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THE GEOLOGY, STRUCTURE, AND ORIGIN OF THE BISHOFTU* EXPLOSION CRATERS

PAUL A. MOHR

Introduction

This paper is a preliminary account of a region which, considering the many fascinating geological features in its immediate vicinity, has been surprisingly neglected by geologists. The author would emphasise, right from the start, that he has not been able to make a detailed geological survey of the region described owing to insufficient time being available. The lack of geological map with this paper is therefore regretted, as such a map would be of major help in a further understanding of the origin of the craters. The author's visits have been chiefly concentrated on the larger lake-filled craters, often in the company of friends to whom many thanks are due for their critical observation and disputation; especially the members of the staff of University College of Addis Ababa: Mr. R. D. Greenfield (Asst. Prof. of Geography), Mr. T. Dean (Lecturer in Geography), Ato Mesfin Wolde-mariam (Lecturer in Geography) who first suggested to the author the possibility that the explosions may have been sub-aqueous, and Mr. Pierre Gouin (Director of the Geophysical Observatory) who kindly undertook the geomagnetic measurements of Z and deviation of D in the vicinity of some of the craters.

If this paper stimulates further argument concerning the causes and mechanisms of origin of the Bishoftu explosion craters it will have fulfilled its purpose.

Situation (See Map 1.)

The town of Bishoftu, with a population of about 5000 persons, lies at about 45Km. south-east of Addis Ababa, and is situated both on the Addis Ababa-Jibuti railway and on the main road from Addis Ababa to southern Ethiopia and Kenya. On old maps the name of the town is given as Les Addas, an appellation of the French engineers who built the railway. The native Galla name however, is Bishoftu and the modern name Debra Zeit.

The town itself, now rapidly expanding, is spread over the narrow region between two of the largest of the craters, occupied by Lake Bishoftu (to the south of Bishoftu) and Lake Biete Mengest (to the north). East of Bishoftu passes the Main Ethiopian Rift, though its western boundary in this region (north of the upwarped Gurage Mts.) is ill-defined and has not yet been delineated. Except for minor faulting at Mojjo, Dukam, Akaki, and Bishoftu itself, there is a gradual slope from Lake Koka on the Rift floor up uninterruptedly to Addis Ababa. Bishoftu, situated about half-way between Addis Ababa and the floor of the Rift, lies at an altitude of about 1900m..

The region, like most of the Main Ethiopian Rift, has had extensive Pliocene-Quaternary vulcanicity and the geomorphology is one characteristic of a volcanic area, modified somewhat by lacustrine deposition during the Pluvial periods.

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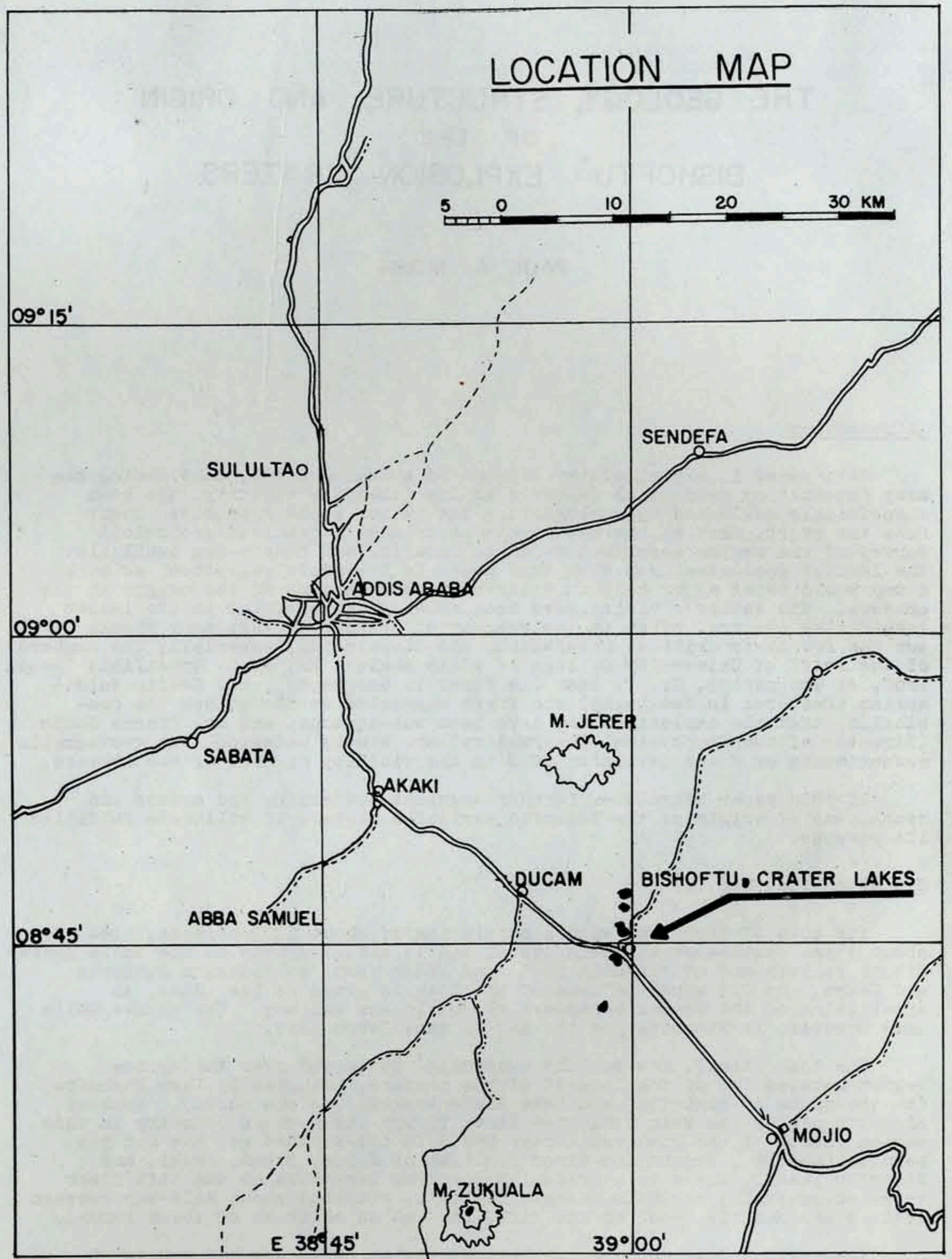
* = The name of the town called Bishoftu has recently been officially changed to Debra Zeit. As foreign geologists are familiar with the original name it has been retained in this paper.



MAP I

The Craters

The author has so far recognised at least sixteen explosion-type craters in the vicinity of Bishoftu, not including some ill-preserved or doubtful

remnants. Being a volcanic region there are, of course, numerous cinder and lava cone craters, as well as craters of old major volcanic centres, but the explosion craters are quite distinct from these being sunken, basin-shaped depressions wholly below ground-level except for their rims. They have steep sides and flat bottoms, have diameters close to 1Km, and are not directly associated with lava flows. Some of the craters intersect as 'twins'. The five largest and deepest craters, one a twin, are occupied by permanent lakes. Others of the craters contain shallow lakes at the end of the rainy season (July-September).

Various names have been ascribed to the five permanent lakes. Two main sources have been taken for the names finally adopted in the present paper: the 1:500,000 British War Office map, sheet NC 37/5 "Addis Ababa", 3rd edition, 1946, which is largely based on original Italian sources; and the 1:4000 survey map of the Bishoftu region, with a contour interval of 10m., made in 1958 by V. Gautschi from trigonometric and aerial photograph data. The complete list, with reference numbers (see below), of the craters studied by the author is as follows:

Reference number	British War Office Map	Survey of V.Gautschi	Adopted name
1.	L. Verde	(not included)	L.Aranguadi*
1A.(Crater immediately south of 1.)			
2.	L.Bisciofto	L.Bishoftu	L.Bishoftu
2A.(Small crater immediately south of 2.)			
2B.(Deep crater situated on the north flank of a volcanic hill which itself is south of a large ash-cone.)			
3A and 3B.(twin)	L.Hora Orsedi	L.Biete Mengest	L.Biete Mengest
3C (Shallow crater immediately north of Bishoftu town.)			
3D (Small crater east of 3B and north of 3A.)			
4A and 4B (twin) (Small craters north-east of 3D.)			
5.	L.Guda	L.Hora	L.Hora
6.	L.Chilotes	(not included)	L.Kilotes
6A.(Small crater east of 6.)			

As noted in the above list, all the significant explosion craters have been assigned arbitrary numbers for convenience of reference. Map 2. shows the geomorphology of the Bishoftu region, together with the craters and their reference numbers. (Note: a large oval crater north-east of Jerer has not been included in the present study).

The Physical Features of the Craters

The Bishoftu craters, characteristically circular but occasionally oval, are aligned N. by E.-S. by W., with the exceptions of craters 6. and 6A. which lie off to the eastern side of the general alignment. The alignment strikingly includes the recently eruptive lava cone midway between Bishoftu and Zuquala (see Map 2.). Neither Zuquala itself, nor Jerer, are situated on the line of the Bishoftu craters.

From the survey map (1:4000) of V. Gautschi the author has constructed geomorphological profiles of craters 2, 3A, 3B, 3C, 3D, 4A, 4B, and 5, along the sixteen points of the compass. A closer contour interval than that given (10m.) would have been desirable. The profiles, with equal horizontal and vertical scales, are given in figs. 1-6. Unfortunately no survey has yet been made of crater 1, the deepest and perhaps the most interesting of all Bishoftu craters.(Fig. 1 to 6 on pp. 95 to 100).

Table 3

Profile data on crater 3B (L.Biete Mengest)
Altitude of lake surface 1850 ± 5m.

P	d_1	d_r	θ_1	θ_o	h
N	0.299	0.464	43	28	116
NNE	0.289	0.444	(42)	19	140
NE	0.297	0.416	(45)	16(3D)	84
ENE	0.315	0.432	37	42(3D)	65
E	0.295	(0.464)	(29)	8(3A-3D Rim)	111
ESE	(0.363)*	(0.438)	13	18	(17)
SE	-	-	-	-	-
SSE	-	-	-	-	-
S	(0.290)**	(0.306)	32	9(3A Rim)	(12)
SSW	0.234	(0.320)	(53)	27	(46)
SW	0.198	0.414	40	17	165
WSW	0.214	0.426	36	18	132
W	0.288	0.422	43	22	117
WNW	0.305	0.432	40	40	98
NW	0.364	0.486	39	23	88
NNW	0.379	0.502	(39)	26	95
Averages	0.290	0.444	37.9	22.4	110.0

A_r (approx) = 0.655 β = 006°
α = 223° h_m = 166

*0.296 to extrapolated shore line of original crater.
**0.249 to extrapolated shore line of original crater.

Data for 3A + 3B (L.Biete Mengest) taken together:

A_1 = 1.135
A_r = 1.986
C^r = 5.48

Max. depth of lake (in 3A) as measured by the Italian Hydrological Survey in 1940 = 38.7m.

Table 4

Profile data on crater 3C.

P	d_r	θ_1	θ_o	h
N	0.584	7	-	35
NNE	0.538	5	-	52
NE	0.564	29	-	96
ENE	0.594	11	-	105
E	0.438	22	14	78
ESE	0.452	13	12	59
SE	0.496	14	11	39
SSE	0.438	10	35	39
S	(0.480)	12	8	51
SSW	0.534	20	-	47
SW	0.584	21	-	60
WSW	0.500	14	14	49
W	0.460	18	12	37
WNW	0.440	27	22	41
NW	0.428	6	-	28
NNW	0.494	22	19	54
Averages	0.501	16.3	16.3	54.4

A_r = 0.796
C^r = 3.34
h_m = 90 (neglecting Rim 3A values)
α = 213°

Table 5

Profile data on crater 3D.

P	d_r	θ_i	θ_o	h
N	0.244	19	3	52
NNE	0.232	20	16	40
NE	0.228	21	20	36
ENE	0.244	30	22	44
E	0.246	28	10	46
ESE	0.248	29	10	55
SE	0.250	38	23	76
SSE	0.272	48	26(3A)	102
S	0.262	40	27(3B)	101
SSW	0.246	48	21(3B)	79
SW	0.202	38	17(3B)	48
WSW	0.192	34	30(3B)	51
W	0.256	15	20(3B)	71
WNW	0.294	31	2	95
NW	0.246	39	23	73
NNW	0.254	49	7	64
Averages	0.245	32.9	17.3	64.6

A_r = 0.188 α = 195°
C^r = 1.68 h_m = 107

Table 6

Profile data on crater 4A.

P	d_r	θ_1	θ_o	h
N	0.212	44	24(rim 4B)	22
NNE	0.200	39	26(4B)	26
NE	0.210	21	20(Rim 4B)	20
ENE	0.270	22	34	31
E	0.292	23	16	41
ESE	0.282	37	19	35
SE	0.242	13	14	31
SSE	0.222	25	33	39
S	0.228	23	23	41
SSW	0.240	18	8	45
SW	0.252	21	15	54
WSW	0.252	26	24	50
W	0.252	29	25	43
WNW	0.260	21	20	33
NW	(0.290)	27	22	41
NNW	0.228	18	-	48
Averages	0.246	25.4	21.5	37.5

A_r = approx 0.19 h_m = 55
α = 241°

Table 7.

Profile data of crater 4B.

P	d_r	θ_i	θ_o	h
N	0.302	10	3	29
NNE	0.320	15	-	30
NE	0.312	12	17	41
ENE	0.298	11	32	41
E	0.284	15	-	34
ESE	0.322	19	7	41
SE	0.322	27	-	43
SSE	0.336	24	2	43
S	0.276	33	15(Rim 4A)	34
SSW	0.238	29	30(4A)	35
SW	0.270	19	20(Rim 4A)	29
WSW	0.332	18	-	35
W	0.306	27	13	65
WNW	0.296	28	11	63
NW	0.280	22	18	52
NNW	0.294	12	-	33
Averages	0.299	20.0	15.3	40.5

A_r (approx) = 0.304
α = 270°
h_m = 65

Data for 4A + 4B taken together
A_r = 0.497
C_r = 2.76

Table 8.

Profile data on crater 5 (L. Hora)
Altitude of lake surface 1870 ± 5 meters.

P	d_1	d_r	θ_i	θ_o	h
N	0.537	0.660	18	3	24
NNE	0.488	0.628	15	15	(38 Cinder
NE	0.449	0.572	25	8	(51 Cone
ENE	0.435	0.520	18	10	22
E	0.431	0.520	16	9	23
ESE	0.506	0.564	27	27	26
SE	0.564	0.600	31	2	22
SSE	0.560	0.652	32	4	24
S	0.539	0.592	35	13	24
SSW	0.447	0.564	19	19	37
SW	0.429	0.568	27	20	56
WSW	0.420	0.562	20	13	52
W	0.438	0.588	19	11	37
WNW	0.431	0.552	17	9	39
NW	0.452	0.556	16	7	28
NNW	0.496	0.582	26	1	29
Averages	0.476	0.580	23.2	11.3	31.6

A_1 = 0.731 α = 234°
A_r = 1.045 β = 121°
C = 3.86 h_m = 72

Provisional data for other craters include:

Crater 1. (L. Aranguadi)
A_1 = 0.49
A_r = 1.17
h (average) = approx. 200
α = approx. 225°

Crater 6. (L. Kilotes)
A_1 = 0.68
A_r = 0.92
α = approx. 270°

Crater 6A.
A_r = 0.52

Profile data of the craters studied thus show diameters (from rim to rim through the crater centre) whose averages range between 0.490Km. (3D) and 1.362Km. (3A).

Average values for the inner slope of the rims range from 16.3° (3C) to 37.9° (3B), but it is certain that the higher figures are the more significant in that some of the crater rims (eg. 3C, 4B, 5 and 6) have been subject to considerable sub-aqueous denudation since their formation. Average values for the outer slope of the rims range from 7° (2) to 22.4°(3B). Again, the higher values represent more closely the original values before denudation, and also lacustrine deposition, contributed to decreasing the original outer slope inclinations.

Millman (1956), in his study of the New Quebec Crater, collected data from many sources on the inclinations of the inner and outer slopes of explosion crater rims. He states that: "the inner slope (31°) for New Quebec is close to but slightly less than the average for craters of similar size on the moon", the lower values being attributed to the glaciation which affected the region of the New Quebec Crater after its formation. Fauth (1894) found that for 113 lunar craters with diameters between 1 and 18 miles the average inner slope inclination was 33.5°, and that there was no tendency for this inclination to vary according to the magnitude of the crater diameter. However, considering that $g_{(Moon)} = 1/6g_{(Earth)}$ approx., it is difficult to understand the significance of Millman's comparisons. Individual values close to 50° for θ_i have commonly been observed for the Bishoftu craters, especially where the rim gravels lie directly upon lavas rather than tuffs or lacustrine clays and silts. These values indicate that the craters are relatively recent in origin, especially considering the severity of wet-season denudation on the Ethiopian Plateau. The Barringer meteorite crater, one of the most recently formed of this type of crater on the Earth's surface, shows values for θ_i up to a maximum of 49°.

Regarding the outer slope inclination of explosion-type crater rims, Millman (1956) states that: "the mean slope of 8.5° measured for the top of the outer rim wall at the New Quebec Crater is equal to the maximum of the outer slopes reported for the moon, and is probably near the centre of the range for outer slopes of terrestrial craters". However, for the Barringer meteorite crater the average value of θ_o is about 15°. All the Bishoftu craters whose profiles have been studied reveal average values of θ_o greater even than 15°, except for craters 2, 3A and 5. Whilst only small changes in the depth of the focus of an explosion forming crater would be very critical in deciding the shape and slopes of the rim of ejecta, it seems manifest that the average inclination given by Millman for the outer slopes of fresh explosion crater rims is far too low a value.

Regarding the average height of a rim above the crater bottom only one of the Bishoftu crater lakes, Lake Biete Mengest, has been charted for depth, and therefore these values can only be given for this crater (3A) and those which are dry. The values range from 37.5m. (4A) to 114.4m. (3A) though this latter figure is certainly exceeded by crater 3B, and also crater 1. There is a rough direct correlation between h and the diameter of a crater as would be expected for craters of the same order of size.

It must be remembered that the values of h have been considerably modified by denudation of the rims and deposition in the crater bottoms. Mathematical evidence for this is given later. It may be noted here that the crater profiles clearly reveal, what is very evident in the field, that most of the craters have suffered at least partial breaching of their rims. This breaching was effected by exterior lacustrine waters either immediately after the explosion or at a later period during a wet climatic phase.

The values for α, the direction of the highest point of a rim measured from the crater centre, are of considerable interest and are tabulated below:

Crater	α (bearing from true North)
(1	c.225°)
2	207°
3A	241°
3B	223°
3C	213°
3D	195°
4A	241°
4B	270°
5	234°
(6	c.270°)

The average value taken from the above-listed craters is 228°, with a standard deviation of only 22°. The similarity of these values is too great to be coincidental, and the significance of this "alignment" is pertinent to any enquiry of the origin of the Bishoftu craters. The relationship of α to the origin of the craters will be discussed in the last section, but it can be noted here that α is <u>not</u> coincident with the approximate north-south alignment of the craters.

