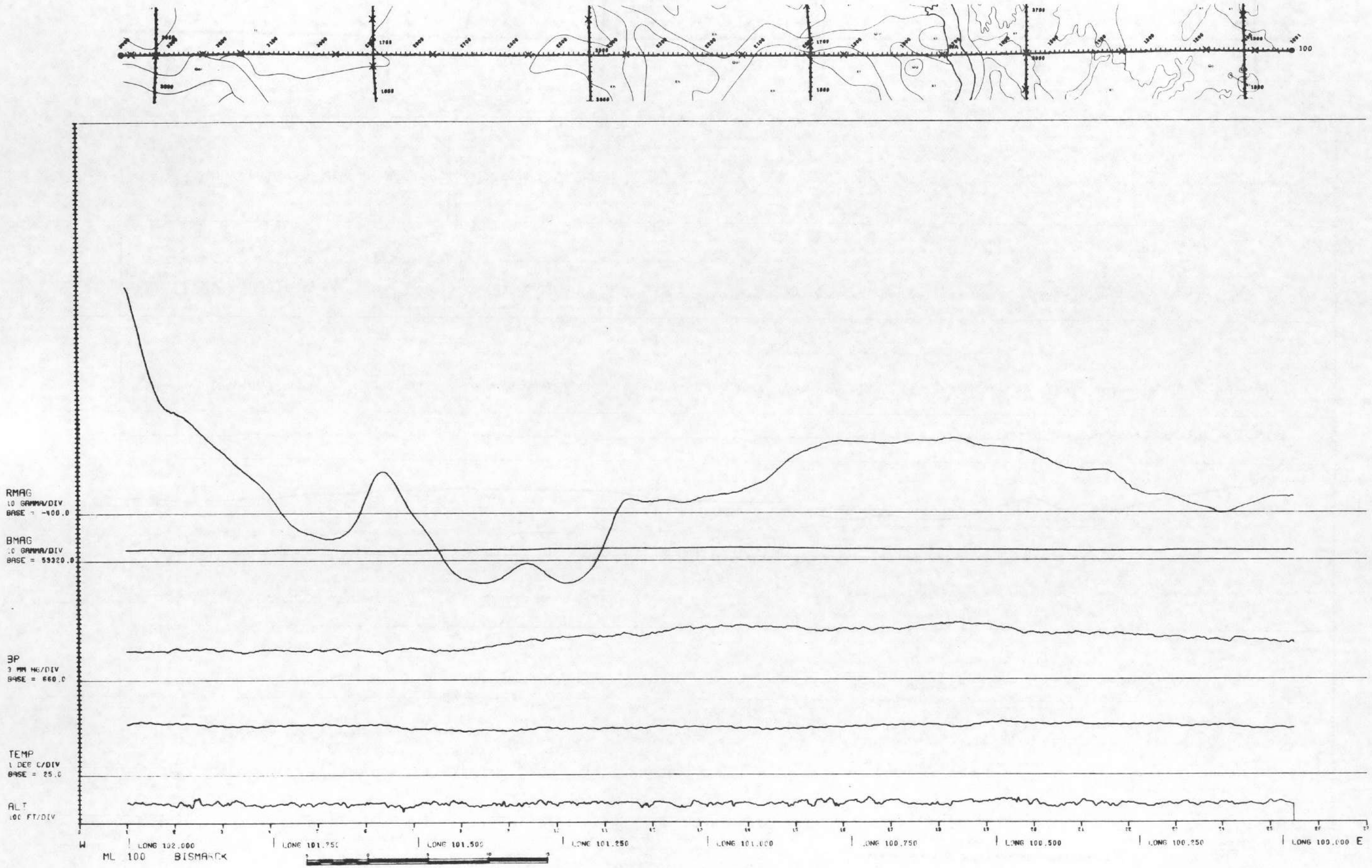
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ALT
100 FT/DIV
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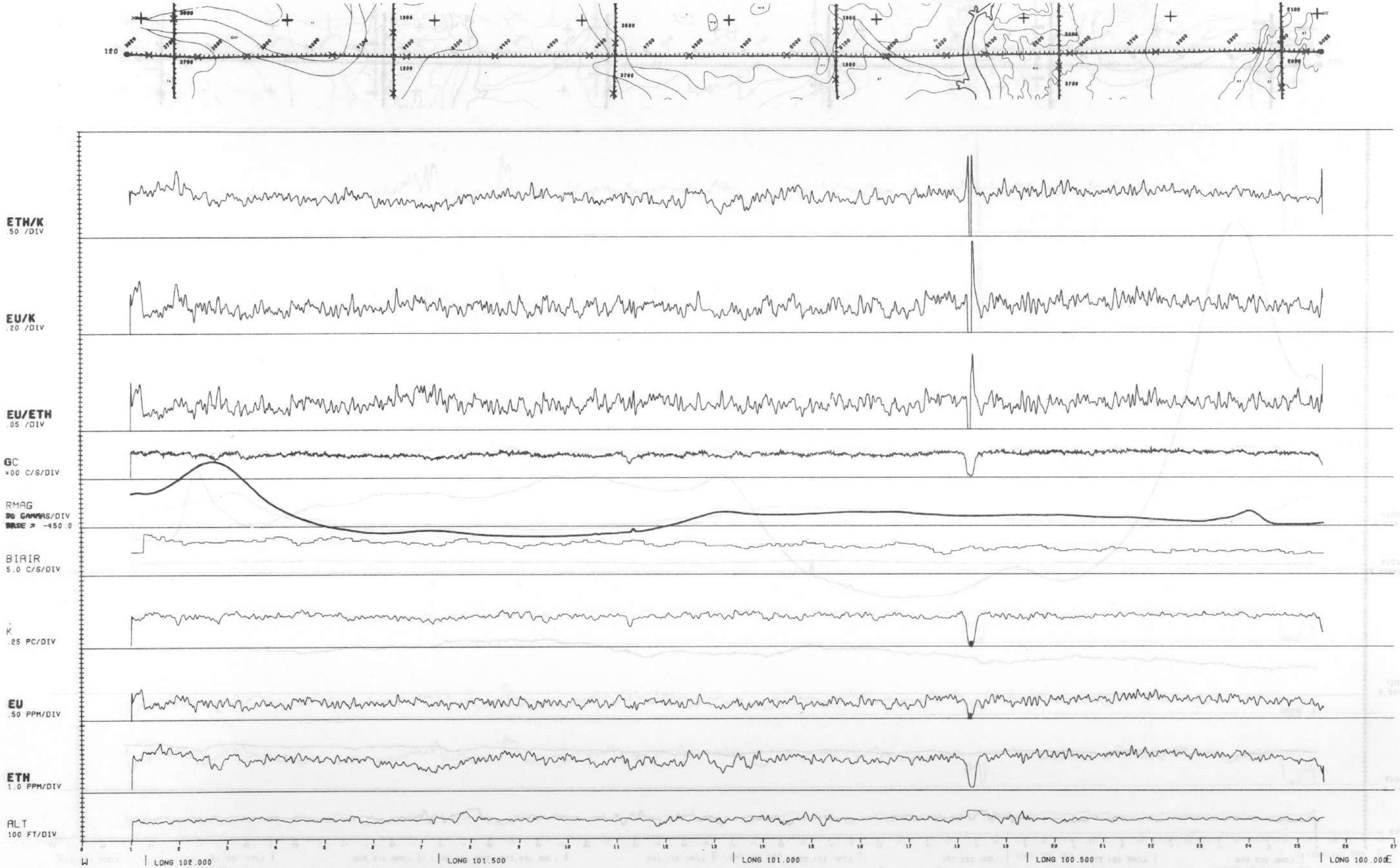

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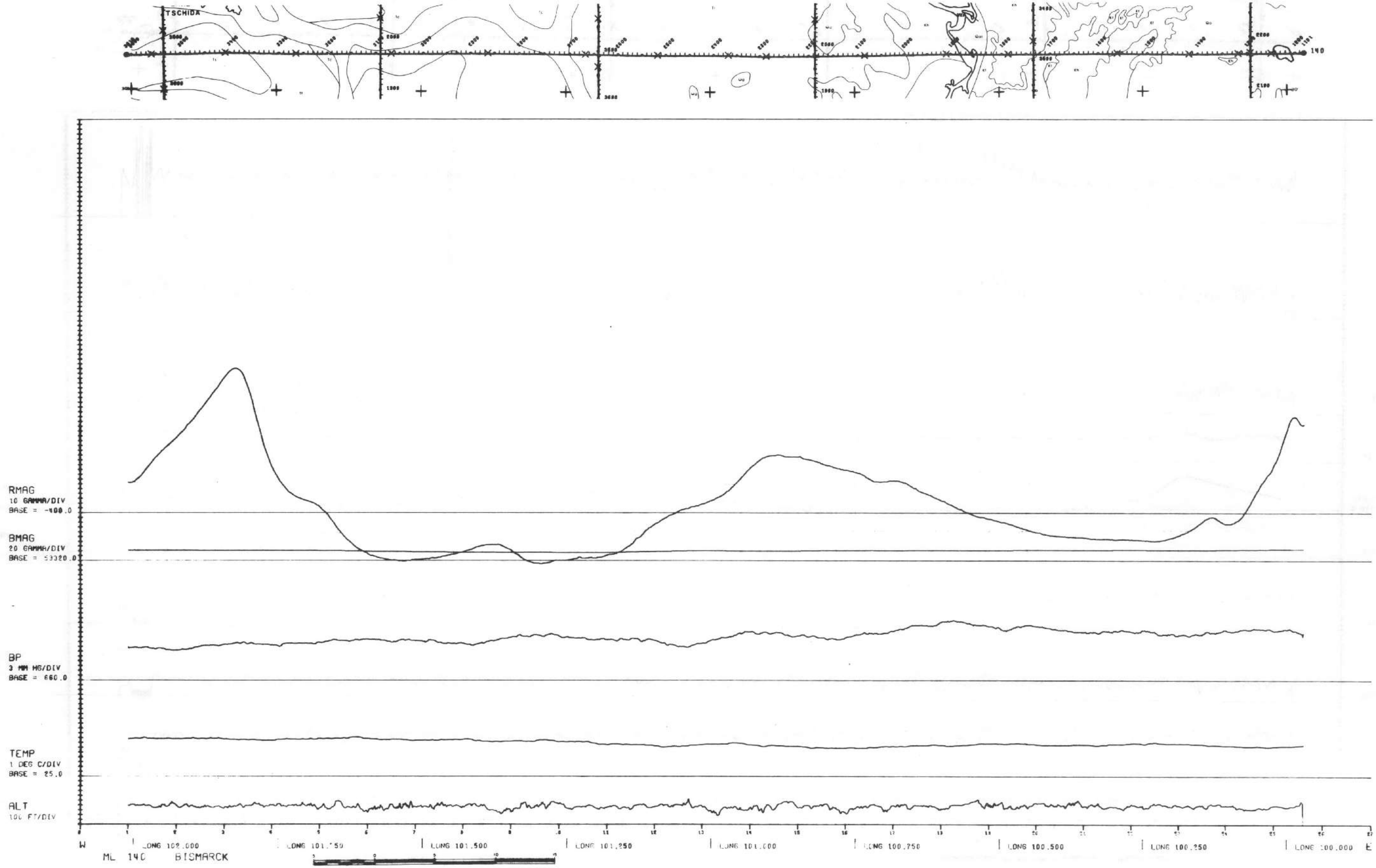
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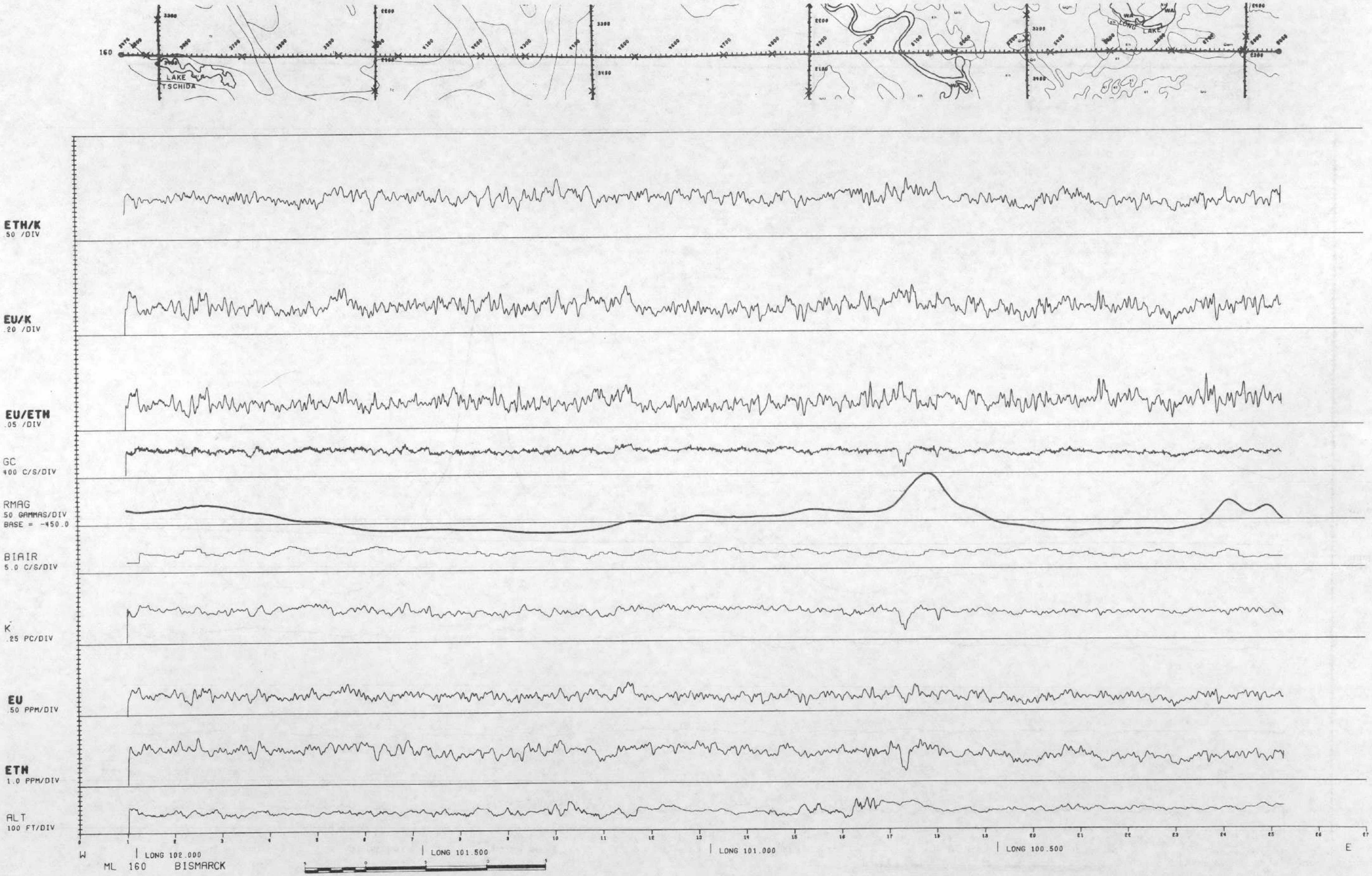
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BASE = -450.0
BIAIR
5.0 C/S/DIV
K
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EU
.50 PPM/DIV
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100 FT/DIV
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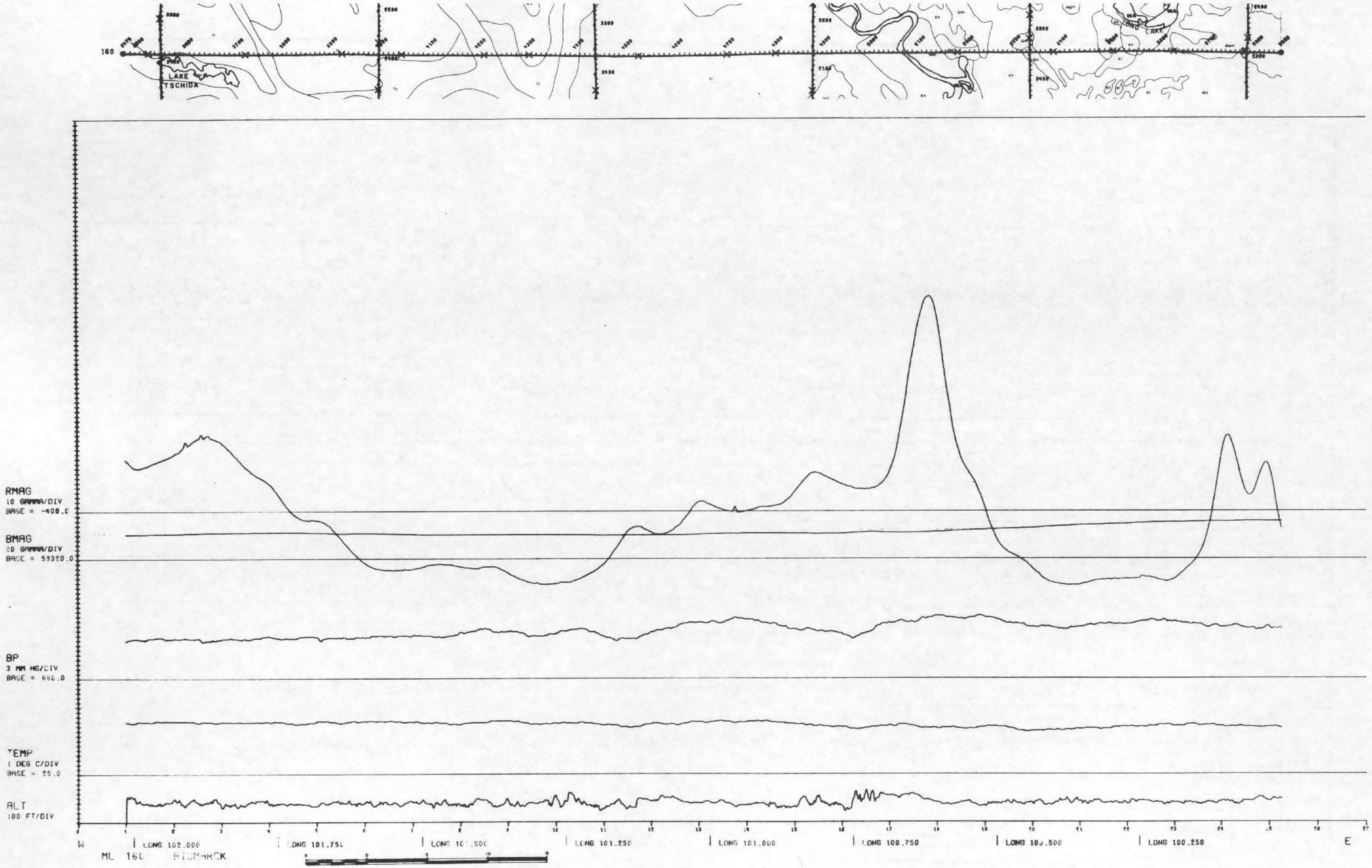
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TEMP
1 DEG C/DIV
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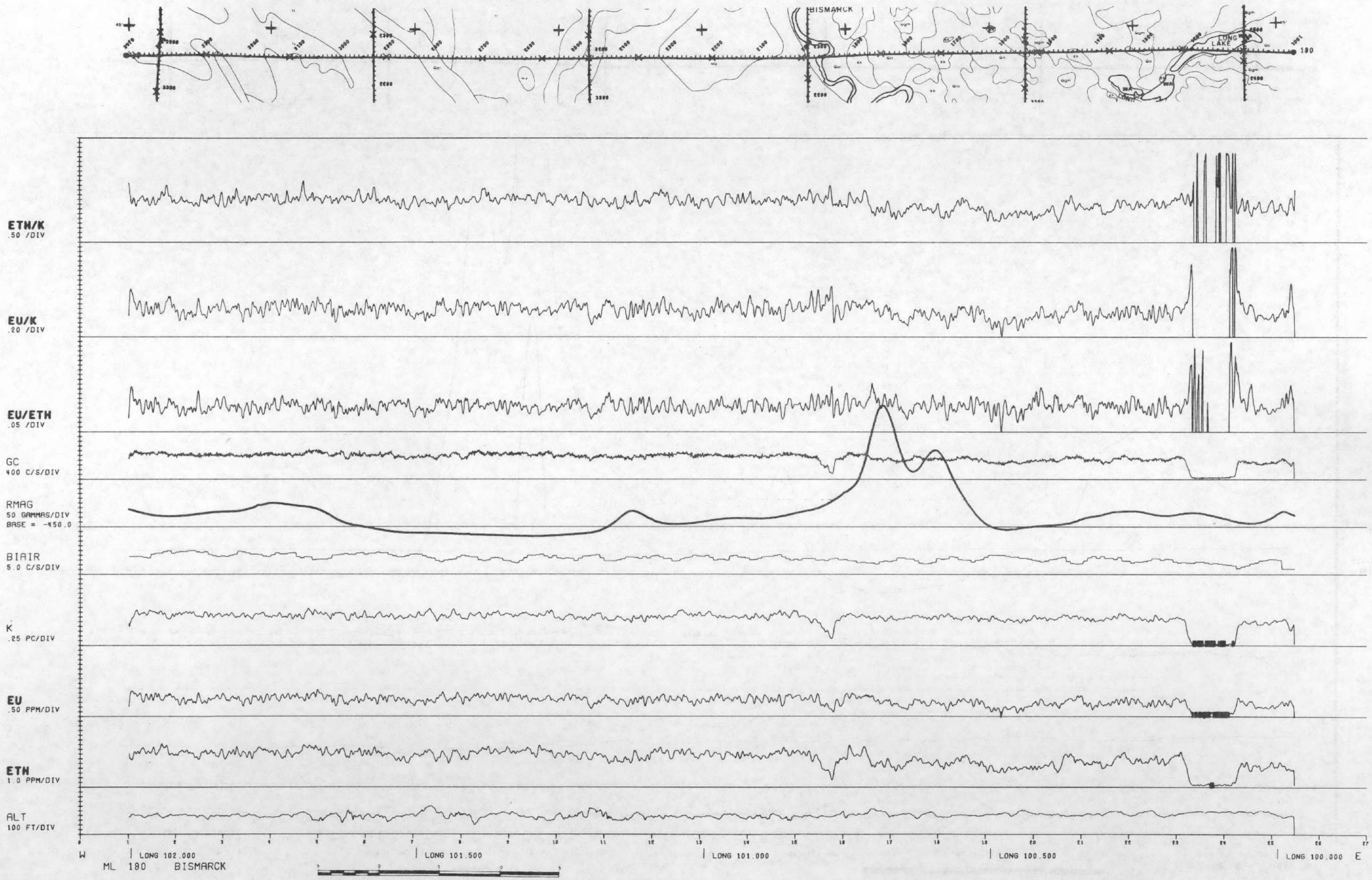
ML 160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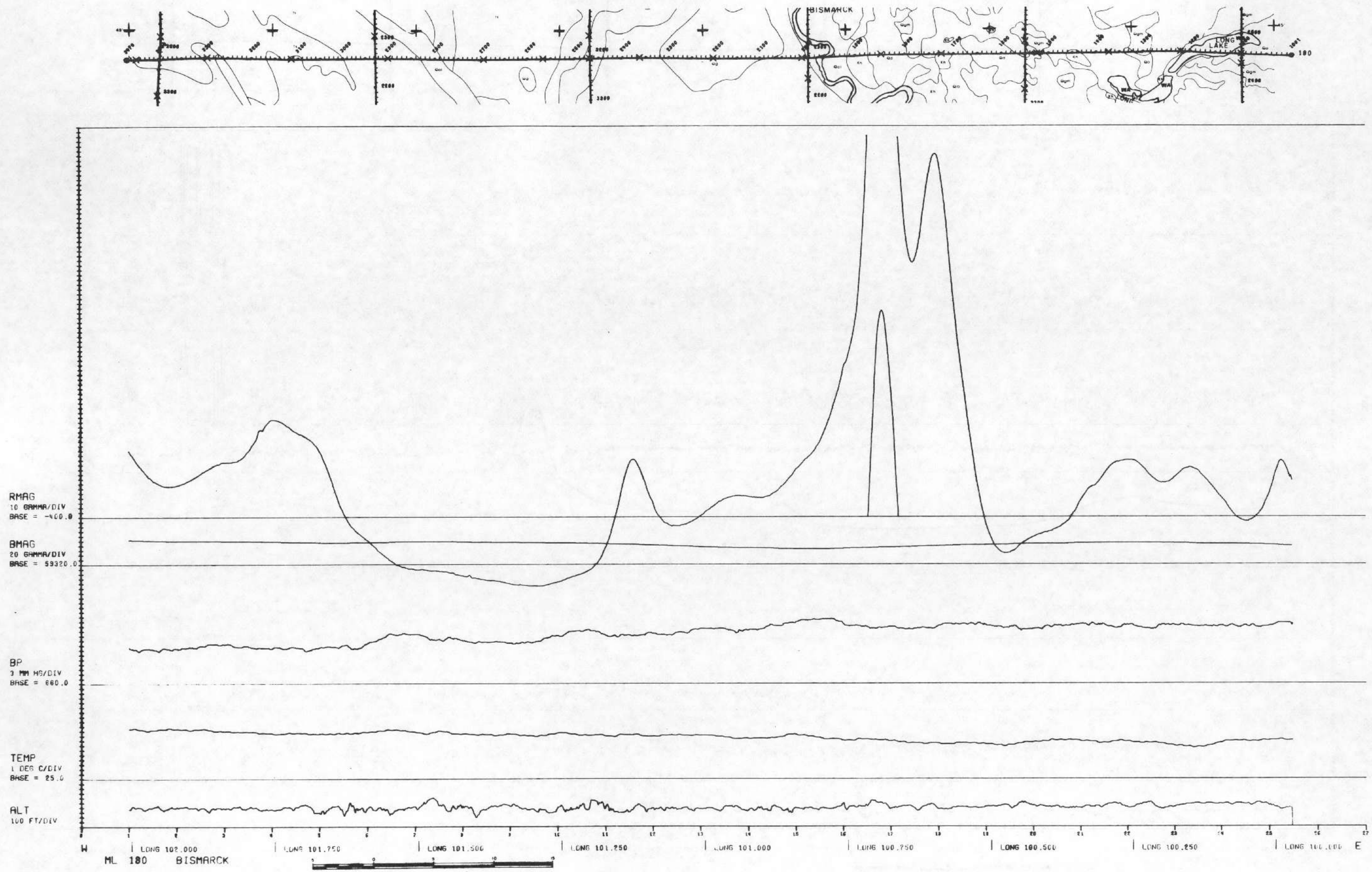
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TEMP
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ALT
100 FT/DIV
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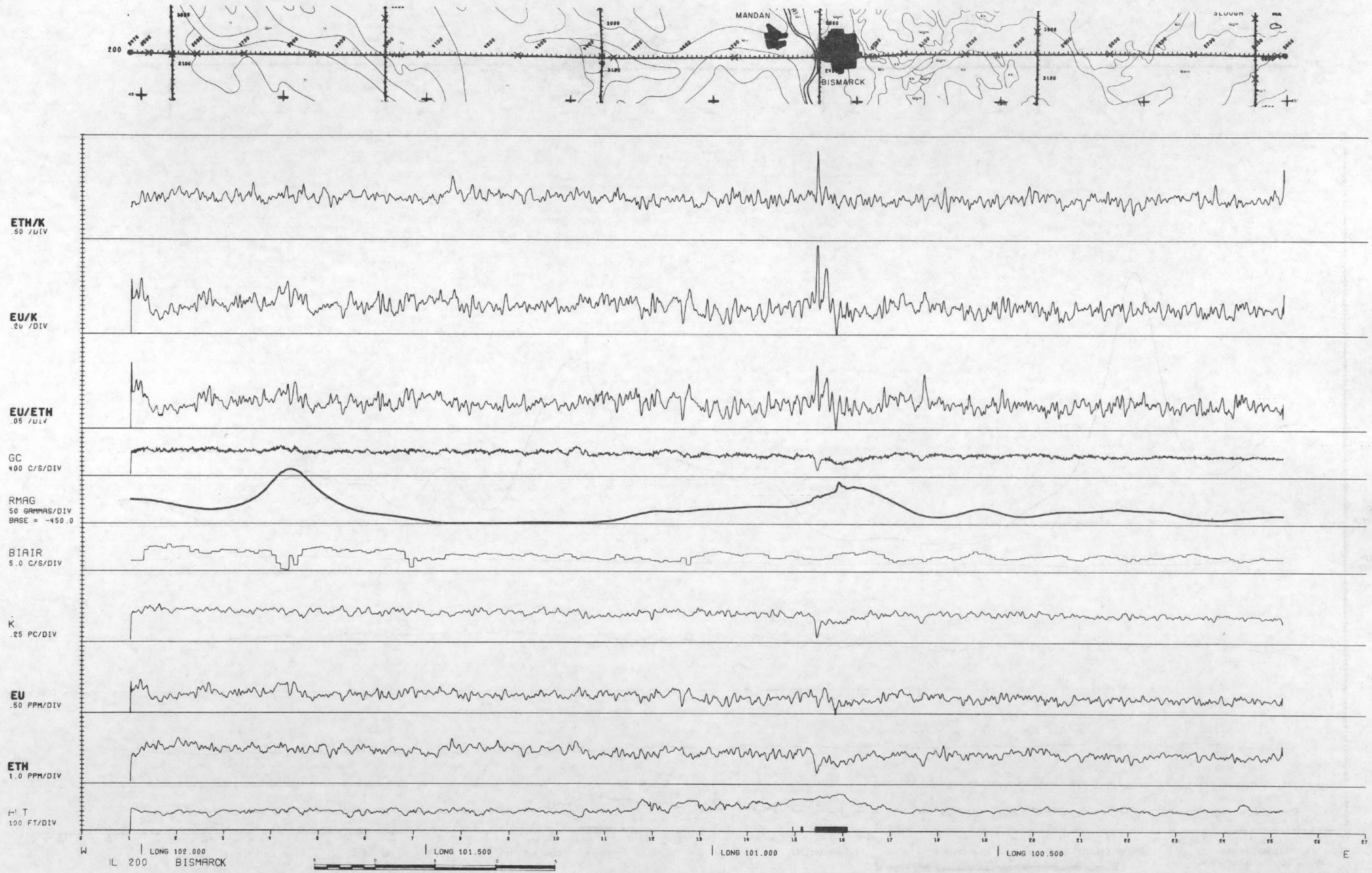

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BISMARCK
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EU/K
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RMAG
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BASE = -450.0
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K
.25 PC/DIV
EU
.50 PPM/DIV
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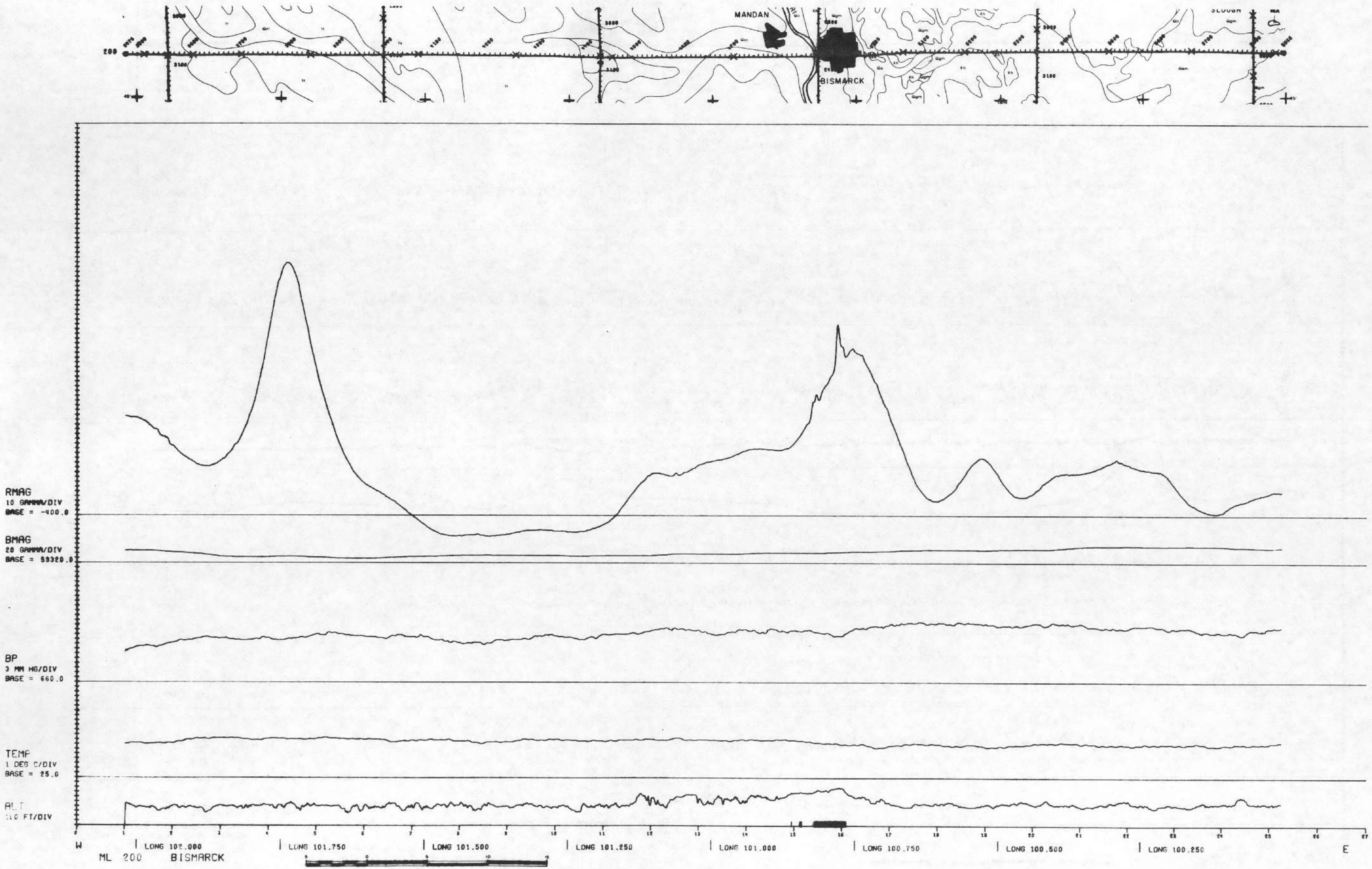
E
IL 200 BISMARCK



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TEMP
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BASE = 25.0
ALT
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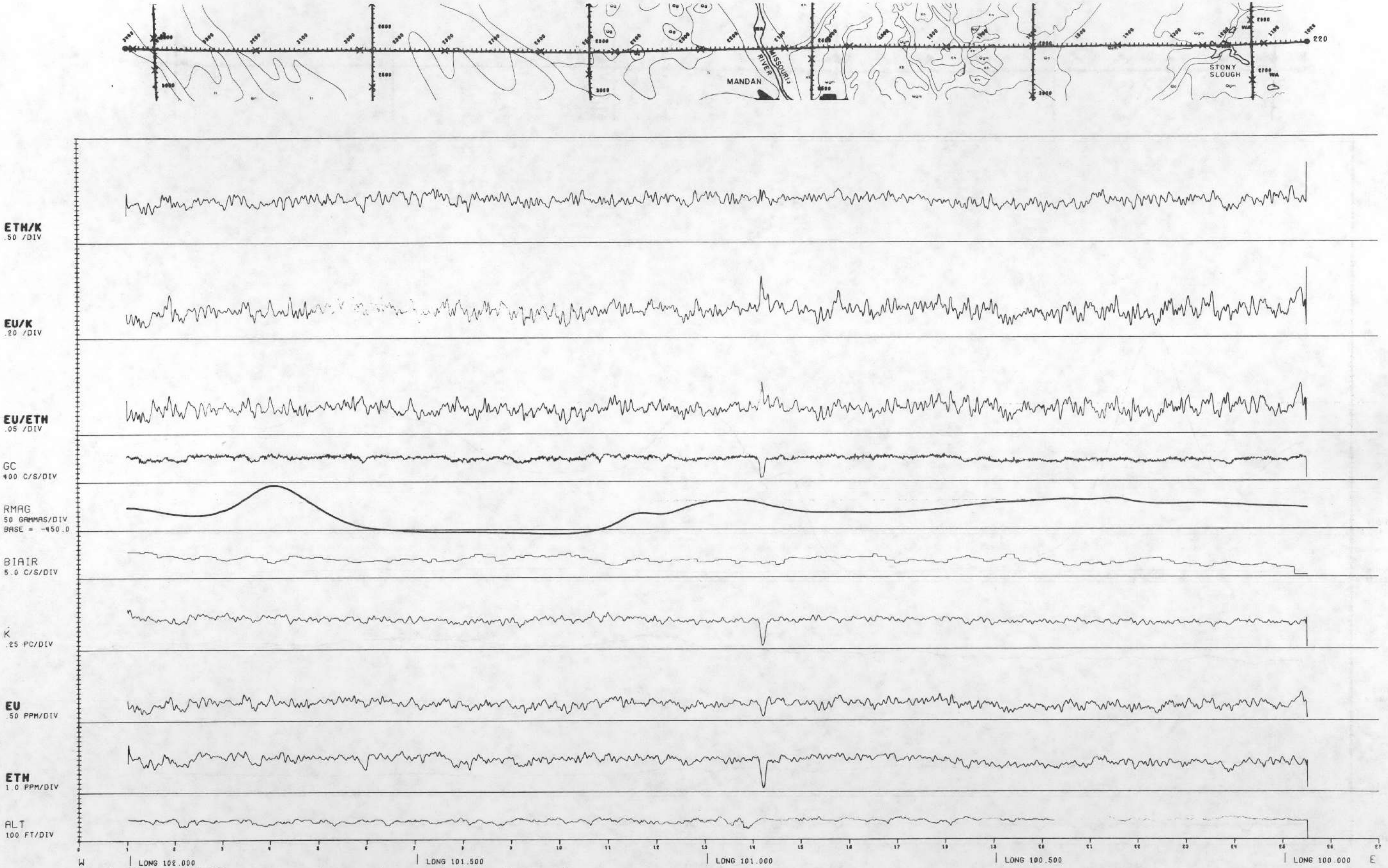
E
ML 200 BISMARCK



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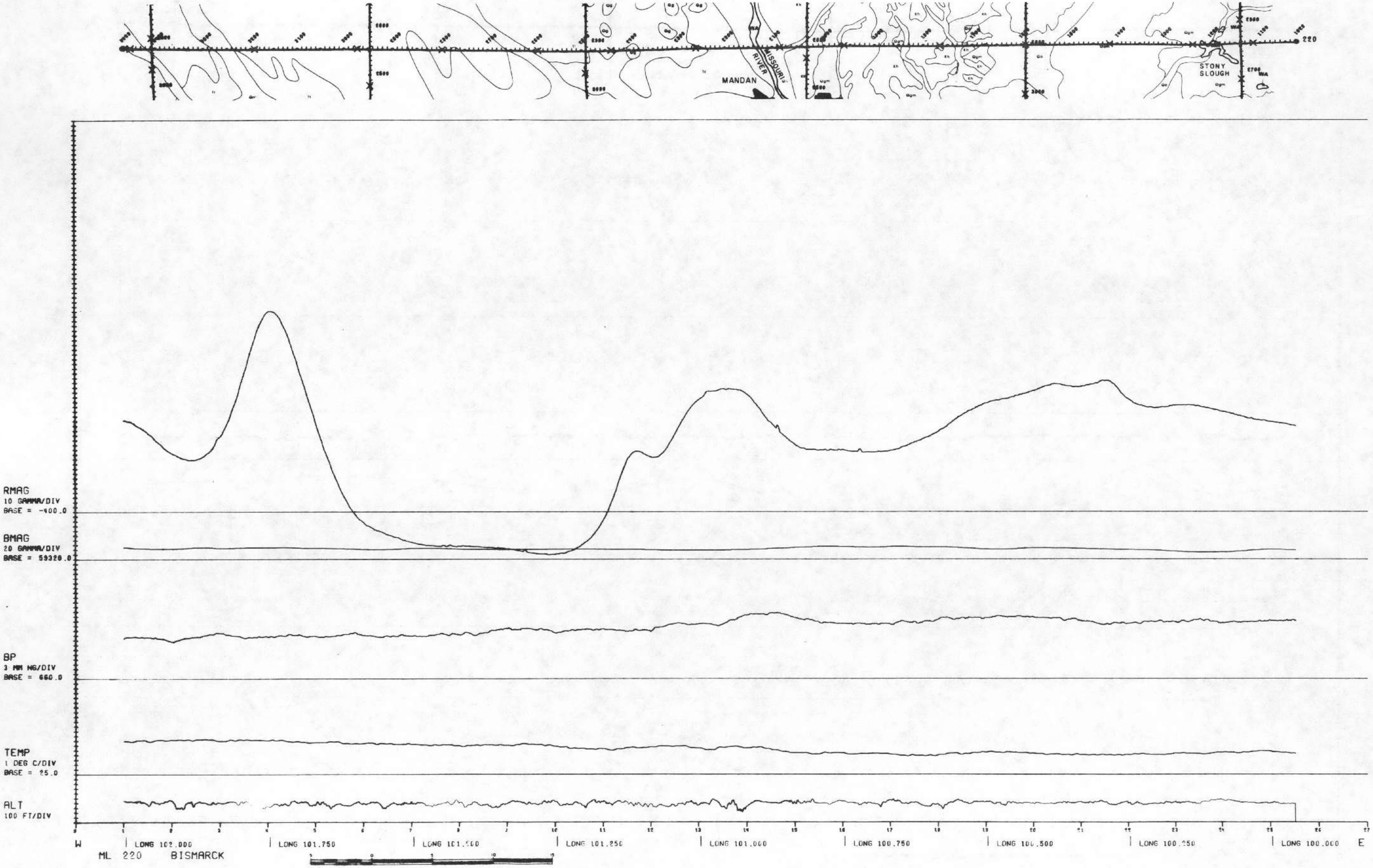
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RIVER
STONY
SLOUGH
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TEMP
1 DEG C/DIV
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ALT
100 FT/DIV
W
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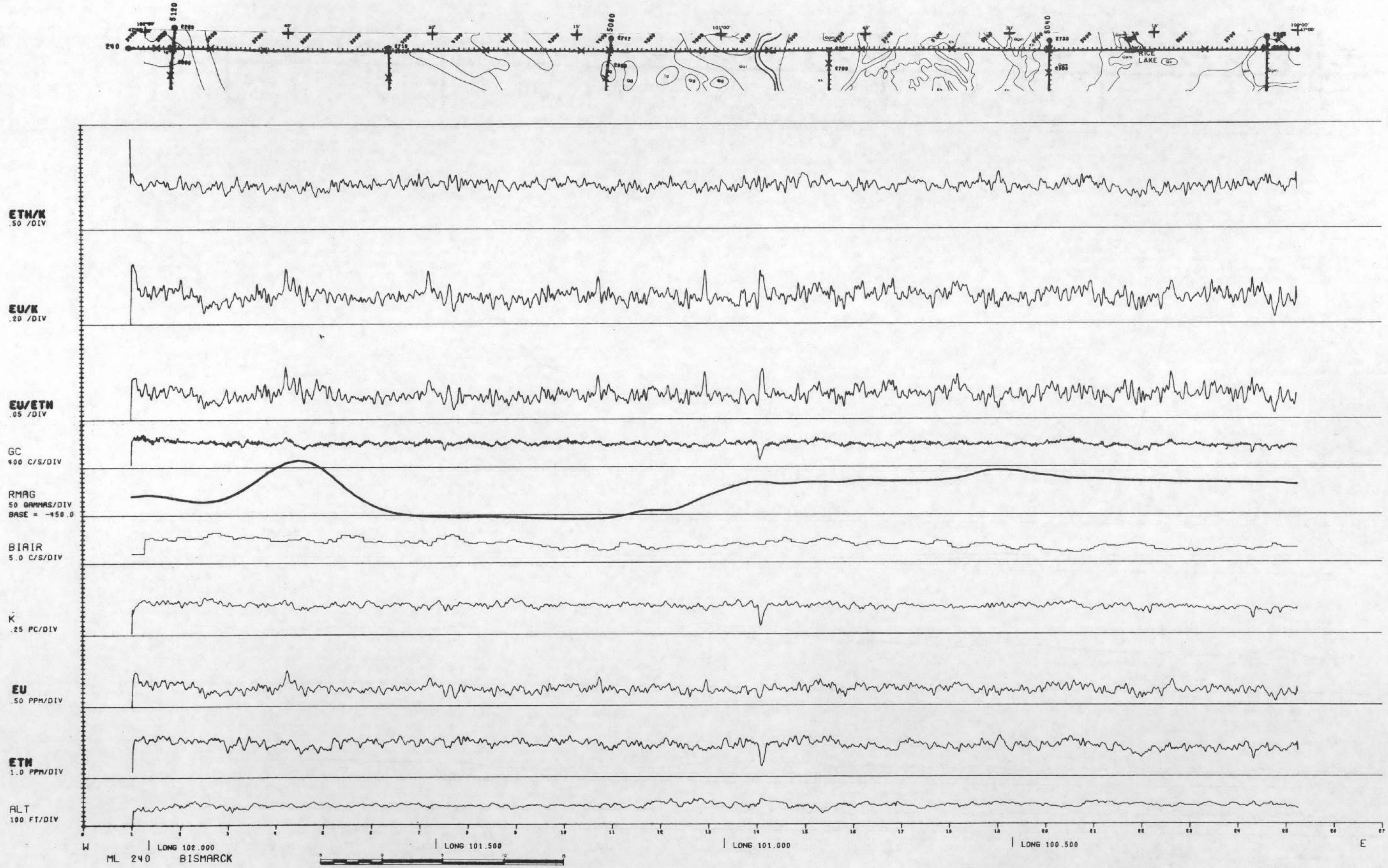

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E
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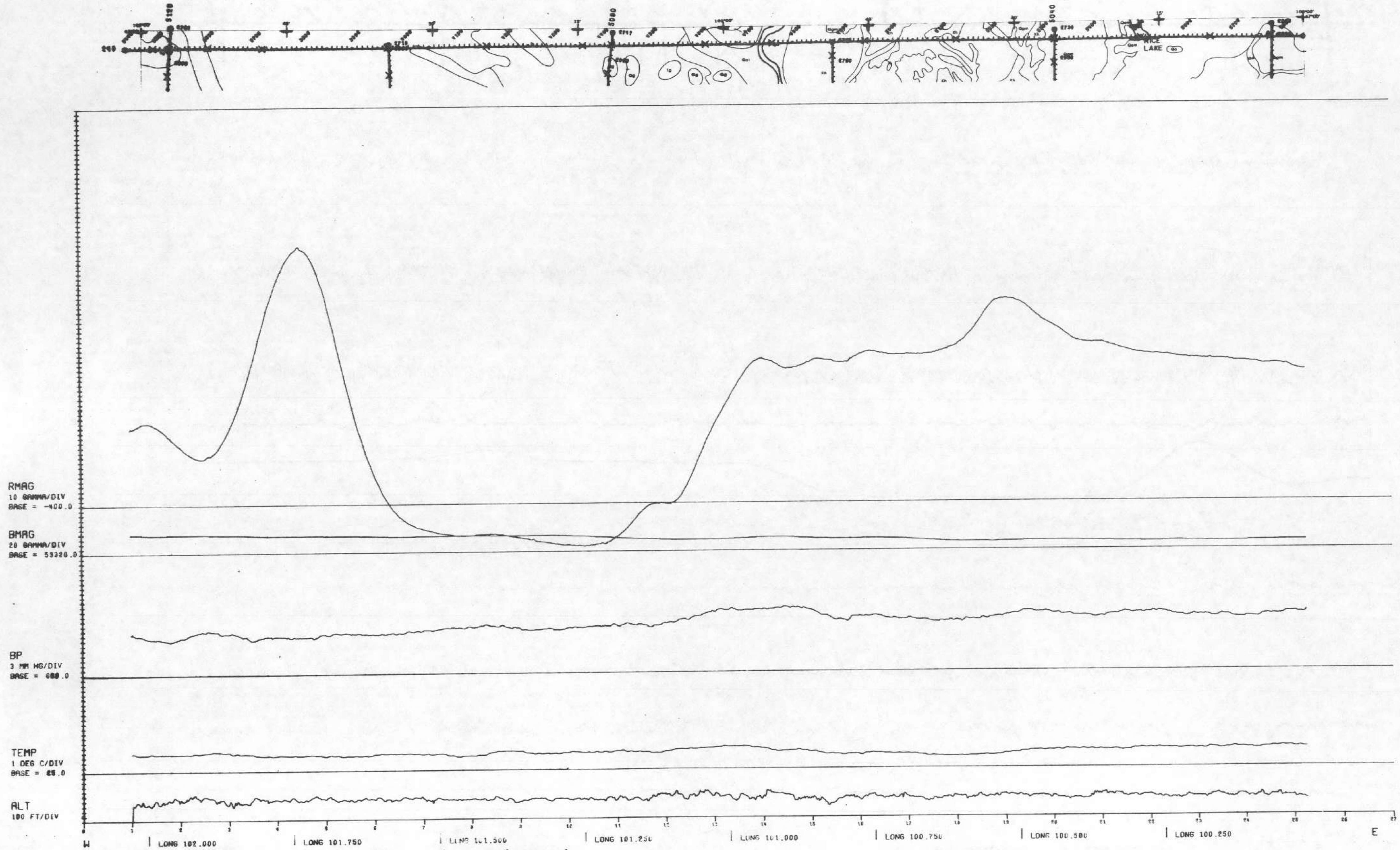

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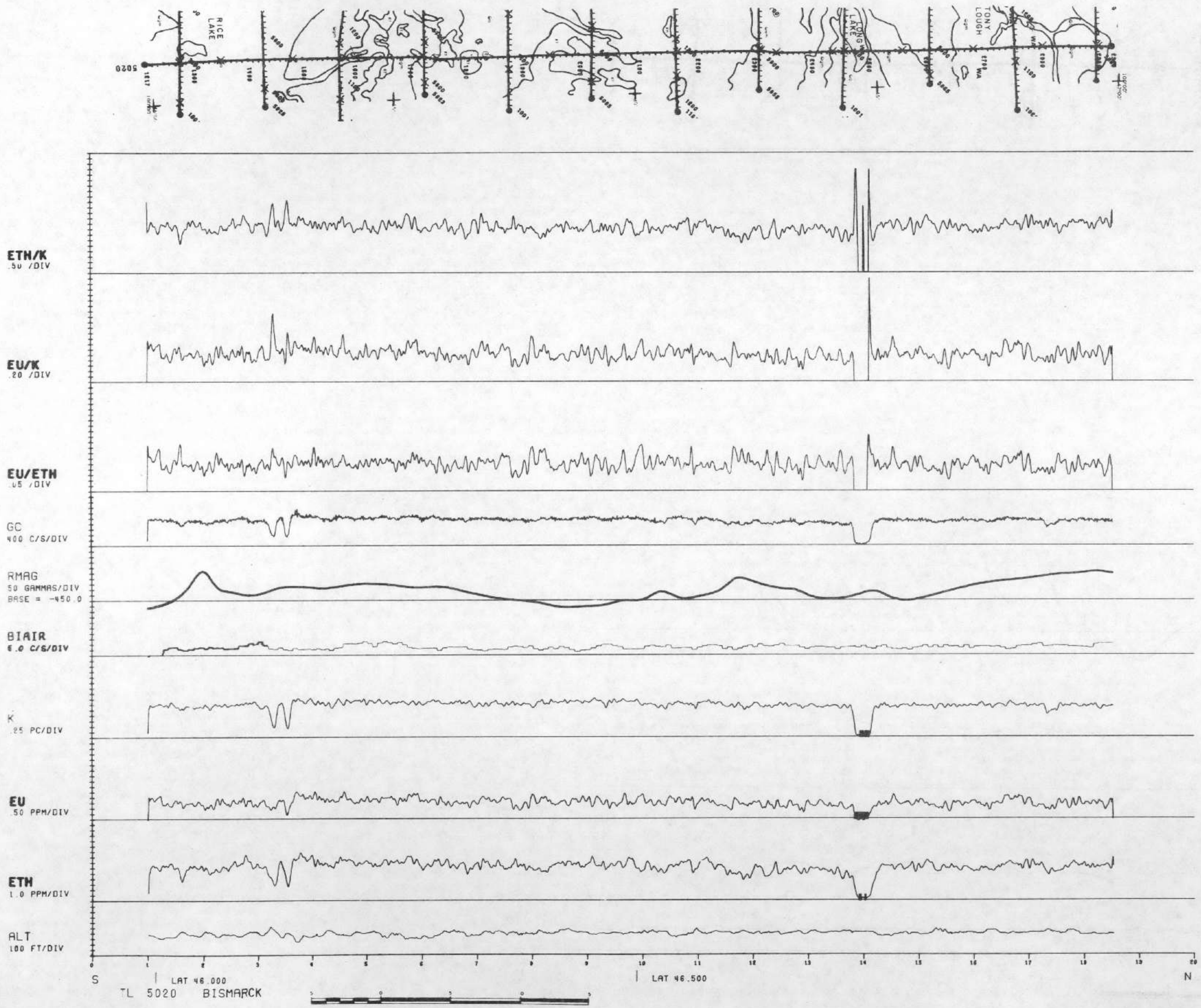

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RMAG
50 GAMMAS/DIV
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BIAIR
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K
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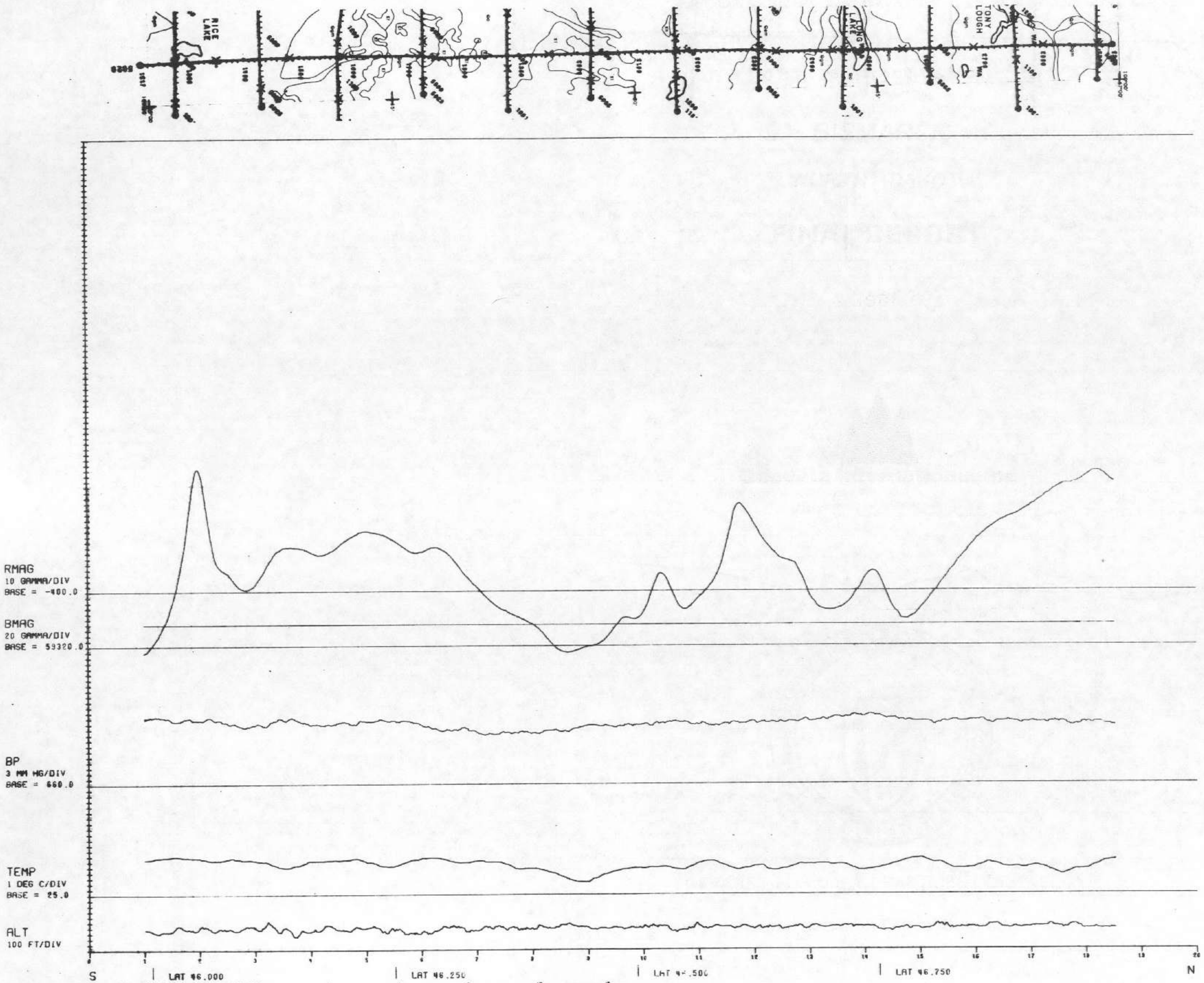

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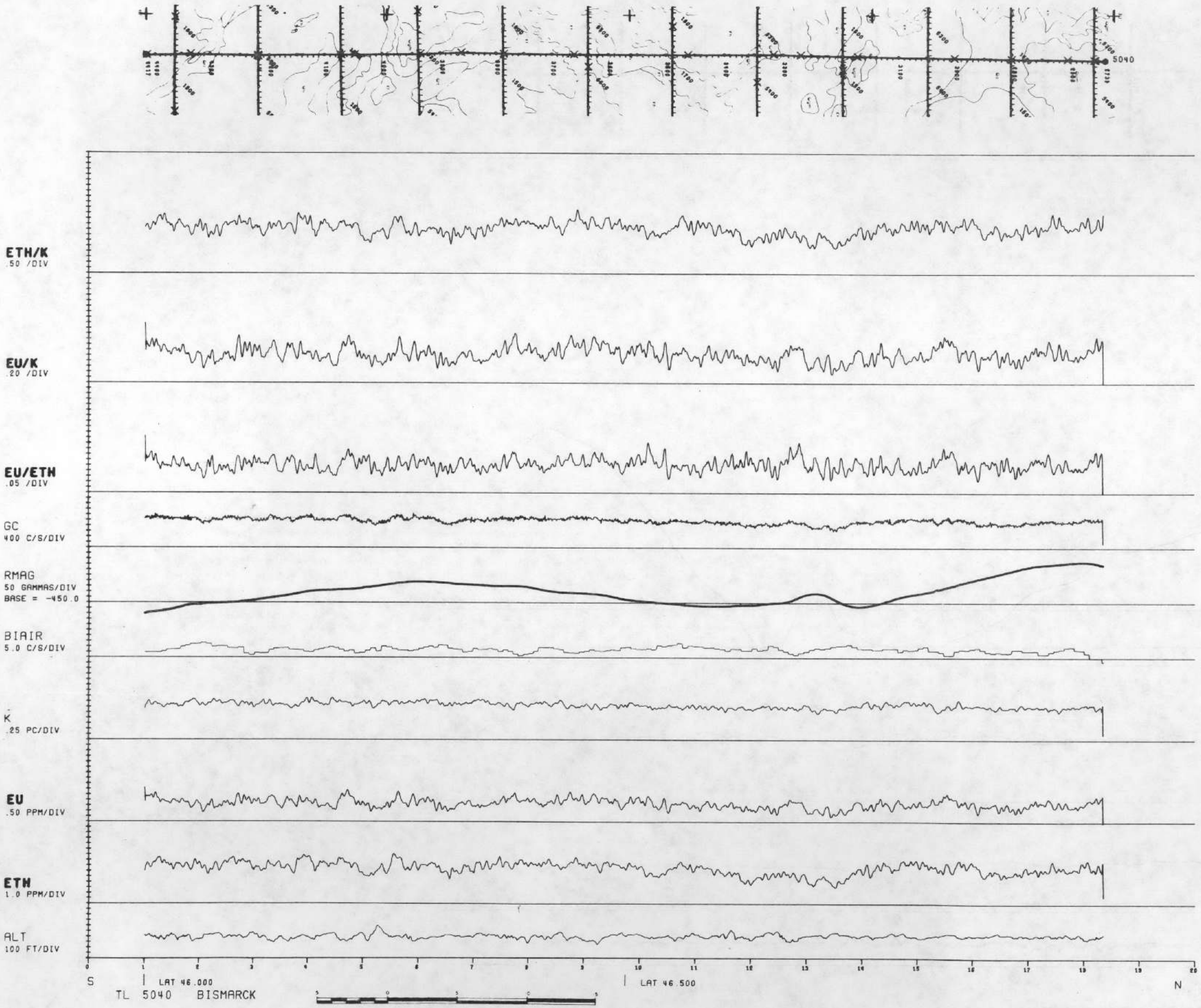

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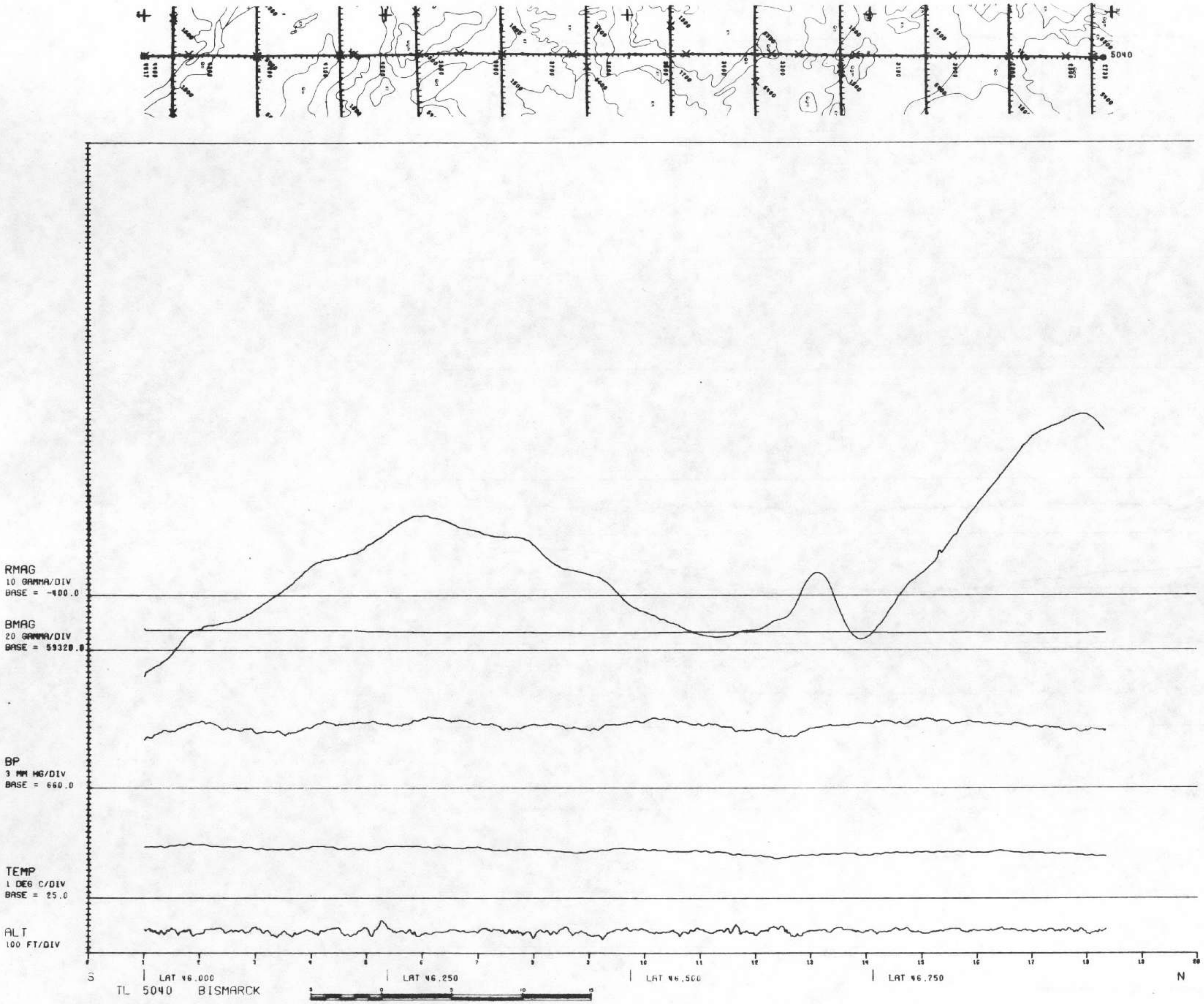
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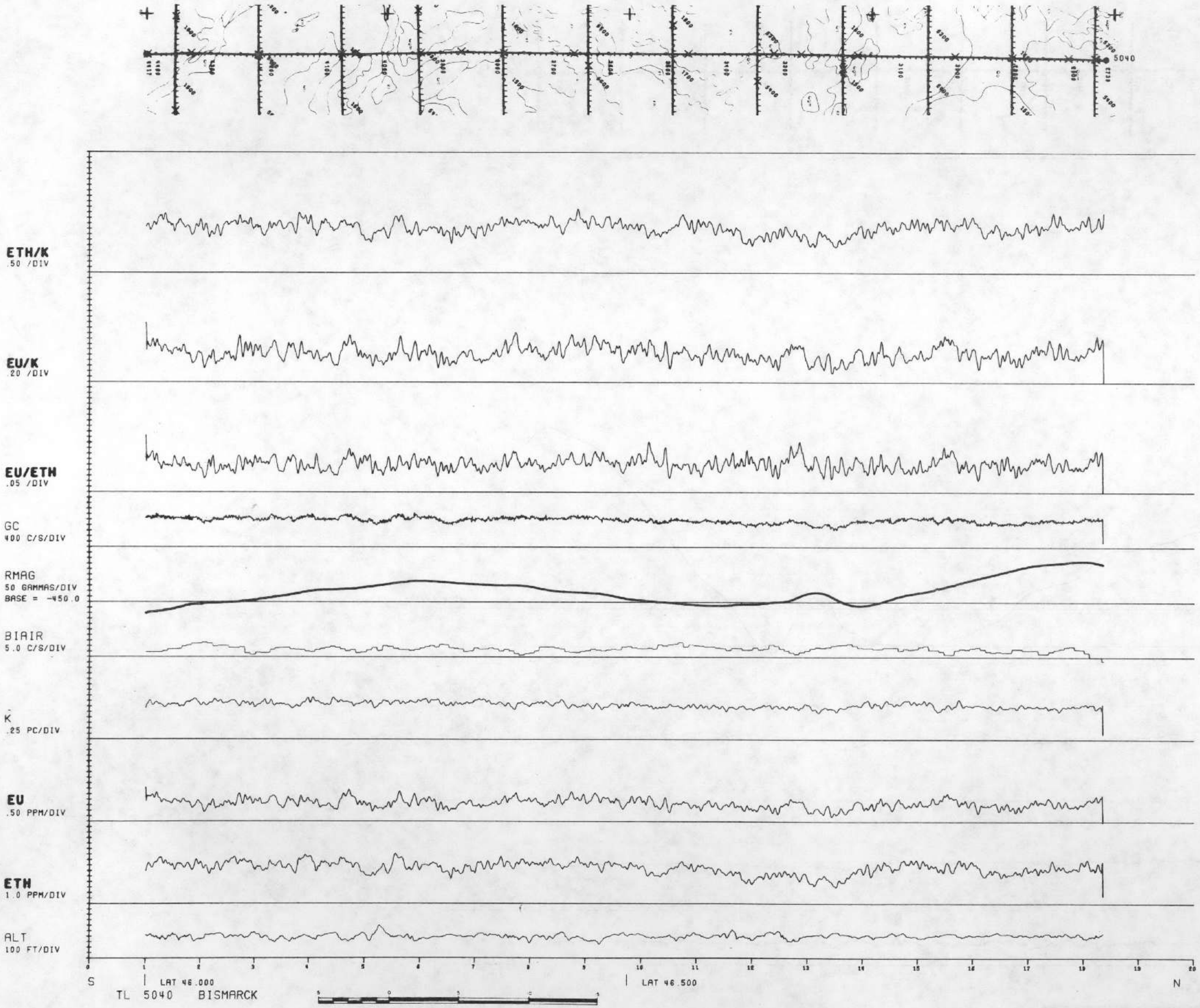
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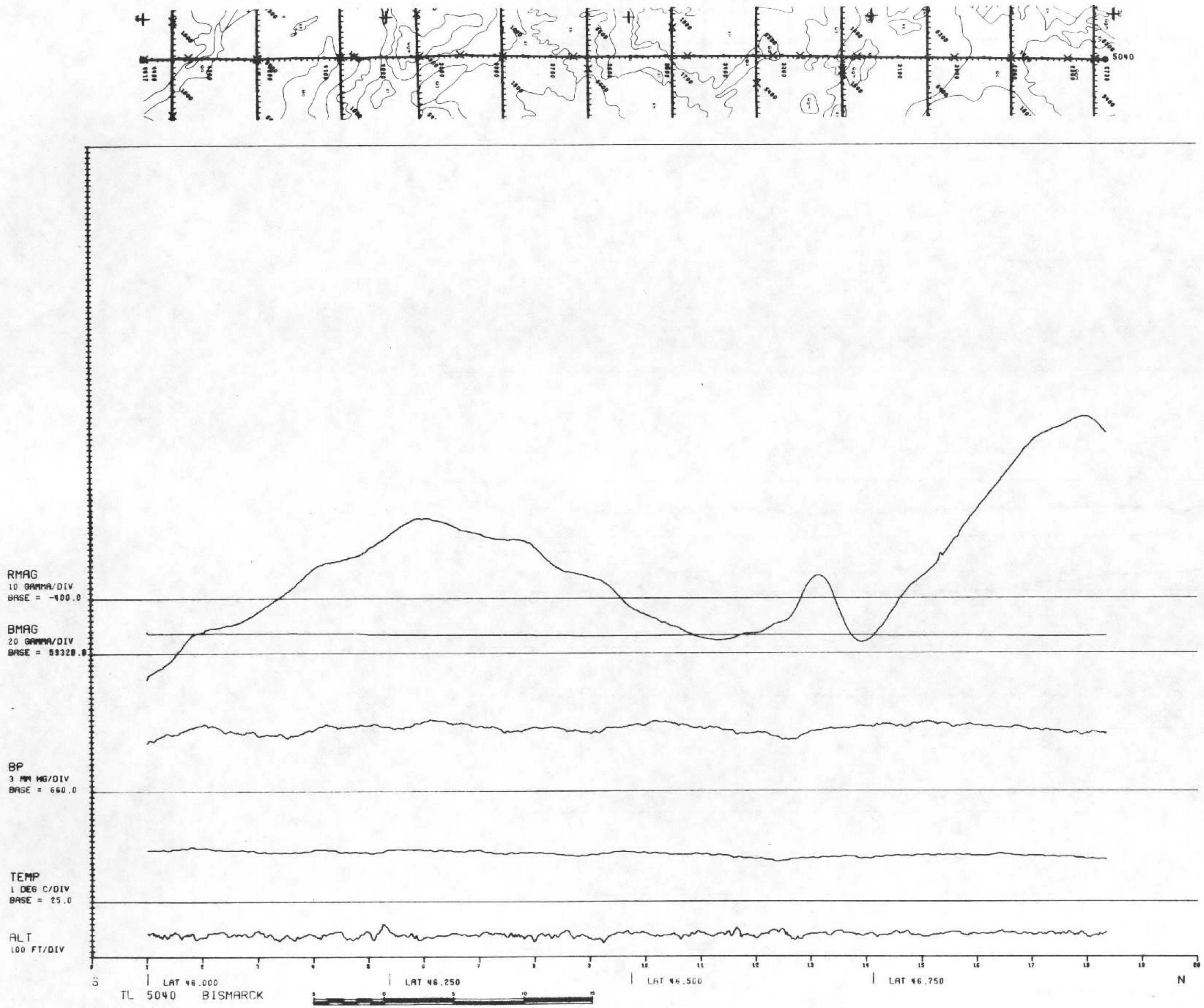

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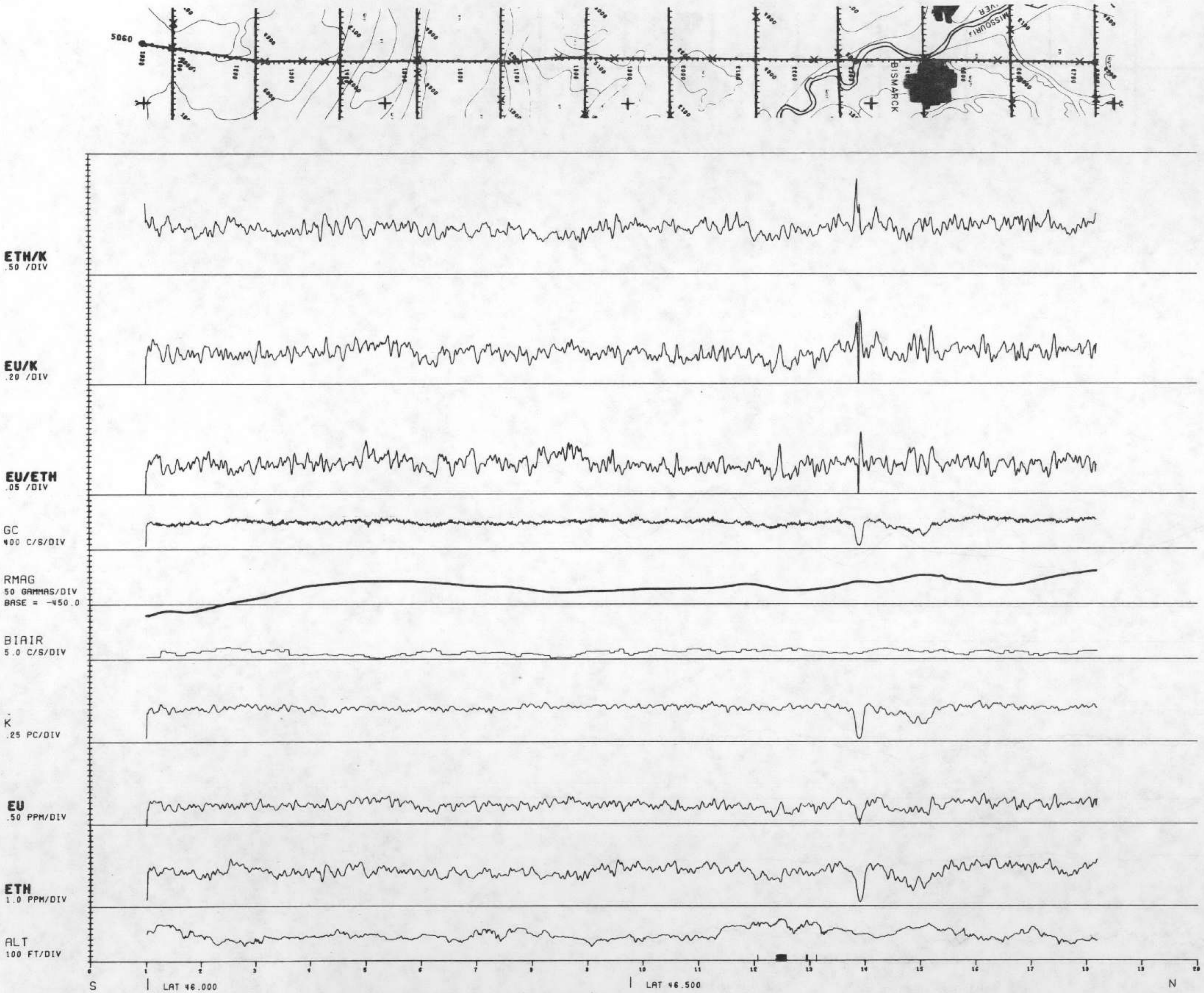