In discussing the values of α, the breachings of the rims must be kept in mind. These breachings, which affected the W. and N.W. rim of crater 2, the E. and S.-E. rim of crater 3A, almost the entire rim of crater 3C, two points on the E. rim of crater 3D, the N. rim of crater 4B, and most of the rims of craters 5 and 6, will by their very mode of origin, however, have occurred away from the higher portion of the crater rims.

Considering all the Bishoftu craters occupied by lakes, the values of β the bearing of the lake centre from the crater centre, are very variable and reveal nothing significant.

Baldwin (1949) evaluated two empirical formulae for explosion craters (chiefly on the Moon) which relate rim diameter, rim height above outside ground level, and total depth. These formulae are:

$$\text{(i)} \ldots\ldots\ldots\ldots D = 0.1083\ d^2 + 0.6917\ d + 0.75$$

$$\text{(ii)} \ldots\ldots\ldots\ldots E = -0.097\ D^2 + 1.542\ D - 1.841$$

where:
D = log diameter (feet), d = log depth (feet), E = log rim height (feet).

If these formulae are applied to two of the best-preserved of the Bishoftu craters for which statistical data are available, the following data are revealed:

<u>Crater 3A</u>

Using a value of d = 114.4m. (352.2ft.) in formula (i) yields D = 442m.. This is radically less than the observed average of D = 1372m.. It indicates the value of d to be too small, probably due to both breaching of the eastern rim of the crater (giving too low an average for the rim height, h) and to infilling of the crater bottom with sediment. The second factor has probably had a larger effect than the first.

Using a value of D = 1372m. (4502ft.) in formula (ii) yields E = 87m.. Examination of the profiles for crater 3A indicates that where the rim is well-preserved the figure of 87m. represents a fair average for the height of the rim crest above the surrounding plains. That the value of E is thus concordant with that of D is further evidence that the original value of d has been decreased by infilling.

<u>Crater 3D</u>

Using a value of d = 64.6m. (211.9ft.) in formula (i) yields D = 242.4m.. This is about half the observed value of 490m.. As with crater 3A some infilling of the crater bottom seems probable, though whether sufficient to account for the observed discrepancy seems doubtful from field evidence where the rim materials are visible for a considerable distance down the rim walls towards the crater centre.

Using a value of D = 490m. (1608ft.) in formula (ii) yields E = 36m.. The profiles of crater 3D reveal that this is a fair average for the height of the rim crest above the plains to the north and east.

In summary, therefore, the formulae of Baldwin (1949) for explosion craters show a fairly exact relationship between rim height and diameter for the Bishoftu craters, but the diameter-depth relationship is such as to indicate appreciable infilling since the craters were formed. This infilling will have taken the form of slumping of the inner rim walls, as well as introduction of wind-blown dust and water-borne sediment, the latter where the rims were breached by exterior lacustrine waters.

Recently La Paz (1958) has criticised the applicability of Baldwin's formulae to explosion craters of the order of a few kilometres in diameter. This will be further discussed in the last section of this paper on the origin of the Bishoftu craters.

Geology and Geological History

The Bishoftu region is situated on the ill-defined western margin of the Main Ethiopian Rift. The basal rocks are probably Trap Series lavas though these are not exposed in the immediate vicinity of Bishoftu, being covered with a great thickness of more recent lavas, tuffs, and lacustrine sediments. Trap Series rocks are exposed at Dukam and Akaki, however, and there seems no reason why these rocks should not continue further eastwards, dipping in that direction and perhaps also downthrown along minor faults, right down to the Rift floor at Mojjo and Koka.

During the Quaternary epoch extensive vulcanicity produced the present topography of the Bishoftu region, as well as forming the splendid volcanic cone of Zuquala to the south, and it was with this late volcanic phase (belonging to the Aden Volcanic Series, and much more recent than the late-Trap Series activity of Jerer and Wachacha) that the formation of the explosion craters was associated. Contemporaneous with this late volcanic phase were periods of very wet climate, the Pluvials, during which there was extensive lacustrine deposition on the Rift floor and including the whole of the Bishoftu region. These lacustrine sediments are intimately associated with the recent lavas and tuffs, and include a great variety of clastic and pyroclastic sediments as well as chemical precipitates. That some volcanic eruptions have occurred within human times is indicated by the recently reported finding of human bones amongst the cinders of a quarried cinder cone about 10Km. S.E, of Bishoftu, and by the fresh appearance of the pahoehoe surfaces of the basalt flows in the area.

The geology and sequence of geological events for each of the main craters will next be discussed:

Crater 1. (L. Aranguadi)

A rough geological sketchmap of this crater is given in fig. 7. The main features of note are as follows:

At the S. end of the crater the inner rim wall is formed of four thick, massive rhyolite flows. These lavas dip gently to the N.E. and are considered to have been derived from the hills to the S.W.. The approximate thicknesses of the flows from the lowest to the highest are: 60m. (base not seen), 30m., 10m. (where seen), and 90m.. Xenoliths of coarse-grained igneous material are common in the lowest flow, which shows well-developed flow-banding and is commonly riddled both with large black phenocrysts of sodic amphibole and variolitic cavities. This pale-green rhyolite, fragments of which have been found blown out as far as 25Km. N. of the crater, is seen to consist microscopically of a flow-banded mass of feldspar microlites with very numerous spherules composed of radiating feldspar and haematite (altered ferromagnesian mineral?) crystals. A relatively large orthoclase crystal usually forms the centre of the spherules. Quartz is fairly abundant as shapeless blebs. Green chlorite is an accessory and is associated with haematite. Some concentric vesicles occur.

The upper part of the topmost flow is composed of pumiceous glass and glassy nodules. It is well exposed about half-way up the track which ascends the S.E. wall of the crater, and is essentially an extremely contorted banded obsidian, layers of glassy globules alternating with solid or pumiceous glass, which has incorporated some rhyolitic and pyroclastic material. The glass globules average ½ to 1mm. diameter. Fig. 8 indicates the complex contortions and layering in a section of the flow.

Clockwise round the crater wall from this exposure of contorted, flow-banded obsidian there is observed holocrystalline rhyolite dipping south at angles near the vertical. The contact with the normal three rhyolite flows outcropping 50m. further clockwise has not been observed.

Directly above the contorted, flow-banded obsidian lies a chaotic mass of obsidian boulders in a sandy matrix. Here the succession is:

6.	Grey, bedded gravels (ejecta?)	c. 50m.
5.	Fine-grained tuff with some pumice	12m.
4.	Pumiceous sediment (dipping 17° to the N.E.)	3m.
3.	Fine-grained tuff with obsidian boulders	15m.
2.	Obsidian boulders in sandy sediment lying on	
1.	Contorted, flow-banded rhyolite obsidian lava.	

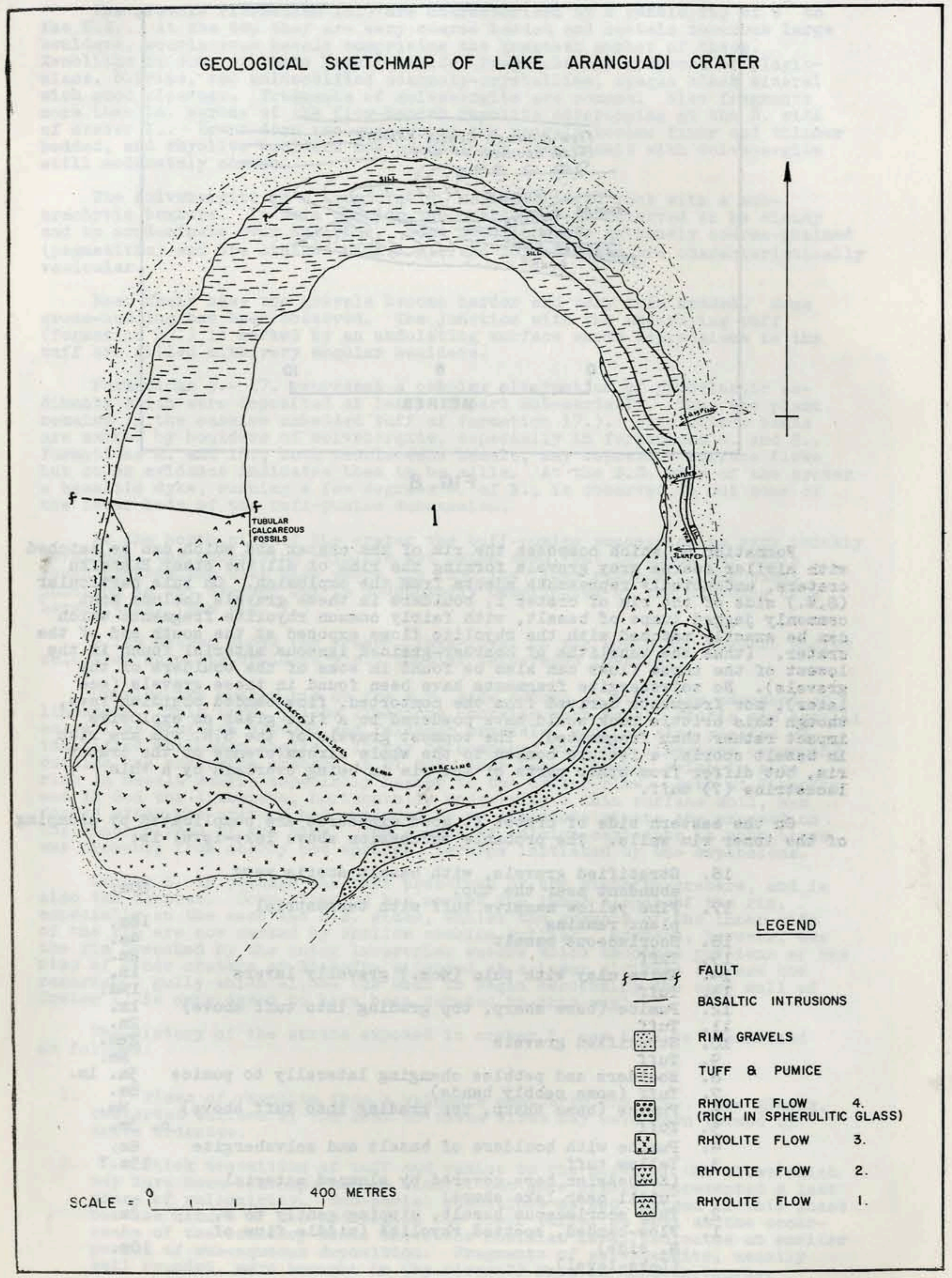


FIG 7

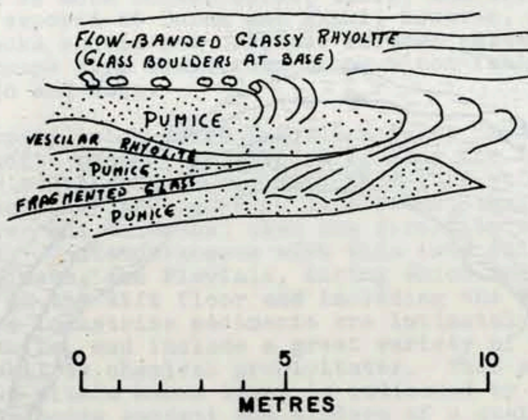


FIG. 8

Formation 6, which composes the rim of the crater and which can be matched with similar coarse grey gravels forming the rims of all the other Bishoftu craters, undoubtedly represents ejecta from the explosion. On this particular (S.E.) side of the rim of crater 1, boulders in these gravels include most commonly jagged lumps of basalt, with fairly common rhyolite fragments which can be exactly matched with the rhyolite flows exposed at the south end of the crater, (thus the xenoliths of coarser-grained igneous material found in the lowest of the three flows can also be found in some of the boulders of the gravels). No solvsbergite fragments have been found in these gravels (see later), nor fragments derived from the contorted, flow-banded obsidian lava, though this brittle rock would have powdered to a fine glass on explosive impact rather than fragmented. The topmost gravels of the S.E. rim are rich in basalt scoria, a feature common to the whole circumference of the crater rim, but differ from other parts of the rim in being overlain by a thin lacustrine (?) tuff.

On the eastern side of crater 1. good exposures are complicated by slumping of the inner rim walls. The probable succession above lake-level is:

18.	Stratified gravels, with basalt scoria very abundant near the top.	60m.
17.	Fine yellow massive tuff with terrestrial plant remains	18m.
16.	Scoriaceous basalt	4m.
15.	Tuff	2m.
14.	White clay with thin (½cm.) gravelly layers	1m.
13.	Tuff	1¼m.
12.	Pumice (base sharp, top grading into tuff above)	1m.
11.	Tuff	2m.
10.	Stratified gravels	2½m.
9.	Tuff	¾m.
8.	Boulders and pebbles changing laterally to pumice	3m. 1m.
7.	Tuff (some pebbly bands)	8m.
6.	Pumice (base sharp, top grading into tuff above)	½m.
5.	Tuff	c. 3m.
4.	Pumice with boulders of basalt and solvsbergite	6m.
3.	Yellow tuff	15m.?
	(Succession here covered by slumped material until near lake shore)	
2.	Thin scoriaceous basalt, dipping gently to N.	2m.
1.	Flow-banded, spotted rhyolite (middle flow of S. side)	10m.
	(Lake-level)	

The gravels (formation 18.) are characterised by a gentle dip of 9° to the N.W.. At the top they are very coarse bedded and contain numerous large boulders, scoriaceous basalt comprising the greatest number of these. Xenoliths in some of these basalt boulder fragments are composed of plagioclase, olivine, and unidentified coarsely-crystalline, opaque black mineral with good cleavage. Fragments of solvsbergite are common. Also fragments more than 1m. across of the flow-banded rhyolite outcropping at the S. side of crater 1.. Lower down the succession the gravels become finer and thinner bedded, and rhyolite boulders now predominate over basalt with solvsbergite still moderately common.

The solvsbergite is a leucocratic, medium-grained rock with a sub-trachytic texture. In thin section the orthoclase is observed to be cloudy and to predominate over aegerine. Some specimens are extremely coarse-grained (pegmatitic) and are stained pink. All the solvsbergite are characteristically vesicular.

Near their base the gravels become harder and very thin bedded. Some cross-bedding has been observed. The junction with the underlying tuff (formation 17.) is marked by an undulating surface whose depressions in the tuff are filled with very angular boulders.

Formations 3.- 17. represent a complex alternation of pyroclastic sediments which were deposited at least in part sub-aerially. Thus the plant remains in the massive unbedded tuff of formation 17.). Some coarse bands are marked by boulders of solvsbergite, especially in formations 4. and 8.. Formations 2. and 16., both scoriaceous basalt, may represent surface flows but other evidence indicates them to be sills. At the S.E. side of the crater a basaltic dyke, running a few degrees W. of N., is observed to cut some of the lower beds of the tuff-pumice succession.

At the north side of the crater the tuff-pumice succession is very thickly developed, the underlying rhyolite not being seen, but it thins out again round towards the west side where the rhyolite flows reappear. The exact junction is not exposed but is undoubtedly complicated by the presence of a large fault. (See Fig. 7.)

A few metres above the present lake-level on the south and western shores calcreted rhyolite boulders yield tubular calcareous fossils.

Outside the crater rim on the N.E. side occurs an extensive pavement of limestone. This hard, yellow limestone contains much basalt scoria and lapilli as well as obsidian slivers and feldspar crystals, and has also yielded unidentified molluscan shells. It may be compared with the limestone occurring outside the explosion craters at El Sod, near Mega, Borana, which is also rich in basalt scoria especially nearer to the crater rims. Both at Bishoftu and El Sod the limestone, horizontally underlying a thin surface soil, was formed after the craters had exploded as no limestone strata are exposed on the inner slopes of the rims. The source of calcium carbonate in both cases was probably from nearby hot springs, perhaps initiated by the explosions.

Crater 1. is perhaps the best preserved of the Bishoftu craters, and is also the deepest. Some slumping has marked the inner slopes of the rim, especially on the east and S.E. sides, whilst the gravels of the inner side of the rim are now marked by shallow erosion gullies. Nowhere, however, was the rim breached by the outer lacustrine waters which smoothed portions of the rims of other craters at Bishoftu situated at a lower altitude (unless the remarkable gully which allows the bath to begin descending the east wall of Crater 1. is considered to have been denuded in this way).

The history of the strata exposed in crater 1. may thus be summarized as follows:

1. Flows of rhyolite from a volcanic centre to the S.W.. The glassy, contorted surface of the last of these flows may have been formed by nuées ardentes.

2. Thick deposition of tuff and pumice to the north of the flows which may have been contemporaneous with 1. but more likely represented a last phase of vulcanicity. Sub-aerial conditions marked the end of this phase but the nature of the bedding in the lower tuffs, as well as the occurrence of the bouldery sands above the obsidian lava, indicates an earlier period of sub-aqueous deposition. Fragments of solvsbergite, usually well rounded, were brought in (by rivers?) from an unknown source.

3. Eruption of scoriaceous basalt from cinder and lava cones. Such lavas were discharged from a fissure line on the east side of the large ash cone between craters 2A and 2B. Probably contemporaneous was the central eruption of basalt from a lava cone 10Km. south of Crater 1.. Tentatively ascribed to this period are the basaltic sills and dyke now exposed in the crater. Eruption of basalt scoria from cinder cones were probably common from now on until period 6. as scoria abound in the top-most rim gravels as well as in the limestone of period 5.

4. Explosion of the crater, forming a rim of ejecta. Bedding in the rim gravels suggests sub-aqueous deposition. The stratified nature of the beds, however, and the irregular distribution of boulders which in fact tend to be more common at the top than at the base, raise the problem of whether the gravels could have been deposited from a single explosive phase.

5. During a wet climatic phase (Makalian?) the level of the lake in the crater rose to at least 6m. above the present-day lake level. An extensive shallow lake, extending N.W. as an arm from a major Rift Valley lake, deposited clays and reworked tuffs outside the crater rim, whilst hot springs supplied calcium carbonate for local deposition of limestone. Contemporaneous eruptions of basalt scoria are indicated by the presence of lapilli and scoria in the limestone.

6. Drying of climate and lowering of lake-level. A temporary end to volcanic activity in the Bishoftu region.

<u>Crater 2.</u> (L. Bishoftu)

At the east side of the crater the succession is:

3.	dusty, grey, bedded gravels with boulders	60m.
2.	yellow tuffs	5-- 10m.
1.	green, flow-banded rhyolite	>5m.
	Lake level .	

The rhyolite shows beautiful thin flow-banding which is frequently extremely contorted in miniature overfolds. Microscopically the lava is seen to consist of a fine-grained mosaic of orthoclase and quartz crystals with some orthoclase phenocrysts. The banding is marked by concentration, in certain layers of minute needles of a ferromagnesian mineral, often with associated haematite. Rare aegerine phenocrysts indicate that the lava is sodic. Some specimens show microspherules of radiating needles of quartz.

On the west side of the crater the rhyolite lavas form cliffs rising out of the lake and extend up close to the rim crest, being overlain by a thin succession of gravels with the tuffs of formation 2. missing. It is possible that the tuffs were originally there but were denuded immediately after the explosion (see later).

On the south side of crater 2. a hill exposes horizontally bedded gravels covered by gravels 2 - 10m. thick whose bedding follows the surface contours. This phenomenon is also observed with the rim gravels of craters 3A, 3B and 3C. The horizontally bedded gravels of the southern hill of crater 2. appear to be underlain by thick yellow tuffs below which no rhyolite is exposed. It may be, therefore, that this southern hill represents an old ash cone cut by the explosion, but aerial photographs reveal the possible existence of four craters about this elongated (N. - S.) hill: crater 2. at its northern end, 2A at the southern end, and obscure remnants of two other craters situated directly east and west of the hill, which would thus have composed a common part to the rims of all four craters.

The rim gravels of crater 2. tend to be finer-grained than for the other craters, except 4A and 4B. Small clayey nodules occur concentrated in certain layers. As such clay nodules are commonly found in lacustrine deposits outside the craters, and as they presumably required an appreciable time to form before deposition of the next, superimposed, layer, the problem of the origin and deposition of the rim gravels of the Bishoftu craters becomes even more acute.

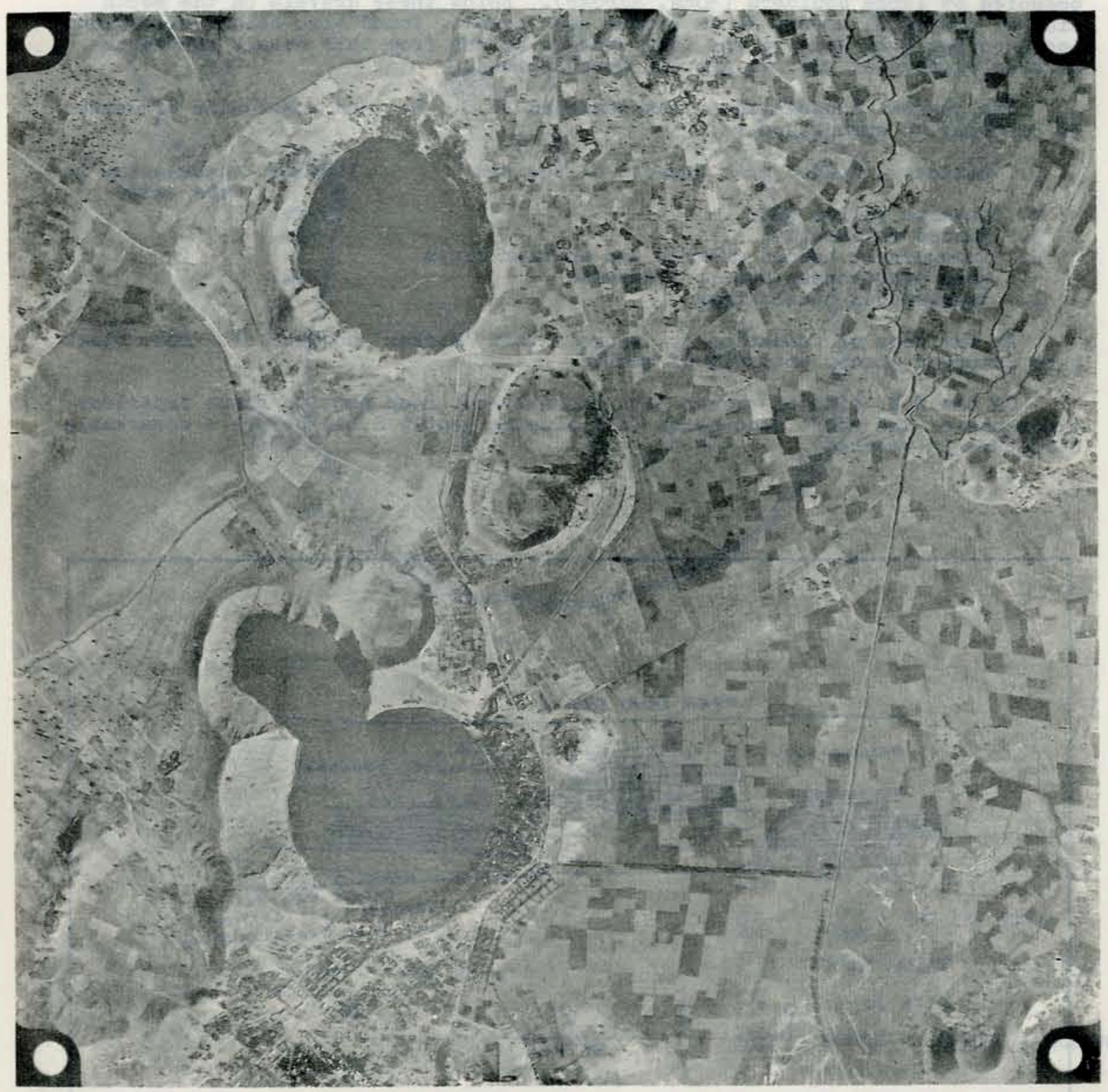
The fragmented boulders in the gravels of crater 2. show an extreme preponderance of the flow-banded rhyolite exposed as formation 1.. The only other fragments so far obtained from the gravels are basalt scoria which are notably more rare than in the rim gravels of the other craters.

The history of the strata exposed in crater 2. may be summarized as follows:

1. Eruption of rhyolite lavas.(from the hills to the south?)
2. Deposition of thin tuffs.
3. Explosion of crater with formation of rim. The explosion was probably sub-aqueous. Lake waters swirled into the newly formed hole from the west, removing the tuff formation from above the rhyolite and also inhibiting the formation of a rim on this side.
4. Continued denudation of rim during a wet climatic phase with lake-level higher than at present.
5. Drying of climate and lowering of lake-level.

<u>Craters 3A, 3B, (3C and 3D)</u> (L. Biete Mengest)

Some good exposures around the lake shore of craters 3A and 3B show a complex and variable succession beneath the thick gravels which constitute the rim. (See fig. 9). Discussion of the sub-gravels geology will be given first, that of the gravels will follow separately.



ILLUSTRATING CRATERS 3A, 3B, 3C, 3D, 4A, 4B, AND 5. (COURTESY OF I.H.A.)

On the S.E. side of crater 3A the gravels, about 17m. thick, rest on pale-yellow massive tuff. Boulders up to 3m. in diameter in the gravels slightly depress the gravels-tuff junction. Some large boulders occur in the tuff just below the junction with the gravels. On this (S.E.) side of crater 3A the top 10 - 15cm. of the soft yellow tuff has been altered to a hard black rock, though rather brittle, in which original feldspar crystals are still preserved. The junction between the tuff and overlying gravels is about 10m. above lake-level ie. the approximate height of the land surface outside the crater on this (S.E. side.

Clockwise round the lake shore of crater 3A towards the S.W. side other beds are observed to come in below the tuff, all dipping gently to the S.E.. Directly beneath the Palace Hotel very fine-grained, bedded tuffs come in below the massive tuffs. The thickness of the individual layers varies between 5 and 15cm.. Beneath the bedded-tuffs lie irregularly-bedded gravels, often with cross-bedding poorly developed, in which occur frequent coarse layers. The coarse layers contain angular boulders up to 15cm. in diameter, composed either of fresh olivine basalt (see below) or red cinders. In some parts the gravel and pebbles seem to have been compacted together into a hard massive rock. On the south side the cliff beside the track exposes a sudden depression within these gravels occupied by large boulders (30cm. across). Below these gravels on the south side of crater 3A occurs fresh scoriaceous basalt, found also below the diving board on the S.E. side of the lake shore. It was from this basalt that much of the boulders of the rim gravels were derived.

The general succession on the southern (S.E., S., and S.W.) side of crater 3A can thus be summarized as:

5.	Bouldery, bedded grey gravels of the rim	150-20m. (decreasing to the east)
4.	Massive yellow tuff	5-2m.
3.	Bedded yellow-tuff	5m.
2.	Irregularly bedded gravels and nodular clays with scoriaceous basalt fragments	3m.
1.	Scoriaceous basalt lava	

At the base of formation 3. occurs a thin 'marker' horizon of a 2cm. black band composed almost entirely of scoria.

On the S.W. side of crater 3A a recently-cut road section shows excellent exposures of the above succession (all dipping gently S.E.) before a remarkable structure is reached

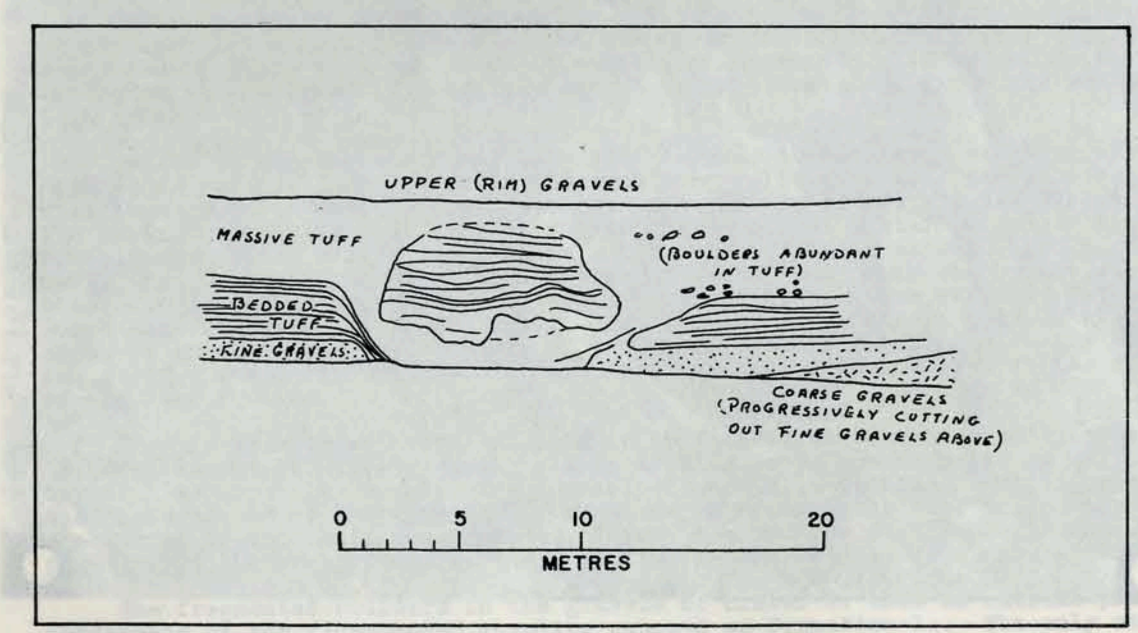


FIG. 10

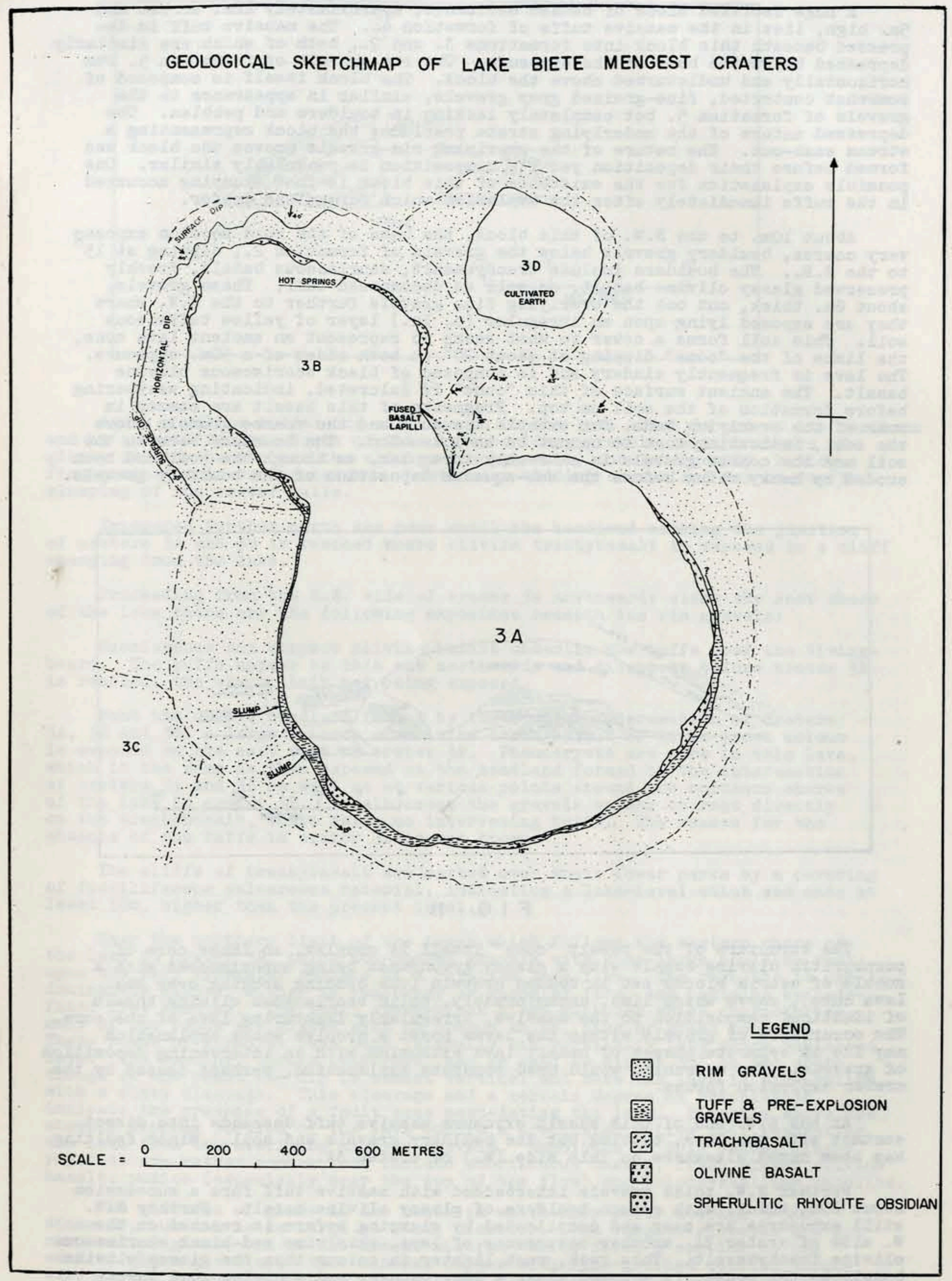


FIG. 9

A huge isolated block of bedded sediments, approximately 12m. across and 5m. high, lies in the massive tuffs of formation 4.. The massive tuff is depressed beneath this block into formations 3. and 2., both of which are similarly depressed below the base of the exposure. The rim gravels of formation 5. run horizontally and undisturbed above the block. The block itself is composed of somewhat contorted, fine-grained grey gravels, similar in appearance to the gravels of formation 5. but completely lacking in boulders and pebbles. The depressed nature of the underlying strata precludes the block representing a stream wash-out. The nature of the overlying rim-gravels proves the block was formed before their deposition yet its composition is remarkably similar. One possible explanation for the existence of this block is that slumping occurred in the tuffs immediately after the explosion which formed the crater.

About 10m. to the N.W. of this block, the base of the road section exposes very coarse, bouldery gravels below the gravels of formation 2., dipping at 15° to the S.E.. The boulders include trachybasalt, scoriaceous basalt, freshly preserved glassy olivine basalt, as well as decomposed tuff. These gravels, about 6m. thick, cut out the overlying fine gravels further to the N.W. where they are exposed lying upon an irregular (c. 1m.) layer of yellow tuffaceous soil. This soil forms a cover to what seems to represent an ancient lava cone, the limbs of the "cone" dipping at about 20° on both sides of a 50m. exposure. The lava is frequently cindery and is composed of black scoriaceous olivine basalt. The ancient surface of this "cone" is calcreted, indicating weathering before formation of the soil on top. Fragments of this basalt are common in some of the overlying beds, for example the soil and the coarse gravels above the soil, indicating that it cannot be an intrusion. The boundary between the soil and the coarse gravels is extremely irregular, as though the soil had been eroded by heavy rains before the sub-aqueous deposition of the bouldery gravels.

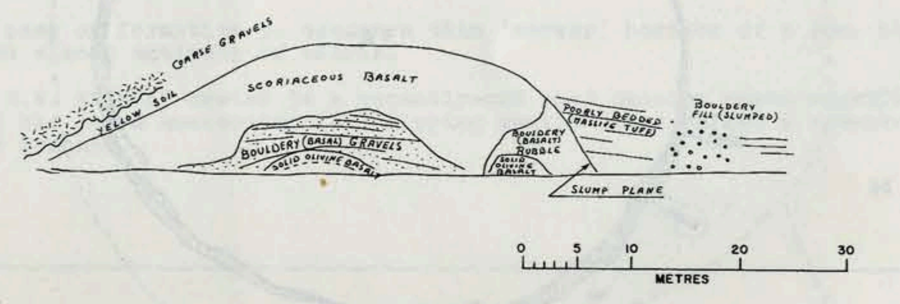


FIG. 11

The structure of the basalt "cone" itself is complex, an inner core of porphyritic olivine basalt with a glassy groundmass being superimposed with a rubble of scoria blocks set in bedded gravels (the bedding arching over the lava core), above which lies, unconformably, solid scoriaceous olivine basalt of identical composition to the massive, irregularly fracturing lava of the core. The occurrence of gravels within the lavas poses a problem whose explanation may lie in separate phases of basalt lava extrusion with an intervening deposition of gravels. The uparching would need separate explanation, perhaps caused by the crater explosion forces.

At the N.W. end of this basalt exposure massive tuff descends into direct contact with the lava, cutting out the bouldery gravels and soil. Minor faulting has been noted elsewhere on this side (W.) of crater 3A.

Further N.W. thick gravels interbedded with massive tuff form a succession about 20m. thick, with common boulders of glassy olivine basalt. Further N.W. still exposures are poor and complicated by slumping before is reached on the W. side of crater 3A, another occurrence of lava, this time red-black scoriaceous olivine trachybasalt. This rock, much lighter in colour than the glassy olivine basalt to the south, is exposed along a 10m. outcrop and contains some layers of compact lava of identical composition to the scoriaceous material

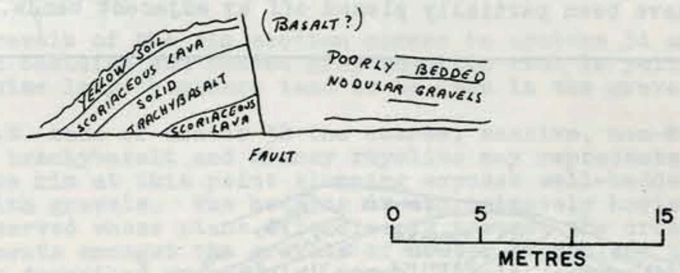


FIG. 12

Again a yellow tuffaceous soil occurs on the lava which is cut at its northern end by a small fault. North of this lava bouldery gravels (with boulders of glassy olivine basalt and the olivine trachybasalt) undulate gently, having a fine-grained thin-bedded nature. Lenticular bedding occurs and may be due to slumping of the crater walls.