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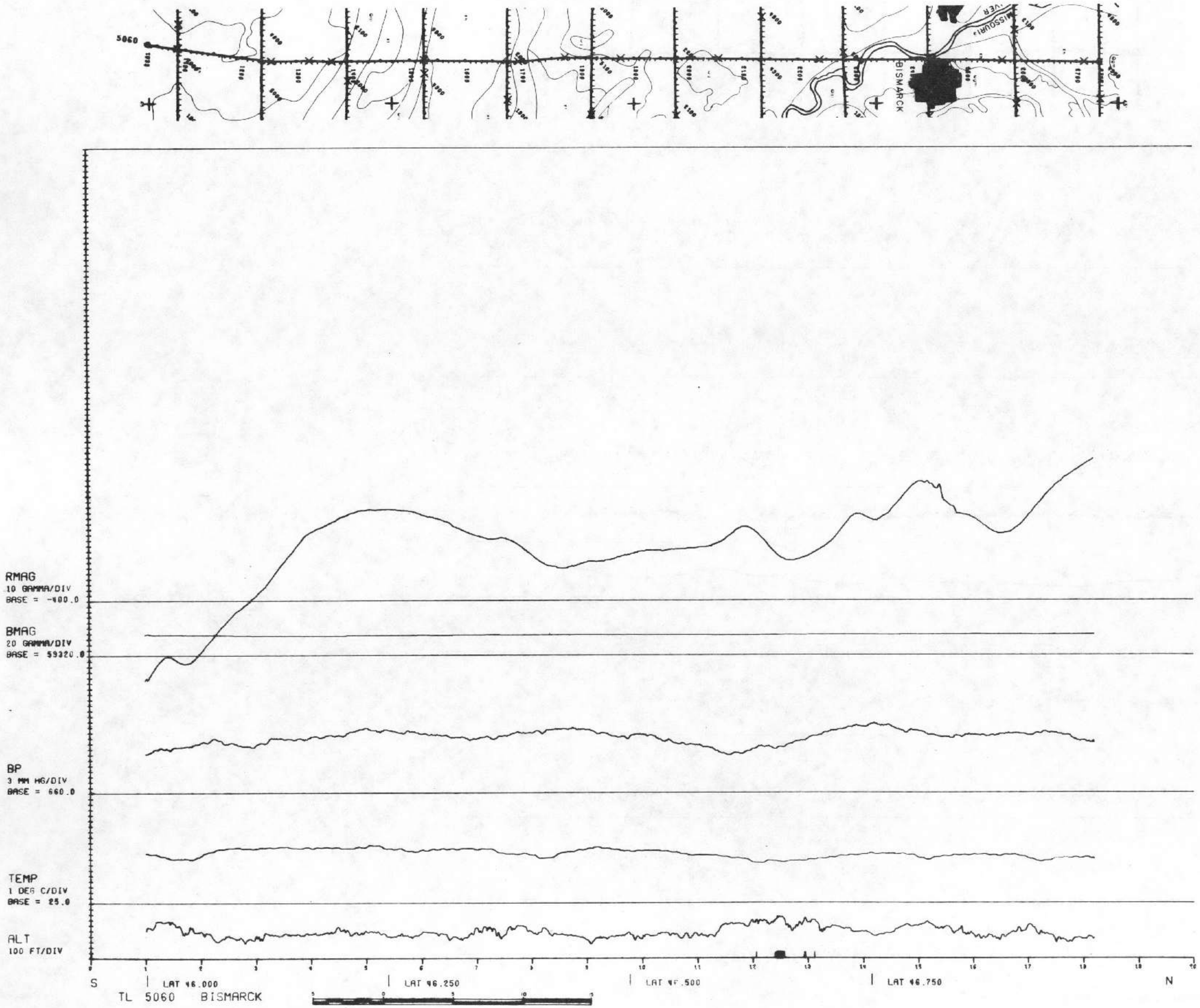
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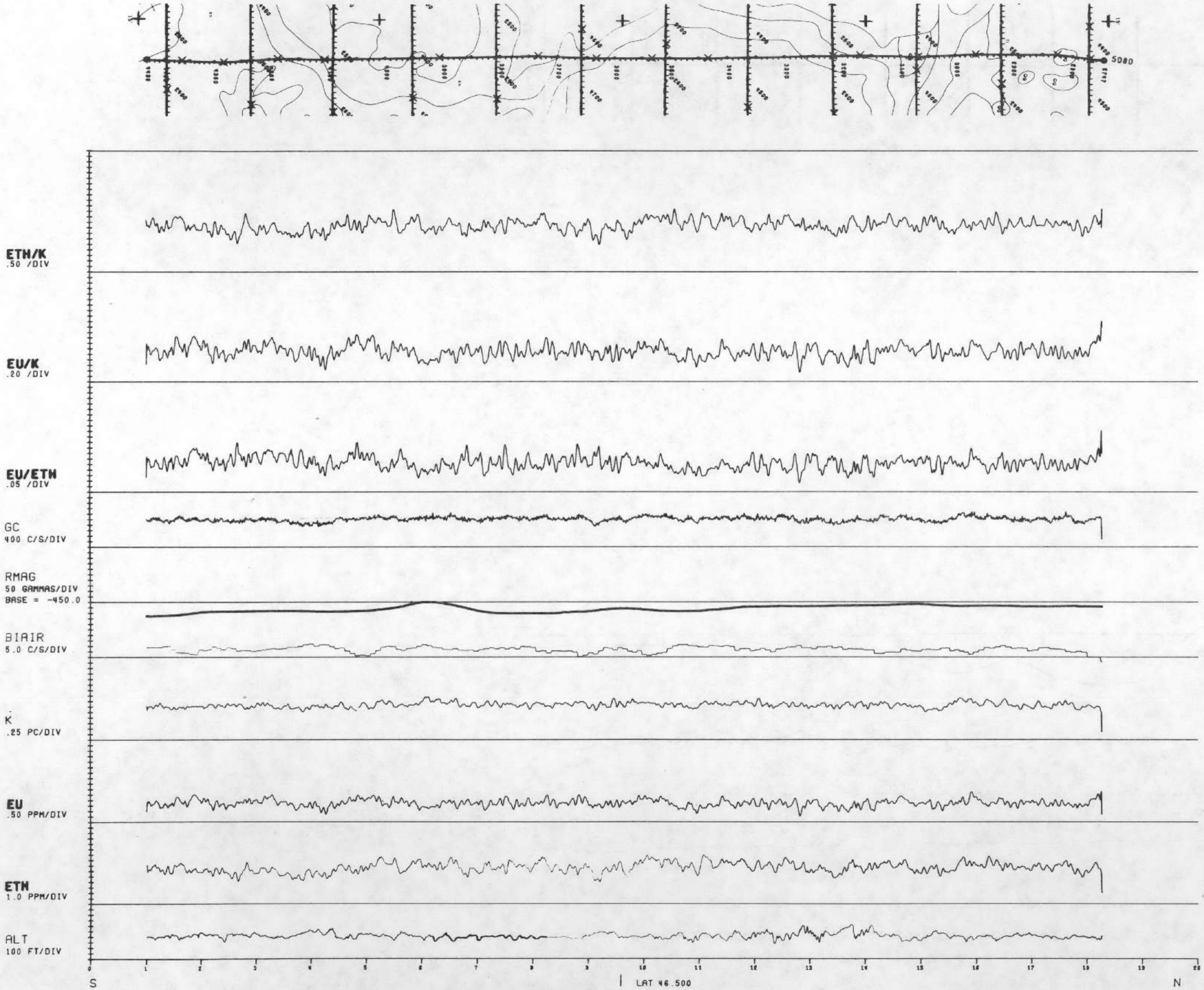

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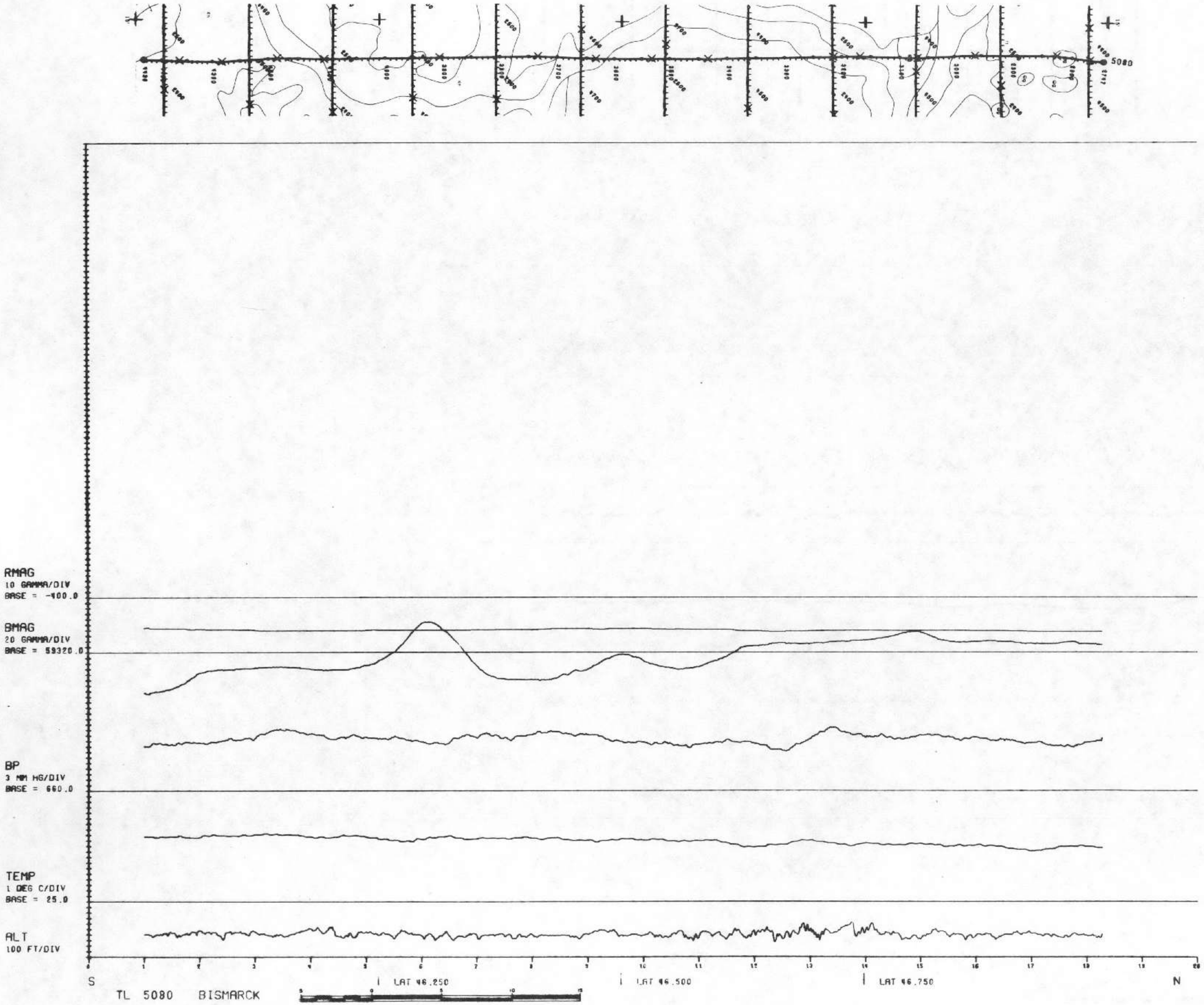
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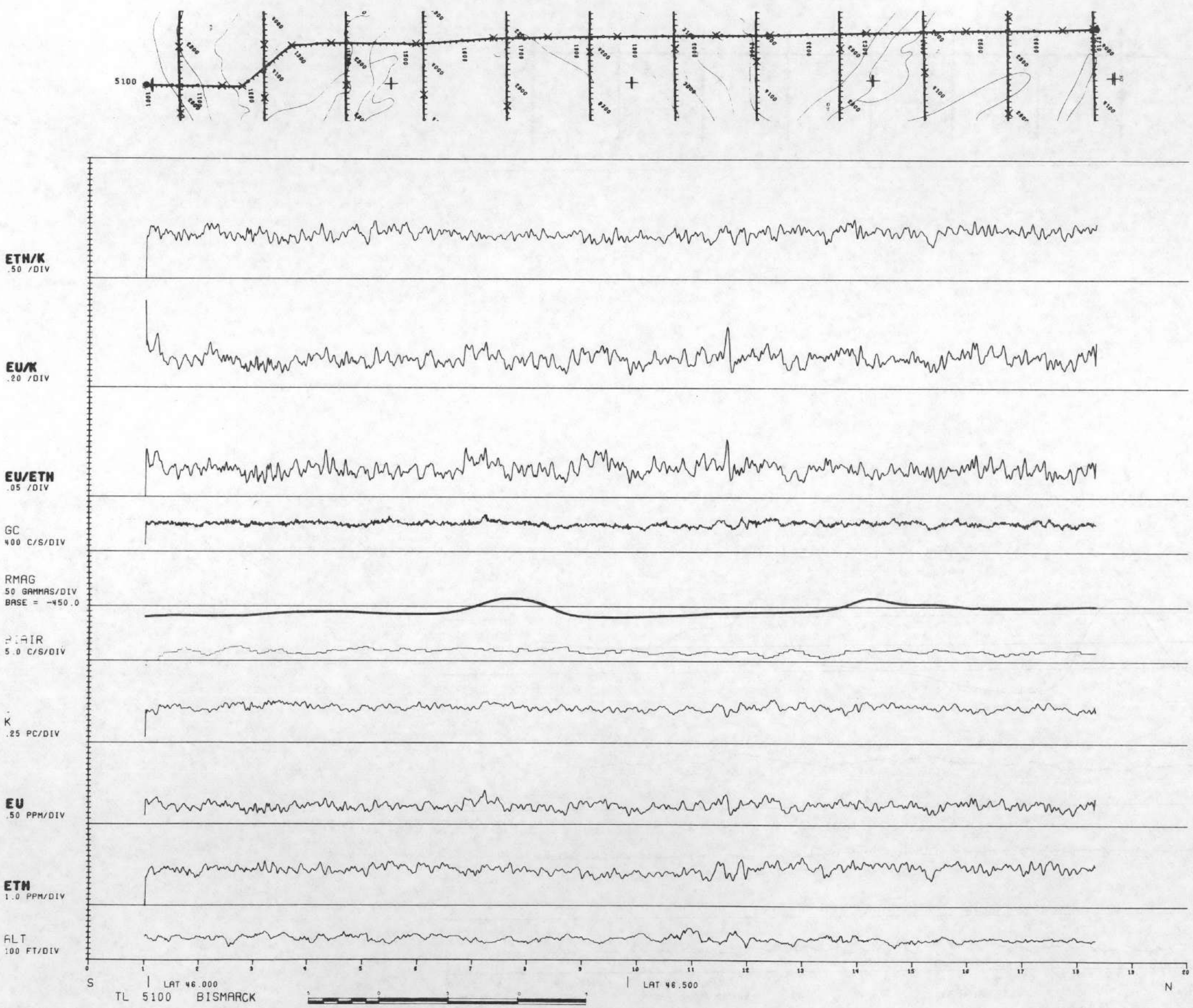

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K
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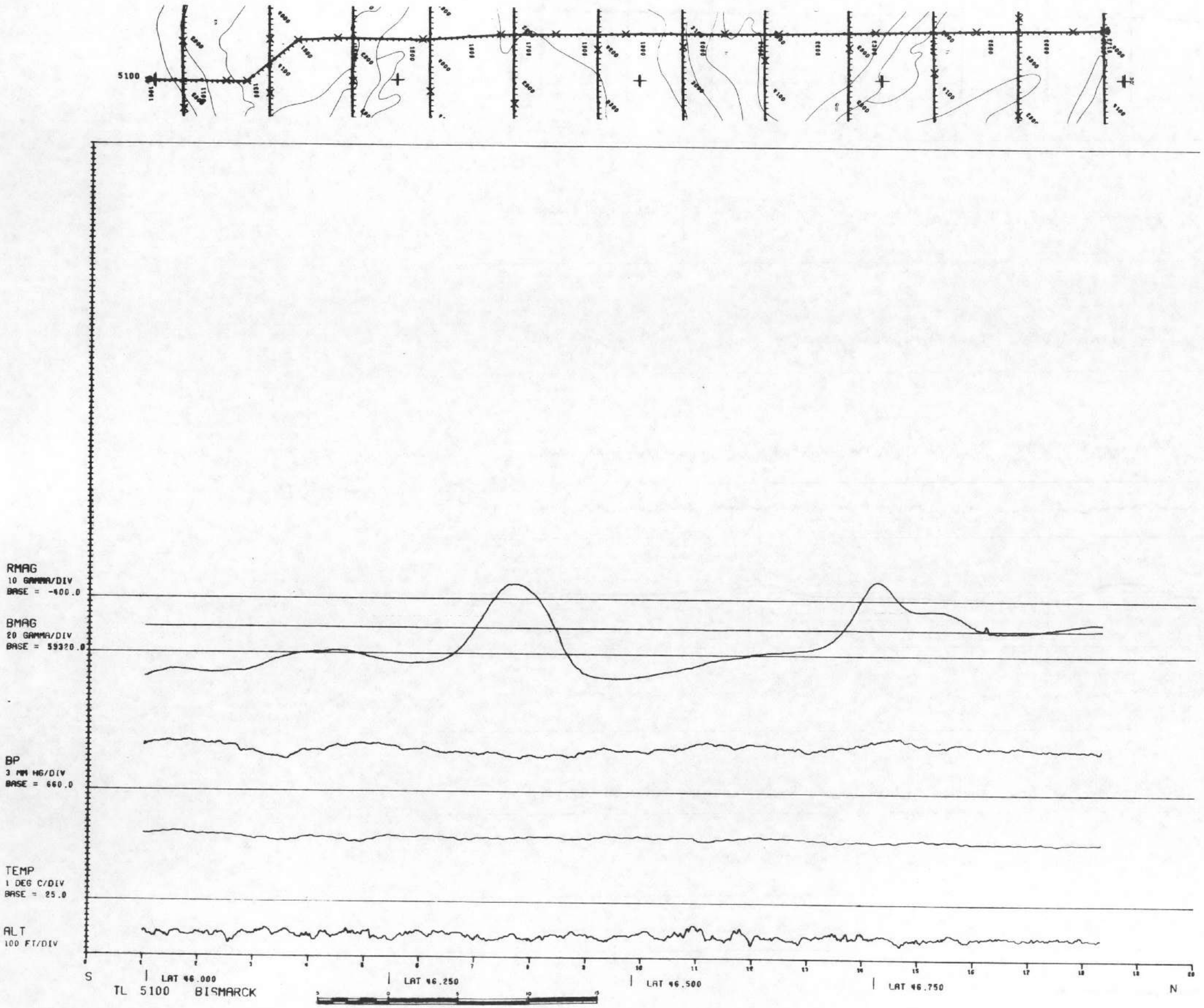
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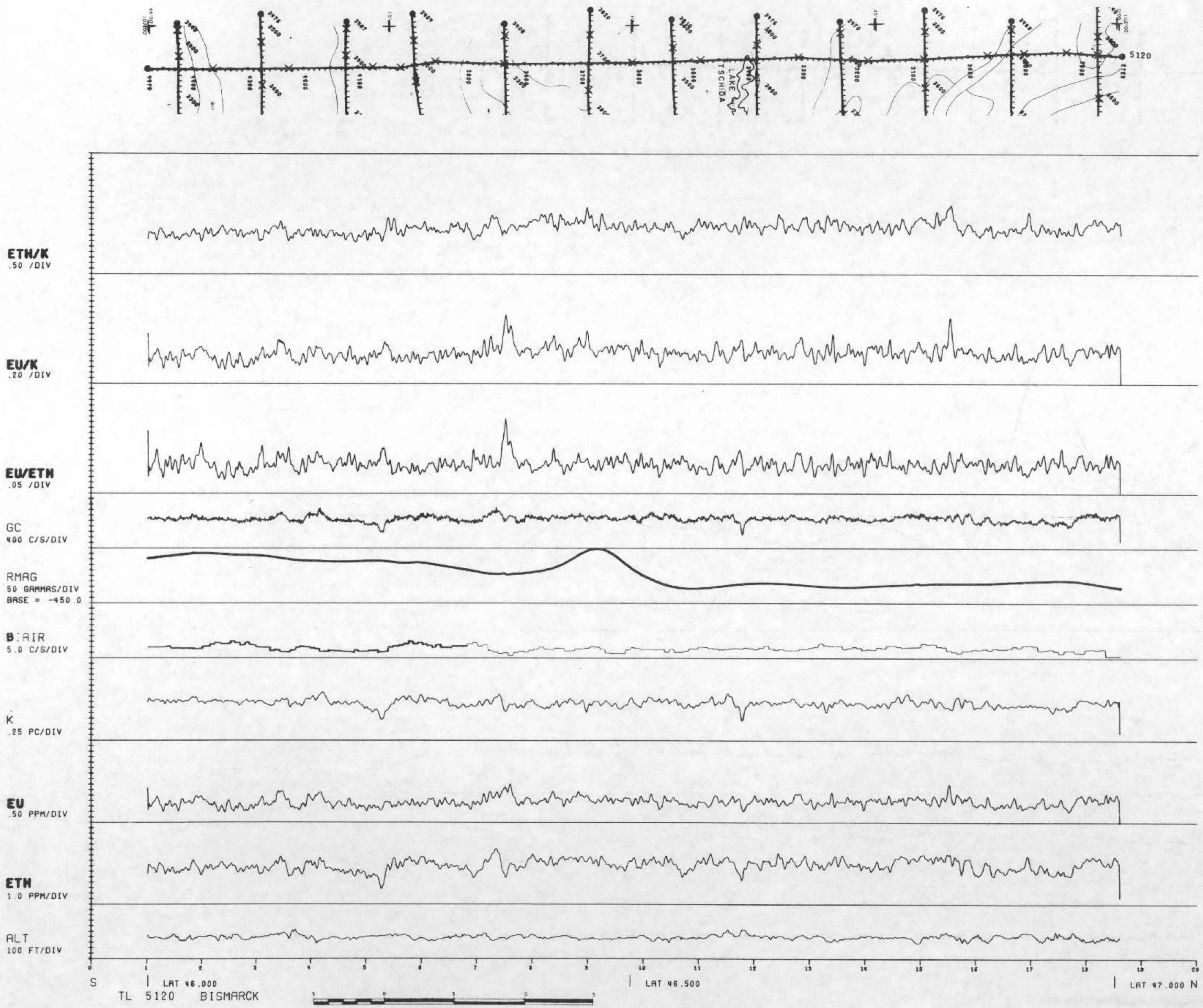
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B:AIR
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K
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EU
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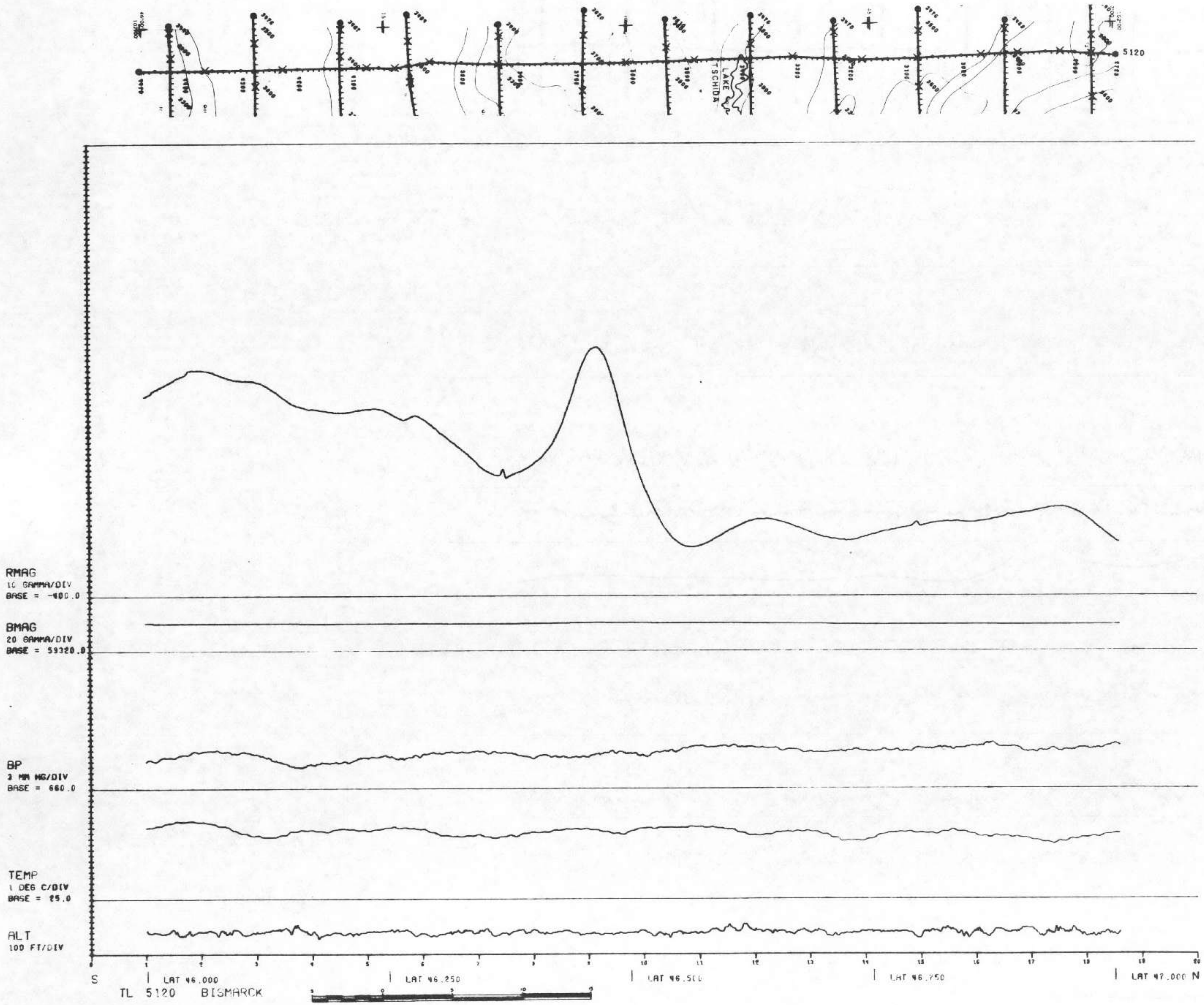
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TEMP
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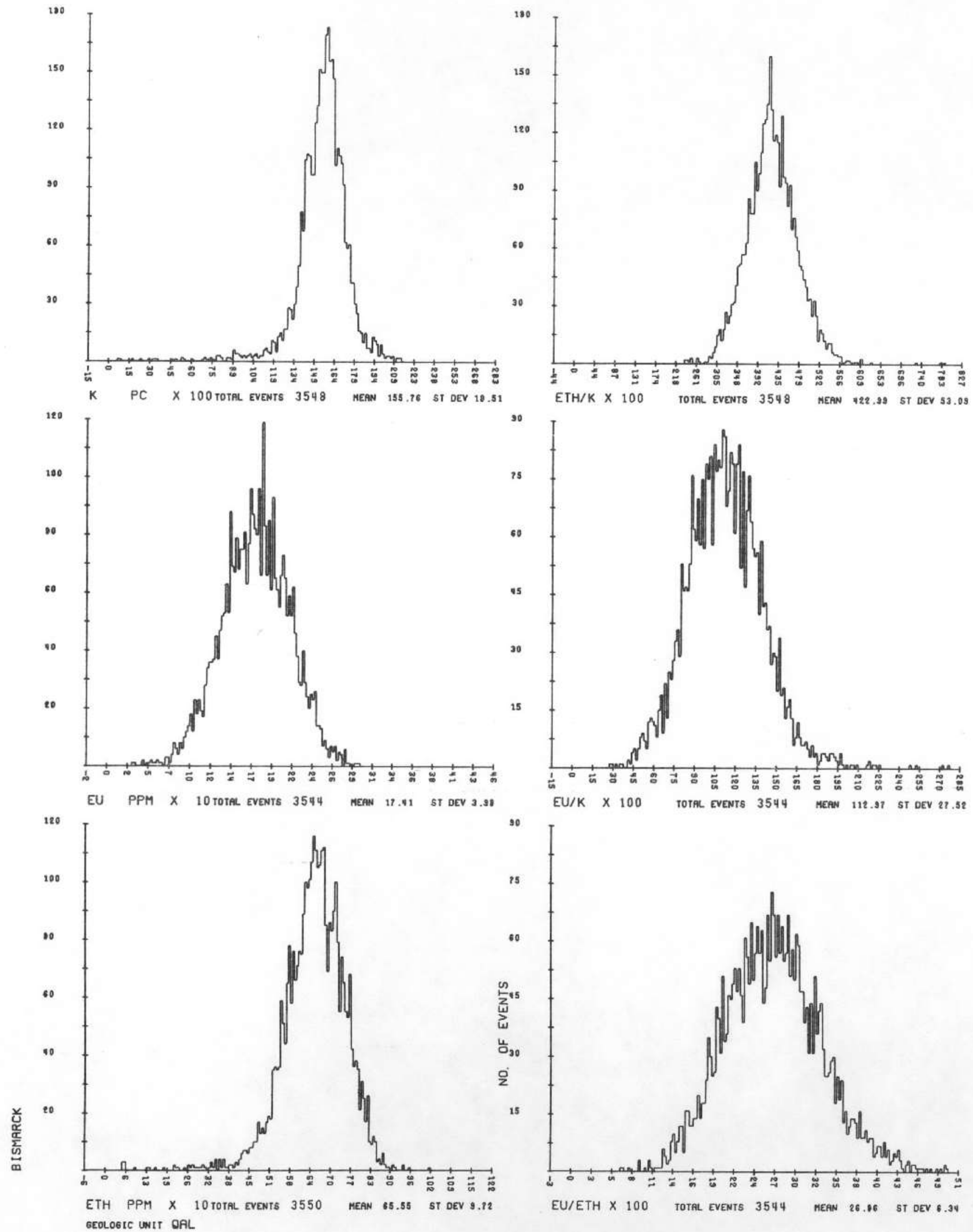
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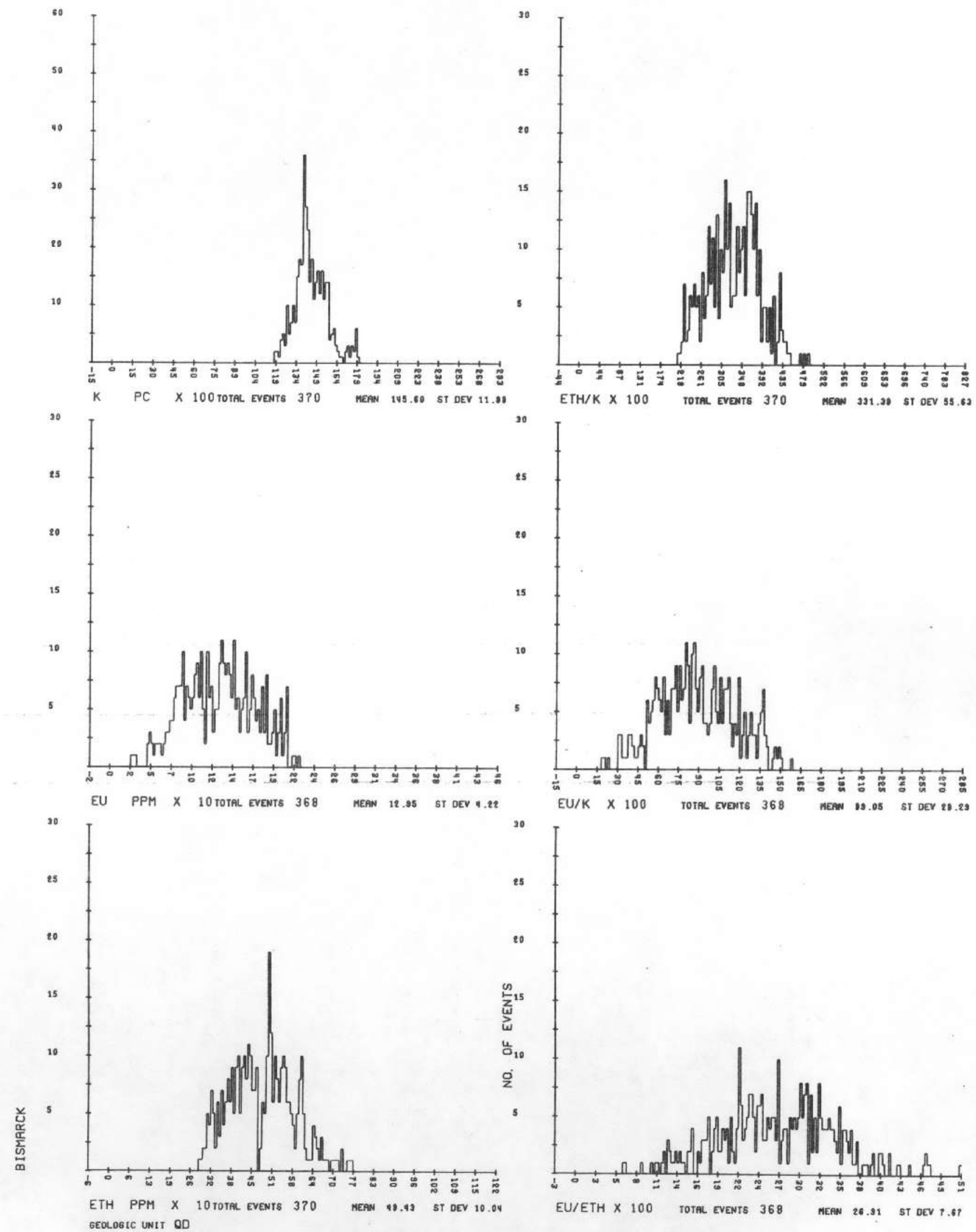
A1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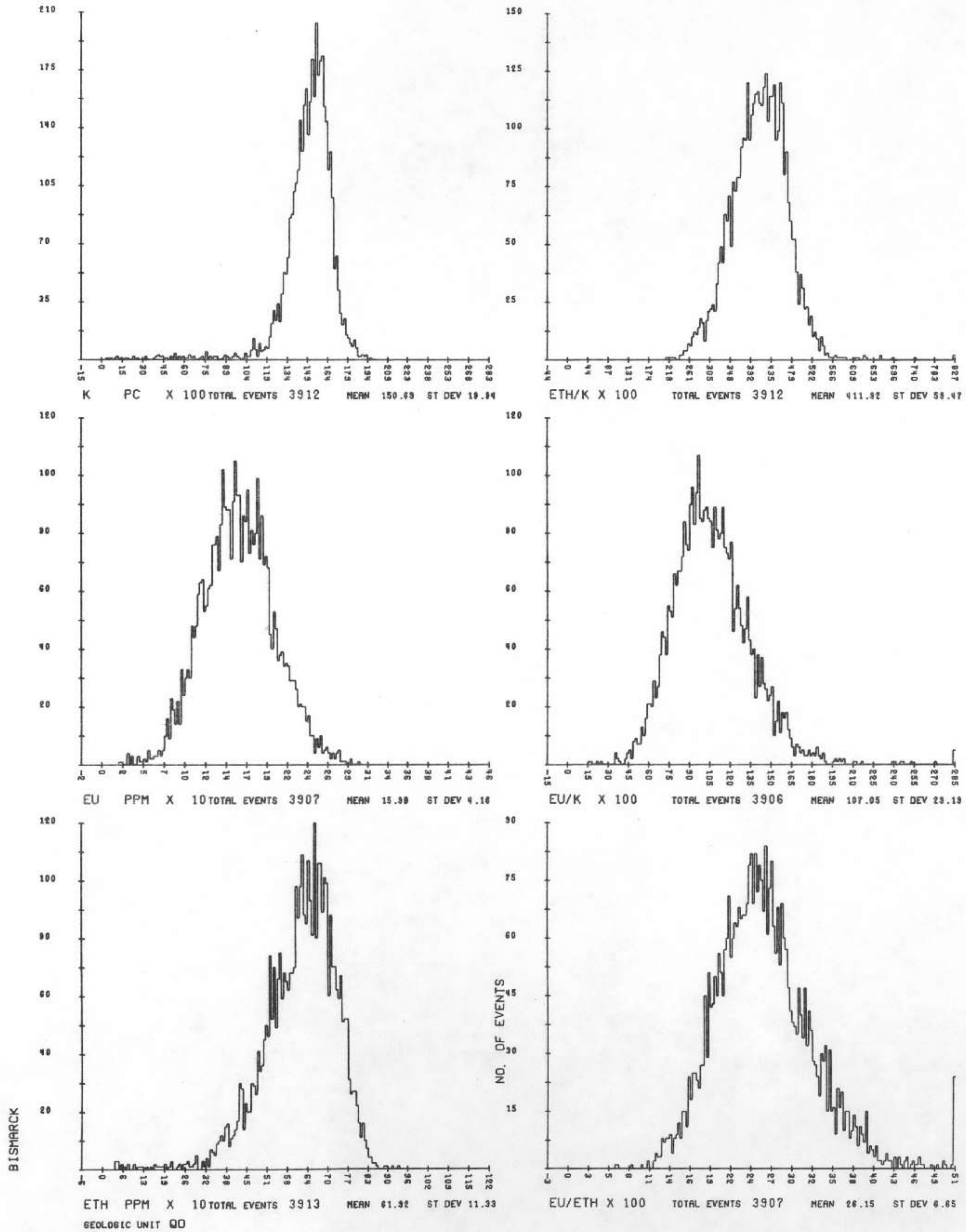
A2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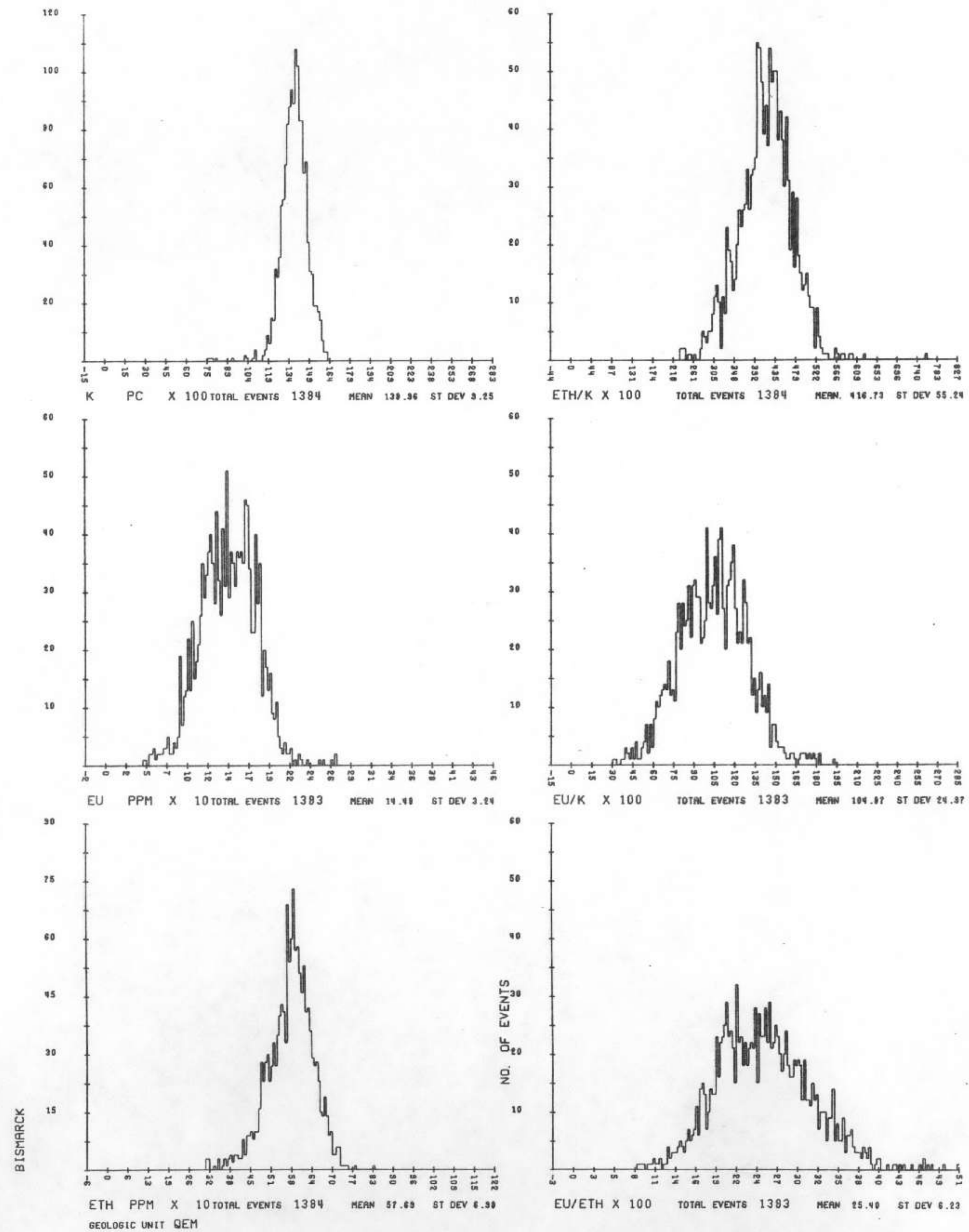
A3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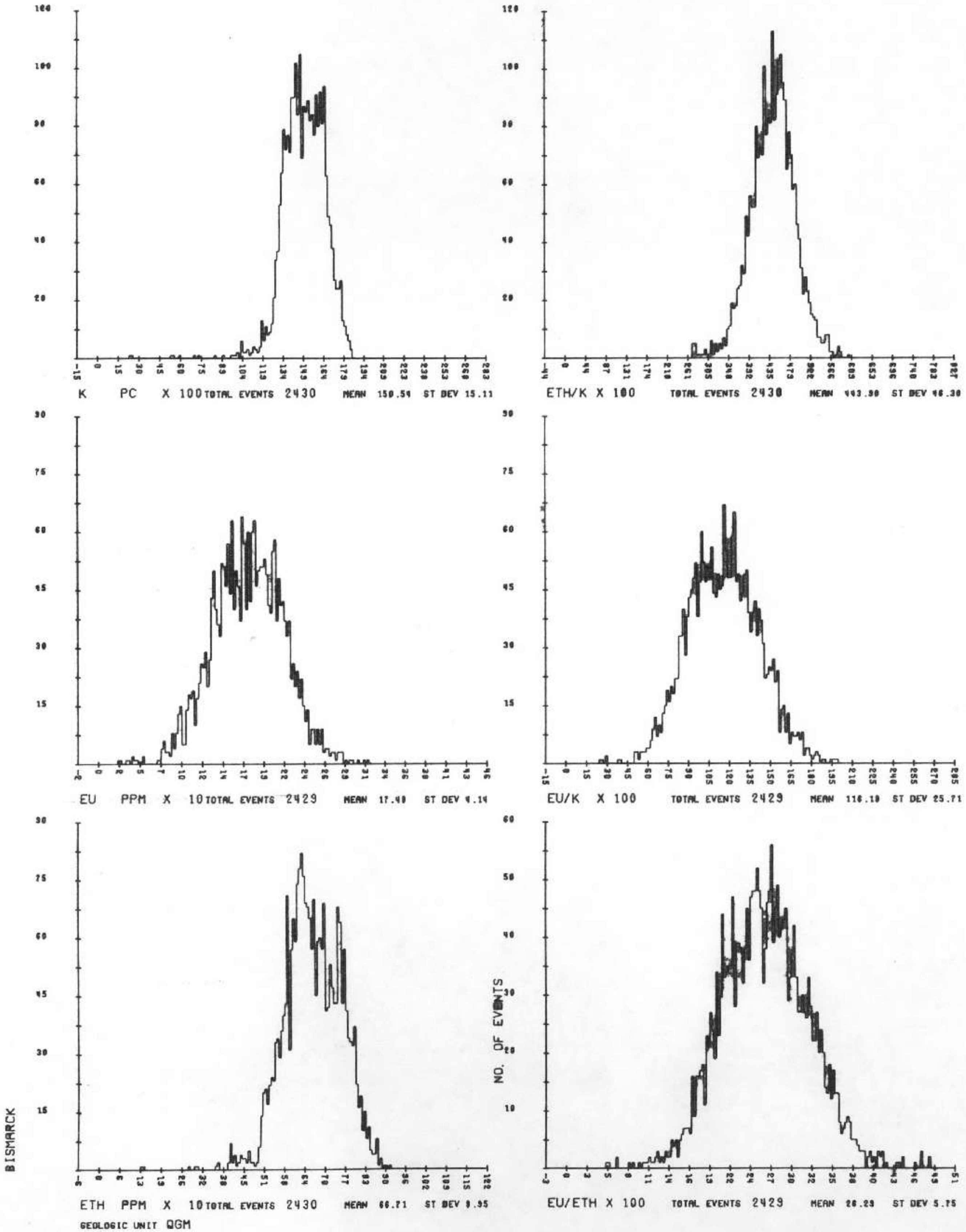
A4