Exposures further north are poor until the headland marking the junction of craters 3A and 3B is reached where olivine trachybasalt is exposed in a cliff emerging from the lake.

Proceeding from the S.E. side of crater 3A northwards along the east shore of the lake there are the following exposures beneath the rim gravels:

Scoriaceous and compact olivine basalt underlie the tuffs near the diving-board. The tuffs appear to thin out northwards and disappear before crater 3B is reached, the exact limit not being exposed.

Past the double headland formed by the complex intersection of craters 3A, 3B and 3D, a large outcrop of olivine trachybasalt of light green colour is exposed on the east side of crater 3B. Phenocrysts are rare in this lava, which is the same as that exposed on the headland formed by the intersection of craters 3A and 3B as well as at various points around the northern shores of the lake in crater 3B. In all cases the gravels appear to rest directly on the trachybasalt, there being no intervening tuffs. The reason for the absence of the tuffs in crater 3B is not known.

The cliffs of trachybasalt are marked over their lower parts by a covering of fossiliferous calcareous material, indicating a lake-level which was once at least 10m. higher than the present level.

Near the northern limit of the track which follows the eastern shore of the lake in crater 3B, thick non-bedded gravels with some large boulders rest upon the very irregular surface of a rhyolite lava flow. The rhyolite is predominantly glassy, either in pumiceous or globular form, and contains well-defined flow banding. The small green-black glass globules which characterize many of the bands are glazed with an opaque white, pink or green material. These bands of globules pass both laterally and vertically into dense pumiceous lava. The banding, though contorted, can be said to dip at 35° to the south, though at one point the dip is almost vertical and here the lava is pink-yellow with a slaty cleavage. This cleavage and a certain degree of brecciation indicate the presence of a fault zone post-dating the lava. Directly above the steeply dipping portion of the lava occurs a brecciated yellow soil separating the lava from the overlying massive gravels. Xenoliths in this banded glassy rhyolite are rather common, and include scoriaceous basalt, fresh glassy olivine basalt, pumice (especially near the top of the flow) and holocrystalline rhyolite.

The globules of glass in the bands in which they occur average 3-5mm. diameter, but can be as large as 15mm. diameter. The largest globules are not composed of glass, but of the opaque mineral which forms a coating to the smaller glass globules; this mineral occurs with fine-grained oolitic structure in the largest globules. Other large globules externally show an irregular 'botryoidal' shape, and whilst these are sometimes made of obsidian but more commonly show a radiating internal structure of needles of an opaque mineral with an earthly lustre. Microcospic examination of the globular lava reveals glass and quartz as the main constituents, the latter mineral occurring both in mosaic and radial clusters. The pink bands are coloured by haematite. The large globules composed of radiating needles (of an unidentified mineral) also show a concentric zoning through which the needles pass. Some of the globules in many many bands have been partially planed off by adjacent bands.

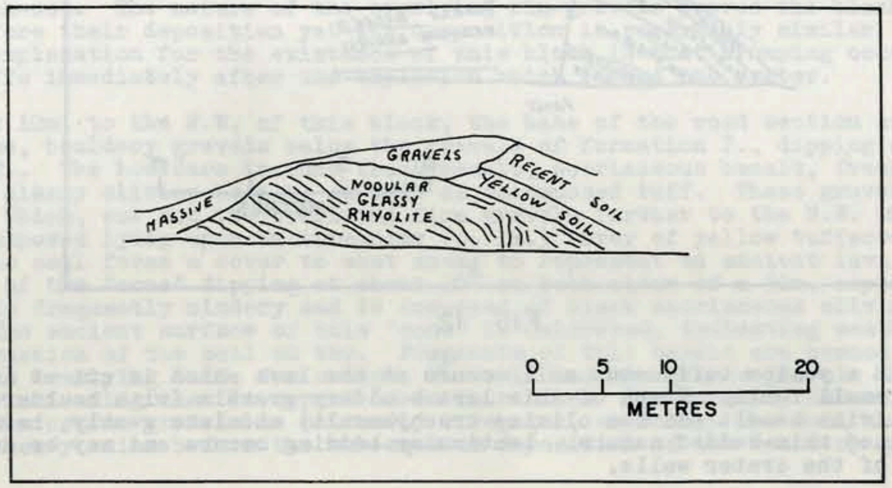


FIG. 13

The origin of the glass globules in this rhyolite is a problem to which the author does not pretend to have an easy answer. Spencer(1933) has described forms of silica glass from the presumed meteorite craters at Wabar, Arabia. Blackwelder (1953) has also described various forms of silica glass from the Arizona (Meteor) crater as follows: "masses of silica glass, ranging in size from minute droplets to spongy fragments more than 2 feet long, have been found in the material of the parapet and especially at depths of 40 to more than 150 feet in the sedimentary deposit inside the crater." The origin of this glass according to Blackwelder is related to fusion of country rock material on meteoritic impact. At Bishoftu, whilst similar spongy glass and glassy droplets are found at the N.E. side of crater 3B, these cannot be paralleled with those of Arizona because of their localised occurrence in a single flow (except where fragments were later distributed by the explosion). Obsidian lavas are common in the Rift Valley of Ethiopia but the author considers that the Bishoftu rock may represent an ignimbrite though the definition of this term remains uncertain, both welded tuffs and spherulitic obsidian lavas being included by different previous authors under the same name.

The structure of the rim gravels of craters 3A and 3B is complex, especially where the junctions with crater 3C and 3D occur. Slumping down the inner rim walls has further complicated interpretation.

On the S.E. side of crater 3A the rim is low and is formed of gravels only about 17m. thick. Some extraordinary large boulders occur in the gravels on this side of the crater, the largest so far observed being at least 3m. across. These boulders characteristically depress the underlying gravels, whilst the higher gravel layers curve up over the boulders. It seems indes-putable that the boulders came to rest in a sub-aqueous (fluvial?) environment. The boulders are most commonly composed of light grey trachybasalt, normal and porphyritic basalts, olivine basalt, and the fresh glassy olivine basalt exposed in situ on the S.W. side of crater 3A. Clockwise and westwards from the S.E. side of crater 3A the gravels thicken rapidly to at least 150m.. They are characterized by their linear bedding, a notable difference from the S.E. where the gravels show some cross-bedding and seem to have been deposited in fast-moving waters. On the west side of crater 3A the gravels keep their linear bedding although the underlying tuffs curve over the lavas; that is, they were deposited on a flat surface.

The rim common to craters 3A and 3C is marked by a covering of gravels whose perfect bedding forms the surface slope. This phenomenon is especially well seen at the inner northern side of the rim of crater 3B where the horizon-tal gravels inside the rim curve downwards as tney emerge. Undoubtedly the

Bishoftu crater rims were formed of gravels whose bedding originally took the form of an 'anticline', but it was exactly this form of bedding which facilitated slumping down the steep inner slopes of the rims, thus accounting for the rarity with which surface-dip gravels are preserved on these inner rim slopes. On the outer rim slopes of the craters surface dipping gravels are observed to be the general rule.

In the gravels of the rim section common to craters 3A and 3C fragments of spherulitic obsidian and banded grey rhyolite rich in yellow amygdales occur. Otherwise large boulders tend to be rare in the gravels of crater 3C.

At the N.E. side of crater 3B the coarse, massive, non-bedded gravels overlying the trachybasalt and glassy rhyolite may represents slumped material. Half-way up the rim at this point slumping exposes well-bedded yellow tuffs interbedded with gravels. The bedding is approximately horizontal but uncon-formity is observed whose plane dips steeply towards the crater centre. Bouldery fragments amongst the gravels of crater 3B include the fresh glassy olivine basalt described previously, normal basalt, coarse olivine basalt, basalt scoria, trachybasalt, fragments of the glassy rhyolite described pre-viously, and rare rounded pebbles of solvsbergite. The average thickness of the rim gravels of crater 3B is about 100m.

At the junction of craters 3A and 3B on the eastern side, the gravels form a conspicuous 'anticlinal' structure whose limbs give rise to the double headland separating the two craters. The anticlinal formation forms a common rim to crater 3A and 3B but is complicated eastwards where gravels from the explosion of crater 3D are encountered. A detailed study of the gravels in this region might reveal information on the order of explosion of the three craters, but the author has not had time to pursue this.

Along the track between the two headlands separating crater 3A and 3B the dipping gravels of the two limbs appear to be unconformably overlain by horizontally bedded gravels (or, more probably, the bedding follows the surface slope of the face of the 'anticline'). Whilst these overlying gravels may re-present the effects of slumping, they could also be explained as being derived from the explosion of crater 3D following those of craters 3A and 3B and there-by depositing ejecta on their common rim at this point.

Within these 'anticlinal' gravels occurs an indefinitely bounded c.2m. layer composed of basalt lapilli fused together to give a 'crinkled peas' structure. (Average diameter of lapilli 4mm.). Within the layer occur bands of coarser material, mostly irregular basalt scoria fragments up to 4cm. across together with fragments of banded rhyolite and olivine basalt, all similarly fused together. The cement is a pale-green translucent material which entirely covers the fragments or lapilli. Rare fragments of limestone have been observed amongst the basalt lapilli. This 2m. band, exposed in both limbs of the 'anticline' along the track, seems to be the product of intense heat.

Above the track at the more northerly of the two headlands a fragment has been found, unfortunately not in situ, of a red-brown nodular siltstone with at least two bedding planes showing spatterings of scoriaceous basalt. The pattern of the fragments indisputably suggests a derivation from the splashing of fallen liquid drops. Whilst nodular clays and silts are common in the strata exposed in the Bishoftu craters, the specimen described above is unique in having a colour (bright reddish-brown) different from the usual monotonous grey. Presumably the iron of the sediment has been oxidised to the ferric state, but whether this oxidation was original or due to secondary causes cannot be ascertained until the rock is found in situ.

The history of the strata exposed in craters 3A, 3B, 3C and 3D may thus be summarized as follow:

1. Eruption of olivine trachybasalt and glassy olivine basalt lavas, probably followed at a later date (according to the presence of xenoliths) by eruption of glassy rhyolite lava.

2. Formation of calcretes and soils on these flows.

3. Soils eroded by heavy rains, followed by flooding of the region beneath fluvial waters in which very coarse gravels were deposited. One flow of glassy olivine basalt seems to have formed during this phase.

4. Sub-aqueous deposition of fine gravels in a lacustrine(?) environment.

5. Sub-aqueous deposition of tuffs.

6. Sub-aerial deposition of tuffs, followed by weathering of surface.

7. Explosion of craters with formation of rims. Lacustrine waters entered the east side of crater 3A in a torrent which was able to move extremely large boulders, and prevented high growth of the rim on this side. Intensely hot gases from a secondary explosion fused the ejecta forming the surface of the rims at that time. This secondary explosion may have been related to the formation of crater 3D which seems to have post-dated craters 3A and 3B.

8. Hot-springs provided calcium carbonate for fossils living in the deeper lake of that time. Slumping of the inner crater walls. Considerable denudation of the low-lying rim of crater 3C by sub-aqueous agents.

9. Lake-level fell as climate became dryer. Denudation of rims continued.

<u>Crater 5.</u> (L. Hora)

This almost perfectly circular crater is situated at a lower elevation than the crater previously described. Not only does its contained lake fill it more fully, but its rim has been notably denuded, presumably by sub-aqueous agents.

Because of the height of the lake only the very topmost beds underlying the rim gravels can be observed. (Note: in craters 3C, 3D, 4A and 4B only the rim gravels are exposed). At the N.E. side of crater 5 occurs a cinder cone which was sheared through in the explosion. On the W. side of the crater similar red scoria occur, here not protruding up to form part of the rim but overlain by horizontal, bedded gravels. On the S. side of the crater fine-grained yellow tuffs are exposed beneath the rim gravels. On the western side of the crater where the gravels are best developed they reveal numerous very coarse, rubbly layers in perfect uniform horizontal bedding. These coarse layers are composed almost entirely of basalt scoria. Numerous boulders, up to 1½m. across, occur in the gravels whose bedding planes they appear to cut through abruptly. The boulders include normal basalt, amygdaloidal basalt, coarse olivine basalt, flow-banded pumiceous rhyolite with quartz phenocrysts, yellow and pink flow-banded rhyolite (microscopically revealing a quartz mosaic with spherulites and vesicles; orthoclase common; haematite replacing corroded remnants of ferromagnesian minerals), porphyritic trachyte, basalt scoria etc.. At the north side of crater 5 the gravels of the rim are fine and dusty, coarse rubbly layers of scoria being virtually absent; the boulders are relatively small (up to ½m. across) but still cut the bedding planes of the gravels sharply. Solvsbergite is represented amongst the boulders on this (N.) side of the rim.

The tuffs underlying the gravels at the south side of the rim are clayey and nodular. This nodular structure also occurs in the finer-grained layers of the rim gravels, and has also been noted in the rim gravels of craters 4A and 4B.

The inner rim wall of crater 5 on the west side reveals a coating on the rocks of white carbonate, frequently as much as 3mm. thick and bearing obscure fossil remains. This carbonate coating extends on rocks up to 15m. above present lake-level; at this height the lake would have been close to overflowing the eastern rim of the crater.

The history of the strata of crater 5, less well evidenced than for the other large, lake-filled craters because of the height of the lake in the crater, may be summarized as follows:

1. Eruption of cinder cones.

2. Sub-aqueous (?) deposition of tuffs around the cinder cones. The cinder cone of the N.E. rim was probably formed shortly before stage 3.

3. Explosion of the crater and formation of the rim.

4. High lake-level and denudation of rim by external lacustrine waters.

5. Climate becomes dryer and lake-level falls.

<u>Craters 6. (L.Kilotes) and 6A.</u>

The crater occupied by L. Kilotes has been extremely denuded. This fact may be due either to its being older than the other Bishoftu craters, or to its low-lying situation which subjected it to the vigorous action of fluvial and lacustrine agents during the Pluvial. The relatively well preserved crater 6A indicates that both the above factors played a part.

The rim of crater 6, and the gravels forming it, are fairly well preserved only on the west side, presumably the highest side of the original rim. Elsewhere the land slopes gently down to the lake shores from a very worn-down rim never higher than about 15m. above the outside plain level. The inner slopes of the rim are strewn with boulders of basalt (probably once occurring in the gravels, though originally derived from a flow to the south), highly leucocratic porphyritic rhyolite (containing xenoliths of basalt scoria) and, especially on the northern side, fragments of dense, white chalky limestone with common plant remains. This limestone is rarely crystalline and siliceous. Rare fragments of an altered plutonic(?) igneous rock show large feldspar phenocrysts preserved in a soft weathered greyish matrix.

Crater 6A is much better preserved than crater 6, and is remarkable for being bisected by an E.-W. fault, downthrown north. (See Map 3). This fault is observed to breach the rim of crater 6A at its east and west sides, but cannot be traced across the crater floor which is covered with fresh lacustrine sediments. It may be noted that faulting is common in this region. To the east of crater 6A the fault which cuts that crater turns to resume the N.E.-S.W. trend, downthrown N.W., characteristic of several other parallel faults. The fault which curves westwards to bisect crater 6A continues towards crater 6 which it would also bisect except that the fault fails to reappear on the west side of the rim of that crater.

Crater 6A shows a small, rounded hill rising from the centre of the crater floor. The author has been unable to visit crater 6A to investigate the nature of this hill.

From the evidence at present available the history of crater 6, and 6A may be summarized as follows:

1. Volcanic activity with lava flows and deposition of cinders.

2. Explosion of crater 6, probably along a fault line, followed much later by the explosion of crater 6A along the same fault line.

3. Deposition of limestone with hot springs probably supplying the calcium carbonate. Considerable denudation of the rims of crater 6 (this began before crater 6A formed) by fluvial and lacustrine agents.

4. Renewal of faulting along the old fault line.

5. Recession of lake-levels as the climate became dryer.

Except in the craters themselves the strata of the Bishoftu region are rarely exposed. The hills south of Bishoftu represent denuded rhyolitic cones together with some ash cones in an intricate relationship not yet fully mapped in detail. Amongst these hills there is evidence of a number of faults along which vertical displacements have occured, some of very recent date and freshly preserved.

Cinder cones are numerous and scattered over the plains to the east and north-east of Bishoftu. 4Km. E. of the Palace Hotel lies a lava crater which has poured out scoriaceous basalt over the plains to the south. The red cinders of the cone 1Km. N.E. of the E.A.F. Tower are at present being quarried for road metal. The quarry exposes an overlapping of the base of the cinder cone by horizontally bedded, fine-grained silts and clays. The clays are frequently nodular, perhaps the result of post-depositional dessication. A thin band of basalt scoria near the top of this lacustrine succession represents a late contemporaneous phase of vulcanicity. Similar lacustrine deposits are rarely exposed in stream sections of the plains, though nearer to the craters these sediments are overlain by the coarser rim gravels.

Various limestone deposits associated with the Bishoftu craters, as with those of El Sod, Borana, have already been discussed as derived from hot-spring sources of calcium carbonate. The only hot-springs known to the author which are actively associated with the Bishoftu craters today occur close to lake-level along the eastern shore of crater 3B. The waters of these springs have not yet been analysed, but an analysis of the waters of L. Biete Mengest by the

Italian Hydrological Survey in 1940 revealed the following data:

1.538 gms.(of solid salts)/litre,
Cl' 0.178g.
Ca^{++} 0.016g.
Mg^{++} 0.0077g.
Na^{+} 0.216g.
K^{+} 0.026g.
remainder (CO_3", HCO_3', SO_4", etc.) 1.0943g.

A microscope analysis of lacustrine silt from the quarried cinder cone near the E.A.F. Base has revealed a composition almost entirely of rounded feldspar and quartz grains. Virtually no iron oxide or ferromagnesian mineral grains are present, and heavy minerals are rare.

Summarized geological history of the Bishoftu region.

1. Eruptions of trachybasalt (crater 3B) and glassy olivine basalt (crater 3A) from unknown sources. Associated eruptions of cinder cones. The basalt of crater 6 may also belong to this stage.

2. Eruptions of flow-banded rhyolite lavas from a centre in the Bishoftu hills. Though petrographically distinct from the phonolites of Zuquala they were probably temporally related. The last of these rhyolite flows took an ignimbritic structure (crater 1) which is even better shown by a probably contemporaneous flow now exposed in crater 3B.

3. Widespread sub-aqueous deposition of yellow tuffs (and pumice at crater 1) was preceeded in the region of crater 3A by fluvial gravels. The tuffs, derived probably from the ash-cones of the Bishoftu hills, were deposited in a quiet lacustrine environment.

4. Continued deposition of tuffs, but now in a sub-aerial environment. Fossils indicate that plants flourished on the tuffs.

5. Extensive basaltic eruptions forming the dyke and sills of crater 1, the lava field of the E.A.F. base, and possibly the lava flows from the cone 10Km. south of crater 1 and from the cone 4Km. east of crater 3A.

6. Explosions of craters in a sub-aqueous environment and formation of rims of ejecta. (note: crater 6, and perhaps other obscure crater remnants, formed shortly after stage 1). The ejecta were deposited under water and were derived from the bed-rocks and from deeper-seated basalt. The crater explosions were associated with old fault lines.

   A direct consequence of the explosions was the filling of some of the craters by exterior lacustrine waters. The force of the entering waters swept away bed-rock in places and reduced the growth of the rim at such points; their force is evidenced by the huge boulders which were moved. Some craters suffered more from the denudation than other craters which were situated at higher elevations. The Bishoftu region at this time was occupied by an arm of the huge lake then occupying the Rift floor and which extended north-westwards almost as far as Addis Ababa.

7. Deposition of lacustrine sediments outside the crater-rims. Limestone was deposited outside craters 1 and 6, otherwise the sediments were predominantly fine, clastic types. Inside craters 1, 2, 3A and 3B, 5 and 6, hot spring activity enabled deposition of calcium carbonate and carbonate-secreting fossils. Some water-borne clastic sediment may have entered the lower craters (eg. crater 5), but a larger factor in filling their bottoms was slumping of the inner slopes of the rims.

   The presence of scoria and crystals in the limestone north of crater 1 indicates either contemporaneous cinder cone activity or the transport of these materials into the waters of deposition.

8. Renewal of faulting near crater 6A and in the Bishoftu hills.

9. Climate became dryer, causing the crater lake-levels to lower to those observed today, and causing almost complete disappearance of the Rift Valley lake.

Regarding fixing absolute ages for any of these stages nothing can yet be stated with certainty.

Mr. J. Webb, Secondmaster at Debra Zeit Secondary Technical School, has discovered obsidian artifacts on several cinder cones and on all the crater-rims of the Bishoftu region. He ascribes their cultural level to Wilton A and indicates that tentative correlation with Kenya suggests a date around 1000 B.C.. The crater explosions are thus earlier than 1000 B.C..

The author very tentatively suggests the following correlations:

1. the pyroclastic sediments of stage 3. were deposited at the end of the 2nd major pluvial in Ethiopia (the Gamblian of Kenya) ie. about 10,000 B.C.

2. the explosions occurred at the beginning of the Makalian post-pluvial wet phase ie. between 6000 and 4000 B.C., the crater-leke levels remaining high for an appreciable time after the explosions. Further evidence for this choice of age for the explosions is presented in the next section of this paper.

The Cause of the Explosions.

Many early travellers (see Dainelli 1943 Vol III p. 635) referred to the existence of circular craters near Bishoftu but few observations were made regarding their structure and geology. A. Aubry in 1886 noted that the rim of "l. Addo crater" (Biete Mengest) was lowest on the eastern side where columnar trachyte was exposed whilst on the western side lava, scoria, tuff and trachyte cinders occurred in regular strata. Aubry noted several craters open at one end whose rims took the form of a horseshoe; these were undoubtedly some of the numerous cinder cones in the vicinity. H. Reck in 1930 commented on the perfectly circular shape of some of the craters but did not discuss their origin; he noted the presence of five crater lakes: "Bishoftu, Addo, Arsadi, Corisso and Chilole".

The first detailed discussion of the Bishoftu craters relative to their origin was given by Major Tore Sjögren in 1951 in a series of five semi-popular articles in the "Ethiopian Herald". In these articles arguments were advanced for a meteoritic origin for the Bishoftu craters. Despite the numerous manifestations of volcanic activity about Bishoftu, Sjögren justifiably pointed out that: "the universe has certainly no law which could prevent meteors from hitting a volcanic country". Because Sjögren has admirably marshalled all possible evidence for a meteoritic origin of the explosion craters the author will list list these and then deal critically with each argument in turn:

1. "The likeliness (of terrestrial meteoritic craters) to the Bishoftou lakes is striking: the same circular rim rises over the country, the same steep inner sides, the waving lines along the edge of the big hollow. And the same circular form!"

2. With volcanic craters "there seems to be only one hollow in each place, and usually lava has poured out along the rim. This is not the case in Bishoftou".

3. "All the crater lakes in Bishoftou, and the dry holes in the ground, show a very regular, circular form"..... "The biggest lake consists of two circles, going into one another. It is difficult to understand how pressure from the inner (parts) of the earth could have made two craters so very close together. It seems more natural that the volcanic eruptions would have caused one, common hole".

4. "The rims around them (the craters) are always higher on the southern side, a fact difficult to explain with any other (non-meteoritic) theory".

5. "None of them (the craters) has an island in the center".

6. "Volcanic craters are usually found along a curved line or in a swarm around the biggest one. The straight line (alignment of the Bishoftu craters) corresponds well to the meteoritic theory".

7. "Some details along the inner edge (of the rim) indicate a terrible heat. Just under the edge there is a zone with dark, crusted slag walls, which are much harder and resist the weathering better. These slag walls can be found on photos from the Arizona crater and are, clearly, the result of enormous heat at the impact of the meteor".

8. "Until now, no stones or iron fragments have been found which could solve the problem about the craters'origin......" "If smaller parts of an exploding iron meteor remain on the surface, they will soon rust and vanish, especially in a tropical climate....." "Fragments from a stone meteor might be so very similar to the products of volcanicity that it will be an intricate job to differentiate them".

9. "It is....a fact that the compass shows remarkable deviation here. Elsewhere in the country, the magnetic deviations are very small. This observation indicates a method to find iron fragments, buried in the ground".

10. "The air resistance must.... have drawn out the swarm (of meteorites) along a line, with the heaviest body first and the other(s) behind and beneath"....."The deepest, and most violent, crater lies in the south, and the northern ones indicate a decidedly smaller amount of energy"....

11. "The craters are.... situated along a straight line, going north-south, with a slight deviation of 10 degrees to the east. The Great Rift Valley, on the bottom of which these craters are spread, goes here in the direction northeast-southwest".

Sjögren finally goes on to discuss the size of the meteorites which produced the craters, their direction and time of entry into the Earth's atmosphere, and the temperature generated on impact. He considers, from a study of the degree of denudation of the crater rims, that the explosions occurred about 3000 B.C..

It may be first be noted that neither of LaPaz's (1958) principal criteria for authentication of a meteorite crater are satisfied for the Bishoftu craters. Firstly, there was no recorded witness of falling meteorites (inevitable considering the early historical times when the craters were formed), and secondly no fragments of either unaltered or oxidised meteorites, or of metamorphosed material definitely known to have resulted from meteoritic impact, have been found. The occurrence of silica glass at Arizona (Meteor) Crater in relation to that of crater 3B and a meteoritic origin has already been commented on (page 84). In a very interesting paper Hager (1953) considers that the Arizona Crater formed, not by meteoritic impact, but from graben faulting and sink hole processes associated with postulated underlying beds of evaporite and limestone, and that the silica glass was derived from earlier volcanic eruptions. Certainly there is a remarkable alignment of Arizona Crater with local tectonic features.

Neither are LaPaz's auxiliary criteria for meteorite craters satisfied as regards radial faulting, the presence of radial percussion ridges or radially aligned jets of ejecta, and the upturning and overthrow of strata. However, tendencies to bilateral symmetry and for a decrease in the amount and size of ejecta with distance away from the craters, have been noted at Bishoftu.

Dealing with Sjögren's arguments for a meteoritic origin for the Bishoftu craters in the order given, it may be noted:

1. Circular explosion craters of non-meteoritic origin with very similar profiles to the Bishoftu craters are known eg. the Katwe-Kikorongo craters near Ruwenzori, and the explosion craters of northern Kenya at Marsabit and north of the Isiolo-Garba Tula road.

2. Explosion craters associated with faulting in a volcanic region very rarely show lava. Of nearly fifty such explosion craters known in Ethiopia only one shows evidence of associated lava eruptions.

3. Twin explosion craters of non-meteoritic origin are known from Katwe-Kikorongo, and from other parts of Ethiopia than Bishoftu.

4. The rims are not highest on the south side but on the S.W. side. As the craters are aligned almost due N.-S. this offset of the rim summits is no more explained by the meteoritic theory than by any other.

5. Explosion craters associated with faulting rarely manifest an island in their central lake.

6. Explosion craters associated with faulting will be sited along the faults, whatever lines the faults may happen to take. In the case of the Bishoftu craters evidence will be given below to suggest that the craters are in fact aligned along gentle curves.

7. The author has been unable to find any evidence of a slag zone under the inner edge of the crater rims, with the exception of the band of fused basalt lapilli and scoria in the rim gravels at the junction of craters 3A and 3B.

8. The author's researches have not led to the finding of a single fragment of iron. As stone meteorites are usually of an ultrabasic or basic composition distinguishing of them from some of the coarser olivine basalt lavas of the Bishoftu region would undoubtedly be difficult.

9. A survey made by P. Gouin in the company of the author has shown that compass deviations about the major Bishoftu craters are less than 1°, if present at all. Similarly, measurements of magnetic dip have revealed no significant anomalies. However, no such deviations or anomalies would be expected with stone meteorite fragments.

10. Whilst crater 1 is the deepest of the Bishoftu craters, the small remnant of crater 1A lies south of it. Also the craters are definitely <u>not</u> in order of size and depth from north to south. The presence of some older, denuded explosion craters eg. crater 6 is inexplicable on the meteoritic theory.

11. The alignment of the Rift Valley, whose western margin is obscure in the Bishoftu region, is not N.E.-S.W. but about 30° E. of N.. This is still not the alignment of the Bishoftu craters, but it will be shown that the apparent straight N.-S. alignment is not fundamental and is to a certain extent accidental.

Further argument for a non-meteoritic origin is found in the occurrence of other explosion craters south of Bishoftu along the western margin to the Main Ethiopian Rift, especially near Butagira and Kolito. Besides three beautifully preserved craters at each of these localities there occur older ones either largely filled with sediment or crowded with cinder cones. Explosion craters are also very numerous in the volcanic region south of L. Tana, but perhaps some of the most interesting explosion craters in Ethiopia are those at El Sod, Borana. Though related to fresh faulting and basalt cinder eruptions the El Sod craters have exploded through Basement Complex granites. There is,therefore, a better opportunity for studying the relationship of the ejecta to the bedrock than at Bishoftu where the bedrock is itself volcanic. At the main crater at El Sod, an immense depression about 350m. deep and 1 to 1½Km. in diameter, the rim ejecta resting upon the granites are largely composed of basalt fragments, together with mush less common ultramafic granite, biotite pegmatite, hornblende granite-gneiss, and dunite. Dunite has not been found in the ejecta of the Bishoftu craters with the doubtful exception of a very weathered specimen from crater 4A. It is the predominance of basalt lapilli, however, which is of significance, indicating an origin for the explosion craters related to magmatic activity, though, as mentioned previously, no lavas have been directly observed in relation to fresh explosion craters in Ethiopia with the exception of the most southerly of the Kolito craters. The occurrence of post-explosion limestone outside the El Sod craters is remarkably paralleled at Bishoftu.

Thus the occurrence of explosion craters over widely scattered parts of Ethiopia, many aligned along the western margin of the Rift Valley, and always associated with evidence of recent vulcanicity, must eliminate any possibility of a meteoritic origin for the Bishoftu craters. Sjögren in advocating a meteoritic origin for explosion craters has evidently confused volcanic craters (centres of lava and pyroclast eruptions, such as Zuquala) with explosion craters associated with faulting in volcanic regions; in fact they are quite distinct in their structure and in the respective presence and absence of lavas.

So far as the author is aware there is as yet no profile criterion for distinguishing explosion craters of impact origin from those of subterranean origin. Certainly the profiles of the Bishoftu explosion craters, allowing for infilling, can be closely matched with those of small terrestrial meteoritic craters. Therefore the satisfying of Baldwin's (1944) formulae, even if LaPaz's criticisms are neglected, can give no clue as to the origin of explosion craters.

It is in geological features that a theory of the origin of the Bishoftu explosion craters must be sought.

Because explosion craters in volcanic regions and of non-meteoritic origin are always, so far as is at present known, associated with faulting, it is pertinent to look for faulting associated with the Bishoftu craters. In fact the direct association of faulting with crater 6 and 6A has already been noted, whilst faulting in the Bishoftu hills, some of very recent date, is indicated on Map 2.. However, for all the craters on the main approx. north-south alignment there is no evidence of any faulting yet detected. It must be recalled that deposition of lacustrine sediments would have obscured surface evidence of such faults in the absence of renewed movements, though vertical displacements might be expected to have been preserved in geomorphological features.

A closer examination of the crater alignment at Bishoftu, however, reveals that the evident north-south alignment can be represented as a series of offset parallel arcuate alignments trending approximately 30°E. of N.. These alignments are found to include many of the cinder cones also (Map 3.). If the alignments are genuine surface manifestations of deeper-seated phenomena then they would be expected to be directly related to faulting. In fact some of the alignments pass into known faults.

The author therefore suggests that the Bishoftu explosion craters are associated with a series of parallel arcuate faults produced by wrench movements acting to the immediate west of the region in a clockwise direction. Being tear faults there are generally no vertical displacements manifested. Furthermore it will be noted that the new suggested alignments now include the highest portions of the crater-rims. This does not explain why the S.W. sides of the crater-rims are generally highest, but that there is a relationship to the alignments is significant. Of course, the orientation of the rim summits could be coincidentally similar to the alignments, and actually be due to some unrelated cause of which the most likely is the prevalence of N.E. winds (common today) at the time of the explosions. However, it would seem more credible that the crater alignments and rim summit orientations are fundamentally related to a similar cause, and that wrench faulting caused the release of explosive steam to be somewhat inclined rather than vertically upwards.

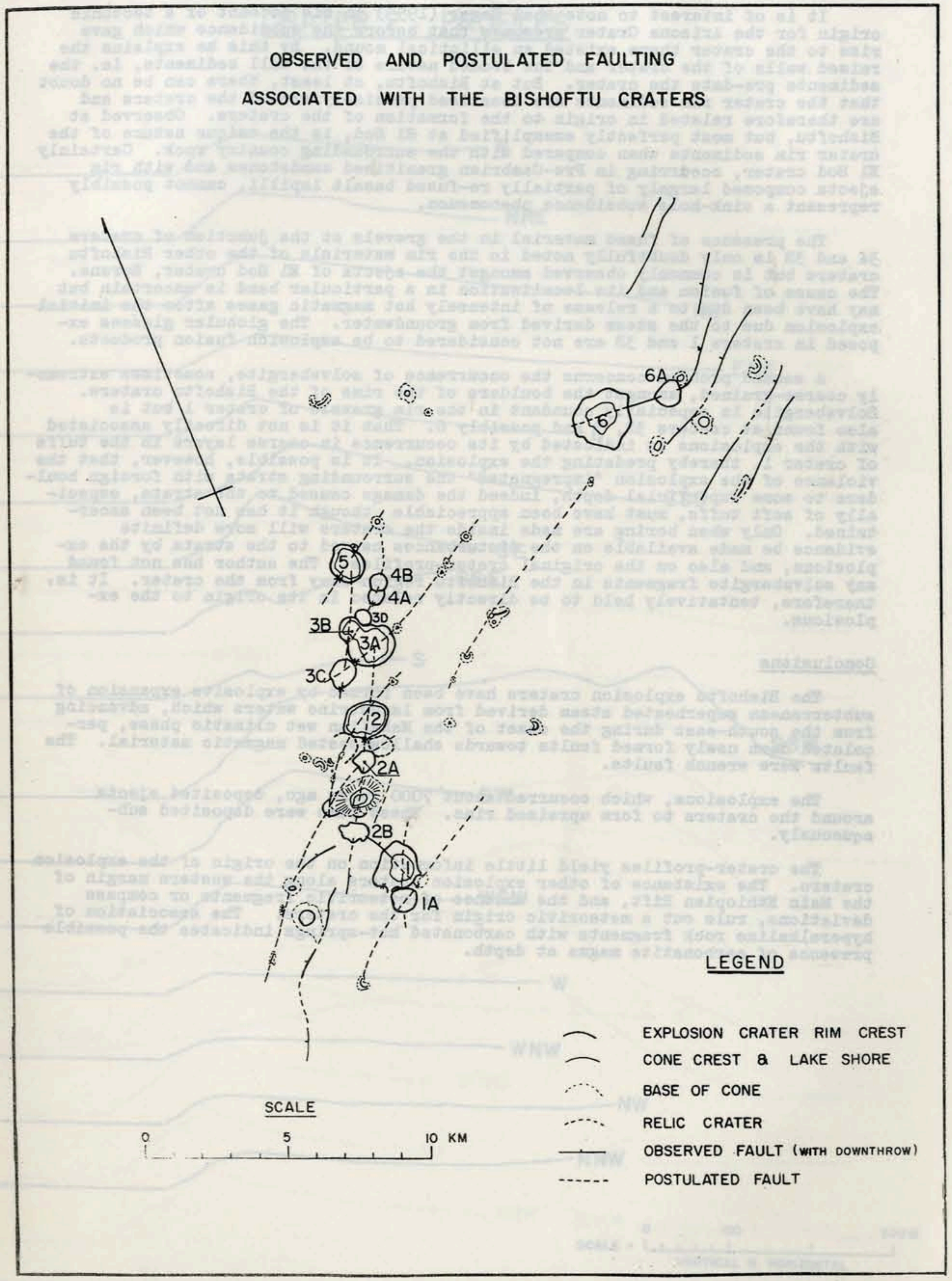
The coincident orientations of the Bishoftu crater alignment arcs and the Main Ethiopian Rift faults may be noted. Indeed, the line of the main horst of the Gurage Mts. can be produced in a notherly direction and found to pass directly through the Bishoftu region; the Butagira explosion craters lie at the foot of the Gurage horst.

If the relation of the Bishoftu craters to possible wrench faulting is accepted, pertinent information with regard to the strata exposed in the craters can be next considered. One of the major problems of the Bishoftu craters is the composition of the rims; presumably composed of ejecta, the rims are marked by often beautifully developed bedding. It is evident that deposition of the ejecta occurred over an appreciable time, there occurring repeated alternations of gravelly or bouldery beds with the finest dust. How this came to be the author does not yet presume to answer. What is certain, however, is that deposition was sub-aqueous, current bedding and also the presence of some immense boulders in the bedded gravels admitting of no other explanation. But the tuffs immediately below the rim gravels in most of the craters are massive and contain terrestrial plant remains. The explosions of the Bishoftu craters and of El Sod would thus seem to have been coincident with the return of a wet climate and perhaps reformation of lacustrine waters.