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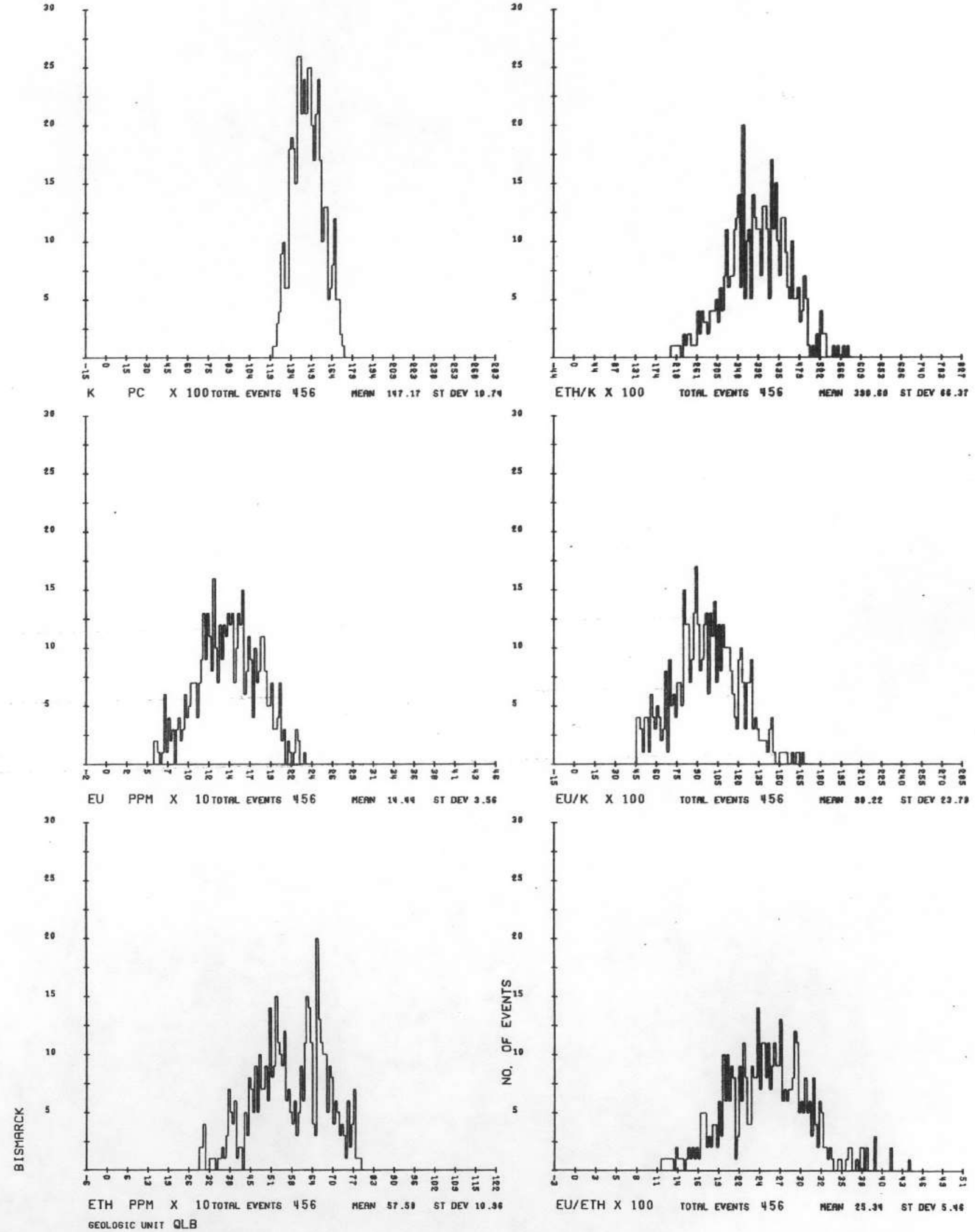

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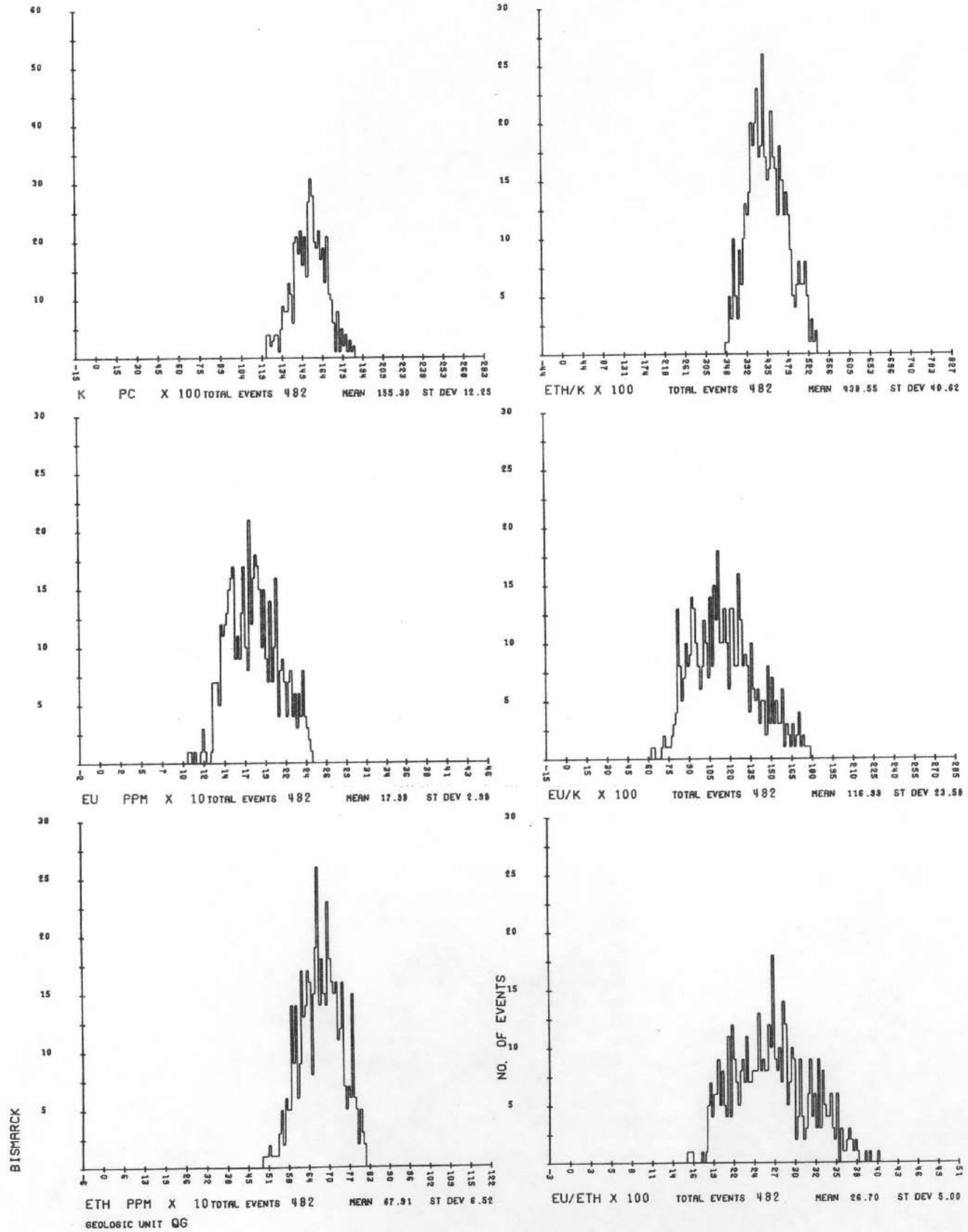
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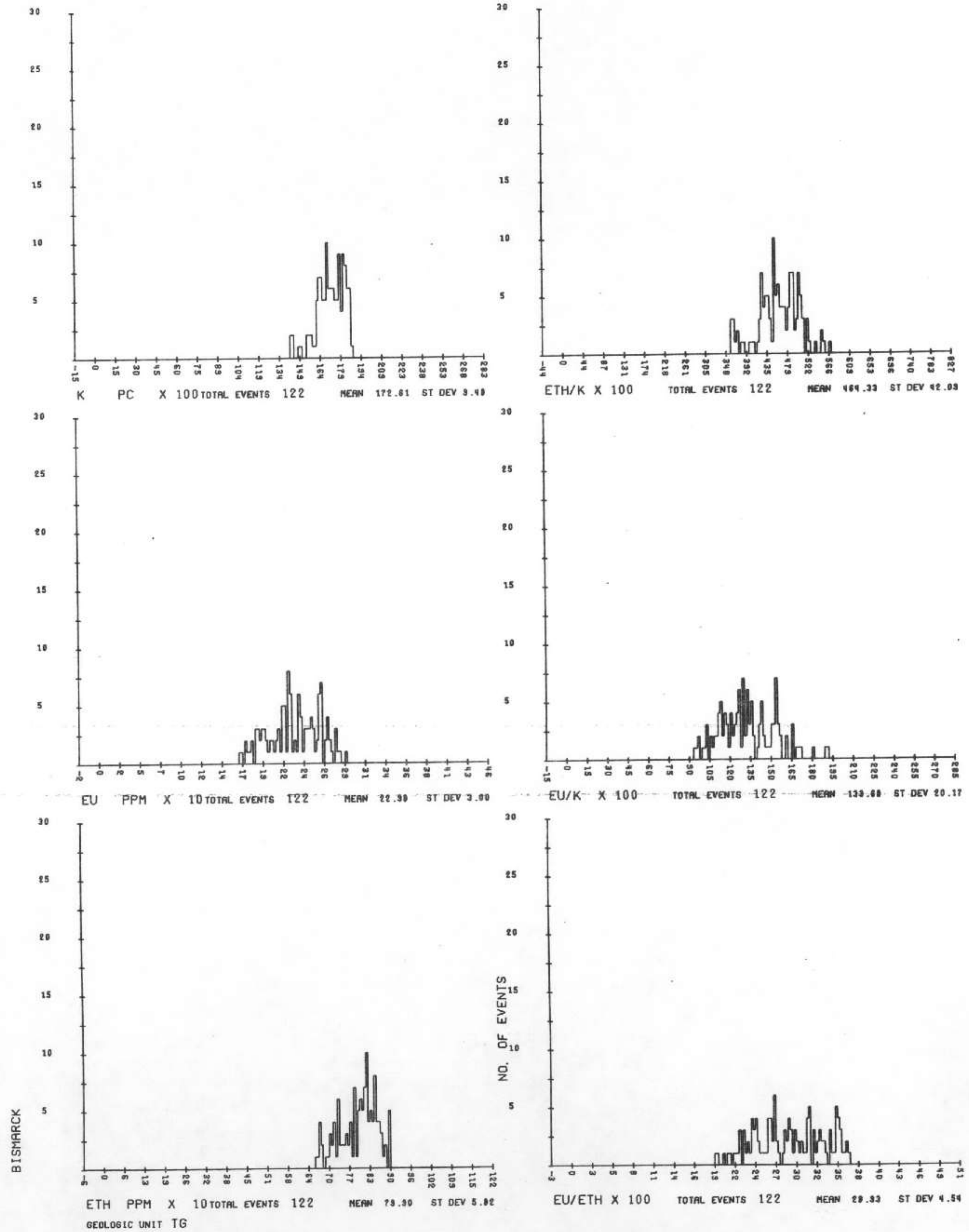
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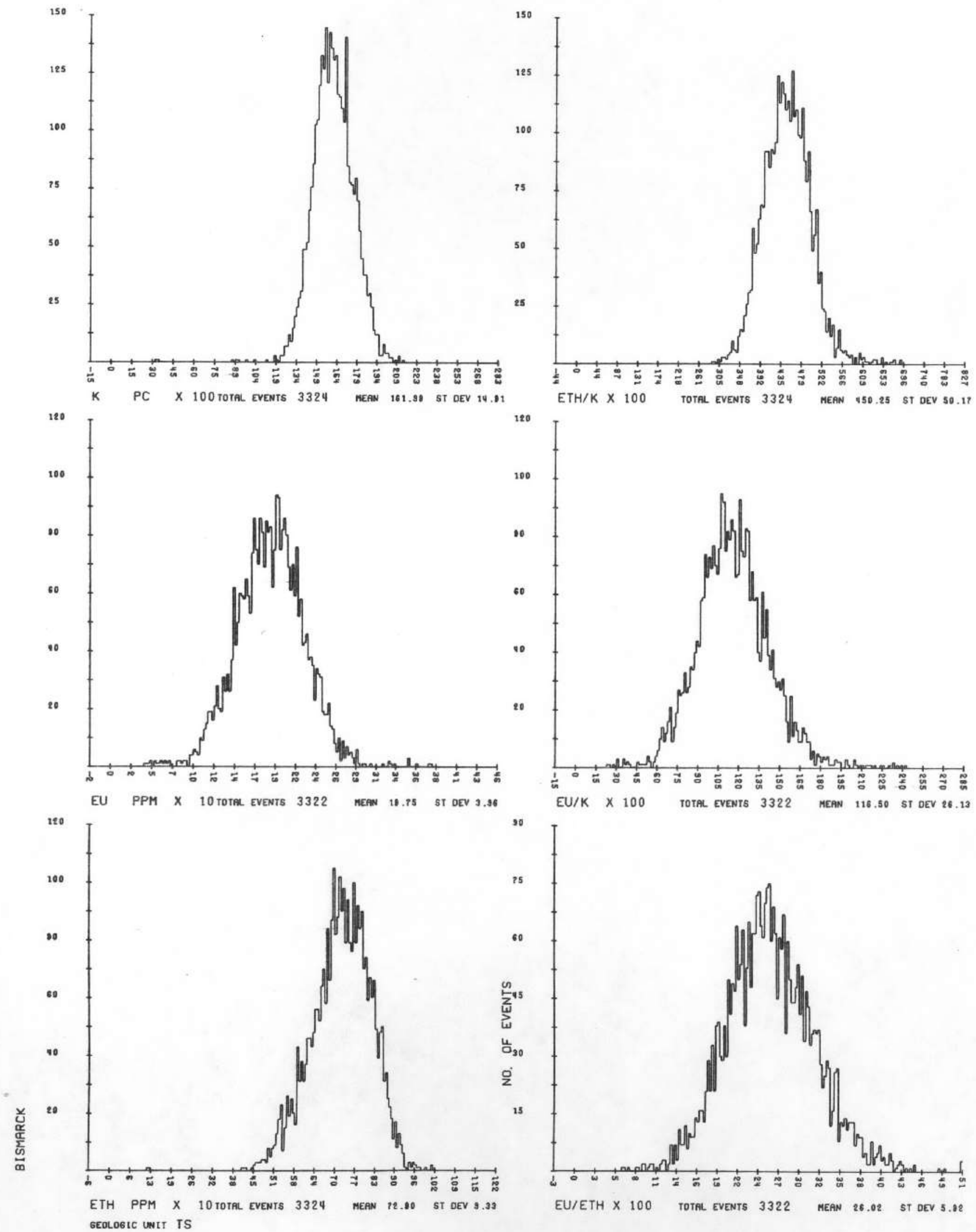
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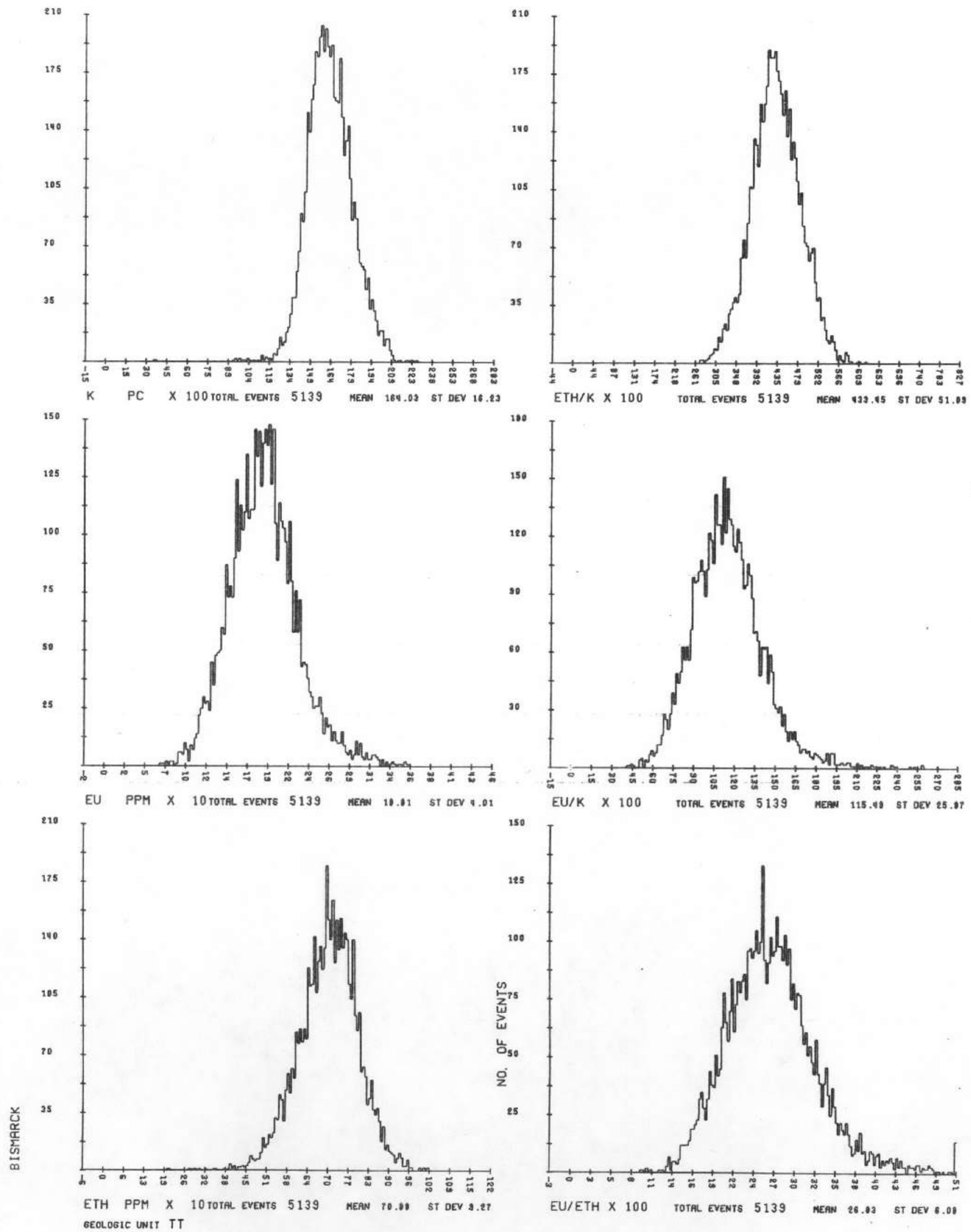
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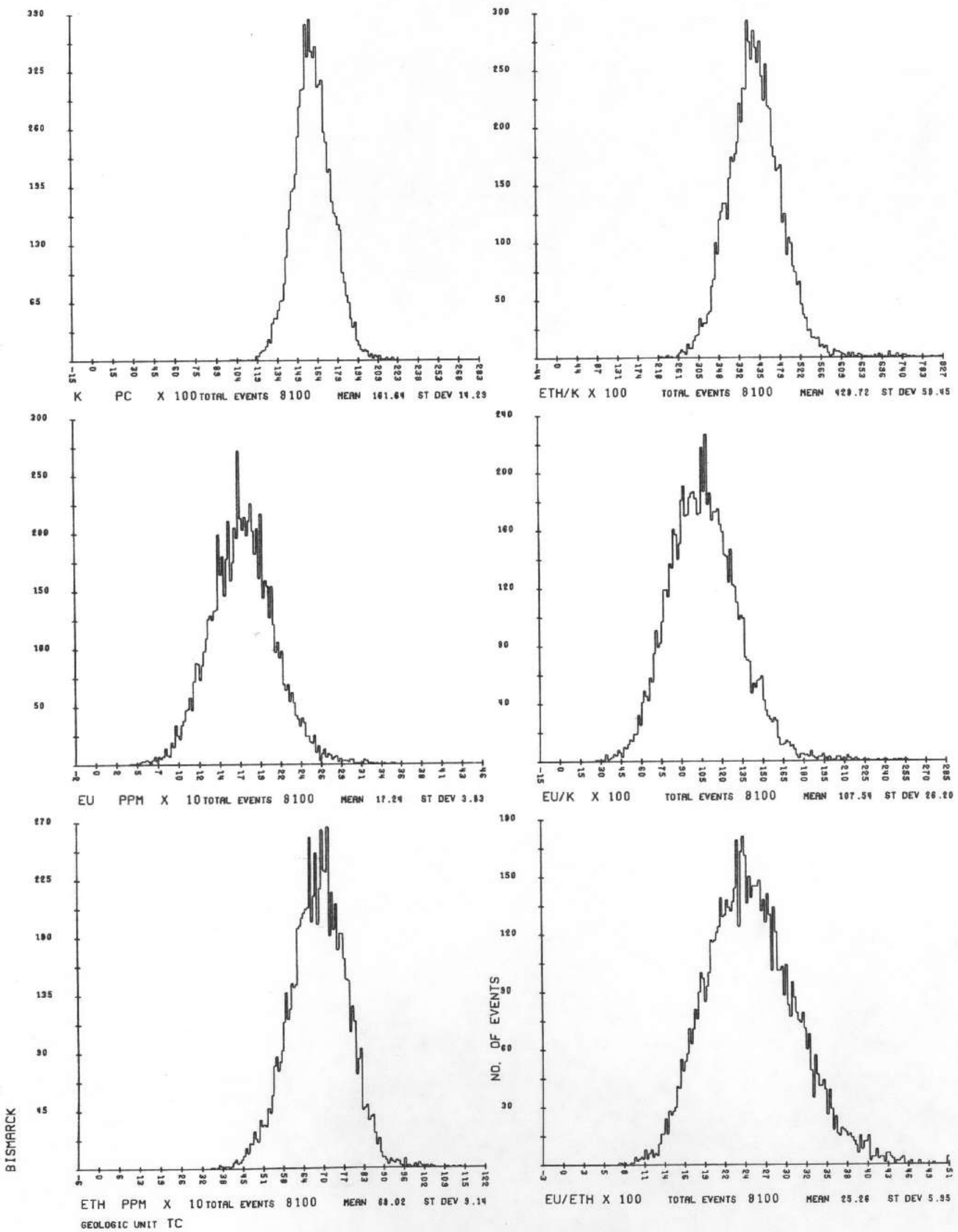
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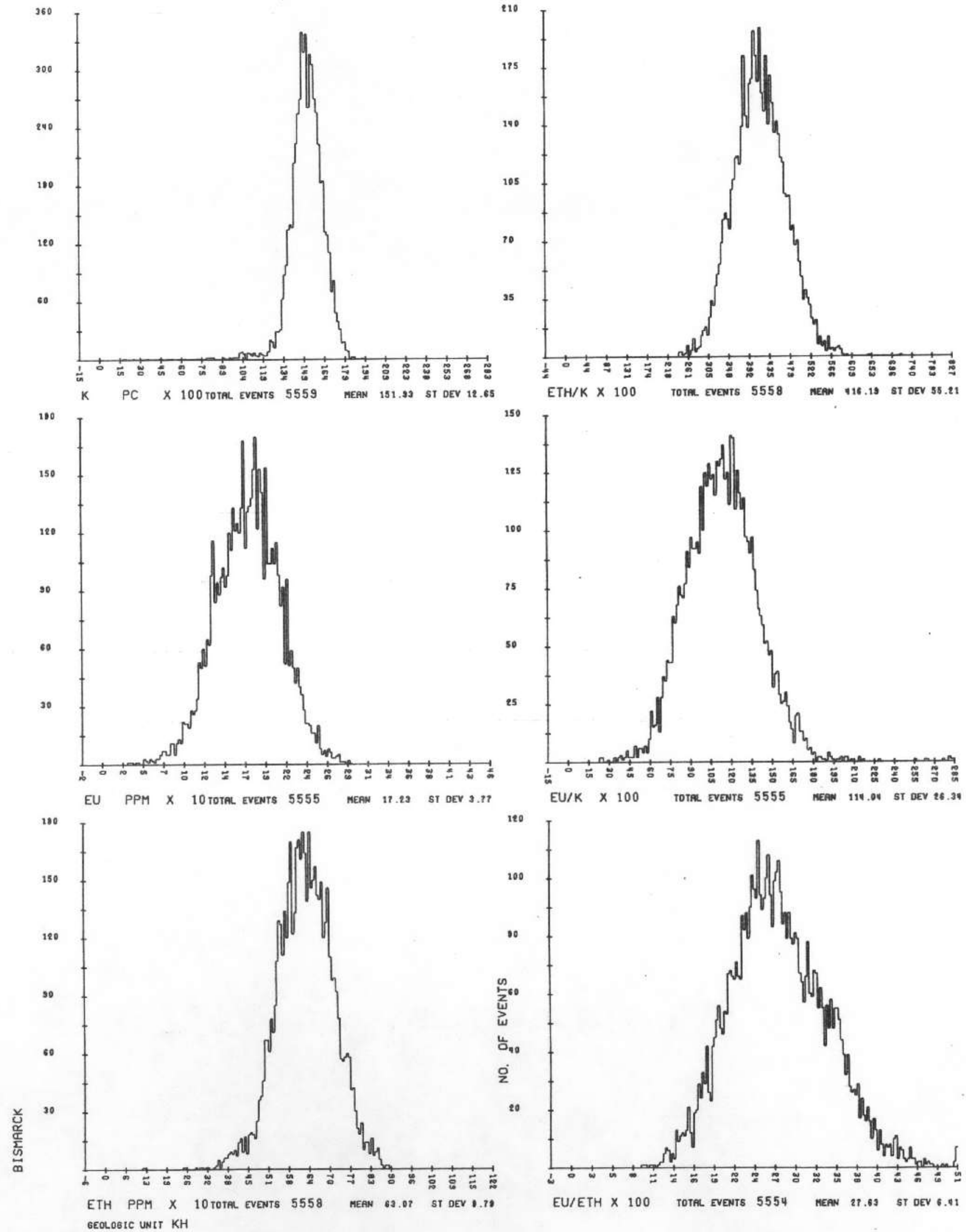
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EU/K X 100 TOTAL EVENTS 5555 MEAN 114.04 ST DEV 26.34
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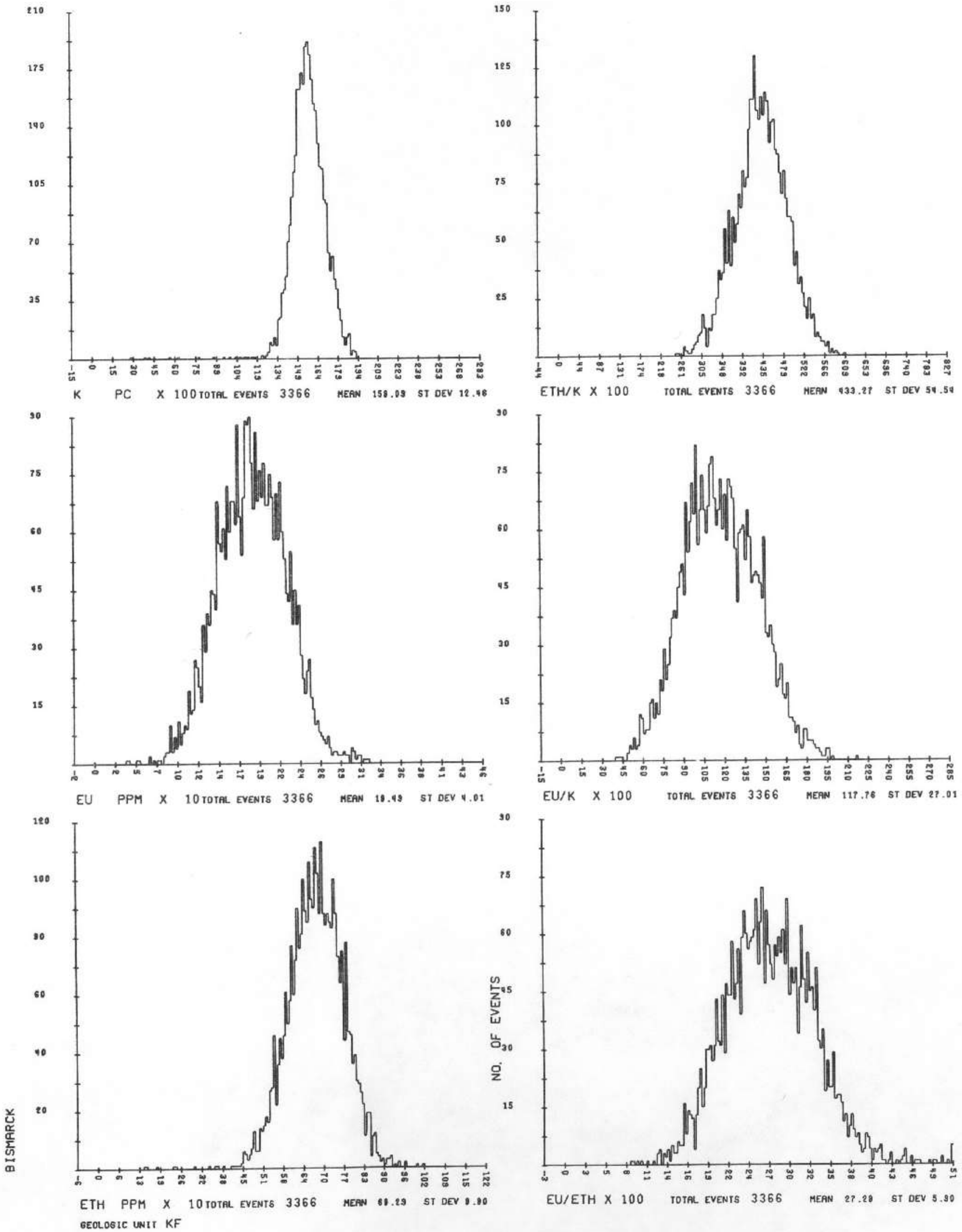
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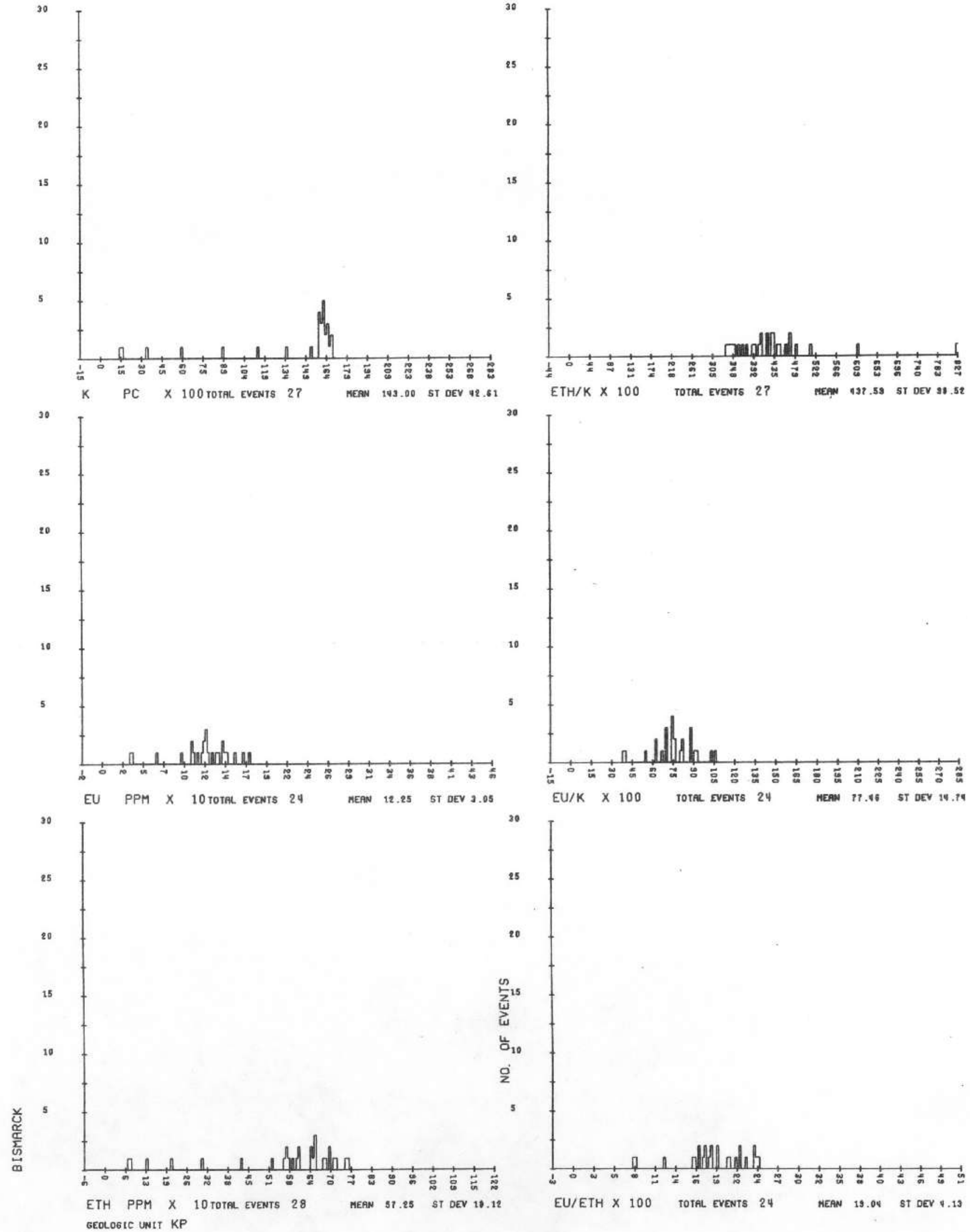
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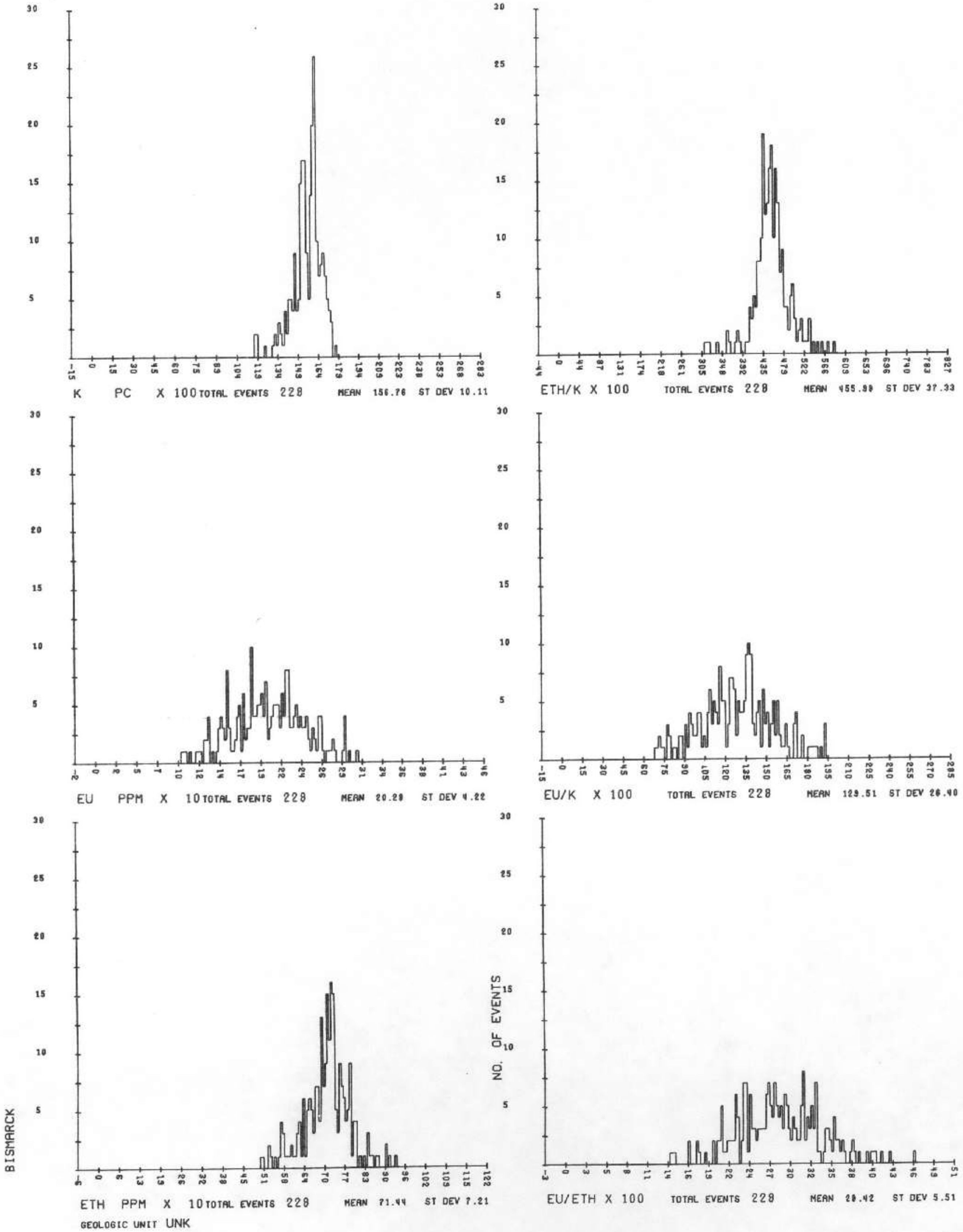
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EU/K X 100 TOTAL EVENTS 228 MEAN 129.51 ST DEV 26.40
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EU/ETH X 100 TOTAL EVENTS 228 MEAN 28.42 ST DEV 5.51
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GEOLOGIC UNIT UNK

SECTION V

GEODATA DATA AQUISITION AND PROCESSING

SECTION V.

GEODATA DATA ACQUISITION AND PROCESSING

A. DATA ACQUISITION SYSTEM

A brief description of the computer-linked Geodata Data Acquisition System (GDAS), used in the present survey, is presented here. The five primary components of the GDAS, which are mounted aboard a Douglas Super DC-3 aircraft, Figure V.1, are:

1) An array of nine (9) 11½" dia. by 4" thick NaI(Tℓ) detectors;

2) a NOVA mini-computer system

3) a Collins ALT-50 radar altimeter system;

4) a proton precession magnetometer; and

5) a Bendix DRA-12C doppler navigation system.

The nine-crystal detector array has been calibrated to measure the gamma radiation spectrum between 0-6 MeV. The contents of the 3 to 6 MeV interval is monitored in order to reduce the contributions of the cosmic events in the 0-3 MeV interval, which is of primary interest in this survey. Eight of the nine detectors are mounted to measure the 4π solid angle gamma radiation spectrum emanating from the earth's surface. The ninth detector, which is partially shielded underneath by a 3.5-inch lead plate, is situated to measure the ^{214}Bi radiation incoming from the upper 2π solid angle.

Each crystal detector has an estimated volume of 415.5 cubic inches, resulting in a total volume for the entire 4π system of 3324 cubic inches. The estimated volume to velocity ratio for this system is 23.7, where the average speed for the DC3-S is approximately 140 mph.

The energy resolution of the GDAS as calculated from the ^{137}Cs 662 keV photopeak was 10.7%, where each individual crystal was 9.0% or better. Automatic digital gain calibration for the eight detector array and the single detector system was accomplished by stabilizing on the ^{40}K photopeak data.

The NOVA computer, shown in the system block diagram of Figure V.2. is the control center of the GDAS. The data is gathered by the computer for every one-second period in a manner giving no dead time when readout to the magnetic tapes for storage. Two magnetic tape recorders are used; one to record the total spectral data and the computer tabulated results (LDT), and the other to record only the computer tabulated results (CDT).

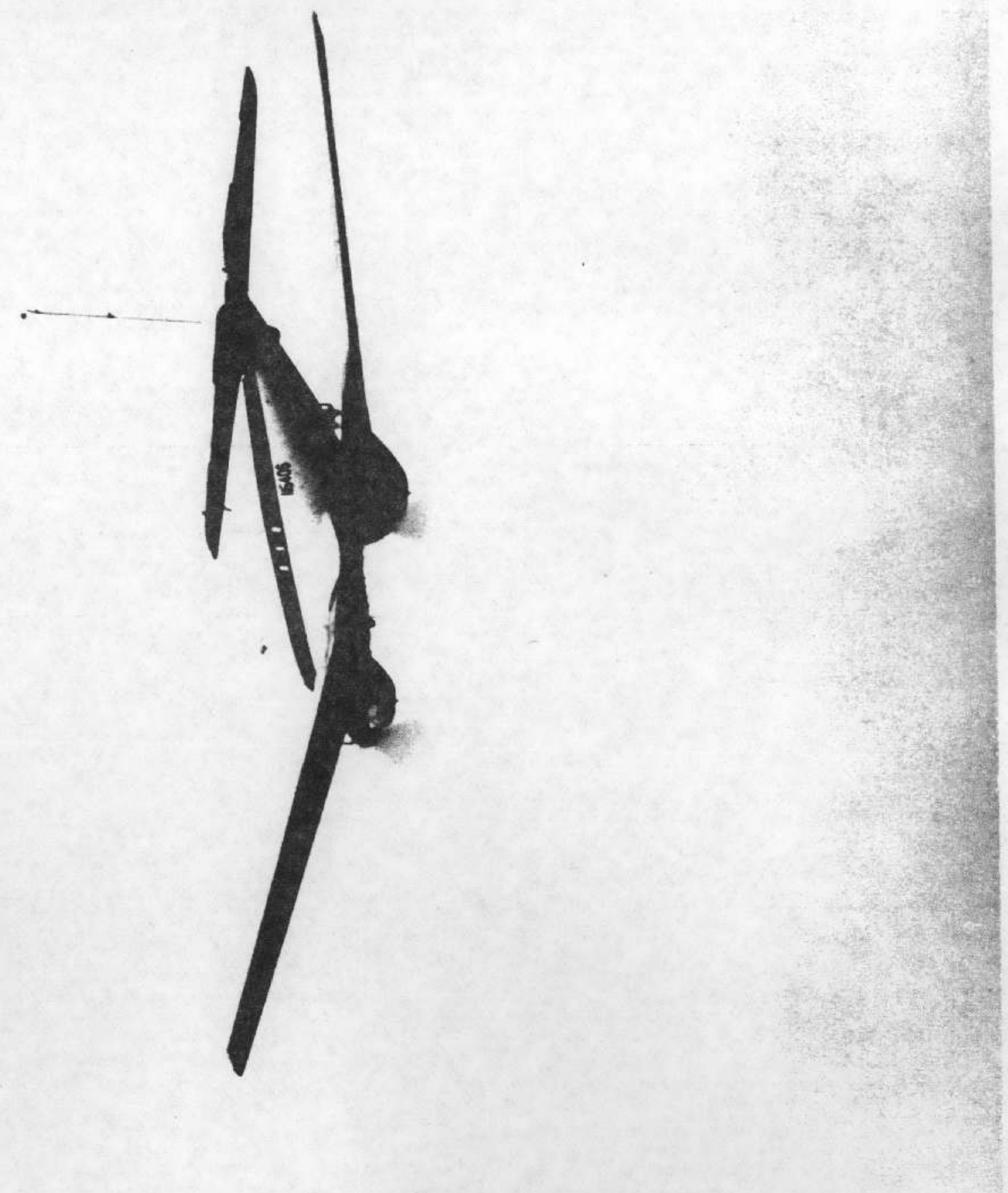


Figure V.1 Survey Aircraft

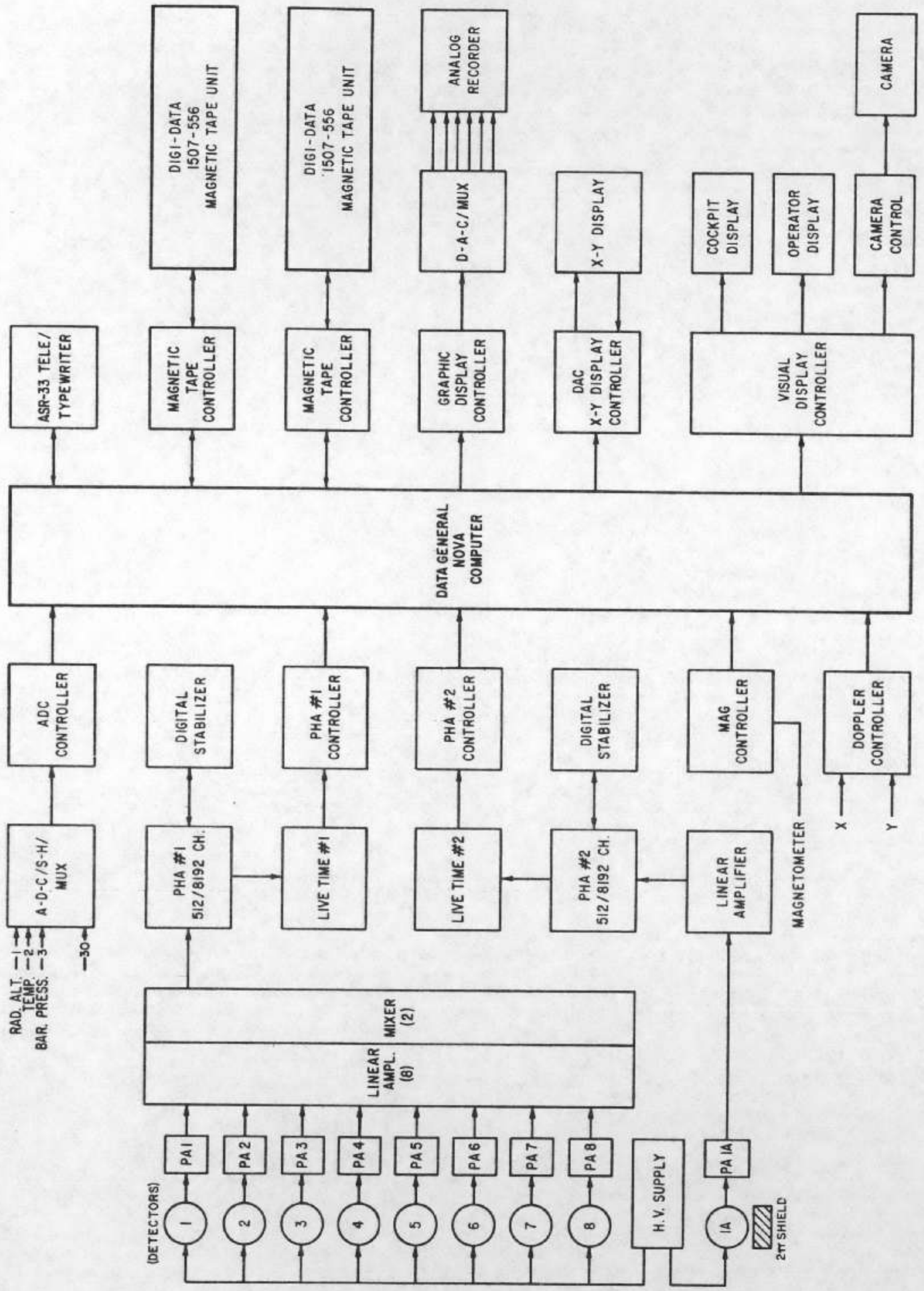


Figure V.2 System Block Diagram

Digital-to-analog conversion of the resultant intensities, their ratios and the magnetic field data are plotted on multi-track paper, allowing immediate examination for anomalous data.

The spectral data from the single detector system gathers and records the 2π spectral data every nine seconds. This 2π data is necessary to determine the amount of atmospheric ^{214}Bi radiation in the 4π spectral data. A third segment of the computer's core gathers and sums the total 2π and 4π gamma radiation spectra for each flight line, which can then be plotted as shown in Figure V.3 (EOFL spectrum).

Due to the dependence of the gamma ray data on altitude, a highly accurate radar altimeter is used. The Collins ALT-50 system is designed to make a series of 8 measurements per second, where the resulting altitude is the average.

Since the gathered data are dependent on the current ambient temperature and pressure readings, a Senso-Tek barometric pressure sensor and a Hy-Col thermocouple sensor were used to monitor conditions outside the aircraft.

A proton precession magnetometer sensor, having a 0.25 gamma readout resolution and less than a 1.0 gamma noise envelope, is sampled every second to yield a measurement of the total intensity of the earth's magnetic field below the aircraft. The sensor is carried as a "bird" on a 100-foot cable in order to minimize the magnetic effects of the aircraft.

A Bendix DRA-12C navigation system with a ±100th/nautical mile accuracy provides a doppler navigation cross-track and along-track analog signal to be recorded each second onto magnetic tape. Two other methods are used to properly locate the aircraft's track: visual sightings and photography. The first method is employed by the navigator, who marks flight map location reference points with computer-displayed record numbers. The second method is a 35mm film that records a continuous, recoverable track which has a 20% overlap/frame at an elevation of 400 feet.

There are three basic operating modes of the GDAS that the operator can manipulate:

1) CALIBRATE, which allows proper gain calibration for the detectors;

2) OPERATE, which allows data to be collected, summed and recorded; and

3) PLAYBACK, which allows the operator to examine the newly acquired data.

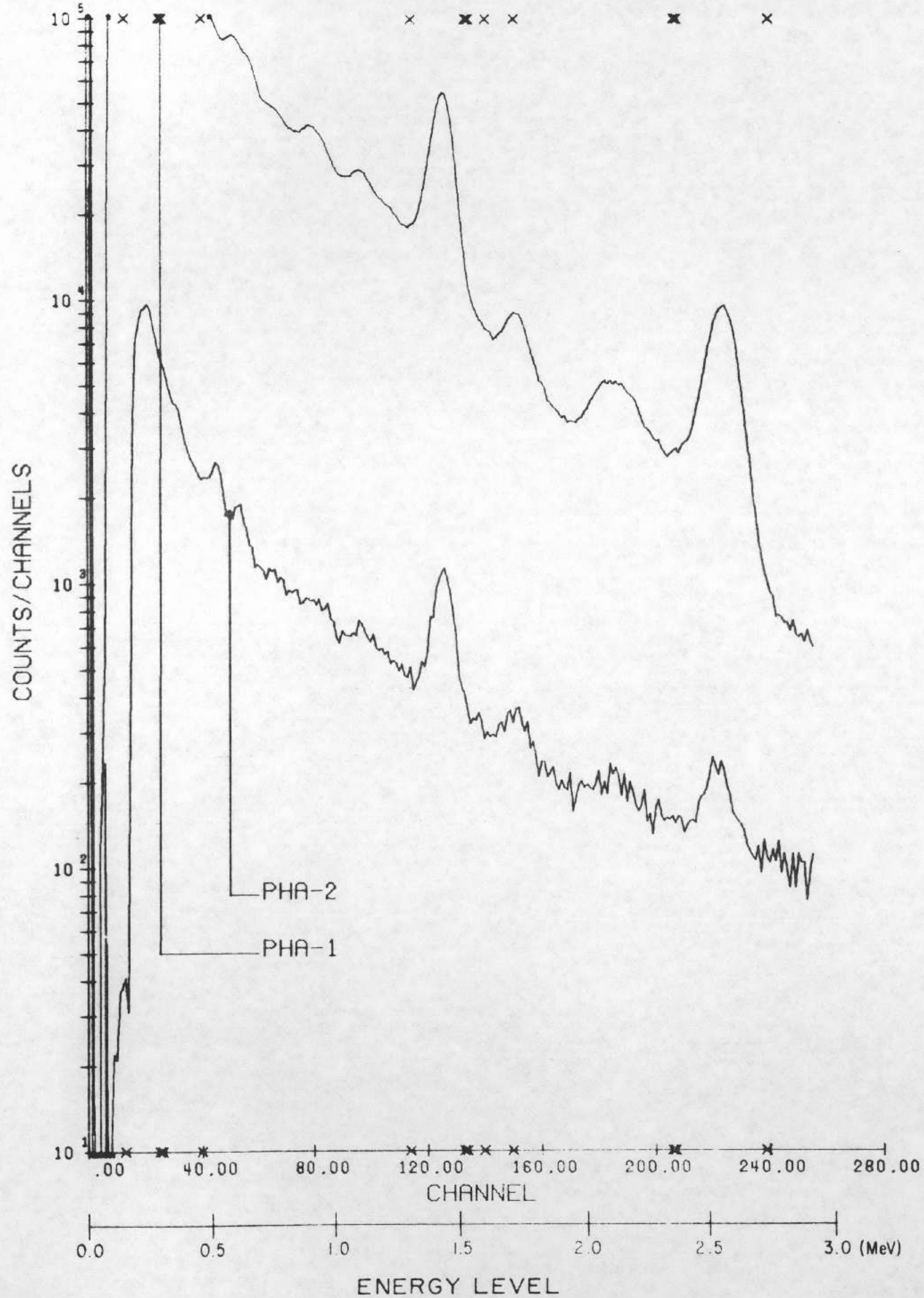


Figure V.3 Typical End-of-Flight-Line Spectral Plot

B. DATA PROCESSING

1. Data Reduction

The field data tapes produced by the data acquisition system (Section V.A) contain the 4π and 2π gamma radiation spectra, measured between 0 to 6 MeV. The resulting gamma ray spectra are composite spectra of the several different isotopes that emit gamma rays within the detectors' energy range. The method used in this work to determine the concentrations of the different isotopes monitored is discussed in this section.

In this work, there are four different isotopes which contributed to the resultant composite spectra under consideration. In order of the highest to lowest energy emitter, they are: cosmic, $^{208}T\ell$, ^{214}Bi and ^{40}K counting rates.

Isotope	Energy Interval (MeV)
Cosmic	3.0 to 6.0
$^{208}T\ell$	2.410 to 2.796
^{214}Bi	1.661 to 1.860
^{40}K	1.357 to 1.556

Due to the occurrence of Compton scatter at all gamma ray energy intervals, a 4 x 4 matrix method approach is used to "spectrally strip" the group summed counting rates into their individual counting rates attributed only to the isotope associated with that energy interval.

This matrix method approach is theoretically applicable to a spectrum containing any number of isotopic gamma rays. For convenience, the four isotopes will be denoted as: COS, TL, BI and K. The channel group sum for each energy interval can be considered to consist of fractional components of each of its constituents. For instance, one can write for the TL channel group sum:

$$aCOS + 1.0TL + fBI + 0.0K = MTL$$

where MTL is the channel group sum count;

and the coefficients, which are known as Compton coefficients, for each variable represent the responses of the data gathering system to each isotope over the entire energy spectrum.

Similarly, equations can be written for the energy interval group sums for MCOS, MBI and MK, as shown below in matrix notation by

$$\begin{bmatrix} 1.0 & 0.0 & 0.0 & 0.0 \\ a & 1.0 & f & 0.0 \\ b & \alpha & 1.0 & g \\ c & \beta & \gamma & 1.0 \end{bmatrix} \begin{bmatrix} COS \\ TL \\ BI \\ K \end{bmatrix} = \begin{bmatrix} MCOS \\ MTL \\ MBI \\ MK \end{bmatrix}$$

where each element of the 4 x 4 matrix is a Compton coefficient. By inverting the 4 x 4 matrix and multiplying on the left by the channel group sum matrix, the resulting column matrix, whose elements are COS, TL, BI and K, represents the counts in each energy interval attributed only to the indicated isotope source.

Table V.1 contains the data reduction parameters, coefficients and backgrounds used in this survey. The listed Compton coefficients were determined from data acquired during high altitude flights and from "known" test pad data concentrations in Grand Junction, Colorado.

The resulting reduced counting rates for COS, TL, BI and K must then be normalized with respect to the measured live time counting rate of the data acquisition system. This is necessary in order to restore the linear relationship between the photopeak counts and the source's intensity. This procedure is accomplished by dividing the reduced counts by the live time, LTC1:

thus,

$$\begin{aligned} COS1 &= COS/LTC1 \\ TL1 &= TL/LTC1 \\ BI1 &= BI/LTC1 \\ K1 &= K/LTC1 \end{aligned}$$

The next step in the data processing involves the subtraction of the background counts present on board the aircraft. The background counts, which exist in the aircraft and its equipment, are determined from high altitude data where the data acquisition is free from all ground sources and atmospheric ^{214}Bi contamination. The background counts, denoted as B_{TL}, B_{BI} and B_K, used in this work are listed in Table V.1. During the processing, the backgrounds are checked by observing the resulting counting rates over large bodies of water, where the rates would have near-zero intensities. The gross count's background counting rate, B_{GC}, over channels 35-239, is also given in Table V.1.

After the backgrounds have been subtracted from the live time corrected photopeak counts, thus

$$\begin{aligned} \overline{TL1} &= TL1 - B_{T\ell} \\ \overline{BI1} &= BI1 - B_{Bi} \\ \overline{K1} &= K1 - B_K \end{aligned}$$

The resulting counting rates for $\overline{TL1}$ and $\overline{K1}$ represent the counts contributed only by the sources below the aircraft on the earth's surface. In the case of $\overline{BI1}$, an additional source of ^{214}Bi radiation, which is caused by atmospheric ^{214}Bi, BIAIR, is still eminent.

The 2π detector system data is used to determine the magnitude of the BIAIR to be subtracted. Since the predominate variable source affecting the 2π detector is the atmospheric ^{214}Bi, it is possible to utilize most of the 2π spectrum in the BIAIR determination, and thereby produce some improvement in the statistical error. The energy interval used for the 2π crystal is between 1.05 to 2.79 MeV. Within this interval, the aircraft's background, $B_{2\pi}$, and its Compton coefficient, $C_{2\pi}$, have been determined from the high altitude data. (See Table V.1.)

The BIAIR associated with the unshielded detector array is determined, using the shielded detector by the relation:

$$BIAIR = \frac{G(x)}{(1 - k_2 G(x))} [VC - C_{2\pi} \cdot COS1 - B_{2\pi} - RVALM]$$

where

G(x)	is the relationship between the 4π and 2π solid angles, the channel group sums and the number of detectors in the detector arrays;
VC	is the 2π total count group sum of channels 91-239, c/s:
COS1	is the 4π cosmic count, greater than 3.0 MeV, c/s;

and,

$$RVALM = k_1\overline{TL1} + k_2\overline{BI1} + k_3\overline{K1}$$

where k_1, k_2, k_3 are constant factors that correct for the penetration/spill of the emanated surface radiation. These penetration/spill constants are dependent on the amount of lead shielding used on the 2π crystal. The values used in this work are listed in Table V.1.

$\overline{TLI}$, $\overline{BII}$ and $\overline{KI}$ have already been defined as the 4π reduced data counting rates, c/s.

Finally, the ^{214}Bi counting rate caused only by the surface sources is given by

$$BISUR = \overline{BII} - BIAIR$$

Briefly summarizing, $\overline{TLI}$, BISUR and $\overline{KI}$ are the counting rates as measured at the height of the aircraft. All interfering counts from cosmic, backgrounds and atmospheric ^{214}Bi have been removed.

Since the various counting rates are dependent upon the height of the aircraft above the surface terrain, it is necessary to correct the associated isotope's counting rate to an altitude of 400 feet above the surface terrain. This is accomplished through the equations indicated below:

$$TLS = \overline{TLI} \cdot e^{-\mu_1(400 - \frac{\rho}{\rho_o} x)}$$

$$BIS = BISUR \cdot e^{-\mu_2(400 - \frac{\rho}{\rho_o} x)}$$

$$KS = \overline{KI} \cdot e^{-\mu_3(400 - \frac{\rho}{\rho_o} x)}$$

and

$$GC(\text{gross count}) = (\overline{GC} - B_{GC} - S \cdot BIAIR) \cdot e^{-\mu_4(400 - \frac{\rho}{\rho_o} x)}$$

where

$\overline{GC}$	is the live time corrected gross count, channels 35-239,
S	is the ratio of the BI data, channels 35-239 to channels 143-159,
B_{GC}	is the gross count background,

TLS, BIS, KS	are the respective photopeak's counting rates at 400 feet;
ρ_o	is the air density at standard temperature and pressure; 0.001293 gm/cc
ρ	is the air density at the time the survey data was flown;
μ_1,μ_2,μ_3,μ_4	are the respective linear attenuation coefficients;
x	is the aircraft's height above the surface terrain in feet.

The attenuation coefficients and other constants used in the altitude normalization are listed in Table V.1.

After each flight line of data has undergone the above data reduction, the average values for each radiation variable and variable ratios for each of the flight lines were plotted to demonstrate the consistency of the average values and that a smooth flow continues from day to day, and from the start to the finish of each day.

Diurnal variations of the magnetic field base station intensity were measured and applied to the field data. (See Section II.D and Appendix I.C.) The magnetic heading corrections for the aircraft and its equipment used in this survey were determined by flying a predetermined path at a survey altitude in first an east to west direction, then in a west to east direction. The same procedure is used on a north to south path. Based on the data obtained in this fashion, see Table V.1, the heading corrections were removed from all the data. The magnetic field data were then IGRF corrected to give the residual magnetic field. The International Geomagnetic Reference Field subtracted was provided by the U.S. Geological Survey with reference to the IAGA Bulletin #38, "Grid Values and Charts by the IGRF 1975.0", National Technical Information Service Report #PB265483.

The system sensitivities at 400 feet used in this survey are shown in Table V.1.

2. Description of Data Processing

The processing flow chart representative of the work performed in this survey is shown in Figure V.4.

As stated in Section V.A., the original field data tapes were recorded to contain the various tag words, 4π and 2π spectral

TABLE V-1: DATA REDUCTION PARAMETERS AND CONSTANTS - N540S - 1980

AIRCRAFT BACKGROUNDS				COSMIC CORRECTION RATIOS	
Detector	Parameter	Window	Value (CPS)	Parameter	Value
Terrestrial (4π)	B_K	Potassium	29.98	c	0.2069
	B_{Bi}	Uranium	9.40	b	0.1651
	$B_{T\ell}$	Thorium	5.83	a	0.2202
	B_{GC}	Gross	286.69	-	-
Atmospheric (2π)	$B_{2\pi}$	Uranium	8.33	$C_{2\pi}$	0.2232

DERIVED STRIPPING COEFFICIENTS AND RATIOS			
Coefficient	Value	Coefficient	Value
α	0.2755	k_1	0.030
β	0.4058	k_2	0.0
γ	0.8595	k_3	0.0
f	0.0693	S	17.5
g	0.0156	-	-

LINEAR ABSORPTION COEFFICIENTS		
Radio Element	Parameter	Value ($x10^{-3}$ per ft.)
Potassium	μ_1	2.448
Uranium	μ_2	1.329
Thorium	μ_3	1.899
Gross	μ_4	1.430

MAGNETIC HEADING CORRECTION	
Flight Direction	Correction (gammas)
West to East	+3.56
East to West	-3.56
North to South	-1.0
South to North	+1.0

RADIOELEMENT	SYSTEM SENSITIVITIES AT 400 FEET
Potassium (cps/%K)	98.05
Uranium (cps/ppm eU)	13.52
Thorium (cps/ppm eTh)	7.15

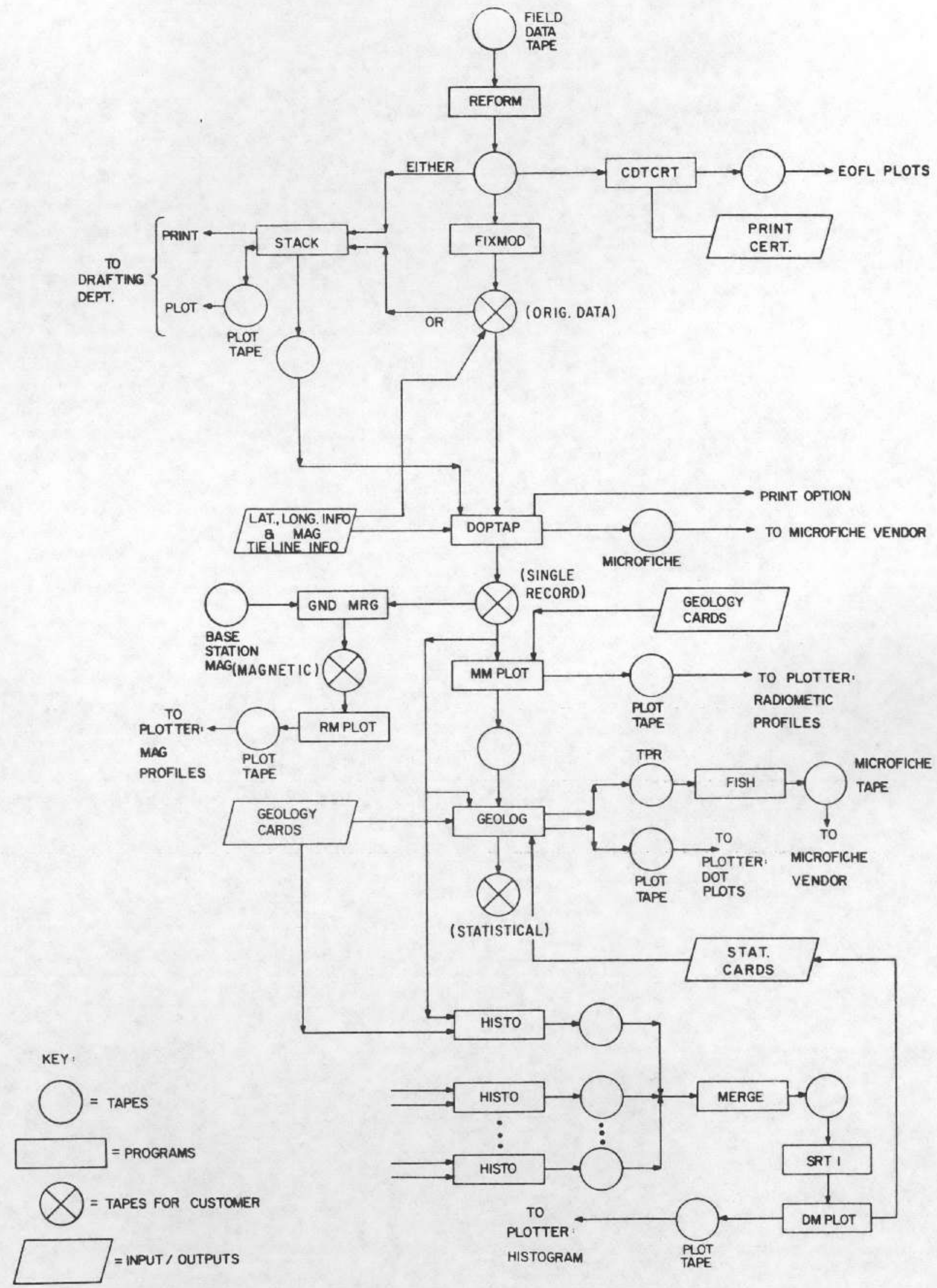


Figure V.4 Data Reduction Flow Chart

data and the trailer record sums for each flight line. The purpose of the REFORM program is to sum the raw spectral data (LDT) into the proper group sum energy intervals for each second for each line. The CDTPLT program is a data certification program that produces the EOFL spectral plots, Figure V.3, and profiles of each of the channel group sums, which are plotted as a function of each line's record numbers.

A brief summary of each program and its uses is given below:

PROGRAM	FUNCTION
REFORM	Produces energy group sums and EOFL spectra.
FIXMOD	Primary processing for "spectral stripping" matrix reduction, live time normalization, background and BIAIR subtraction, and altitude corrections.
STACK	Flight path recovery to produce record location map at a scale of 1:250,000.
DOPTAP	Single record processing with latitude/longitude positioning, IGRF and single point statistical adequacy computations, and magnetic heading corrections.
GNDMRG	Merges aircraft magnetometer and ground magnetometer in proper time sequence and applies diurnal corrections to the field data.
VARPLT	Produces radiometric and magnetic stacked profile plot tapes.
HISTO,MERGE, and SORT1	Preliminary programs to prepare/sort data as a function of geologic type for the entire area.
HISPLT	Produces geological histograms, mean and standard deviation tables, and plot tape for the entire area.
GEODOT	Produces plot tape for standard deviation "dot plots" related to geologic type.
FICHE	Produces average record and single record reduced data listings and microfiche tapes, which are sent to microfiche vendor.
CUSTOMER	Produces all customer required tapes.

3. Data Presentation

The surveyed area was positioned geographically to completely cover the specific National Topographic Map. Each topographic map has been used as the flight base, and sufficient geographical and 15' location information has been shown. The flight line pattern has been superpositioned onto these created base maps, where the standard deviation levels for each independent variable and each ratio of these variables have been plotted (NGRMS), based on the data contained within the total map area. Every fifth data point along each map line has its standard deviation value shown at the location of that value. Therefore, there are six NGRMS sheets which indicate the location and magnitude of anomalous data.

The multivariable map line profile, which represents 10 variables as a function of their latitude and longitude location for each line, is presented at a scale of 1:500,000. Each profile presents:

1. Aircraft altitude above the surface
2. eTh (^{208}Tℓ from ^{232}Th decay series)
3. eU (^{214}Bi from ^{238}U decay series)
4. K (^{40}K from natural potassium)
5. BIAIR (atmospheric ^{214}Bi)
6. Residual magnetic field
7. Gross count (greater than 400 keV)
8. eU/eTh (^{214}Bi/^{208}Tℓ) ratio
9. eU/K (^{214}Bi/^{40}K) ratio
10. eTh/K (^{208}Tℓ/^{40}K) ratio
11. Geologic data, including aircraft flight path

The residual magnetic field map line profile, which represents five variables as a function of their latitude and longitude location for each line, plus geologic data at a scale of 1:500,000, is presented as:

1. Aircraft altitude
2. Atmospheric temperature
3. Atmospheric pressure
4. Residual magnetic field data
5. Magnetic field base line station data
6. Geological data, including aircraft flight path

The output of these various computations supplies, beyond two profile sets, the following data:

* Histograms of the radiation data distribution within each geologic unit.

* Histograms of the average velocity distribution for each one-second record for each map and tie line.

* Histograms of the average altitude distribution for each one-second record for each map and tie line.

* Tables giving the average radiation concentration of each geologic unit for each flight line.

* Average radiation concentration for each variable as a function of flight line, including the atmospheric ^{214}Bi.

* Set of maps showing the standard deviation data as a function of location and radiation variable.

* Printer plot contour maps of eTh, eU, K, eU/K, eU/eTh, eTh/K and the magnetics at a scale of 1:500,000.

4. Statistical Analysis Procedures

It is necessary to exclude from the statistical analysis all variables which have too low a counting rate to be statistically valid, and data which were obtained at altitudes above 1,000 feet. To this end, a statistical adequacy test was run on all data for each data record. If a given value of Tℓ, Bi or K failed the test, that variable value, and any ratio value associated with it, were not used in the statistical determinations of mean and standard deviation values. In addition, such values are indicated on the radiometric profiles by a vertical (tick) mark along the base line for the variable, and are flagged in the single record and averaged record listings (microfiche). The ratio values are set to zero in the Radiometric Profile Plots. The flags in the listings appear under the heading AKUT for altitude, ^{40}K, ^{214}Bi and $^{208}T\ell$, respectively. The flags are zero for statistically valid data, and one for rejected data in the case of K, U and T. For altitude (A), a zero indicates altitudes to 700 feet, a one (1) indicates altitudes between 700 and 1,000 feet, and a two (2) indicates altitudes above 1,000 feet.

The tests used to reject data were as follows:

(1) $\overline{T\ell I} < 1.5 \sqrt{T\ell w - \overline{T\ell I}} = 1.5\sigma T$

(2) $BISUR < 1.5 \sqrt{Biw - BISUR} = 1.5\sigma B$

(3) $\overline{KI} < 1.5 \sqrt{Kw - \overline{KI}} = 1.5\sigma K$

where the "w" subscript refers to the respective window counting rates from the raw data and $\overline{T\ell I}$, BISUR and $\overline{KI}$ have previously been defined. If any of the above inequalities were true, the associated variable was flagged, and that value was rejected in all statistical determinations.

The values of the radicals in the above equations, which are indicated as σT, σB, σK and the barred values, were calculated on the basis of a single record value for determining flags in the single record listings and the 7-point weighted values for determining flags in the averaged records listings.

The mean value and standard deviations were calculated assuming the data to have a normal distribution within a geologic type. The equation used in determining the variance is:

$$\sigma^2 = \frac{1}{N-1} \left\{ \sum_{i=1}^{N} x_i^2 - N\bar{x}^2 \right\}$$

where N is the number of statistically valid samples for a given geologic type, x_i is the value of the variable for sample number i, and $\bar{x}$ is the mean value of the variable for the geologic type. Values from the entire survey of the area are used in these computations.