If, therefore, faulting with related magmatic activity not far below the surface was closely followed by flooding of the region by lacustrine waters, the possibility arises of major seepage of water down the faults where it would be transformed into steam in proximity to magma, and ultimately the accumulating pressure would be released with explosive violence. The results of such a phenomenon were actually observed in May 1918 north of L. Rudolf in the lower Omo basin; rising to an almost unprecedented level the waters of L. Rudolf flooded northwards up the wide, flat, low graben of the lower Omo. Explosions were heard, and visitors to the region when the lake level had later fallen to normal observed fresh explosion craters where none had previously existed. (See Holland 1926).

Before concluding it will be advantageous to review problems concerning the Bishoftu craters which still await even partial explanation:

Firstly, and most important, the manner of deposition of the rim gravels. The difficulties of explaining the bedding, alternations of fine and coarse material, and the distribution of large boulders, at present seem irreconcilable with an immediate falling back to earth of ejecta from an instantaneous explosion. On the other hand, that there were successive explosions from the same crater seems equally untenable. The 'anticlinal' structure of the rim gravels can best be explained by settling of ejecta, and the localisation of bouldery gravels to the crater rims and the nature of the boulders themselves point indisputably to a source of such ejecta from subterranean explosions.



MAP 3

It is of interest to note that Hager (1953) in his account of a tectonic origin for the Arizona Crater presumes that before the subsidence which gave rise to the crater there existed an elliptical mound. By this he explains the raised walls of the crater and the bedded nature of the wall sediments, ie. the sediments pre-date the crater. But at Bishoftu, at least, there can be no doubt that the crater rim sediments are localised precisely around the craters and are therefore related in origin to the formation of the craters. Observed at Bishoftu, but most perfectly exemplified at El Sod, is the unique nature of the crater rim sediments when compared with the surrounding country rock. Certainly El Sod crater, occurring in Pre-Cambrian granitised sandstones and with rim ejecta composed largely of partially re-fused basalt lapilli, cannot possibly represent a sink-hole subsidence phenomenon.

The presence of fused material in the gravels at the junction of craters 3A and 3B is only doubtfully noted in the rim materials of the other Bishoftu craters but is commonly observed amongst the ejecta of El Sod crater, Borana. The cause of fusion and its localisation in a particular band is uncertain but may have been due to a release of intensely hot magmatic gases after the initial explosion due to the steam derived from groundwater. The globular glasses exposed in craters 1 and 3B are not considered to be explosion fusion products.

A second problem concerns the occurrence of solvsbergite, sometimes extremely coarse-grained, amongst the boulders of the rims of the Bishoftu craters. Solvsbergite is especially abundant in the rim gravels of crater 1 but is also found at craters 3B, 5 and possibly 6. That it is not directly associated with the explosions is indicated by its occurrence in coarse layers in the tuffs of crater 1, thereby predating the explosion. It is possible, however, that the violence of the explosion "impregnated" the surrounding strata with foreign boulders to some superficial depth, indeed the damage caused to the strata, especially of soft tuffs, must have been appreciable though it has not been ascertained. Only when boring are made inside the craters will more definite evidence be made available on the disturbances caused to the strata by the explosions, and also on the original crater-profiles. The author has not found any solvsbergite fragments in the Bishoftu region away from the crater. It is, therefore, tentatively held to be directly related in its origin to the explosions.

Conclusions

The Bishoftu explosion craters have been formed by explosive expansion of subterranean superheated steam derived from lacustrine waters which, advancing from the south-east during the onset of the Makalian wet climatic phase, percolated down newly formed faults towards shallow-seated magmatic material. The faults were wrench faults.

The explosions, which occurred about 7000 years ago, deposited ejecta around the craters to form upraised rims. These rims were deposited subaqueously.

The crater-profiles yield little information on the origin of the explosion craters. The existence of other explosion craters along the western margin of the Main Ethiopian Rift, and the absence of meteoritic fragments or compass deviations, rule out a meteoritic origin for the craters. The association of hyperalkaline rock fragments with carbonated hot-springs indicates the possible presence of carbonatite magma at depth.