APPENDICES

I PRODUCTION SUMMARY

II TAPE FORMAT STATEMENTS

III COMPUTER LISTINGS

IV LINE PRINTER CONTOURS

AI.A PRODUCTION SUMMARY - SURVEY TIME PERIOD

ML/TL	DATE FLOWN	SURVEY LINE MILES	AVERAGE SPEED/DAY	AVERAGE ALTITUDE/DAY
ML240,220, 200,180,160	7/26/80	479.92	142.43	414.35
ML140,120, 100,80,60, 40,20	7/27/80	678.11	144.77	395.07
TL5020,5040, 5060,5080, 5100,5120	7/28/80	410.91	145.82	412.11

AI.B TEST LINE RESULTS

	JULY, 1980		
UNIT	26	27*	28
PRE COS	38.58	40.29	40.61
POS COS	39.01	41.57	-
Tl	33.30	44.03	42.06
Tl	33.99	44.60	-
Bi	17.17	21.57	21.67
Bi	15.64	24.58	-
K	114.36	151.47	149.10
K	116.47	156.47	-
GC	1433.54	1882.59	1863.79
GC	1435.38	1978.26	-
BiAir	17.30	17.31	4.81
BiAir	16.16	18.41	-
ALT	372.55	388.74	371.71
ALT	403.01	398.59	-

*New Test Line

AI.C DIURNAL CORRECTIONS TO LINE DATA

LINE	DIURNAL CORRECTIONS IN GAMMAS	LINE	DIURNAL CORRECTIONS IN GAMMAS	LINE	DIURNAL CORRECTIONS IN GAMMAS
ML 240	15	ML 160	-49	ML 80	17
ML 220	23	ML 140	26	ML 60	3
ML 200	23	ML 120	23	ML 40	9
ML 180	-19	ML 100	22	ML 20	-12
TL 5020	-11	TL 5060	-6	TL 5100	-26
TL 5040	1	TL 5080	-13	TL 5120	-30

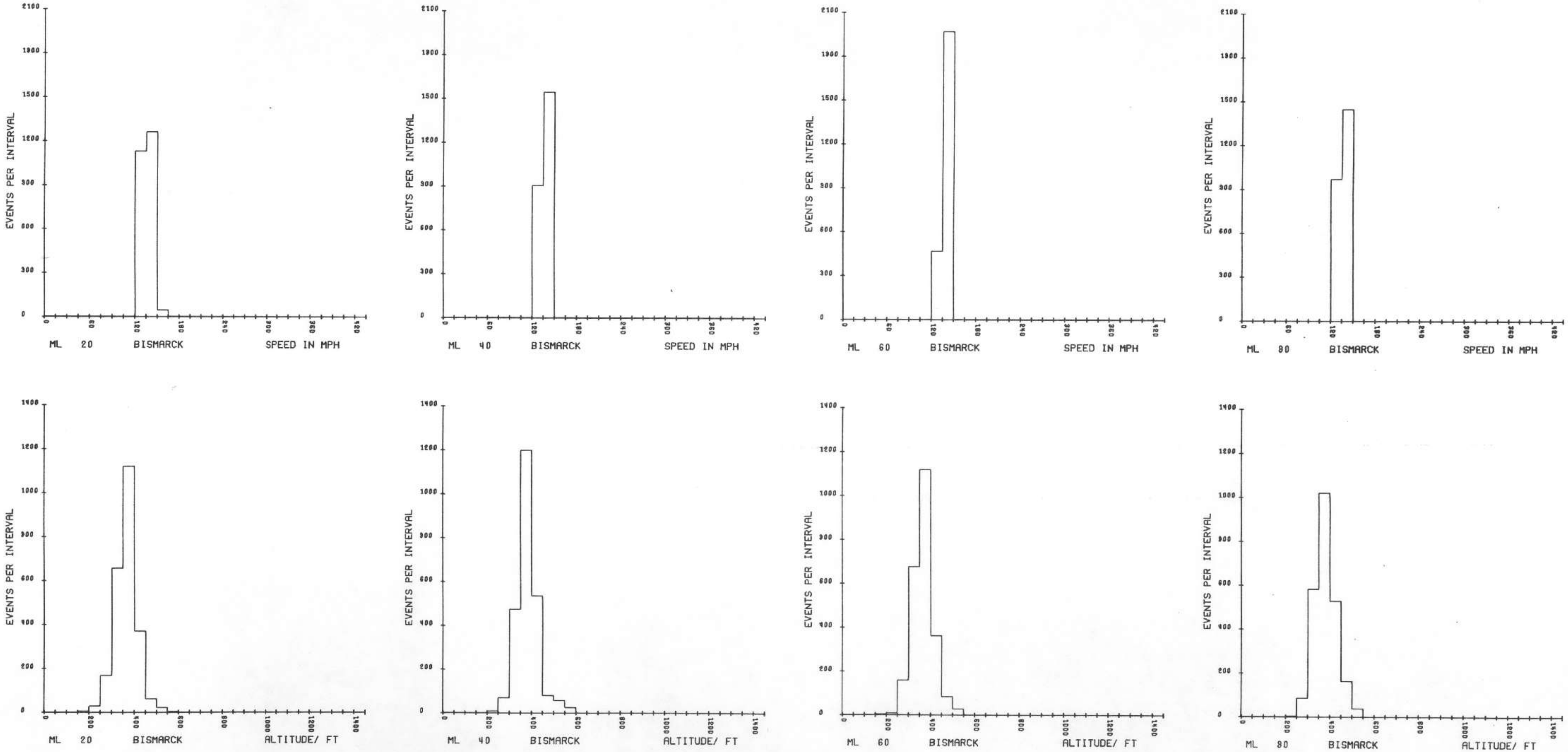
AI.D. EXPLANATORY NOTES

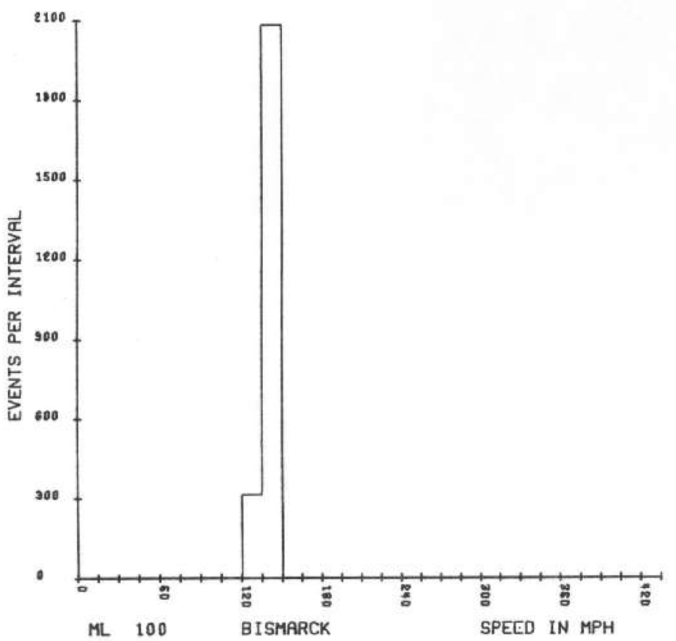
No difficulties were encountered during the processing of the Bismarck quad.

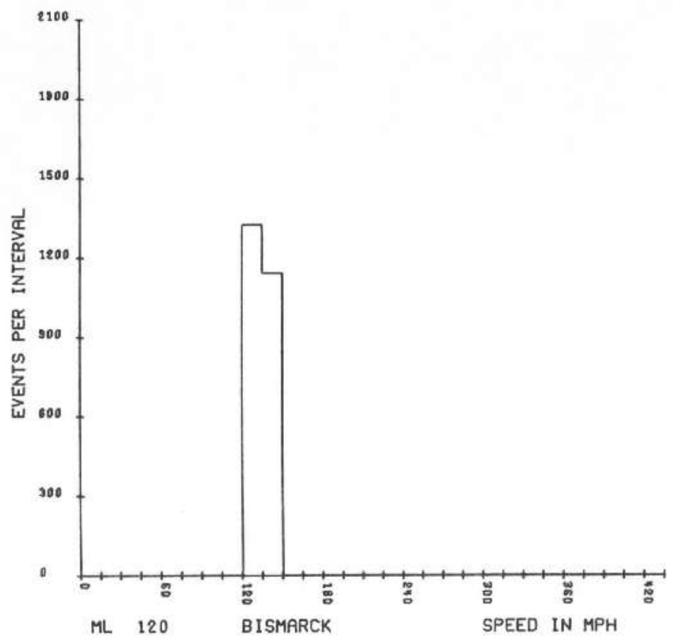
1

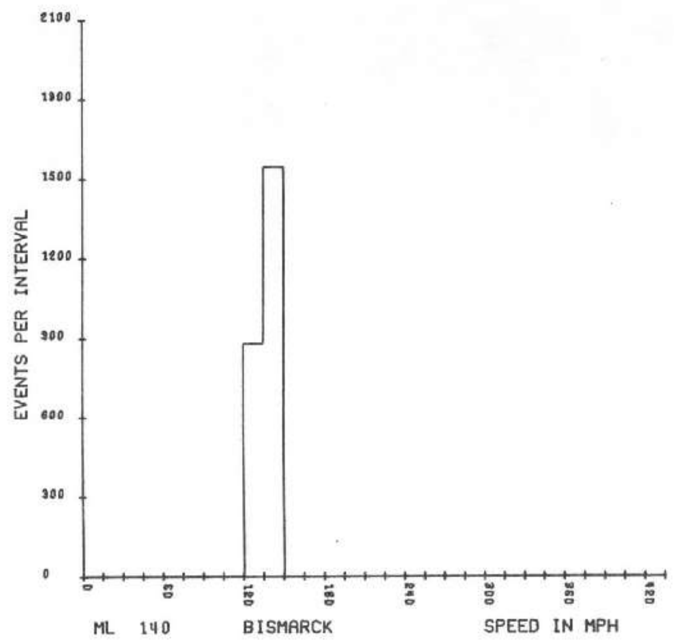
AI.E AVERAGE SPEED AND ALTITUDE DATA SUMMARY

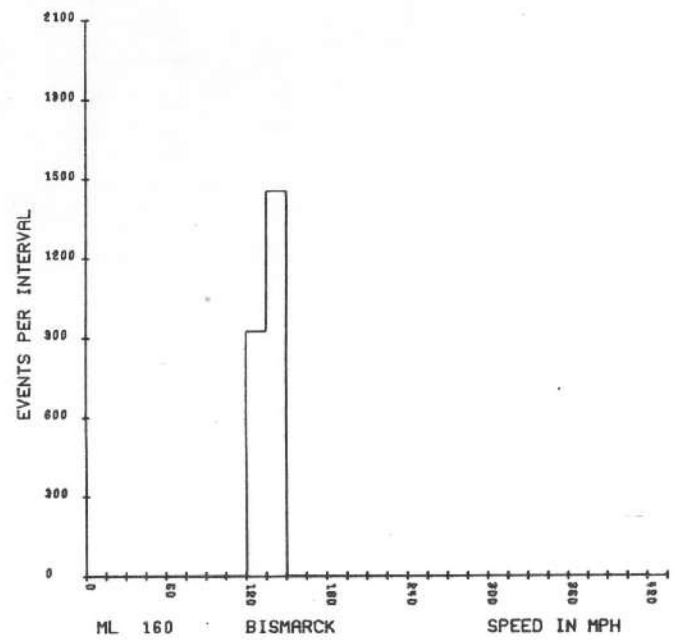
LINE	AVERAGE SPEED (MPH)	AVERAGE ALTITUDE (FEET)	LINE	AVERAGE SPEED (MPH)	AVERAGE ALTITUDE (FEET)
ML 20	143	389	ML 200	142	461
ML 40	144	407	ML 220	143	395
ML 60	147	391	ML 240	143	401
ML 80	144	404	TL 5020	147	389
ML 100	148	398	TL 5040	147	401
ML 120	142	400	TL 5060	144	472
ML 140	145	376	TL 5080	146	416
ML 160	144	410	TL 5100	146	398
ML 180	139	404	TL 5120	144	397

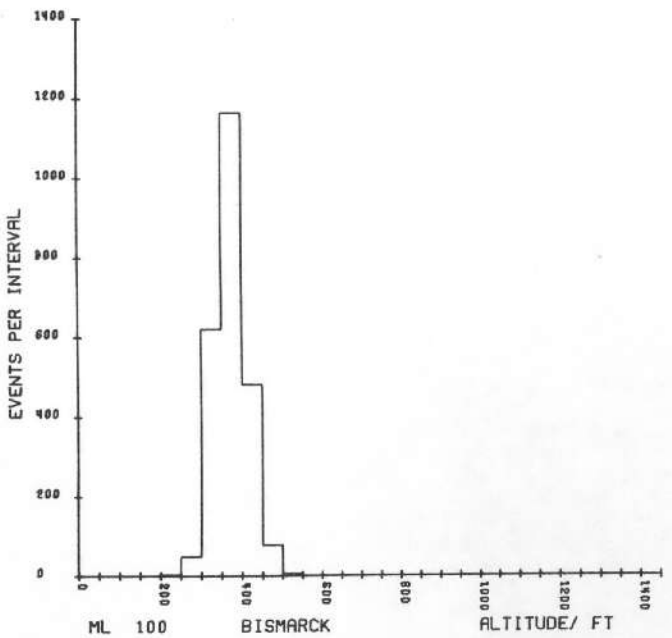

EVENTS PER INTERVAL
ML 20 BISMARCK SPEED IN MPH
ML 40 BISMARCK SPEED IN MPH
ML 60 BISMARCK SPEED IN MPH
ML 80 BISMARCK SPEED IN MPH
ML 20 BISMARCK ALTITUDE/ FT
ML 40 BISMARCK ALTITUDE/ FT
ML 60 BISMARCK ALTITUDE/ FT
ML 80 BISMARCK ALTITUDE/ FT

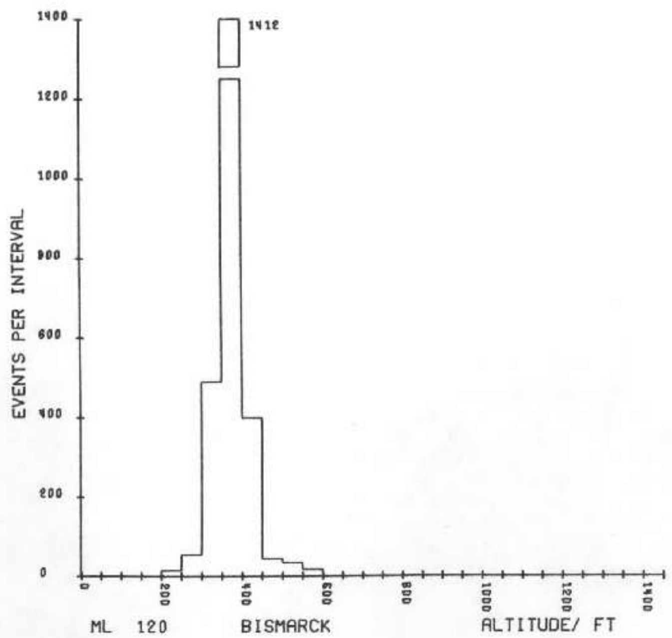

EVENTS PER INTERVAL
ML 100
BISMARCK
SPEED IN MPH

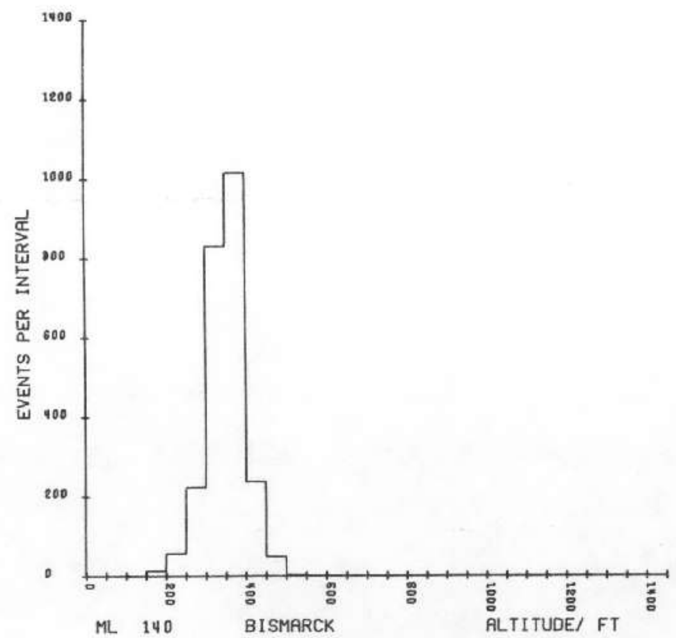

EVENTS PER INTERVAL
ML 120
BISMARCK
SPEED IN MPH

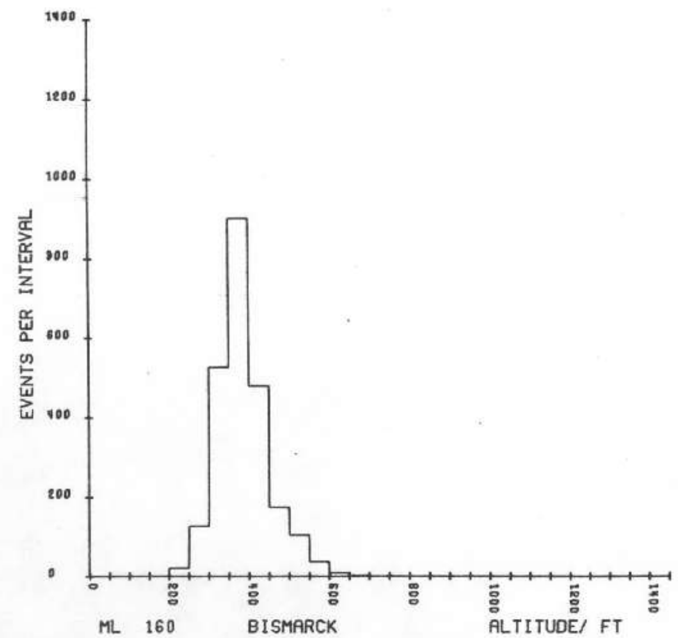

EVENTS PER INTERVAL
ML 140
BISMARCK
SPEED IN MPH

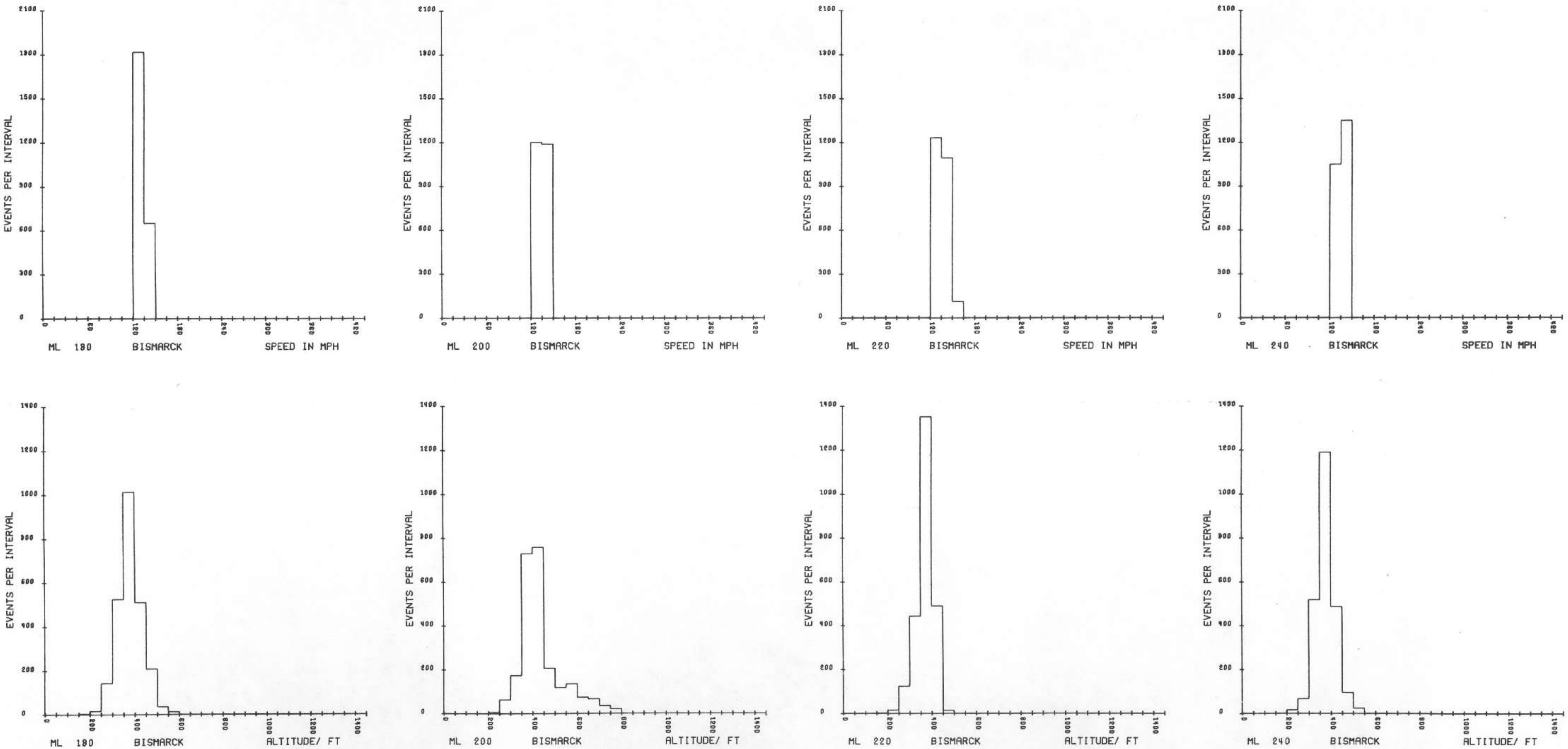

EVENTS PER INTERVAL
ML 160
BISMARCK
SPEED IN MPH

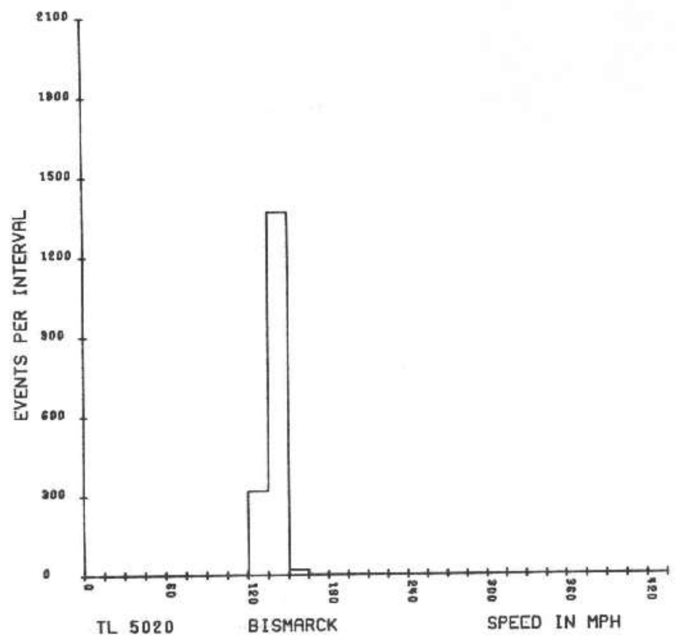

EVENTS PER INTERVAL
ML 100
BISMARCK
ALTITUDE/ FT

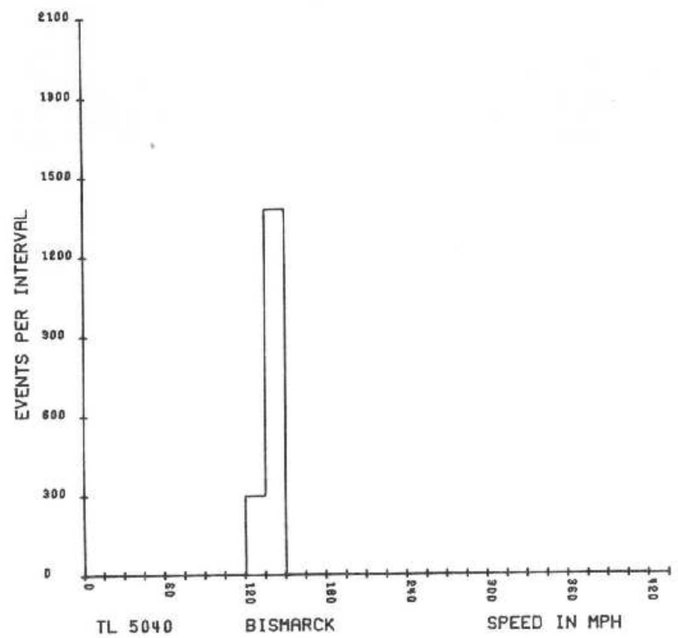

1412
EVENTS PER INTERVAL
ML 120
BISMARCK
ALTITUDE/ FT

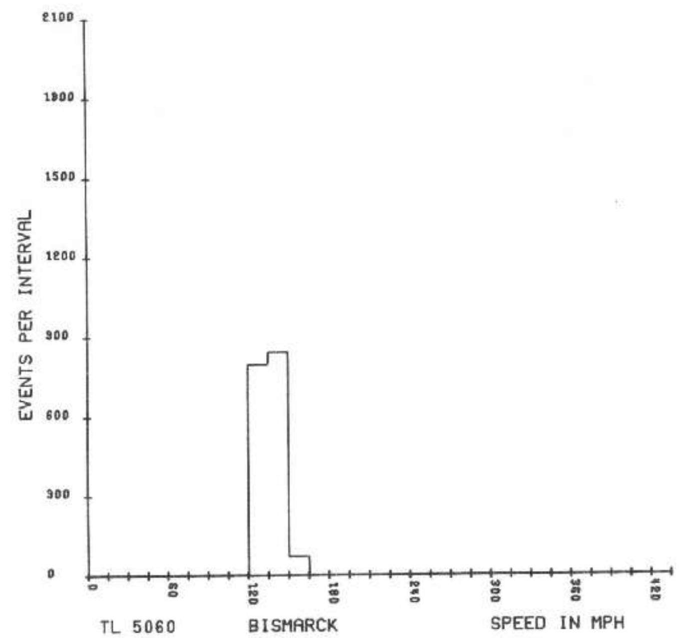

EVENTS PER INTERVAL
ML 140
BISMARCK
ALTITUDE/ FT

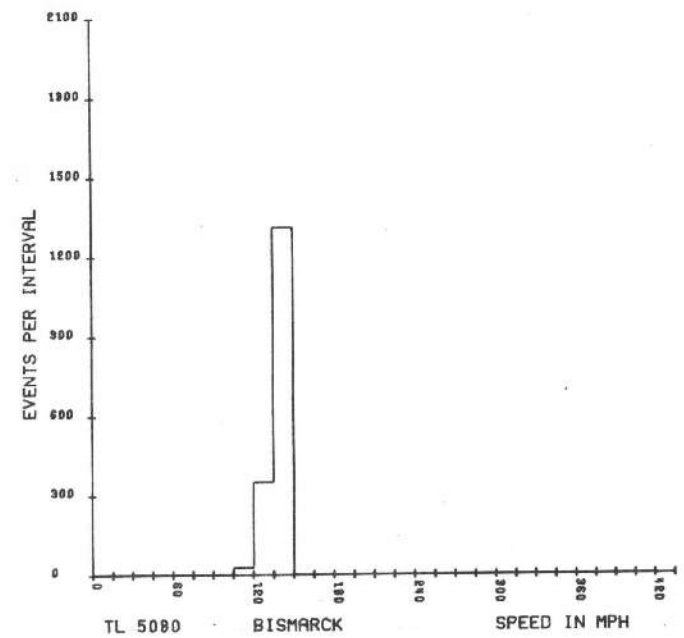

EVENTS PER INTERVAL
ML 160
BISMARCK
ALTITUDE/ FT

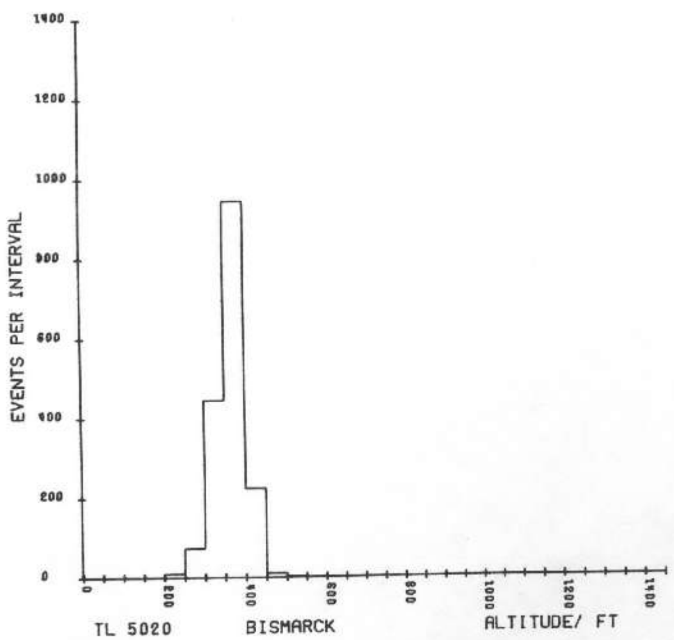

EVENTS PER INTERVAL
ML 180 BISMARCK SPEED IN MPH
ML 200 BISMARCK SPEED IN MPH
ML 220 BISMARCK SPEED IN MPH
ML 240 BISMARCK SPEED IN MPH
ML 180 BISMARCK ALTITUDE/ FT
ML 200 BISMARCK ALTITUDE/ FT
ML 220 BISMARCK ALTITUDE/ FT
ML 240 BISMARCK ALTITUDE/ FT

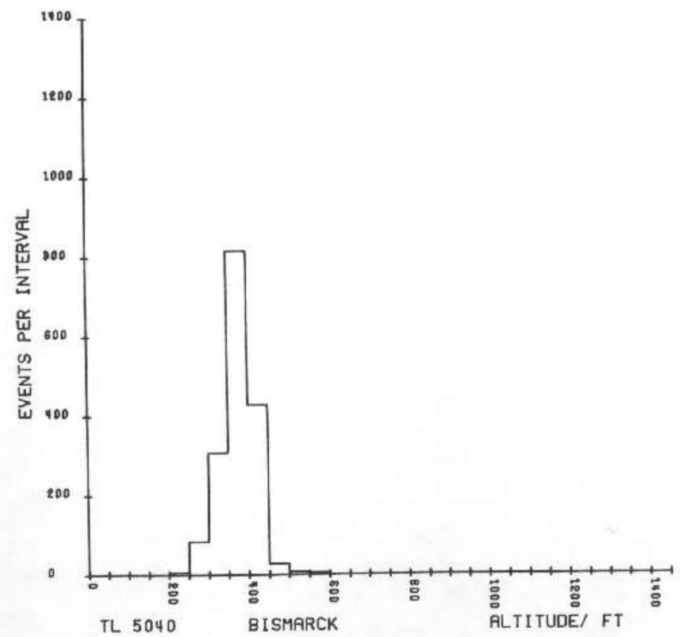

EVENTS PER INTERVAL
TL 5020
BISMARCK
SPEED IN MPH

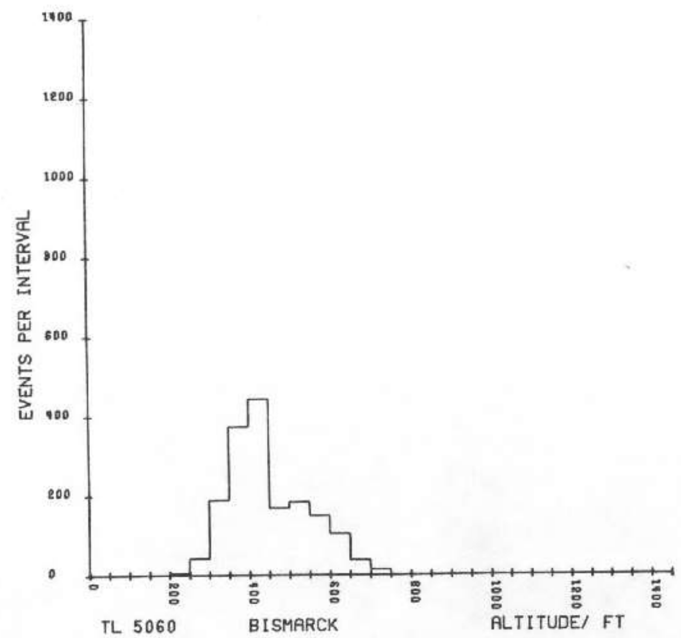

EVENTS PER INTERVAL
TL 5040
BISMARCK
SPEED IN MPH

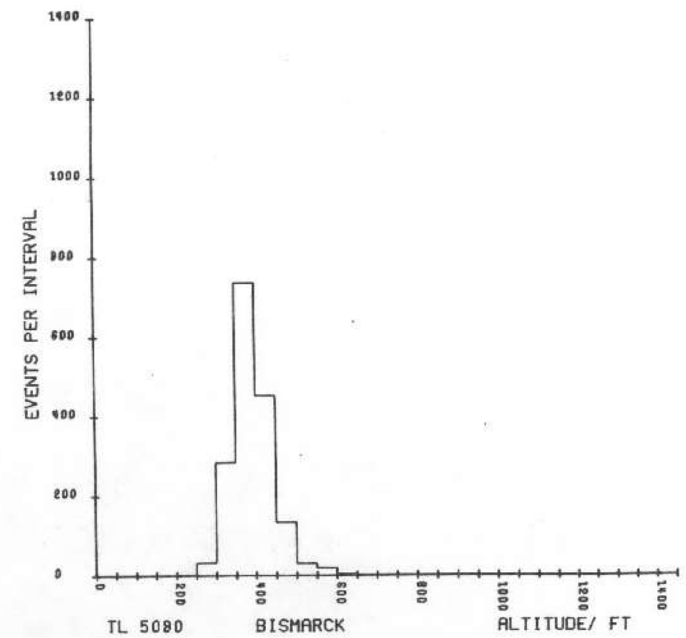

EVENTS PER INTERVAL
TL 5060
BISMARCK
SPEED IN MPH

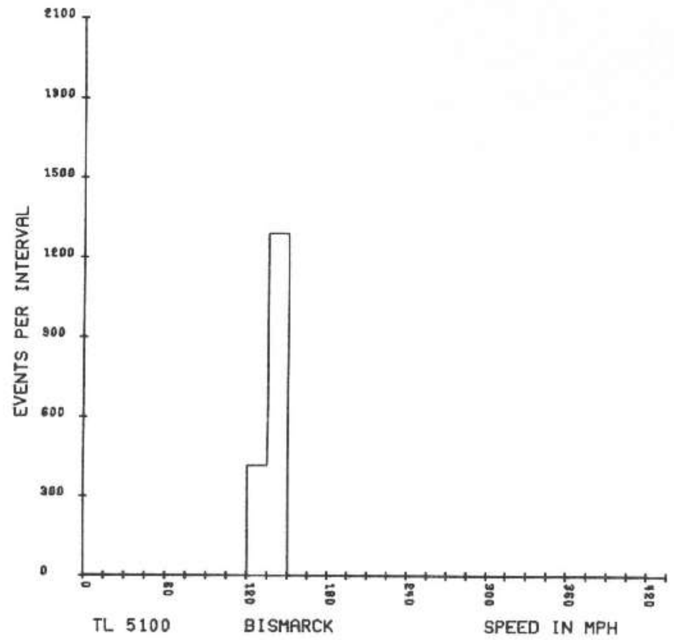

EVENTS PER INTERVAL
TL 5080
BISMARCK
SPEED IN MPH

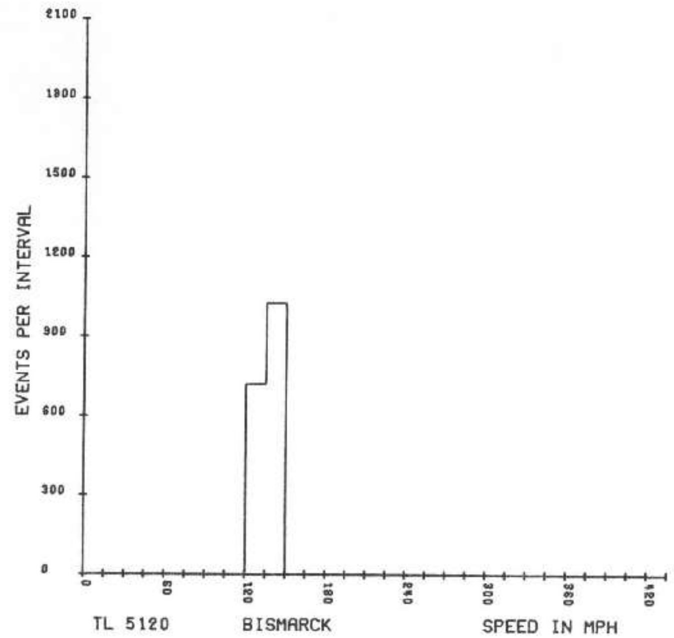

EVENTS PER INTERVAL
TL 5020
BISMARCK
ALTITUDE/ FT

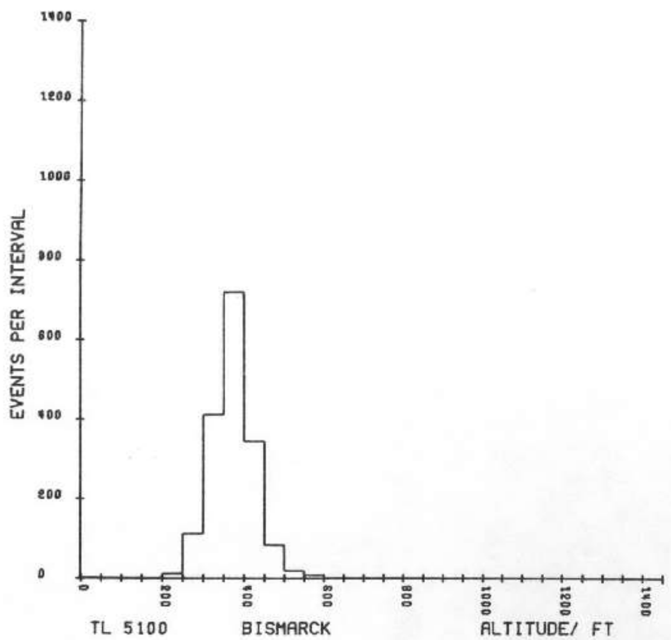

EVENTS PER INTERVAL
TL 5040
BISMARCK
ALTITUDE/ FT

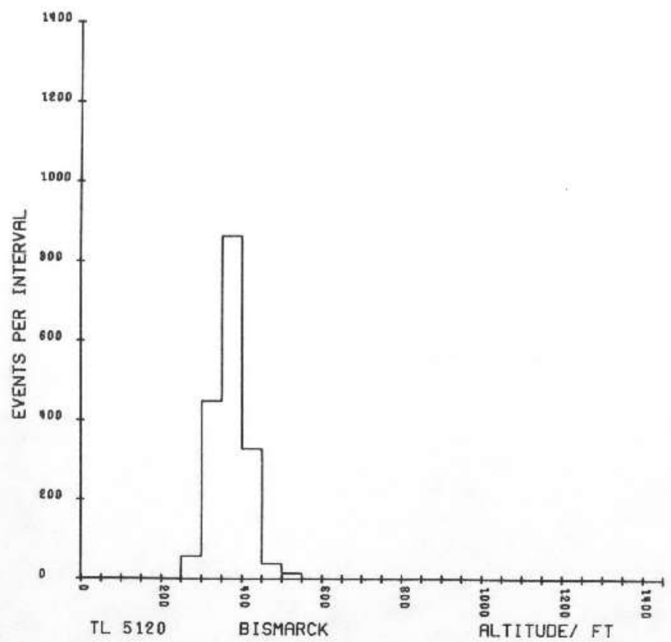

EVENTS PER INTERVAL
TL 5060
BISMARCK
ALTITUDE/ FT


EVENTS PER INTERVAL
TL 5080
BISMARCK
ALTITUDE/ FT


EVENTS PER INTERVAL
TL 5100
BISMARCK
SPEED IN MPH


EVENTS PER INTERVAL
TL 5120
BISMARCK
SPEED IN MPH


EVENTS PER INTERVAL
TL 5100
BISMARCK
ALTITUDE/ FT


EVENTS PER INTERVAL
TL 5120
BISMARCK
ALTITUDE/ FT

APPENDIX II

TAPE FORMAT STATEMENTS

A. DESCRIPTION OF DATA TAPES

A1. General

All data tapes are 9-track, 800 BPI (NRZI), odd parity, EBCDIC code. Each tape contains a gum label giving the survey project name, month and year of survey, tape type, subcontractor name, date tape created, tape reel count, tape recording characteristics, block size in Bytes and location of tape format information.