CRATER 2 PROFILES

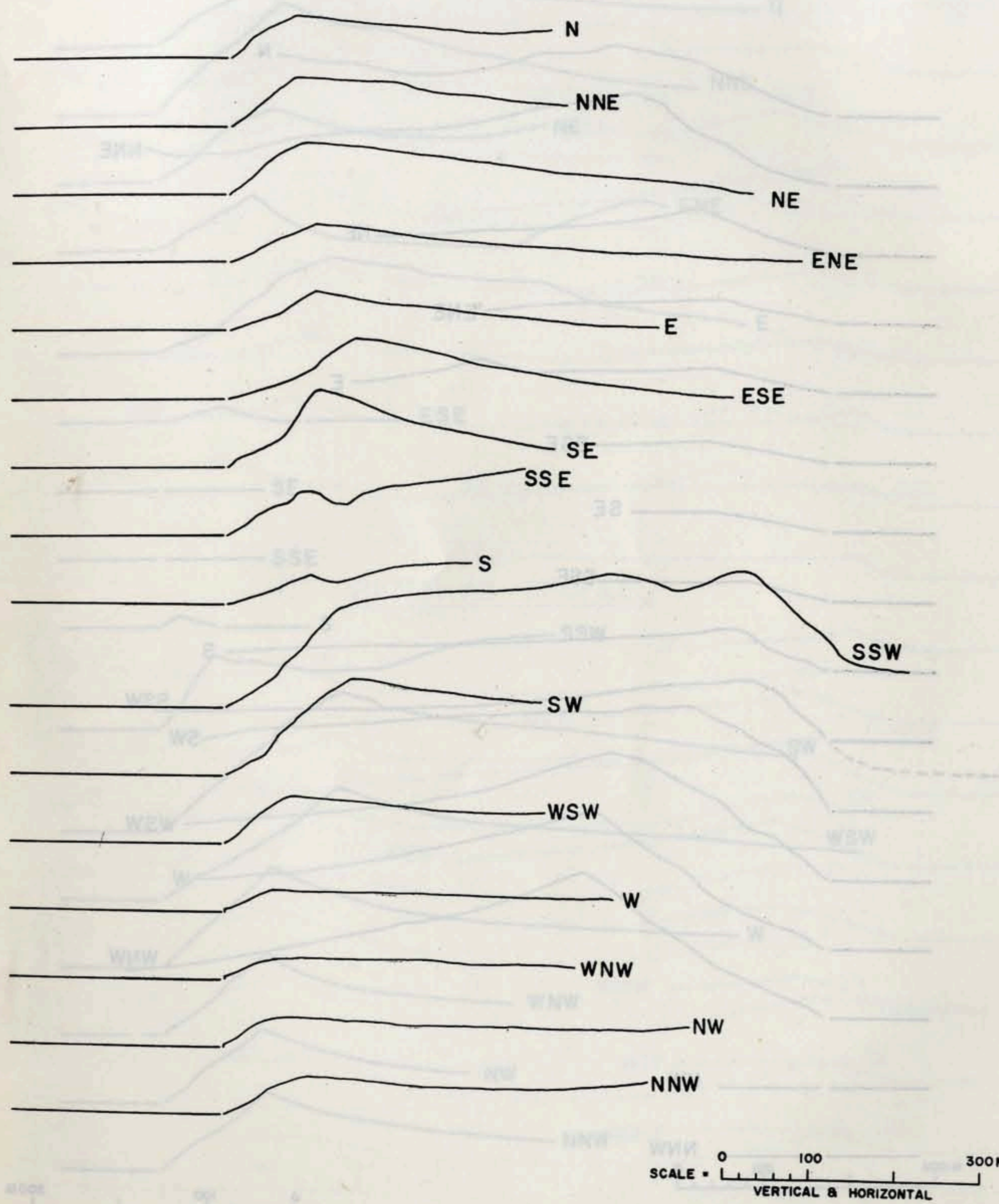


FIG. 1

CRATER 3A PROFILES

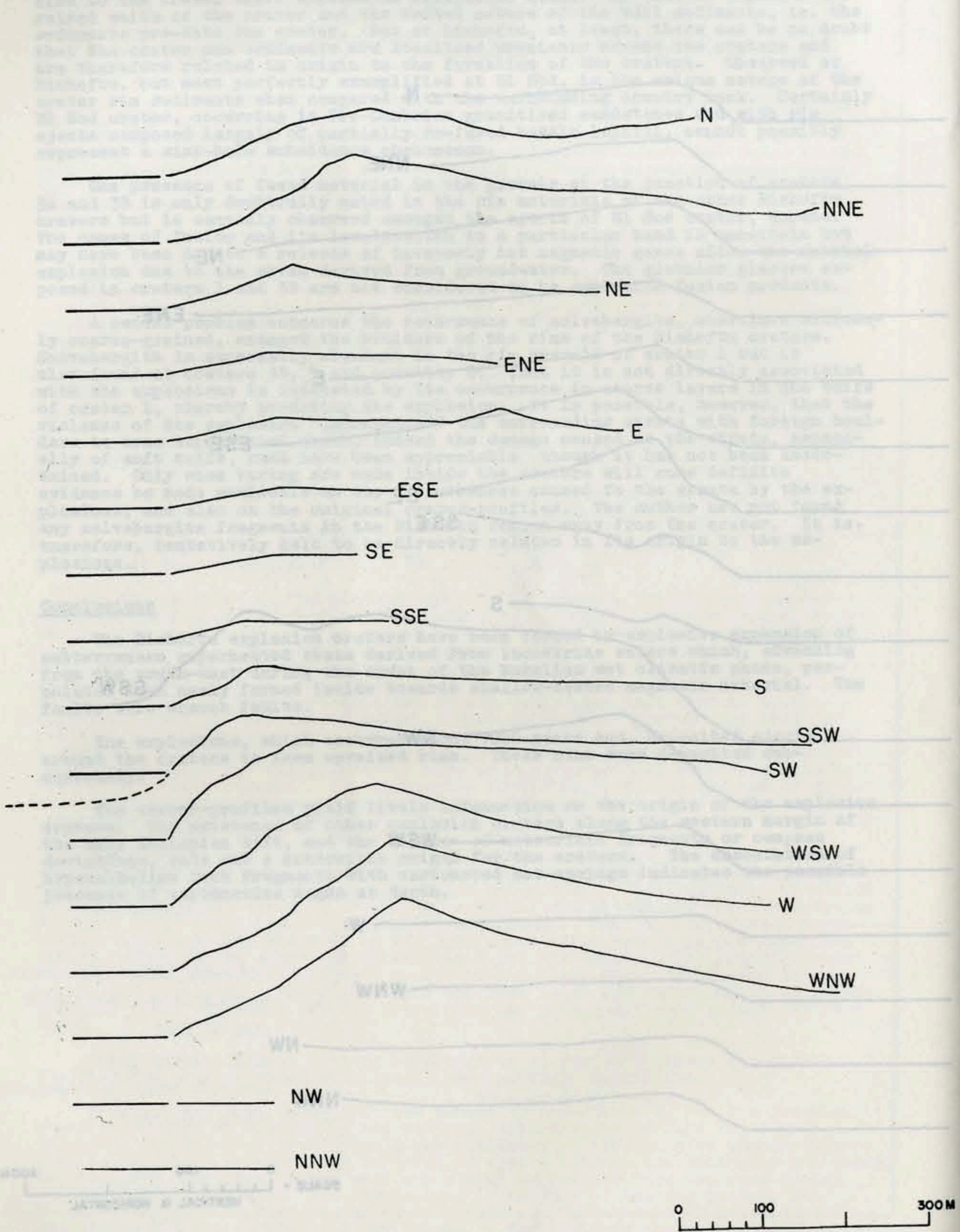


FIG. 2

CRATER 3B PROFILES

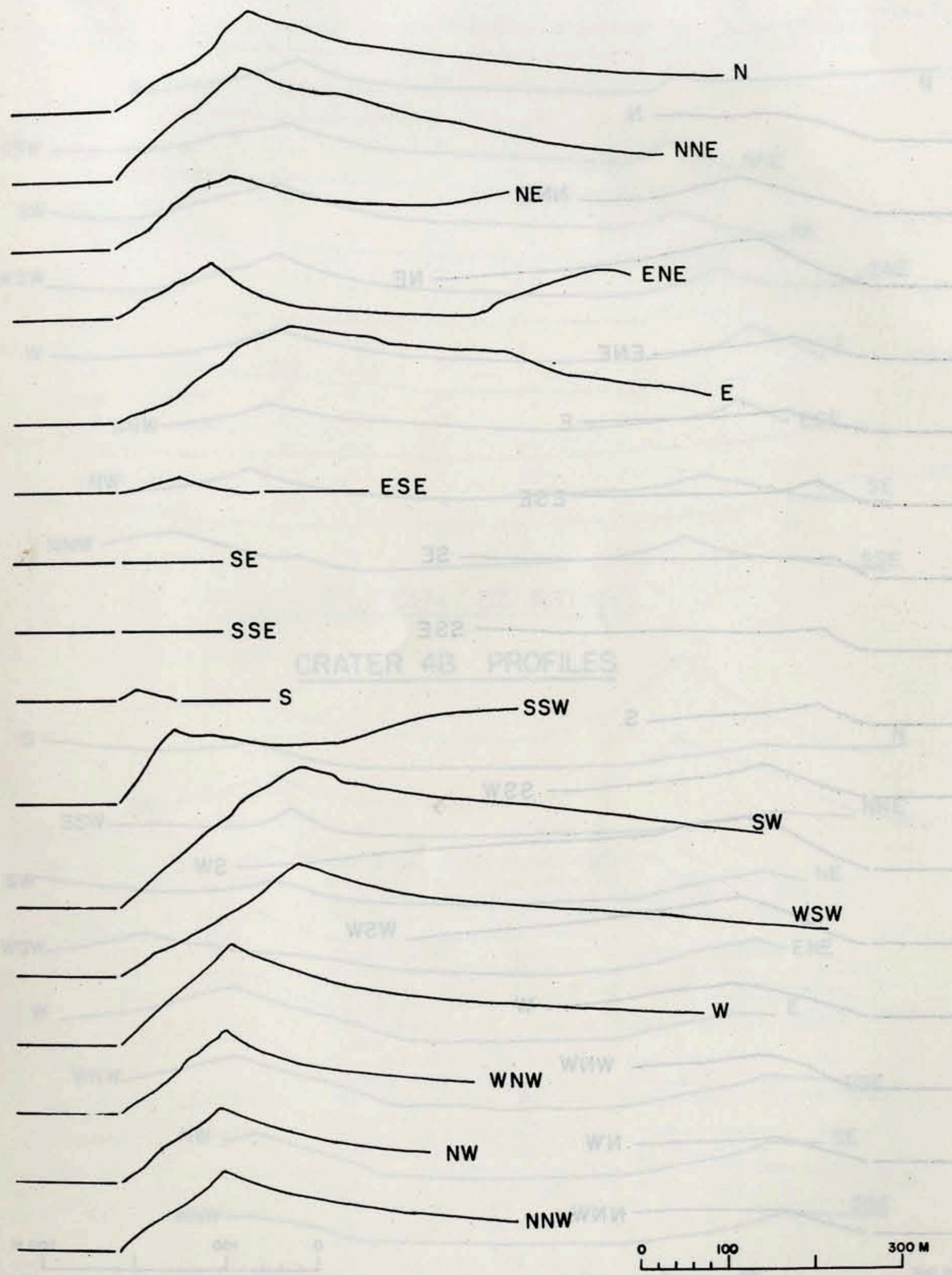


FIG. 3

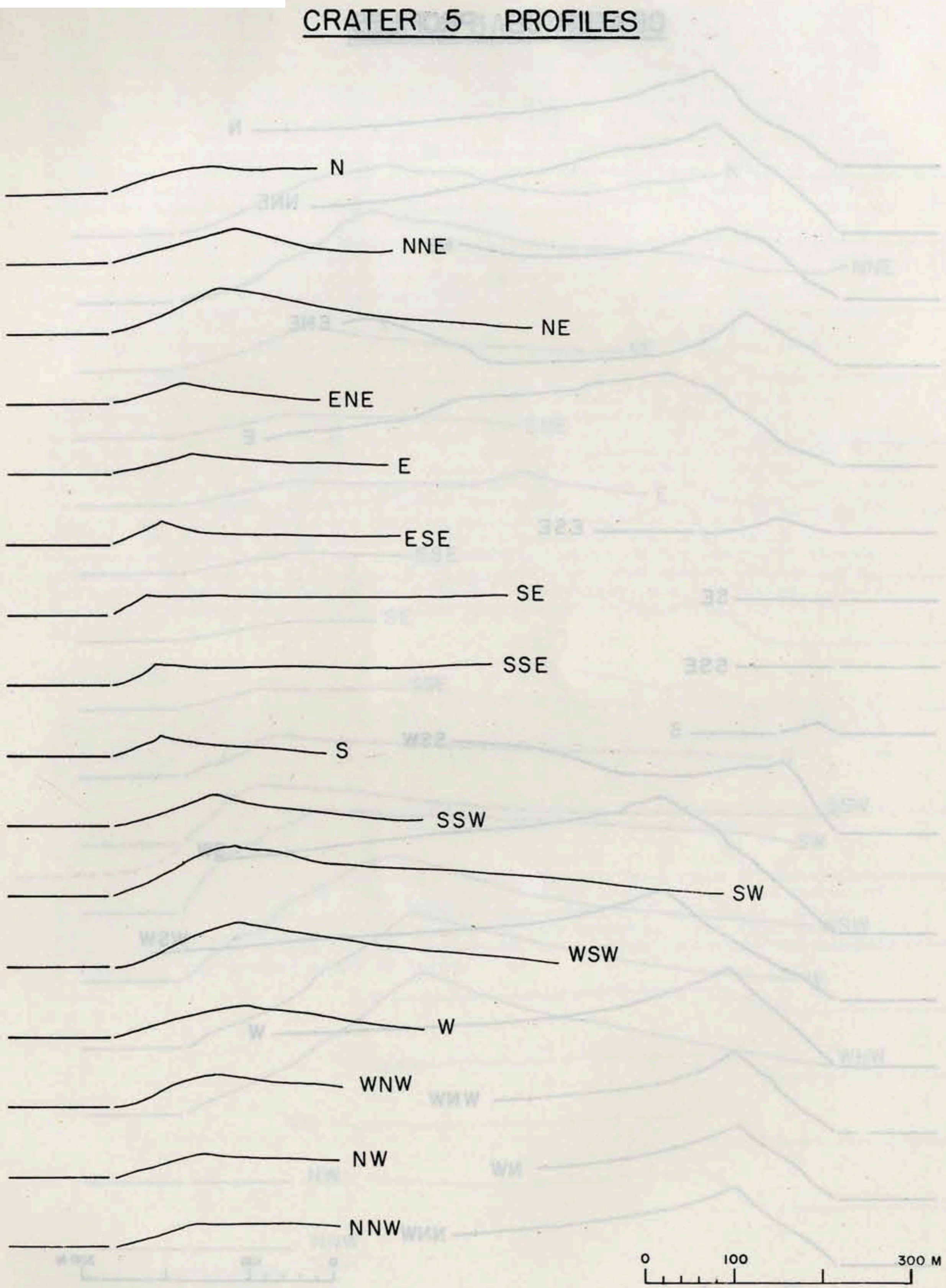

CRATER 5 PROFILES
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FIG. 4

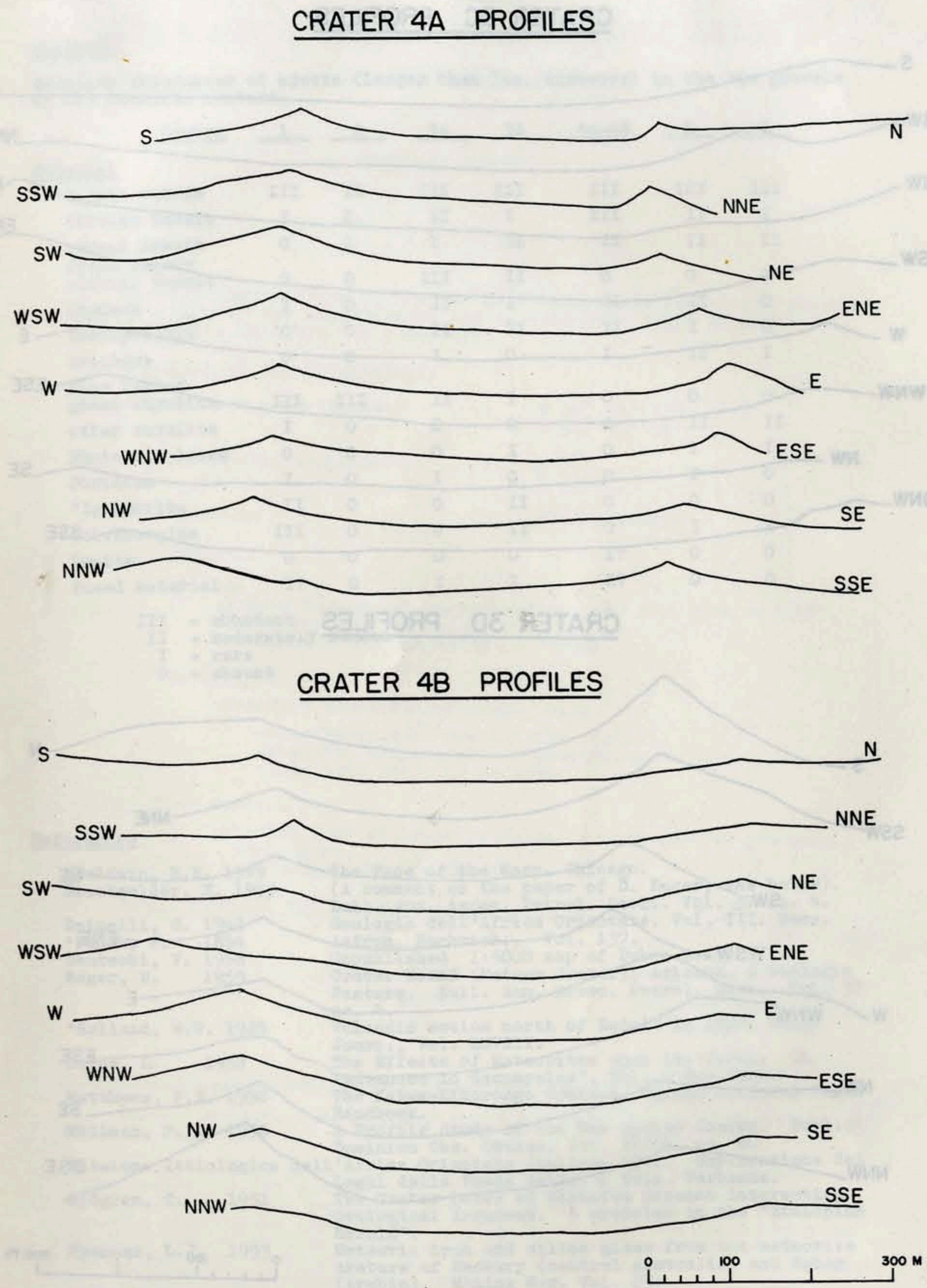
CRATER 4A PROFILES
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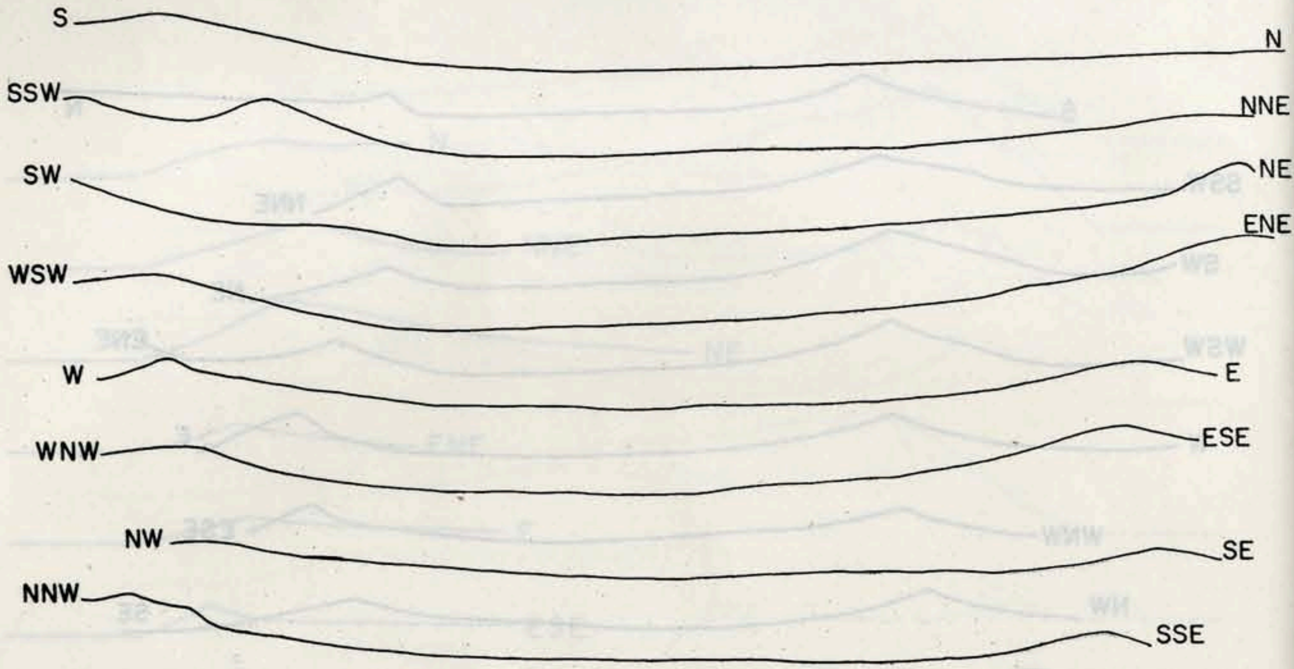
FIG. 5

CRATER 3C PROFILES



CRATER 3D PROFILES

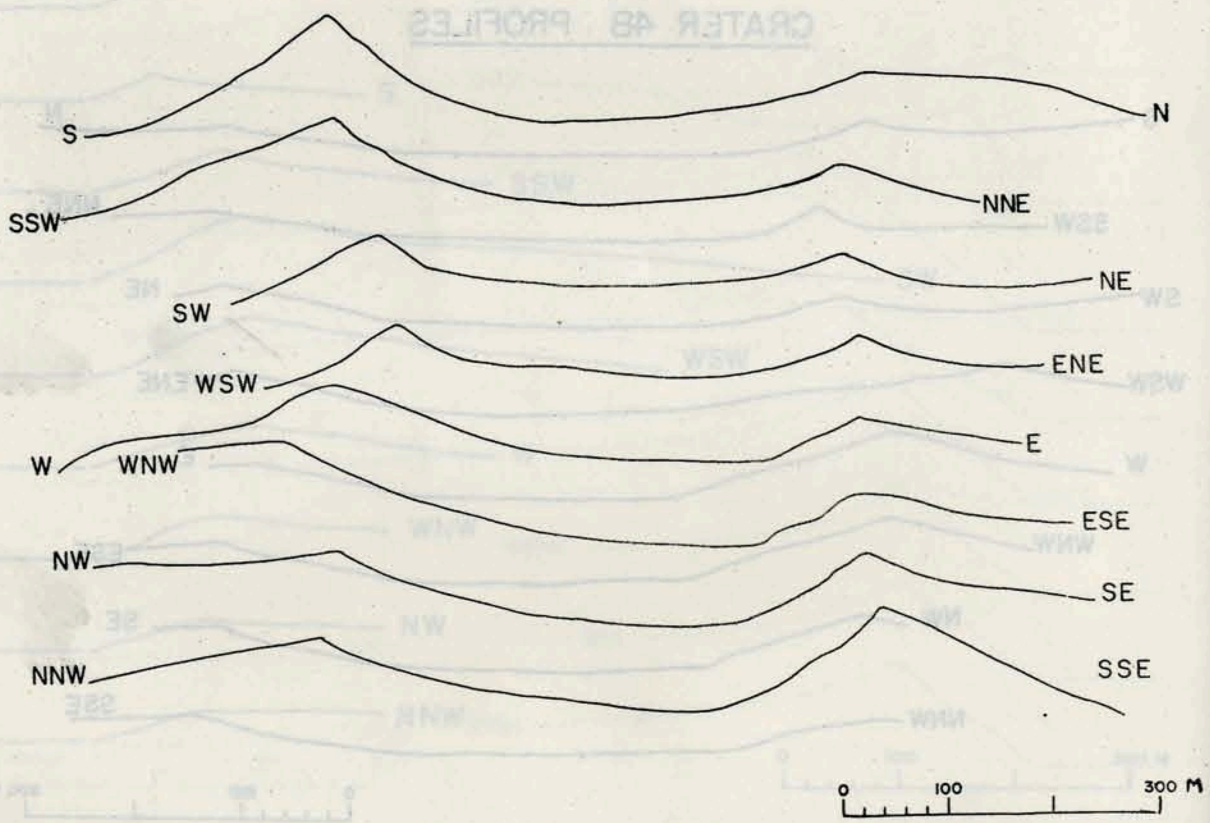


FIG. 6

Appendix.

Relative abundances of ejecta (larger than 1cm. diameter) in the rim gravels of the Bishoftu craters.

Crater Material	1	2	3A	3B	4A-4B	5	.6
Basalt scoria	III	II	III	III	III	III	III
Olivine basalt	I	I	II	I	III	II	I
normal basalt	0	I	I	II	II	II	II
fresh glassy olivine basalt	0	0	III	II	0	0	0
Cinders	I	0	II	I	II	II	0
Trachybasalt	0	0	II	II	II	I	0
Trachyte	0	0	I	0	I	II	I
flow banded green rhyolite	III	III	II	I	0	0	0
other rhyolite	I	0	I	0	0	II	II
Pumiceous lavas	0	0	0	I	0	I	I
Obsidian	I	0	I	0	0	I	0
"Ignimbrite	II	0	0	II	0	0	0
Solvsbergite	III	0	0	II	0	I	I
Dunite	0	0	0	0	I?	0	0
fused material	I?	0	I	I	I?	0	0

III = abundant
II = moderately common
I = rare
0 = absent

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GEOMAGNETIC ACTIVITY AT ADDIS ABABA

JULY-DECEMBER 1959

PIERRE GOUIN

Detailed description of the installation, instrumentation, control, and reduction of the magnetograms has already been given in previous issues of this Bulletin. As a summary:

Location of the Observatory:

Geographic coordinates	:	N 09° 01' 45" E 38° 45' 56"
Geomagnetic coordinates	:	N 5°3 L 109.2
Elevation	:	2242.5 meters

Instruments:

Absolute

- -Quartz Horizontal Magnetometers, no. 377, 378, and 379.
- -Inclinatorium Ruska no. 6393.
- -D-Magnetometer Chasselon no. 65901.

Variographs

- -Standard Ruska Magnetograph, with
  - -Electromagnetic sensitivity control,
  - -Magnetic temperature compensation,
  - -Time base used: 20 mm/hour.

Time control

- -Riefler Type A3 invar pendulum compensated for pressure variations.
- -Controlled by radio daily.

Mean values of the magnetic elements H, Z, and D:

	1958	1959
H	36,084 gammas	36,084 gammas
Z	634 gammas	624 gammas
D	41'1 West	42'1 West

Scale values, Base-Line values, and Temperature variations

Base-line (BLH, BLD, and BLZ) and scale (S_H^o, S_D, and S_Z) values are given in Fig. 1.

As can be seen in Fig. 1, a certain relation does exist between the horizontal force (H) base-line and scale values and the seasonal change in temperature of the recording room. At first it was thought that the magnetic temperature compensation of the variographs was inadequate: an electric heater was then installed in the recorder's section of the variograph room (Bull, Geoph. Obs. I, 1, page 7, Fig. 1.) and measurements were performed over a range much greater than the daily and annual temperature variation ranges. (Note: a decrease in mm of the T° trace on the magnetograms corresponds to an increase in absolute temperature).

The following results were obtained:

T^o	BLH	Δ BLH	Δ BLH^2
10.8 mm	35,970	- 1.1	1.21
10.0	970	- 1.1	1.21
9.7	971	- 0.1	0.01
9.3	972	+ 0.9	0.81
8.0	972	+ 0.9	0.81
6.9	970	- 1.1	1.21
6.0	972	+ 0.9	0.81
5.7	972	+ 0.9	0.81

Mean BLH = 35,971 ± 0.93 gammas

From the above results in which the standard deviation over the whole range of temperature covered is well within the limits of accuracy of the best QHMs working in a magnetic field of approx. 36,000 gammas with an angle of torsion of the quartz wire of about 60° (Copenhague, Communication magnetique no. 15, page 16), it may be concluded:

1. that the magnetic temperature compensation of the H-variograph is very good,
2. that the variations in BLH are not related to rapid change in temperature, even during a period of one day. The same can be said of the variations in S_H,
3. the variations in BLH (and S_H) are an indirect effect of a long term, seasonal temperature variation which produces a periodic tilting of the bed rock and of the piers: this is confirmed by the fact that a Z-variograph has to be relevelled periodically. (It must be noted that in the Ruska model, only the Z-variograph is equipped with tubular 30-second levels).

The tilting effect of the piers on BLH and S_H has been estimated, for an angle of one minute, to be:

Direction of tilting		BLH	S^o_H
Towards	North	+ 38 gammas	+ 0.01 y/mm
	South	- 34 "	+ 0.02 "
	West	- 13 "	- 0.05 "
	East	- 14 "	+ 0.07 "

Although this seasonal tilting of the piers affects both the BLH and the S_H values, it does not by any means affect the accuracy to the records, exception made of one month (July 1959) when, for technical reasons, measurements were made at longer intervals and intermediate values interpolated.

The BLZ also shows a regular decrease in sensitivity, which has no relation whatsoever with temperature variations. No cause for this decrease in sensitivity of S_Z has yet been found.

Acknowledgment

The Director greatfuly acknowledges the help of Mr. Emile Cambron in the determination of the base-line and scale values.

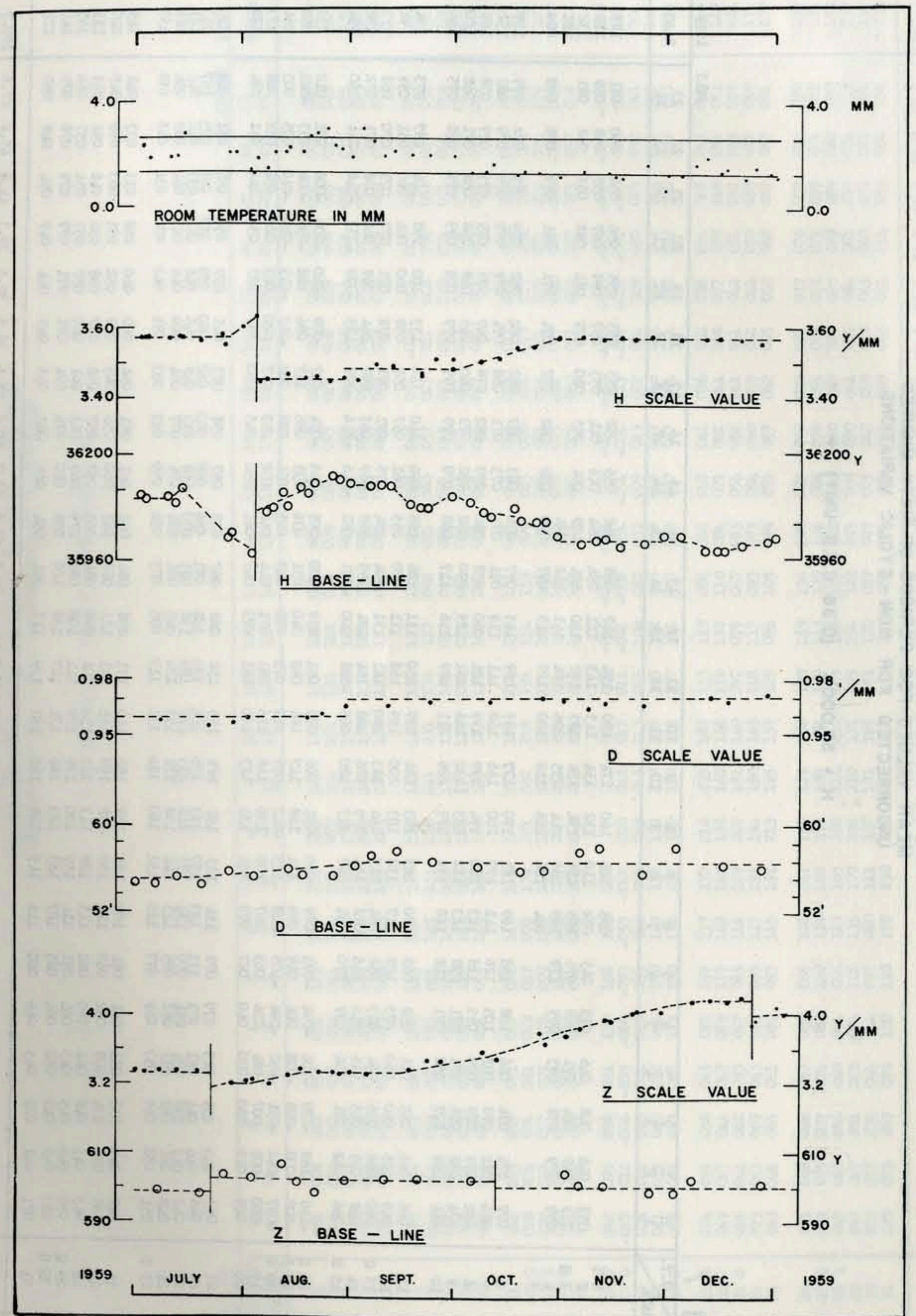


FIG. I

HORIZONTAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON - CYCLIC VARIATIONS