The general description for each of the tape types is as follows:

Block Number	Description
1	Format Description
2	Tape Identification
3	First Data Block
4	Second Data Block
.	.
.	.
.	Last Data Block
EOF	

A2. Raw Spectral Data Tapes

Block Size (Physical Record): 6600 characters
Logical Record, Data : 1100 characters

1. Format Description Block (Block 1)

The Format Description utilizes 4248 characters. The remaining 2352 characters of this block are blanks.

```
Line                           Character Number
Number  12345678901234567890123456789012345678901234567890123456789012

1       01 0978  (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2
3       RAW SPECTRAL DATA TAPE
4
5       FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK ON TAPE)
6
7       ITEM   FORMAT    DESCRIPTION
8       1      A40       QUADRANGLE NAME AS PROJECT IDENTIFICATION
9       2      A20       NAME OF SUBCONTRACTOR
10      3      I4        APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
```

Line Number	Character Number 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012		
11	4	I1	AERIAL SYSTEM IDENTIFICATION CODE
12	5	A20	AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER
13	6	I3	BFEC CALIBRATION REPORT NUMBER
14	7	F6.3	4PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
15			PLACES IN SECONDS
16	8	F6.3	2PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
17			PLACES IN SECONDS
18	9	I3	NUMBER OF CHANNELS (0-3 MEV) FOR 4PI SYSTEM
19	10	I3	NUMBER OF CHANNELS (0-3 MEV) FOR 2PI SYSTEM
20	11	I3	NUMBER OF FLIGHT LINES ON THIS TAPE
21	12	I4	FIRST FLIGHT LINE NUMBER ON THIS TAPE
22	13	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE
23	14	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE WAS
24			COLLECTED
25	15-17	I4,I6,I3	REPEAT OF ITEMS 12-14 FOR SECOND FLIGHT LINE ON THIS
26			TAPE
27	*	*	*
28	*	*	*
29	*	*	*
30	306-308	I4,I6,I3	REPEAT OF ITEMS 12-14 FOR 99TH FLIGHT LINE ON THIS
31			TAPE
32			
33	FORMAT FOR RAW SPECTRAL DATA RECORD (THIRD THRU LAST BLOCK ON TAPE)		
34			
35	ITEM	FORMAT	DESCRIPTION
36	1	I1	AERIAL SYSTEM IDENTIFICATION CODE
37	2	I4	FLIGHT LINE NUMBER
38	3	I6	RECORD IDENTIFICATION NUMBER
39	4	I6	GMT TIME OF DAY (HHMMSS)
40	5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
41	6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
42	7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
43	8	F7.1	TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE
44			IN GAMMAS
45	9	A8	SURFACE GEOLOGIC MAP UNIT CODE
46	10	I4	QUALITY FLAG CODES
47	11	F4.1	OUTSIDE AIR TEMPERATURE TO ONE DECIMAL PLACE IN
48			DEGREES CELSIUS
49	12	F5.1	OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
50	13	F5.3	LIVE TIME COUNTING PERIOD TO THREE DECIMAL PLACES IN
51			SECONDS
52	14	I4	SUMMED RAW OUTPUT FROM COSMIC CHANNELS (3-6 MEV) IN
53			COUNTS
54	15	I4	RAW OUTPUT FROM CHANNEL 1 IN COUNTS
55	16	I4	RAW OUTPUT FROM CHANNEL 2 IN COUNTS
56	*	*	*
57	*	*	*
58	*	*	*
59	270	I4	RAW OUTPUT FROM CHANNEL 256 IN COUNTS
-	-	-	2352 BLANK CHARACTERS

2. <u>Tape Identification Block (Block 2)</u>

The information and format for this block are indicated in lines 8 through 30 of the Format Description Block A2.1, and 1396 characters are produced. The remaining 5204 characters in this block are blanks.

If fewer than 99 flight lines exist, the unused flight line information, 13 characters per flight line, is filled with 9's through the 99th flight line.

3. <u>Raw Spectral Data Blocks</u>

The information and format for the logical records in these blocks are indicated in lines 36 through 59 of the Format Description Block A2.1. One logical record contains 1100 characters. There are six such logical records per 6600 character physical record or block.

The 2π data logical record is recorded after the corresponding 4π data collection intervals at a frequency dependent on the 2π system data collection interval. For example, if the 4π data collection interval is 1 second and the 2π data collection interval is 10 seconds, then 10 records of 4π data are recorded followed by 1 record of the 2π data which was collected during the preceding 10 seconds. The format for the 2π data is identical to that of the 4π data, except for lines 40 through 49 of the Format Description Block given above. These variables are expressed in the 2π record as all nines in the format specified for I and F fields, and all zeros for A fields.

A3. <u>Single Record Reduced Data Tapes</u>

Block Size (Physical Record): 6900 characters
Logical Record, Data : 138 characters

1. <u>Format Description Block (Block 1)</u>

The Format Description utilizes 6768 characters. The remaining 132 characters of this block are blanks.

Line Number	Character Number 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
1	02 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2	
3	SINGLE RECORD REDUCED DATA TAPE
4	
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)
6	

Line Number	Character Number 123456789012345678901234567890123456789012345678901234567890123456789012		
7	ITEM	FORMAT	DESCRIPTION
8	1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20	NAME OF SUBCONTRACTOR
10	3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I1	NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR
12			THIS QUADRANGLE
13	5	I1	AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM
14	6	A20	AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR
15			FIRST SYSTEM
16	7	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO
17			TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE
18			IN CPS PER PERCENT K FOR FIRST SYSTEM
19	8	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO
20			TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE
21			IN CPS PER PPM EQUIVALENT U
22	9	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO
23			TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE
24			IN CPS PER PPM EQUIVALENT TH
25	10	I6	BLANK FIELD (999999)
26	11	F6.3	4PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
27			PLACES IN SECONDS FOR FIRST SYSTEM
28	12	F6.3	2PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
29			PLACES IN SECONDS FOR FIRST SYSTEM
30	13	I3	NUMBER OF CHANNELS (0-3 MEV) IN 4PI SYSTEM FOR FIRST
31			AERIAL SYSTEM
32	14	I3	NUMBER OF CHANNELS (0-3 MEV) IN 2PI SYSTEM FOR FIRST
33			AERIAL SYSTEM
34	15-24	(SAME)	REPEAT OF ITEMS 5-14 FOR SECOND AERIAL SYSTEM
35	*	*	*
36	*	*	*
37	*	*	*
38	85-94	(SAME)	REPEAT OF ITEMS 5-14 FOR NINTH AERIAL SYSTEM
39	95	I3	NUMBER OF FLIGHT LINES ON THIS TAPE
40	96	I4	FIRST FLIGHT LINE NUMBER ON THIS TAPE
41	97	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE
42	98	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT-LINE DATA WAS
43			COLLECTED
44	99-101	I4,I6,I3	REPEAT OF ITEMS 96-98 FOR SECOND FLIGHT LINE ON THIS
45			TAPE
46	*	*	*
47	*	*	*
48	*	*	*
49	390-392	I4,I6,I3	REPEAT OF ITEMS 96-98 FOR 99TH FLIGHT LINE ON THIS
50			TAPE
51			
52	FORMAT FOR SINGLE RECORD REDUCED DATA RECORD (THIRD THRU LAST BLOCK)		
53			
54	ITEM	FORMAT	DESCRIPTION
55	1	I1	AERIAL SYSTEM IDENTIFICATION CODE
56	2	I4	FLIGHT LINE NUMBER
57	3	I6	RECORD IDENTIFICATION NUMBER
58	4	I6	GMT TIME OF DAY (HHMMSS)
59	5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES

Line Number	Character Number 123456789012345678901234567890123456789012345678901234567890123456789012		
60	6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
61	7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
62	8	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY
63			TO ONE DECIMAL PLACE IN GAMMAS
64	9	A8	SURFACE GEOLOGIC MAP UNIT CODE
65	10	I4	QUALITY FLAG CODES
66	11	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL POTASSIUM
67			(K-40) TO ONE DECIMAL PLACE IN PERCENT K
68	12	F4.1	UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL
69			PLACE IN PERCENT K
70	13	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL URANIUM
71			(BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
72	14	F4.1	UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL
73			PLACE IN PPM EQUIVALENT U
74	15	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL THORIUM
75			(TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
76	16	F4.1	UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL
77			PLACE IN PPM EQUIVALENT TH
78	17	F6.1	URANIUM-TO-THORIUM RATIO TO ONE DECIMAL PLACE IN
79			PPM EQUIVALENT U PER PPM EQUIVALENT TH
80	18	F6.1	URANIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN
81			PPM EQUIVALENT U PER PERCENT K
82	19	F6.1	THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN
83			PPM EQUIVALENT TH PER PERCENT K
84	20	F8.1	GROSS GAMMA (0.4-3.0 MEV) COUNT RATE TO ONE DECIMAL
85			PLACE IN COUNTS PER SECOND
86	21	F6.1	UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL
87			PLACE IN COUNTS PER SECOND
88	22	F5.1	ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL
89			PLACE IN PPM EQUIVALENT U
90	23	F4.1	UNCERTAINTY IN ATMOSPHERIC BI-214 4PI CORRECTION
91			TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
92	24	F4.1	OUTSIDE AIR TEMPERATURE TO ONE DECIMAL PLACE IN
93			DEGREES CELSIUS
94	25	F5.1	OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 49 of the Format Description Block A3.1, and 1922 characters are produced. The remaining 4978 characters of this block are blanks.

If less than nine aerial systems are used, the space allocated for additional systems is filled with 9's in the format specified for each item using I and F fields, and with zeros for A fields.

Similarly, if fewer than 99 flight lines exist, the unused flight line information, 13 characters per flight line, is filled with 9's through the 99th flight line.

3. <u>Single Record Reduced Data Blocks</u>

The information and format for the logical records in these blocks are indicated in lines 55 through 94 of the Format Description Block A3.1. One logical record contains 138 characters. There are 50 such logical records per 6900 character physical record or block.

The data appearing in locations specified by lines 68, 72, 76, 86 and 90 of the Format Description Block A3.1 are 9's in the format specified in each case.

A4. Statistical Analysis Data Tapes

Block Size (Physical Record): 8000 characters
Logical Record, Data : 160 characters

1. Format Description Block (Block 1)

The Format Description utilizes 7560 characters. The remaining 440 characters are blanks.

Line Number	Character Number 123456789012345678901234567890123456789012345678901234567890123456789012		
1	03 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)		
2			
3	STATISTICAL ANALYSIS DATA TAPE		
4			
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)		
6			
7	ITEM	FORMAT	DESCRIPTION
8	1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20	NAME OF SUBCONTRACTOR
10	3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I1	NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR
12			THIS QUADRANGLE
13	5	I1	AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM
14	6	A20	AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR
15			FIRST SYSTEM
16	7	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO
17			TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE
18			IN CPS PER PERCENT K
19	8	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO
20			TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE
21			IN CPS PER PPM EQUIVALENT U
22	9	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO
23			TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE
24			IN CPS PER PPM EQUIVALENT TH
25	10	I6	BLANK FIELD (999999)
26	11	F6.3	4PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
27			PLACES IN SECONDS FOR FIRST SYSTEM
28	12	F6.3	2PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
29			PLACES IN SECONDS FOR FIRST SYSTEM

Line Number	Character Number 123456789012345678901234567890123456789012345678901234567890123456789012		
30	13	I3	NUMBER OF CHANNELS (0-3 MEV) IN 4PI SYSTEM FOR FIRST
31			AERIAL SYSTEM
32	14	I3	NUMBER OF CHANNELS (0-3 MEV) IN 2PI SYSTEM FOR FIRST
33			AERIAL SYSTEM
34	15-24	(SAME)	REPEAT OF ITEMS 5-14 FOR SECOND AERIAL SYSTEM
35	*	*	*
36	*	*	*
37	*	*	*
38	85-94	(SAME)	REPEAT OF ITEMS 5-14 FOR NINTH AERIAL SYSTEM
39	95	I3	NUMBER OF FLIGHT LINES ON THIS TAPE
40	96	I4	FIRST FLIGHT LINE NUMBER ON THIS TAPE
41	97	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE
42	98	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE DATA WAS
43			COLLECTED
44	99-101	I4,I6,I3	REPEAT OF ITEMS 96-98 FOR SECOND FLIGHT LINE ON THIS
45			TAPE
46	*	*	*
47	*	*	*
48	*	*	*
49	390-392	I4,I6,I3	REPEAT OF ITEMS 96-98 FOR 99TH FLIGHT LINE ON THIS
50			TAPE
51			
52	FORMAT FOR STATISTICAL ANALYSIS DATA RECORD (THIRD THRU LAST BLOCK)		
53			
54	ITEM	FORMAT	DESCRIPTION
55	1	I1	AERIAL SYSTEM IDENTIFICATION CODE
56	2	I4	FLIGHT LINE NUMBER
57	3	I6	RECORD IDENTIFICATION NUMBER
58	4	I6	GMT TIME OF DAY (HHMMSS)
59	5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
60	6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
61	7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
62	8	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY
63			TO ONE DECIMAL PLACE IN GAMMAS
64	9	A8	SURFACE GEOLOGIC MAP UNIT CODE
65	10	I5	QUALITY FLAG CODES
66	11	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL POTASSIUM
67			(K-40) TO ONE DECIMAL PLACE IN PERCENT K
68	12	F4.1	UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL
69			PLACE IN PERCENT K
70	13	F5.1	POTASSIUM STANDARD DEVIATION FROM THE MEAN TO ONE
71			DECIMAL PLACE AND ALGEBRAICALLY SIGNED
72	14	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL URANIUM
73			(BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
74	15	F4.1	UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL
75			PLACE IN PPM EQUIVALENT U
76	16	F5.1	URANIUM STANDARD DEVIATION FROM THE MEAN TO ONE
77			DECIMAL PLACE AND ALGEBRAICALLY SIGNED
78	17	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL THORIUM
79			(TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
80	18	F4.1	UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL
81			PLACE IN PPM EQUIVALENT TH

Line Number	Character Number 12345678901234567890123456789012345678901234567890123456789012345678901 2		
82	19	F5.1	THORIUM STANDARD DEVIATION FROM THE MEAN TO ONE
83			DECIMAL PLACE AND ALGEBRAICALLY SIGNED
84	20	F8.1	GROSS GAMMA (0.4-3.0 MEV) COUNT RATE TO ONE DECIMAL
85			PLACE IN COUNTS PER SECOND
86	21	F6.1	UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL
87			PLACE IN COUNTS PER SECOND
88	22	F5.1	ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL
89			PLACE IN PPM EQUIVALENT U
90	23	F4.1	UNCERTAINTY IN ATMOSPHERIC BI-214 4PI CORRECTION
91			TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
92	24	F6.1	AVERAGED URANIUM-TO-THORIUM RATIO TO ONE DECIMAL
93			PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
94	25	F5.1	URANIUM-TO-THORIUM RATIO STANDARD DEVIATION FROM THE
95			MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
96	26	F6.1	AVERAGED URANIUM-TO-POTASSIUM RATIO TO ONE DECIMAL
97			PLACE IN PPM EQUIVALENT U PER PERCENT K
98	27	F5.1	URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM
99			THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
100			SIGNED
101	28	F6.1	AVERAGED THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL
102			PLACE IN PPM EQUIVALENT TH PER PERCENT K
103	29	F5.1	THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM
104			THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY
105			SIGNED

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 49 of the Format Description Block A4.1, and 1922 characters are produced. The remaining 6078 characters of this block are blanks.

If less than nine aerial systems are used, the space allocated for additional systems is filled with 9's in the format specified for each item using I and F fields, and with zeros for A fields.

Similarly, if fewer than 99 flight lines exist, the unused flight line information, 13 characters per flight line, is filled with 9's through the 99th flight line.

3. Statistical Analysis Data Blocks

The information and format for the logical records in these blocks are indicated in lines 55 through 103 of the Format Description Block A4.1. One logical record contains 160 characters. There are 50 such logical records per 8000 character physical record or block.

The data appearing in locations specified by lines 68, 74, 80, 86 and 90 of the Format Description Block A4.1 are 9's in the format specified in each case.

File 2: Statistical Analysis Summary

Block Size (Physical Record): 7000 characters
Logical Record (Data) : 140 characters

1. Format Description Block (Block 1)

The Format Description utilizes 4320 characters. The remaining 2680 characters are blanks.

Line Number Number	Character Number 12345678901234567890123456789012345678901234567890123456789012345678901 2		
1	05	0978	(DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODE)
2			
3	STATISTICAL ANALYSIS SUMMARY TAPE (OR FILE)		
4			
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)		
6			
7	ITEM	FORMAT	DESCRIPTION
8	1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20	NAME OF SUBCONTRACTOR
10	3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I6	NUMBER OF GEOLOGIC MAP UNITS USED FOR THIS
12			QUADRANGLE
13			
14	FORMAT FOR STATISTICAL ANALYSIS SUMMARY DATA RECORD (THIRD THRU LAST		
15	BLOCK)		
16			
17	ITEM	FORMAT	DESCRIPTION
18	1	A8	SURFACE GEOLOGIC MAP UNIT IDENTIFYING CODE
19	2	I6	TOTAL RECORDS FOR GEOLOGIC MAP UNIT
20	3	I6	NUMBER OF POTASSIUM RECORDS COMPUTED FOR GEOLOGIC
21			UNIT
22	4	F6.1	POTASSIUM CONCENTRATION MEAN TO ONE DECIMAL
23			PLACE IN PERCENT K
24	5	F6.1	POTASSIUM CONCENTRATION STANDARD DEVIATION TO ONE
25			DECIMAL PLACE IN PERCENT K
26	6	A3	POTASSIUM CONCENTRATION DISTRIBUTION CODE
27	7	I6	NUMBER OF URANIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
28	8	F6.1	URANIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE
29			IN PPM EQUIVALENT U
30	9	F6.1	URANIUM CONCENTRATION STANDARD DEVIATION TO ONE
31			DECIMAL PLACE IN PPM EQUIVALENT U
32	10	A3	URANIUM CONCENTRATION DISTRIBUTION CODE
33	11	I6	NUMBER OF THORIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
34	12	F6.1	THORIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE IN
35			PPM EQUIVALENT TH
36	13	F6.1	THORIUM CONCENTRATION STANDARD DEVIATION TO ONE
37			DECIMAL PLACE IN PPM EQUIVALENT TH

Line Number	Character Number 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012		
38	14	A3	THORIUM CONCENTRATION DISTRIBUTION CODE
39	15	I6	NUMBER OF URANIUM-TO-THORIUM RATIO RECORDS COMPUTER
40			FOR GEOLOGIC UNIT
41	16	F6.1	URANIUM-TO-THORIUM RATIO MEAN TO ONE DECIMAL PLACE
42			IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
43	17	F6.1	URANIUM-TO-THORIUM RATIO STANDARD DEVIATION TO ONE
44			DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT
45			TH
46	18	A3	URANIUM-TO-THORIUM RATIO DISTRIBUTION CODE
47	19	I6	NUMBER OF URANIUM-TO-POTASSIUM RATIO RECORDS
48			COMPUTED FOR GEOLOGIC UNIT
49	20	F6.1	URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE
50			IN PPM EQUIVALENT U PER PERCENT K
51	21	F6.1	URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE
52			DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
53	22	A3	URANIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE
54	23	I6	NUMBER OF THORIUM-TO-POTASSIUM RATIO RECORDS
55			COMPUTED FOR GEOLOGIC UNIT
56	24	F6.1	THORIUM-TO-POTASSIUM RATIO MEAN TO ONE DECIMAL PLACE
57			IN PPM EQUIVALENT TH PER PERCENT K
58	25	F6.1	THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE
59			DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
60	26	A3	THORIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 11 of the Format Description Block A6.1, and 70 characters are produced. The remaining 6930 characters of this block are blanks.

3. Statistical Analysis Summary Data Blocks

The information and format for the logical records in these blocks are indicated in lines 18 through 60 of the Format Description Block A6.1. One logical record contains 140 characters. There are 50 such logical records per 7000 character physical record or block.

A5. Magnetic Data Tapes

Block Size (Physical Record): 8000 characters
Logical Record (Data) : 80 characters

1. Format Description Block (Block 1)

The Format Description utilizes 3384 characters. The remaining 4616 characters are blanks.

Line Number	Character Number 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012		
1	04 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)		
2			
3	MAGNETIC DATA TAPE		
4			
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)		
6			
7	ITEM	FORMAT	DESCRIPTION
8	1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20	NAME OF SUBCONTRACTOR
10	3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I3	NUMBER OF FLIGHT LINES ON THIS TAPE
12	5	I4	FIRST FLIGHT LINE ON THIS TAPE
13	6	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE
14	7	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE DATA WAS
15			COLLECTED
16	8	F8.4	LATITUDE OF GROUND BASE STATION TO FOUR DECIMAL
17			PLACES IN DEGREES FOR FIRST FLIGHT LINE
18	9	F8.4	LONGITUDE OF GROUND BASE STATION TO FOUR DECIMAL
19			PLACES IN DEGREES FOR FIRST FLIGHT LINE
20	10-14	(SAME)	REPEAT OF ITEMS 5-9 FOR SECOND FLIGHT LINE ON THIS
21			TAPE
22	*	*	*
23	*	*	*
24	*	*	*
25	495-499	(SAME)	REPEAT OF ITEMS 5-9 FOR 99TH FLIGHT LINE ON THIS
26			TAPE
27			
28	FORMAT FOR MAGNETIC DATA RECORD (THIRD THRU LAST BLOCK)		
29			
30	ITEM	FORMAT	DESCRIPTION
31	1	I1	AERIAL SYSTEM IDENTIFICATION CODE
32	2	I4	FLIGHT LINE NUMBER
33	3	I6	RECORD IDENTIFICATION NUMBER
34	4	I6	GMT TIME OF DAY (HHMMSS)
35	5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
36	6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
37	7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
38	8	F5.1	OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
39	9	A8	SURFACE GEOLOGIC MAP UNIT CODE
40	10	F7.1	TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE
41			IN GAMMAS
42	11	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY
43			TO ONE DECIMAL PLACE IN GAMMAS
44	12	F7.1	DIURNAL MAGNETIC INTENSITY VARIATION TO ONE DECIMAL
45			PLACE IN GAMMAS
46	13	F7.1	MAGNETIC DEPTH-TO-BASEMENT TO ONE DECIMAL PLACE
47			IN METERS (IF REQUIRED)

2. Tape Identification Block (Block 2)

The information and format for this block are indicated in lines 8 through 25 of the Format Description Block A5.1, and 2938 characters are produced. The remaining 5062 characters of this block are blanks.

If fewer than 99 flight lines exist, the unused flight line information, 29 characters per flight line, is filled with 9's through the 99th flight line in the format indicated.

3. Magnetic Data Blocks

The information and format for the logical records in these blocks are indicated in lines 31 through 46 of the Format Description Block A5.1. One logical record contains 80 characters. There are 100 such logical records per 8000 character physical record or block.

If the magnetic depth-to-basement is not required, this item is expressed as 99999.9.

B. DESCRIPTION OF LISTINGS

B1. Single record reduced data listings: include the following information on Microfiche:

ITEM	DESCRIPTION
REC	Sequential record number
Lat	Location Y in latitude
Long	Location X in longitude
RMag	Residual magnetic field, gammas
Alt	Surface altitude
GEO UNIT	Geologic Type
AKUT	A=Altitude; K=Potassium; U=Uranium T=Thorium - Results of statistical adequacy test
COS	Cosmic c/s
BIAIR	Airborne ^{214}Bi, 4π data, c/s
GC	Gross count, .4 MeV - 2.8 MeV
eTh	ppm
eU	ppm
K	%
eU:eTh	Ratio
eU:K	Ratio
eTh:K	Ratio
TEMP	Outside Air Temperature (^{o}C)
BP	Atmospheric Pressure (mm Hg)

B2. Averaged record data listings: include the following information on Microfiche:

ITEM	DESCRIPTION
REC	Sequential Record number
GEO UNIT	Geologic type
AKUT	A=Altitude; K=Potassium; U=Uranium; T=Thorium - Results of statistical adequacy test
Long	Longitude of X location of geologic type
Lat	latitude of Y location of geologic type
RMag	Residual magnetic field, gammas
COS	Cosmic, 4π
BIAIR	Atmospheric Bi, 4π, c/s
GC	Gross count, c/s

ITEM	DESCRIPTION
eTh	eTh value, ppm
Rank	eTh standard deviation rank
eU	eU value, ppm
Rank	eU standard deviation rank
K	K value, %
Rank	K standard deviation rank
eU/eTh	Ratio value
Rank	eU/eTh standard deviation rank
eU/K	Ratio value
Rank	eU/K standard deviation rank
eTh/K	Ratio value
Rank	eTh/K standard deviation rank

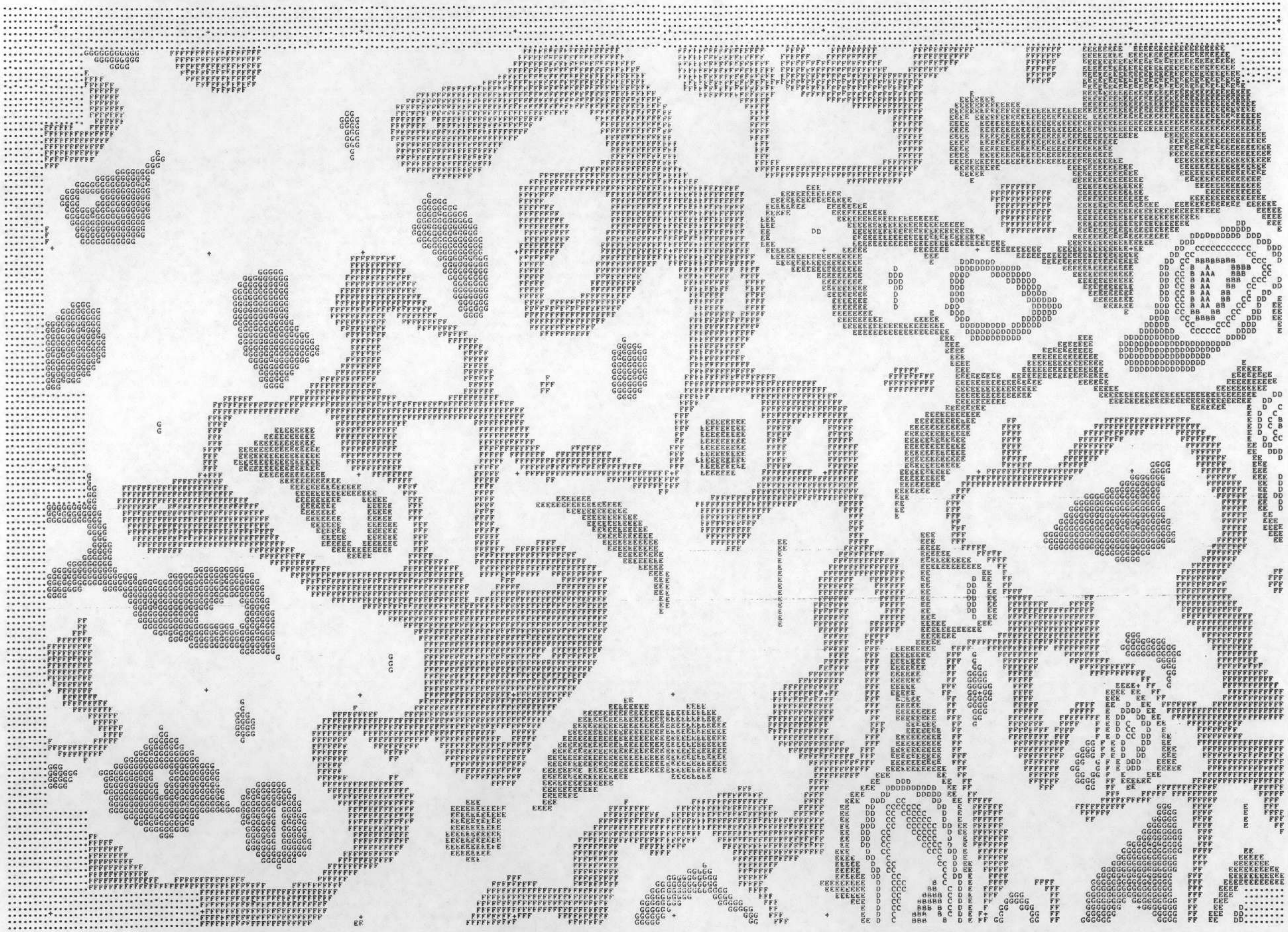
1GEODATA INT. INC. SINGLE REC LISTING 1980
BISMARCK NM 14-04 MAPLINE 240
1 BISMARCK MAPLINE 240

RCN	GEOUNIT	AKUT	LAT	LONG	RMAG	COS	GC	BIAIR	ALT	TEMP	BP	ETH	EU	K	EU/ETH	EU/K	ETH/K
3440	ZNA	0000	46.9798	102.0285	-301.7	40	2097	10.1	390	28.8	690.9	7.0	3.0	1.2	0.43	2.48	5.71
3441	ZNA	0010	46.9799	102.0276	-243.8	13	232	10.1	-61	28.9	685.3	1.3	0.1	0.1	0.12	1.45	12.34
3442	ZNA	0000	46.9799	102.0267	-241.9	40	2185	10.1	322	28.7	684.8	6.6	1.9	1.4	0.29	1.40	4.77
3443	ZNA	0000	46.9799	102.0259	-241.5	45	2242	10.1	311	28.7	683.8	6.6	3.8	1.2	0.59	3.22	5.51
3444	ZNA	0000	46.9799	102.0250	-241.5	40	2319	10.1	301	28.8	685.3	7.8	3.3	1.2	0.42	2.68	6.45
3445	ZNA	0000	46.9799	102.0242	-242.8	49	2334	10.1	300	28.8	684.3	8.3	2.9	1.2	0.35	2.40	6.86
3446	ZNA	0000	46.9799	102.0233	-242.2	45	2388	10.1	297	28.7	686.3	7.3	3.8	1.5	0.52	2.55	4.92
3447	ZNA	0000	46.9799	102.0224	-241.8	44	2518	10.1	312	28.7	683.8	9.4	3.4	1.5	0.36	2.22	6.13
3448	ZNA	0000	46.9799	102.0216	-241.4	35	2656	10.1	332	28.6	684.8	8.0	4.5	1.4	0.57	3.21	5.66
3449	ZNA	0000	46.9799	102.0207	-241.0	49	2462	10.1	347	28.6	683.3	8.5	3.4	1.4	0.40	2.40	6.02
3450	ZNA	0000	46.9799	102.0199	-240.8	46	2319	10.1	370	28.5	684.3	7.0	2.5	1.8	0.36	1.43	3.99
3451	ZNA	0000	46.9799	102.0190	-240.2	34	2555	10.1	380	28.4	683.3	9.1	3.7	1.7	0.41	2.15	5.27
3452	ZNA	0000	46.9799	102.0181	-238.8	40	2343	10.1	367	28.4	683.3	6.6	5.2	1.2	0.79	4.16	5.28
3453	ZNA	0000	46.9799	102.0173	-238.6	58	2362	10.1	365	28.4	684.3	7.6	2.4	1.3	0.31	1.89	6.02
3454	ZNA	0000	46.9799	102.0164	-238.2	48	2764	10.1	363	28.4	684.3	8.3	2.6	2.1	0.31	1.21	3.85
3455	ZNA	0000	46.9799	102.0155	-237.6	53	2646	10.1	352	28.4	682.8	9.5	1.8	1.8	0.19	1.04	5.33
3456	ZNA	0000	46.9799	102.0147	-237.2	53	2260	10.1	330	28.4	684.3	7.8	2.3	1.5	0.29	1.54	5.26
3457	ZNA	0000	46.9800	102.0138	-236.5	52	2537	10.1	317	28.4	684.3	6.7	3.5	1.9	0.52	1.79	3.46
3458	ZNA	0000	46.9800	102.0130	-235.9	47	2623	10.1	314	28.4	683.8	9.7	2.1	1.7	0.22	1.23	5.53
3459	ZNA	0000	46.9800	102.0121	-235.2	45	2343	10.1	325	28.4	683.8	6.9	3.5	1.4	0.51	2.47	4.87
3460	ZNA	0000	46.9800	102.0112	-234.8	63	2637	10.1	355	28.4	683.3	9.8	2.9	1.9	0.29	1.54	5.22
3461	ZNA	0000	46.9800	102.0104	-234.4	48	2405	10.1	399	28.4	683.3	6.4	1.5	2.1	0.23	0.70	3.05
3462	ZNA	0000	46.9800	102.0095	-233.8	67	2761	10.1	400	28.4	684.3	10.9	1.8	1.8	0.16	0.96	5.91
3463	ZNA	0000	46.9800	102.0086	-233.6	62	2551	10.1	364	28.4	683.3	9.4	2.7	1.6	0.29	1.77	6.05
3464	ZNA	0000	46.9800	102.0078	-232.2	64	2626	10.1	332	28.4	683.3	7.7	1.9	1.9	0.25	1.01	4.03
3465	ZNA	0000	46.9800	102.0069	-231.8	40	2601	10.1	309	28.4	683.8	9.8	2.4	1.8	0.24	1.31	5.42
3466	ZNA	0000	46.9800	102.0061	-231.4	53	2837	10.1	316	28.4	683.3	7.7	2.9	2.1	0.37	1.37	3.66
3467	ZNA	0000	46.9800	102.0052	-231.3	47	2312	25.9	304	28.4	682.8	6.4	1.3	1.8	0.21	0.76	3.67
3468	ZNA	0000	46.9800	102.0043	-231.0	34	2287	25.9	306	28.4	683.3	6.3	2.1	1.9	0.33	1.07	3.25
3469	ZNA	0000	46.9800	102.0035	-230.9	46	2726	25.9	310	28.4	682.8	9.7	3.9	1.7	0.41	2.37	5.84
3470	ZNA	0000	46.9800	102.0026	-231.2	42	2186	25.9	304	28.4	682.8	6.6	3.8	1.6	0.57	2.33	4.05
3471	ZNA	0000	46.9800	102.0017	-231.3	42	2402	25.9	320	28.4	680.7	7.7	1.2	1.8	0.15	0.67	4.39
3472	ZNA	0000	46.9800	102.0009	-231.4	50	2395	25.9	339	28.4	682.8	5.5	3.8	1.8	0.69	2.13	3.07
3473	TG	0000	46.9801	102.0000	-231.3	44	2510	25.9	340	28.4	682.3	8.1	2.1	1.8	0.26	1.17	4.60
3474	TG	0000	46.9801	101.9992	-231.6	48	2330	25.9	324	28.5	682.3	6.6	2.9	1.6	0.44	1.84	4.19
3475	TG	0000	46.9801	101.9983	-230.7	48	2523	25.9	315	28.6	682.3	11.7	1.1	2.0	0.09	0.56	5.88
3476	TG	0000	46.9801	101.9974	-230.8	40	2433	27.3	303	28.6	682.8	8.3	2.1	2.0	0.25	1.03	4.11
3477	TG	0000	46.9801	101.9966	-230.9	52	2212	27.3	297	28.7	682.3	5.0	2.1	1.7	0.43	1.27	2.99
3478	TG	0000	46.9801	101.9957	-231.0	50	2424	27.3	293	28.7	681.2	9.2	3.2	1.7	0.34	1.83	5.32
3479	TG	0000	46.9801	101.9948	-231.1	47	2187	27.3	284	28.7	682.8	8.1	2.2	1.5	0.27	1.44	5.27
3480	TG	0000	46.9801	101.9940	-231.2	51	2231	27.3	300	28.7	681.7	8.4	1.9	1.5	0.23	1.26	5.49
3481	TG	0000	46.9801	101.9931	-231.3	48	2206	27.3	322	28.7	681.7	8.1	1.7	1.7	0.21	0.98	4.65
3482	TG	0000	46.9801	101.9923	-231.7	39	2372	27.3	313	28.7	680.7	8.5	0.9	1.9	0.10	0.46	4.38
3483	TG	0000	46.9801	101.9914	-232.0	33	1937	27.3	332	28.6	681.7	8.4	1.8	1.2	0.22	1.50	6.80
3484	TG	0000	46.9801	101.9905	-232.6	57	2384	27.3	368	28.6	681.7	8.4	3.0	1.6	0.35	1.80	5.11
3485	TG	0000	46.9801	101.9897	-233.0	40	1944	25.5	362	28.5	683.3	6.6	1.6	1.5	0.25	1.06	4.36
3486	TG	0000	46.9801	101.9888	-233.8	52	2146	25.5	391	28.5	682.3	7.4	3.1	1.6	0.42	1.97	4.69
3487	TG	0000	46.9801	101.9880	-234.2	36	2223	25.5	405	28.5	681.2	7.4	2.4	1.6	0.33	1.50	4.54
3488	TG	0000	46.9801	101.9871	-234.8	40	2281	25.5	409	28.5	681.2	8.7	3.3	1.5	0.38	2.16	5.63
3489	TG	0000	46.9802	101.9862	-235.4	32	2217	25.5	402	28.5	681.2	7.3	2.8	1.7	0.39	1.65	4.27
3490	TG	0000	46.9802	101.9854	-236.0	39	2348	25.5	406	28.5	682.3	7.8	2.2	2.0	0.28	1.10	3.90
3491	TG	0000	46.9802	101.9845	-236.6	51	2323	25.5	396	28.5	681.2	7.4	2.1	1.9	0.28	1.10	3.93
3492	TG	0000	46.9802	101.9836	-236.8	51	2618	25.5	352	28.5	681.2	10.8	1.6	2.0	0.14	0.79	5.50
3493	TG	0000	46.9802	101.9828	-237.4	40	2253	25.5	336	28.5	682.8	10.2	1.7	1.4	0.17	1.19	7.15
3494	TG	0000	46.9802	101.9819	-238.0	56	2390	24.6	325	28.5	681.7	7.7	3.6	1.7	0.47	2.17	4.60
3495	TG	0000	46.9802	101.9811	-238.6	54	2468	24.6	317	28.5	682.3	8.7	1.1	1.8	0.13	0.63	4.94
3496	TG	0000	46.9802	101.9802	-239.2	55	2259	24.6	317	28.6	681.2	7.0	2.9	1.5	0.41	1.90	4.60

1GEODATA INT. INC. AVERAGE REC LISTING 1980
BISMARCK NM 14-04 MAPLINE 240
1 BISMARCK MAPLINE 240

RCN	GEOUNIT	AKUT	LAT	LONG	RMAG	COS	GC	BIAIR	ETH RANK	EU RANK	K RANK	EU/ETH RANK	EU/K RANK	ETH/K RANK
3440	ZNA	0000	46.9798	102.0285	-301.7	40	2097	10.1	7.0+ 0	3.0+ 1	1.2- 0	0.43+ 0	2.48+ 2	5.71+ 1
3441	ZNA	0010	46.9799	102.0276	-243.8	13	232	10.1	1.3- 2	0.1- 3	0.1- 3	0.12- 2	1.45- 0	12.34+ 8
3442	ZNA	0000	46.9799	102.0267	-241.9	40	2185	10.1	6.6+ 0	1.9- 0	1.4- 0	0.29- 0	1.40- 0	4.77+ 0
3443	ZNA	0000	46.9799	102.0259	-241.5	45	2242	10.1	6.4+ 0	2.7+ 0	1.1- 0	0.43+ 0	2.45+ 1	5.76+ 1
3444	ZNA	0000	46.9799	102.0250	-241.5	40	2319	10.1	7.1+ 0	3.0+ 1	1.2- 0	0.42+ 0	2.48+ 2	5.89+ 1
3445	ZNA	0000	46.9799	102.0242	-242.8	49	2334	10.1	7.8+ 1	3.3+ 1	1.3- 0	0.43+ 0	2.54+ 2	5.91+ 1
3446	ZNA	0000	46.9799	102.0233	-242.2	45	2388	10.1	8.0+ 1	3.5+ 1	1.4- 0	0.44+ 0	2.58+ 2	5.86+ 1
3447	ZNA	0000	46.9799	102.0224	-241.8	44	2518	10.1	8.2+ 1	3.6+ 1	1.4+ 0	0.43+ 0	2.47+ 2	5.73+ 1
3448	ZNA	0000	46.9799	102.0216	-241.4	35	2656	10.1	8.2+ 1	3.6+ 1	1.5+ 0	0.44+ 0	2.41+ 1	5.51+ 1
3449	ZNA	0000	46.9799	102.0207	-241.0	49	2462	10.1	8.1+ 1	3.6+ 1	1.5+ 0	0.45+ 0	2.37+ 1	5.32+ 0
3450	ZNA	0000	46.9799	102.0199	-240.8	46	2319	10.1	7.9+ 1	3.5+ 1	1.5+ 0	0.45+ 0	2.30+ 1	5.17+ 0
3451	ZNA	0000	46.9799	102.0190	-240.2	34	2555	10.1	7.8+ 1	3.5+ 1	1.5+ 0	0.45+ 0	2.28+ 1	5.06+ 0
3452	ZNA	0000	46.9799	102.0181	-238.8	40	2343	10.1	7.8+ 1	3.4+ 1	1.6+ 0	0.44+ 0	2.18+ 1	5.01+ 0
3453	ZNA	0000	46.9799	102.0173	-238.6	58	2362	10.1	7.9+ 1	3.0+ 1	1.6+ 0	0.38+ 0	1.91+ 0	4.98+ 0
3454	ZNA	0000	46.9799	102.0164	-238.2	48	2764	10.1	8.1+ 1	2.8+ 0	1.7+ 0	0.35- 0	1.68+ 0	4.80+ 0
3455	ZNA	0000	46.9799	102.0155	-237.6	53	2646	10.1	8.2+ 1	2.6+ 0	1.7+ 0	0.31- 0	1.50- 0	4.78+ 0
3456	ZNA	0000	46.9799	102.0147	-237.2	53	2260	10.1	8.1+ 1	2.5+ 0	1.7+ 0	0.31- 0	1.47- 0	4.73+ 0
3457	ZNA	0000	46.9800	102.0138	-236.5	52	2537	10.1	8.1+ 1	2.7+ 0	1.7+ 1	0.33- 0	1.56- 0	4.67+ 0
3458	ZNA	0000	46.9800	102.0130	-235.9	47	2623	10.1	8.2+ 1	2.7+ 0	1.7+ 0	0.33- 0	1.56- 0	4.72+ 0
3459	ZNA	0000	46.9800	102.0121	-235.2	45	2343	10.1	8.2+ 1	2.7+ 0	1.7+ 1	0.33- 0	1.54- 0	4.68+ 0
3460	ZNA	0000	46.9800	102.0112	-234.8	63	2637	10.1	8.5+ 1	2.5+ 0	1.8+ 1	0.30- 0	1.41- 0	4.74+ 0
3461	ZNA	0000	46.9800	102.0104	-234.4	48	2405	10.1	8.6+ 1	2.3+ 0	1.8+ 1	0.26- 1	1.25- 0	4.72+ 0
3462	ZNA	0000	46.9800	102.0095	-233.8	67	2761	10.1	8.9+ 1	2.2- 0	1.8+ 1	0.25- 1	1.21- 0	4.89+ 0
3463	ZNA	0000	46.9800	102.0086	-233.6	62	2551	10.1	9.0+ 1	2.2- 0	1.8+ 1	0.25- 1	1.21- 0	4.89+ 0
3464	ZNA	0000	46.9800	102.0078	-232.2	64	2626	10.1	8.6+ 1	2.2- 0	1.8+ 1	0.25- 1	1.19- 0	4.70+ 0
3465	ZNA	0000	46.9800	102.0069	-231.8	40	2601	10.1	8.4+ 1	2.2- 0	1.9+ 1	0.27- 0	1.21- 0	4.53+ 0
3466	ZNA	0000	46.9800	102.0061	-231.4	53	2837	10.1	7.9+ 1	2.3+ 0	1.9+ 1	0.29- 0	1.24- 0	4.22- 0
3467	ZNA	0000	46.9800	102.0052	-231.3	47	2312	25.9	7.6+ 0	2.4+ 0	1.8+ 1	0.32- 0	1.30- 0	4.09- 0
3468	ZNA	0000	46.9800	102.0043	-231.0	34	2287	25.9	7.5+ 0	2.6+ 0	1.8+ 1	0.34- 0	1.41- 0	4.12- 0
3469	ZNA	0000	46.9800	102.0035	-230.9	46	2726	25.9	7.4+ 0	2.8+ 0	1.8+ 1	0.38+ 0	1.59- 0	4.21- 0
3470	ZNA	0000	46.9800	102.0026	-231.2	42	2186	25.9	7.3+ 0	2.8+ 0	1.7+ 0	0.39+ 0	1.65+ 0	4.21- 0
3471	ZNA	0000	46.9800	102.0017	-231.3	42	2402	25.9	7.2+ 0	2.8+ 0	1.7+ 0	0.38+ 0	1.61+ 0	4.18- 0
3472	ZNA	0000	46.9800	102.0009	-231.4	50	2395	25.9	7.3+ 0	2.7+ 0	1.7+ 0	0.37- 0	1.56- 0	4.22- 0
3473	TG	0000	46.9801	102.0000	-231.3	44	2510	25.9	7.6- 0	2.4+ 0	1.8+ 0	0.32+ 0	1.37+ 0	4.33- 0
3474	TG	0000	46.9801	101.9992	-231.6	48	2330	25.9	7.9- 0	2.3- 0	1.8+ 0	0.29- 0	1.26- 0	4.41- 0
3475	TG	0000	46.9801	101.9983	-230.7	48	2523	25.9	8.3+ 0	2.2- 0	1.8+ 0	0.26- 0	1.19- 0	4.55- 0
3476	TG	0000	46.9801	101.9974	-230.8	40	2433	27.3	8.2+ 0	2.2- 0	1.8+ 0	0.26- 0	1.19- 0	4.52- 0
3477	TG	0000	46.9801	101.9966	-230.9	52	2212	27.3	8.0- 0	2.2- 0	1.8+ 0	0.28- 0	1.27- 0	4.52- 0
3478	TG	0000	46.9801	101.9957	-231.0	50	2424	27.3	8.1+ 0	2.3- 0	1.7- 0	0.28- 0	1.34- 0	4.72+ 0
3479	TG	0000	46.9801	101.9948	-231.1	47	2187	27.3	8.0+ 0	2.2- 0	1.7- 0	0.27- 0	1.30- 0	4.80+ 0
3480	TG	0000	46.9801	101.9940	-231.2	51	2231	27.3	8.2+ 0	2.0- 1	1.6- 0	0.24- 1	1.20- 0	5.00+ 0
3481	TG	0000	46.9801	101.9931	-231.3	48	2206	27.3	8.4+ 0	1.8- 1	1.6- 0	0.22- 1	1.12- 1	5.08+ 1
3482	TG	0000	46.9801	101.9923	-231.7	39	2372	27.3	8.2+ 0	1.7- 1	1.6- 1	0.21- 1	1.06- 1	5.05+ 0
3483	TG	0000	46.9801	101.9914	-232.0	33	1937	27.3	8.1+ 0	1.9- 1	1.6- 1	0.24- 1	1.21- 0	5.11+ 1
3484	TG	0000	46.9801	101.9905	-232.6	57	2384	27.3	7.9- 0	2.1- 0	1.6- 1	0.27- 0	1.36+ 0	4.99+ 0
3485	TG	0000	46.9801	101.9897	-233.0	40	1944	25.5	7.7- 0	2.3+ 0	1.6- 1	0.31+ 0	1.50+ 0	4.92+ 0
3486	TG	0000	46.9801	101.9888	-233.8	52	2146	25.5	7.6- 0	2.6+ 1	1.6- 1	0.34+ 1	1.67+ 1	4.85+ 0
3487	TG	0000	46.9801	101.9880	-234.2	36	2223	25.5	7.6- 0	2.7+ 1	1.6- 1	0.35+ 1	1.66+ 1	4.69+ 0
3488	TG	0000	46.9801	101.9871	-234.8	40	2281	25.5	7.7- 0	2.7+ 1	1.7- 0	0.35+ 1	1.62+ 1	4.61- 0
3489	TG	0000	46.9802	101.9862	-235.4	32	2217	25.5	7.9- 0	2.6+ 0	1.8+ 0	0.33+ 0	1.48+ 0	4.51- 0
3490	TG	0000	46.9802	101.9854	-236.0	39	2348	25.5	8.2+ 0	2.3+ 0	1.8+ 0	0.28- 0	1.30- 0	4.57- 0
3491	TG	0000	46.9802	101.9845	-236.6	51	2323	25.5	8.5+ 0	2.2- 0	1.8+ 0	0.26- 0	1.23- 0	4.73+ 0
3492	TG	0000	46.9802	101.9836	-236.8	51	2618	25.5	8.9+ 1	2.1- 0	1.8+ 0	0.23- 1	1.16- 0	5.00+ 0
3493	TG	0000	46.9802	101.9828	-237.4	40	2253	25.5	9.0+ 1	2.1- 0	1.7- 0	0.24- 1	1.23- 0	5.22+ 1
3494	TG	0000	46.9802	101.9819	-238.0	56	2390	24.6	8.7+ 1	2.2- 0	1.7- 0	0.25- 0	1.32- 0	5.24+ 1
3495	TG	0000	46.9802	101.9811	-238.6	54	2468	24.6	8.5+ 0	2.1- 0	1.6- 1	0.25- 0	1.30- 0	5.25+ 1
3496	TG	0000	46.9802	101.9802	-239.2	55	2259	24.6	8.3+ 0	2.2- 0	1.6- 1	0.27- 0	1.36+ 0	5.11+ 1

CONTOUR INTERVAL= 0.50 BISMARCK (ETH) LAT 46.00000000 LONG-102.00000000



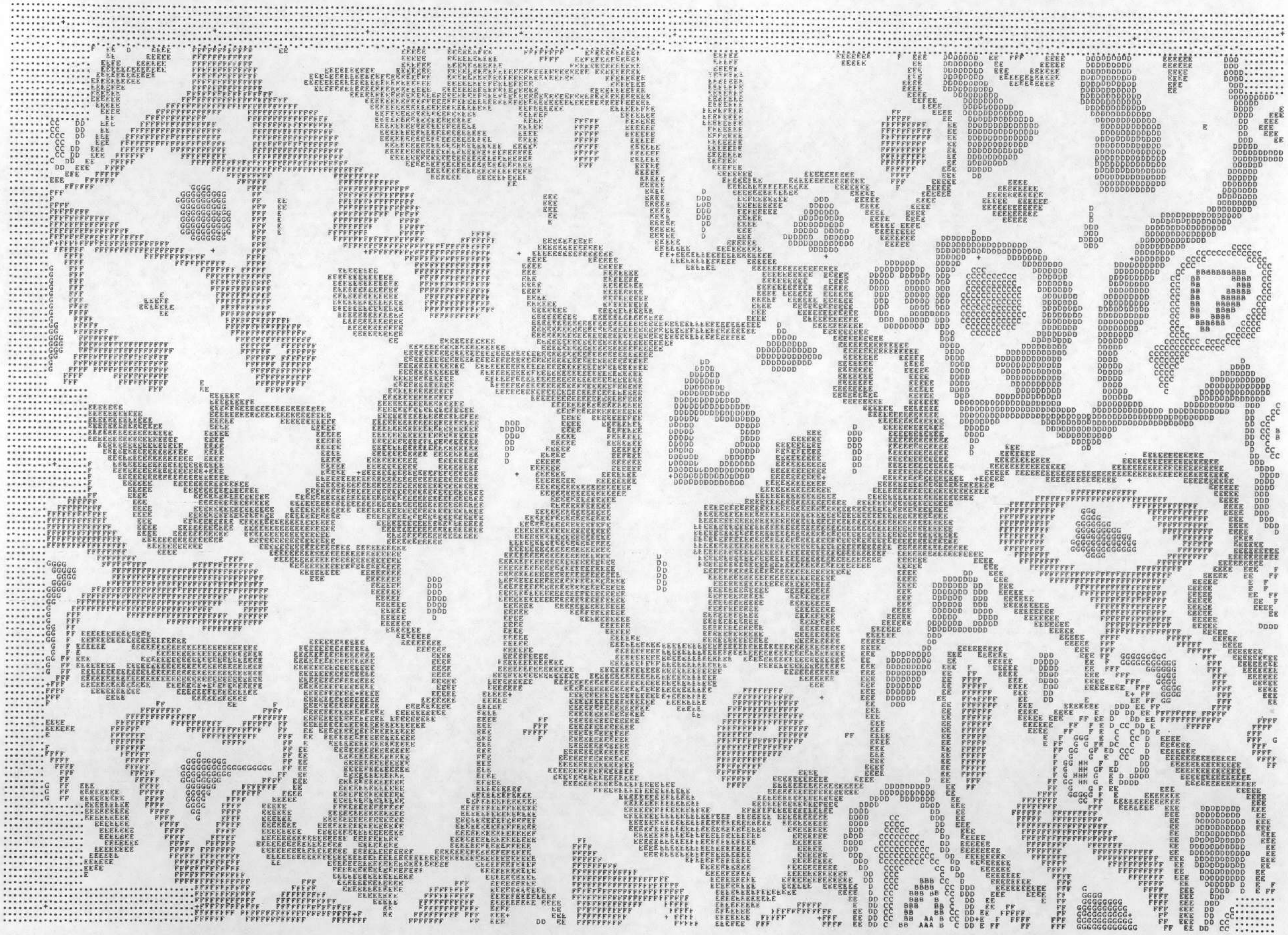
AIV-1 Line Printer Contour

GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A< 2.00 2.50<B< 3.00 3.50<C< 4.00 4.50<D< 5.00 5.50<E< 6.00 6.50<F< 7.00

7.50<G< 8.00

CONTOUR INTERVAL= 0.15 BISMARCK (EU) LAT 46.00000000 LONG-102.00000000



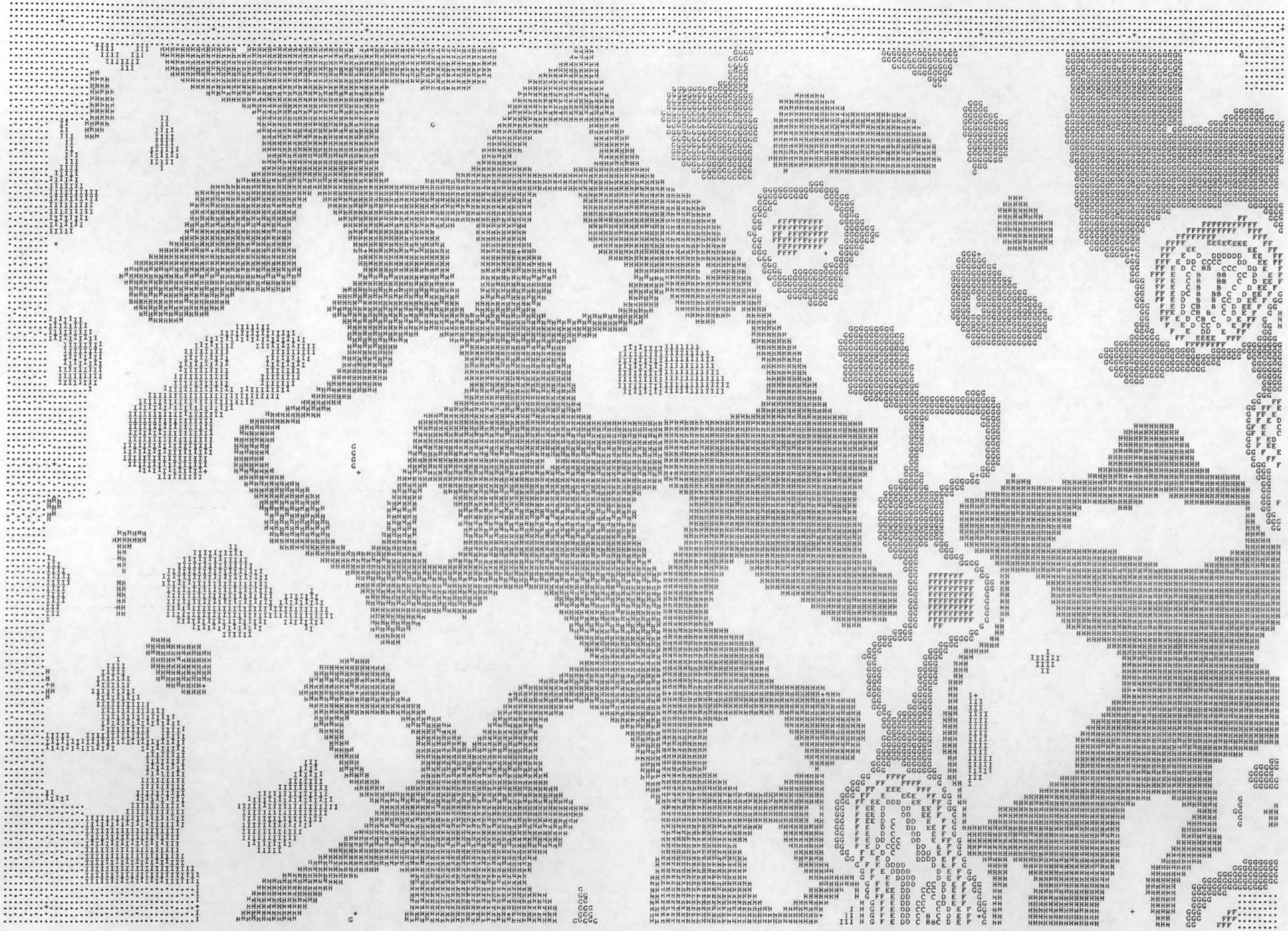
AIV-2 Line Printer Contour

GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A< 0.60 0.75<B< 0.90 1.05<C< 1.20 1.35<D< 1.50 1.65<E< 1.80 1.95<F< 2.10

2.25<G< 2.40 2.55<H< 2.70

CONTOUR INTERVAL= 0.09 BISMARCK ($K) LAT 46.00000000 LONG-102.00000000

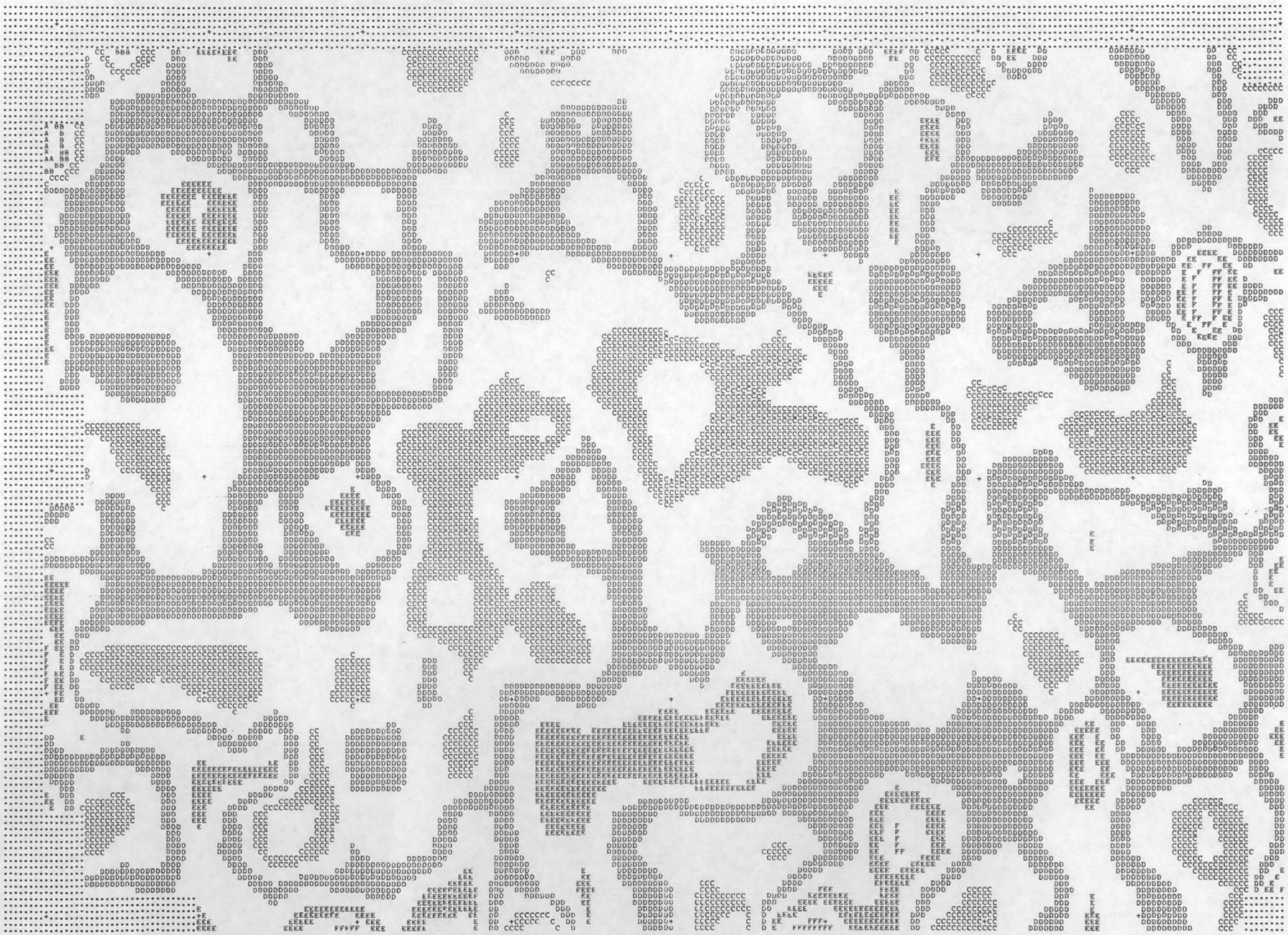


GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A< 0.360 0.450<B< 0.540 0.630<C< 0.720 0.810<D< 0.900 0.990<E< 1.080 1.170<F< 1.260
1.350<G< 1.440 1.530<H< 1.620 1.710<I< 1.800

AIV-3 Line Printer Contour

CONTOUR INTERVAL= 0.02 BISMARCK (KU/ETH) LAT 46.00000000 LONG=102.00000000

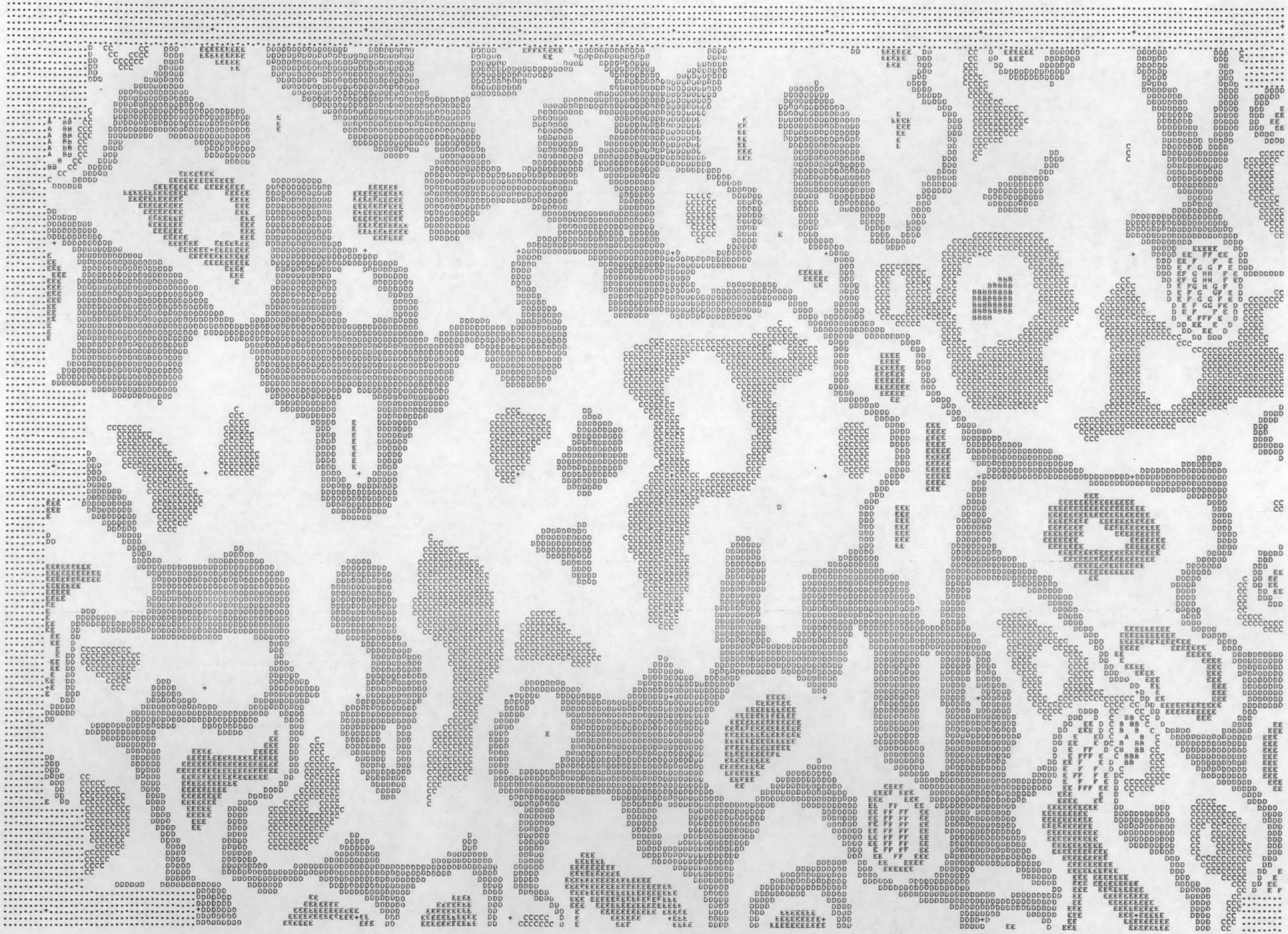


AIV-4 Line Printer Contour

GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A< .160 .180<B< .200 .220<C< .240 .260<D< .280 .300<E< .320 .340<F< .360

CONTOUR INTERVAL= 0.10 BISMARCK (EU/%K) LAT 46.00000000 LONG-102.00000000

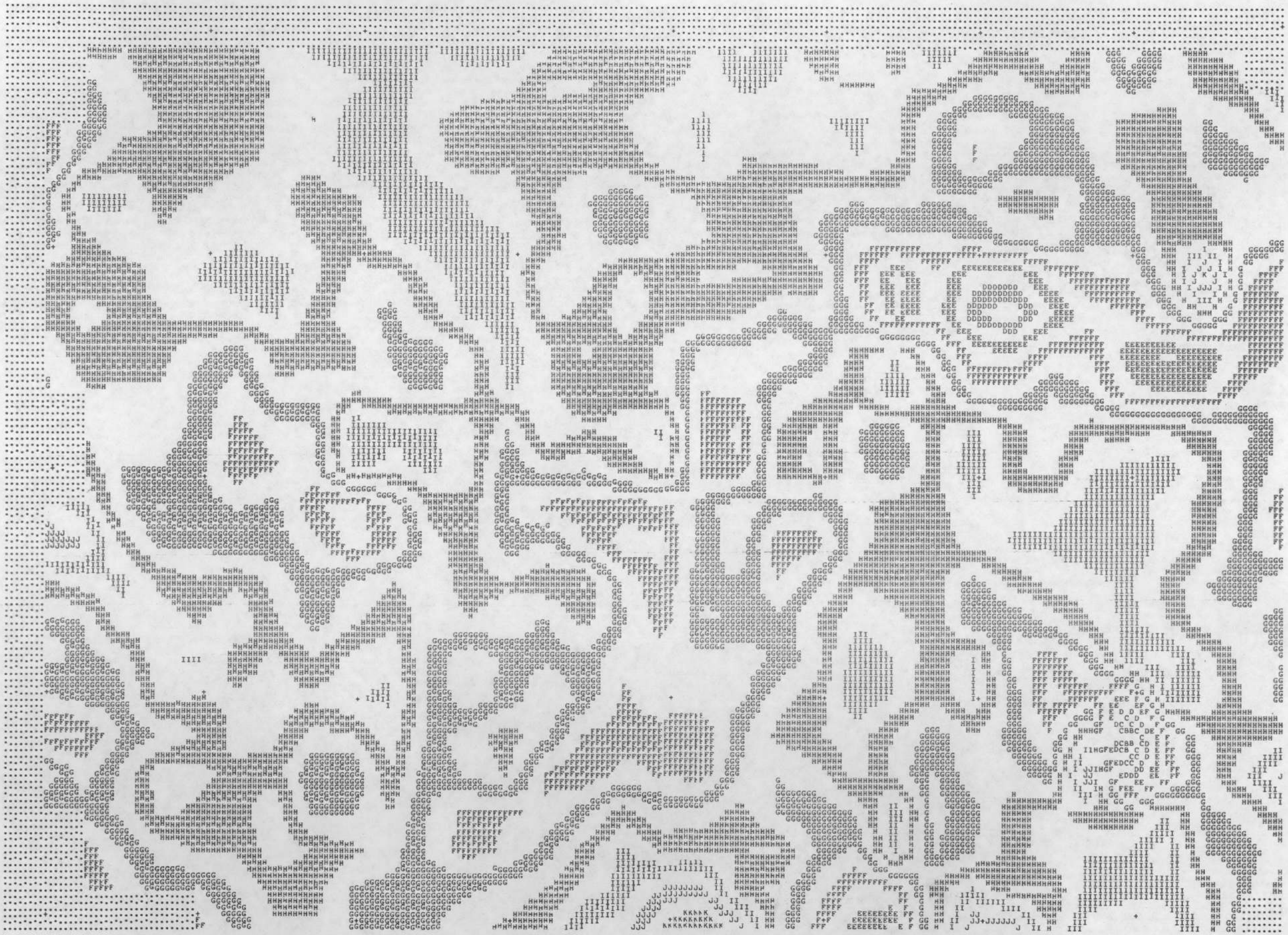


GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A< 0.60 0.70<B< 0.80 0.90<C< 1.00 1.10<D< 1.20 1.30<E< 1.40 1.50<F< 1.60
1.70<G< 1.80 1.90<H< 2.00

AIV-5 Line Printer Contour

CONTOUR INTERVAL= 0.16 BISMARCK (ETH/%K) LAT 46.00000000 LONG-102.00000000

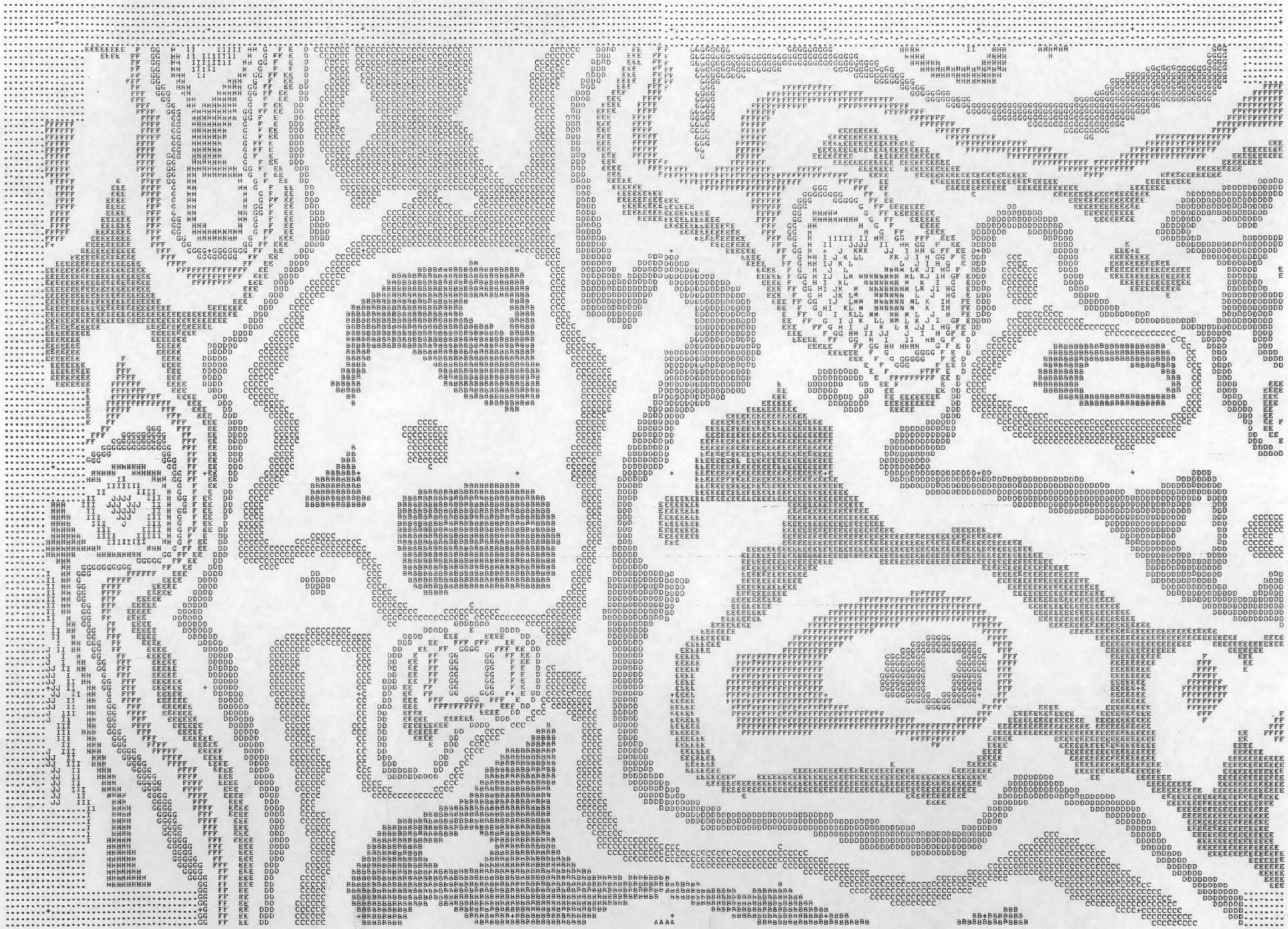


GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A< 2.24	2.40<B< 2.56	2.72<C< 2.88	3.04<D< 3.20	3.36<E< 3.52	3.68<F< 3.84
	4.00<G< 4.16	4.32<H< 4.48	4.64<I< 4.80	4.96<J< 5.12	5.28<K< 5.44

AIV-6 Line Printer Contour

CONTOUR INTERVAL= 40.00 BISMARCK (RMAG) LAT 46.00000000 LONG-102.00000000



GEODATA INTERNATIONAL, INC.
DALLAS, TEXAS

A< -600.   -560.<B< -520.   -480.<C< -440.   -400.<D< -360.   -320.<E< -280.   -240.<F< -200.
-160.<G< -120.   -80.<H< -40.   0.<I< 40.   80.<J< 120.   160.<K< 200.
240.<L< 280.   320.<M< 360.   400.<N< 440.

AIV-7 Line Printer Contour

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