H = 36,000γ (0.36 C.G.S. UNIT) +

H 7 — JULY 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1 Q							085	126	160	174	170	174	117	088	068	055	052	053	055	055	056	056	060	061	127
2	053	046	048	046	053	045	072	110	132	154	143	143	121	094	066	046	044	053	057	057	057	057	058	059	119
3 Q	059	059	064	071	068	076	105	135	154	174	183	172	150	124	109	094	085	080	079	084	082	085	082	081	132
4	079	079	078	083	095	119	158	185	214	235	205	174	141	112	094										185
5							094	106	116	112	120	129	115	097	090	089	082	072	071	071	084	079	078	078	089
6	077	076	074	086	108	138	169	181	190	177	155	129	115	097	076	083	087	082	082	082	079	075	072	079	137
7	086	082	078	093	105	126	141	177	200	166	162	141	119	091	071	073	071	068	074	079	079	079	079	082	152
8	082	079	075	079	095	118	143	200	194	179	139	101	090	078	082	079	082	078	069	076	075	075	079	078	169
9	074	072	076	071	071	098	123	112	123	132	146	161	125	090	082	082	073	060	065	068	068	068	071	068	120
10	061	069	077	072	071	112	148	174	175	206	211	189	156	119	088	078	079	079	079	078	079	079	078	075	164
11	066	066	065	044	032	068	080	123	163	164	159	150	131	106	103	096	140	146	133	100	098	104	087	073	154
12	049	035	050	060	073	103	127	152	183	200	195	168	111	070	055	061	057	059	059	060	061	060	061	059	194
13 Q	060	058	056	054	043	052	084	119	164	183	180	161	131	104	094	076	071	071	072	071	073	071	070	066	157
14	068	069	065	046	016	016	072	151	175	176	188	164	124	095	068	069	065	057	064	069	068	068	071	072	192
15 D	066	062	051	034	039	070	121	167	217	120	065	-028	000	-021	-081	-216	-316	-378	-465	-378	-333	-244	-244	-160	854
16 D	-169	-169	-139	-106	-094	-093	-089	-070	-031	006	035	051	039	020	-005	-016	-024	-017	-009	-010	-006	-006	001	012	230
17 D	-007	-008	-008	-008	004	048	095	131	168	147	104	062	040	031	036	035	086	117	086	028	-038	-004	-033	-022	380
18 D	-037	-042	-031	-052	-094	-103	-128	-123	-042	-059	019	075	078	049	025	034	028	002	-017	-019	-020	-010	005	003	264
19	000	005	007	024	036	065	097	130	136	148	116	091	071	046	046	032	019	027	020	023	028	032	032	028	175
20	025	019	030	030	040	047	079	124	131	123	100	081	073	067	061	052	045	030	037	037	038	040	044	054	127
21	053	042	035	043	079	079	154	183	192	185	155	152	082	067	053	057	058	053	045	039	056	057	051	048	170
22	048	046	044	051	071	111	123	157	163	176	161	136	104	081	064	058	060	062	060	059	057	059	075	057	147
23	042	043	038	031	051	079	132	173	218	233	217	186	138	091	070	068	053	049	048	046	042	037	042	042	123
24	048	061	052	053	062	085	123	144	158	172	153	134	096	081	074	074	077	064	040	046	043	062	069	056	189
25 D	051	058	059	053	059	077	126	151	180	116	131	117	095	073	056	059	052	053	031	042	030	034	045	058	193
26	047	045	033	033	041	061	109	169	159	152	140	131	098	084	066	061	061	054	040	040	058	033	037	048	165
27	038	034	034	048	052	067	120	160	182	199	155	145	123	087	063	060	056	049	049	052	055	063	050	045	210
28	043	045	048	044	050	082	115	129	143	143	132	106	098	084	065	058	057	058	057	058	056	048	052	053	113
29 Q	050	046	045	043	061	091	114	159	190	199	179	141	108	088	079	069	063	061	060	057	057	054	057	056	169
30 Q	053	045	049	052	064	085	127	163	183	186	171	147	138	120	099	080	076	074	071	071	077	079	078	075	144
31	071	069	072	065	066	080	116	145	169	192	169	139	115	061	054	065	062	053	043	044	049	054	048	050	171
MEAN	42.6	41.1	42.3	42.9	49.0	69.0	101.2	133.6	156.7	157.1	197.0	129.7	104.6	79.8	63.6	53.7	50.3	45.6	38.5	39.5	39.3	44.8	45.2	47.8	190.7
Q	55.5	52.0	53.5	55.0	59.0	76.0	103.0	140.4	170.2	183.2	176.6	159.0	128.8	104.8	89.8	74.8	69.4	67.8	67.4	67.6	69.0	69.0	69.4	67.8	145.8
D	-19.2	-07.8	-13.2	-15.8	-17.2	0.0	25.0	51.0	98.4	66.0	70.8	54.4	50.4	30.4	6.2	-20.8	-34.8	-44.6	-87.2	-67.4	-73.4	-46.0	-45.2	-21.8	384.2

HORIZONTAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON - CYCLIC VARIATIONS

H = 36,000γ (0.36 C.G.S. UNIT) +

H 8 — AUGUST 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1	056	068	061	055	074	115	145	153	165	183	173	135	118	091	076	071	057	050	050	062	063	062	061	057	157
2	048	053	053	037	022	041	064	094	097	144	151	133	118	098	079	066	053	047	048	069	068	065	065	060	149
3	056	063	068	071	069	086	151	176	172	177	175	166	121	100	071	057	052	058	058	055	048	054	055	055	154
4	052	048	058	059	082	107	141	177	201	207	150	139	086	070	064	062	058	055	060	056	051	053	059	055	175
5	050	049	050	059	073	106	142	195	223	209	188	157	117	080	076	069	066	069	072	075	069	069	074	072	193
6	073	070	072	082	110	113	147	160	180	162	180	160	113	103	085	082	062	031	-002	019	043	048	047	056	206
7	066	064	062	074	093	085	125	155	210	241	231	176	127	092	071	060	057	047	041	046	066	063	063	056	215
8	058	060	062	073	082	105	135	155	171	155	125	106	067	063	074	071	069	071	069	070	071	071	068	060	128
9	058	058	072	076	099	146	211	216	182	176	138	085	072	052	036	027	034	026	015	007	008	018	030	043	233
10	048	051	047	052	054	059	109	164	197	193	183	135	105	091	073	062	057	057	050	044	052	058	062	062	178
11	062	065	059	051	057	082	117	146	164	173	189	204	168	131	098	068	065	073	073	069	069	069	069	073	167
12 Q	078	074	074	061	043	057	076	174	221	222	218	191	154	119	099	085	078	076	077	077	074	072	074	071	201
13 Q	077	077	077	077	078	079	113	145	156	172	183	174	152	126	104	086	081	083	084	079	071	072	074	075	127
14 Q	080	083	087	085	080	114	173	227	262	251	201	164	141	126	106	098	093	092	087	084	082	083	086	081	209
15	079	082	083	091	083	094	084	209	249	209	174	168	146	132	116	083	079	080	071	062	057	055	057	058	217
16 D	062	076	078	094	132	156	169	157			081	003	-045	-096	-072	079	-072	-083	-093	-083	-077	-067	-022	-020	370
17 D	-027	012	-006	-035	-066	-093	-055	-042	010	042	047	014	-001	-008	-034	-054	-064	-013	-007	-005	-004	-005	009	004	197
18	004	006	005	-004	028	033	042	065	023	045	043	075	106	082	033	009	013	022	034	029	020	023	032	041	204
19	041	035	040	032	044	070	123	132	173	179	189	163	122	083	058	048	049	046	031	056	044	041	041	046	138
20 D	053	052	043	042	123	170	178	237	183	210	213	157	111	073	063	067	067	064	061	068	070	068	063	053	175
21 D	074	055	058	065	072	099	137	177	216	203	187	153	117	086	062	048	042	036	061	038	054	048	043	045	246
22	049	047	041	047	075	117	148	140	132	160	168	159	139	110	084	071	061	044	048	057	059	068	056	051	129
23 D	055	061	062	053	047	085	144	169	209	181	160	097	079	067	055	054	052	041	041	042	051	052	059	057	224
24	073	063	059	055	055	065	117	193	194	180	165	148	117	093	073	054	060	059	062	061	059	063	062	059	174
25	063	068	066	061	057	093	145	191	215	195	159	125	096	105	095	072	057	062	065	062	062	067	067	074	179
26	071	068	068	067	060	065	106	141	157	179	178	170	155	136	109	089	077	073	071	073	076	072	072	070	119
27 Q	071	075	077	074	083	119	156	182	192	188	191	169	143	120	102	088	078	075	075	072	072	075	074	072	131
28 Q	069	068	066	060	054	074	113	165	202	214	210	189	166	143	120	102	090	089	089	089	089	089	088	090	158
29	095	097	091	073	074	102	135	179	191	210	191	175	154	122	099	098	090	084	084	084	081	075	074	073	150
30	075	075	072	064	044	057	080	141	167	191	188	154	120	087	079	075	062	058	057	063	069	071	072	074	164
31	075	075	067	076	100	148	198	250	270	254	217	163	121	088	076	070	063	069	063	051	051	053	054	054	230
MEAN	59.5	58.0	60.4	58.9	67.1	88.6	124.7	162.0	179.5	183.5	169.2	142.2	113.9	89.2	71.9	60.0	54.4	52.9	51.5	52.6	53.8	55.3	57.7	57.3	183.7
Q	75.0	75.4	76.2	71.4	67.6	88.6	126.2	178.6	206.6	209.4	200.6	177.4	151.2	126.8	106.2	91.8	84.0	83.0	82.4	80.2	77.6	78.2	79.2	77.8	165.2
D	43.4	51.2	47.0	43.8	61.4	83.0	114.4	139.4	179.5	159.0	131.5	105.8	51.8	22.2	14.4	6.6	4.4	8.8	12.2	11.6	18.6	21.0	30.4	27.8	242.4

HORIZONTAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

H = 36,000γ (0.36 C.G.S. UNIT) +

H 9

SEPTEMBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1	050	064	066	054	061	104	165	190	161	132	076	069	078	076	072	051	033	025	023	010	034	045	048	057	195
2	055	042	048	050	051	089	153	222	239	181	081	093	091	087	073	055	041	034	024	016	009	020	030	030	299
3	047	057	058	065	087	131	167	196	206	136	105	099	098	101	101	075	050	037	035	031	044	052	045	-027	300
4 D	-012	006	009	-040	-008	023	060	077	094	-024	-043	016	036	046	002	-058	-068	-056	-033	-037	-044	-030	-001	028	274
5	010	016	016	026	060	087	110	170	193	156	133	113	086	055	048	042	034	034	038	025	038	047	072	047	211
6	030	023	035	030	052	097	140	169	165	153	127	111	095	070	064	063	054	053	053	051	050	051	049	048	165
7 Q	045	044	044	042	060	105	153	187	199	172	145	136	122	105	093	080	066	055	058	059	063	066	063	065	169
8 Q	066	067	062	055	065	106	163	165	202	173	162	140	123	105	084	067	071	075	069	062	058	060	060	075	163
9 Q	072	069	069	066	086	117	146	168	178	199	190	180	152	124	100	080	073	075	076	075	073	074	073	080	148
10 Q	080	078	074	073	097	136	178	214	230	233	218	198	174	146	124	115	105	095	084	083	082	079	080	076	174
11	084	083	082	074	066	084	137	172	210	221	182	163	120	112	104	089	080	077	080	077	078	084	083	080	190
12	087	076	069	066	062	104	156	205	217	218	191	170	149	124	102	081	073	078	073	069	076	078	077	077	197
13	077	085	084	074	077	109	153	182	199	210	205	189	167	143	120	139	099	091	091	091	091	080	107	070	164
14	062	067	080	071	081	095	170	197	178	165	148	128	101	097	071	065	064	057	063	069	073	079	078	069	190
15	070	077	080	076	083	134	182	228	218	209	182	148	128	124	102	079	058	053	058	060	068	085	072	067	217
16	068	064	058	048	043	091	146	192	205	187	151	113	099	098	089	067	060	056	055	069	086	080	077	077	181
17	078	084	086	083	089	122	170	209	229	224	163	136	113	114	101	070	070	078	074	066	050	031	045	056	216
18	067	082	076	073	085	134	178	191	210	183	182	138	125	116	101	086	076	069	062	043	039	050	062	083	201
19	068	060	055	048	050	076	126	177	202	192	153	148	090	094	092	079	063	061	061	064	065	071	082	083	178
20 D	079	075	084	075	058	096	161	172	145	149	160	124	076	017	016	011	011	-018	-024	-007	049	018	045	039	228
21 D	022	031	025	039	053	075	090	041	066	060	081	083	082	047	040	004	-020	014	015	011	009	038	025	030	166
22 D	043	046	051	039	019	043	067	134	090	061	058	066	059	045	032	025	015	019	041	043	035	025	029	036	101
23	039	035	033	035	045	087	128	150	134	147	140	119	103	086	068	067	015	043	022	004	-004	018	015	050	171
24	*040	033	032	036	035	054	070	137	151	155	153	137	086	024	012	015	020	029	025	017	016	030	036	036	173
25 D	038	038	039	025	022	066	105	151	170	153	129	085	063	081	011	-021	-015	-005	-013	-009	-005	020	042	038	215
26	036	034	048	037	032	058	109	134	136	114	103	082	061	063	067	056	037	038	034	049	048	041	046	063	124
27	062	059	058	050	071	077	147	155	130	100	089	069	075	069	043	026	035	046	045	051	050	051	060	060	153
28	058	059	061	053	062	097	133	161	155	129	117	110	114	108	082	064	062	055	039	042	055	069	062	059	137
29 Q	058	058	062	063	079	118	173	183	185	148	117	117	109	098	097	073	069	069	073	073	070	067	076	072	144
30	069	071	071	068	089	142	186	205	190	195	141	098	109	090	066	046	041	045	059	056	048	053	057	061	188
MEAN	54.9	56.1	57.1	51.8	60.4	95.2	140.7	171.1	176.2	157.7	134.8	119.2	102.8	88.8	72.6	56.4	55.7	46.1	45.3	43.8	46.8	51.1	55.1	56.2	187.7
Q	64.2	63.2	62.2	59.8	77.4	116.4	162.6	183.4	198.8	185.0	166.4	154.2	136.0	115.6	99.6	83.0	76.8	73.8	72.0	70.4	69.2	69.2	70.4	73.6	159.6
D	34.0	39.2	41.6	27.6	28.8	60.6	96.6	115.2	113.0	79.8	77.0	74.8	63.2	47.2	20.2	-07.8	-15.4	-9.2	-2.8	00.2	08.8	14.2	28.0	34.2	196.8

HORIZONTAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

H = 36,000γ (0.36 C.G.S. UNIT) +

H 10

OCTOBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1 D	065	074	069	058	070	104	125	143	132	175	115	062	048	041	023	011	021	023	035	016	029	034	051	051	193
2	047	042	048	054	076	128	151	146	149	143	138	122	114	090	076	074	075	069	071	065	067	067	068	072	167
3 D	073	071	066	063	039	115	159	180	145	130	126	114	100	074	039	-006	-029	-025	-010	-016	004	-021	008	045	238
4 D	027	020	024	017	029	043	089	113	104	104	085	070	023	022	018	016	009	017	028	030	034	030	031	036	101
5	037	035	041	041	034	068	134	178	181	173	144	119	073	035	029	017	004	-025	-015	007	006	027	037	036	249
6 D	055	050	040	040	057	078	084	*083	081	079	005	028	048	044	017	005	021	014	020	028	068	064	041	044	137*
7	046	047	044	038	050	*089	129	175	191	185	156	146	124	101	092	082	075	073	071	064	065	089	087	071	169
8	066	064	060	058	060	073	145	193	194	175	129	111	101	092	078	066	065	066	071	073	070	070	068	069	147
9	069	073	071	063	079	126	164	184	184	165	151	139	128	109	095	081	079	077	075	076	085	083	081	081	129
10 Q	079	076	075	072	077	117	169	184	184	174	160	147	139	124	112	094	087	101	087	080	083	084	085	086	122
11 Q	091	090	084	077	090	131	184	232	234	200	131	135	129	124	116	100	092	089	086	081	086	094	095	095	168
12	095	090	085	083	104	157	211	247	264	252	217	187	166	145	126	105	088	079	081	076	069	083	087	091	199
13 Q	094	097	096	091	095	133	176	209	223	219	194	177	159	142	125	114	107	102	101	098	095	095	097	092	147
14	100	099	095	090	108	154	193	214	215	198	174	118	127	114	104	093	084	079	062	057	065	074	095	088	205
15	085	090	084	082	100	147	162	191	175	172	160	129	120	112	094	086	087	086	080	074	082	098	086	081	145
16 Q	081	075	069	064	082	120	156	174	191	192	174	154	138	127	117	095	085	086	084	083	090	094	094	099	136
17	104	104	097	097	123	168	231	261	270	274	175	145	122	109	115	093	081	070	063	063	072	081	078	076	269
18	075	071	069	071	073	134	208	264	290	207	119	087	077	076	059	050	053	055	056	062	076	074	065	060	191
19	061	065	058	056	077	117	164	168	165	140	115	115	*111	*103	096	083	077	075	080	083	078	077	077	083	138
20	091	087	084	086	113	167	194	212	170	129	109	094	105	110	101	084	080	081	082	083	086	088	088	089	151
21	087	086	083	079	095	145	200	237	251	232	189	150	123	113	116	112	093	089	090	087	086	085	071	080	188
22	083	096	087	086	116	148	199	224	225	196	142	087	049	034	020	009	032	035	037	049	050	053	060	070	249
23	064	065	065	047	044	072	137	194	195	171	119	084	085	088	088	072	068	070	071	075	078	078	079	080	172
24	079	079	075	071	091	132	184	224	225	217	189	166	136	101	082	084	078	080	080	077	075	069	068	072	168
25	075	080	073	063	058	090	122	116	123	139	116	108	090	084	075	056	045	063	068	066	065	072	084	088	082
26	064	066	067	068	075	109	134	109	115	103	104	112	111	083	033	-006	-006	010	026	030	037	059	078	065	171
27	060	058	056	061	082	092	133	133	118	090	080	078	091	086	074	058	057	069	072	073	077	078	082	080	093
28 Q	080	080	079	093	117	167	206	227	217	194	163	151	142	138	126	102	091	090	089	088	090	093	095	094	159
29	093	091	087	084	108	145	181	199	195	179	162	147	132	124	114	098	099	100	100	100	098	099	103	113	131
30	117	100	105	096	127	177	196	234	241	225	189	150	146	130	120	106	098	096	069	042	011	018	038	064	255
31 D	058	062	062	068	110	146	187	208	196	131	116	067	020	029	029	-010	-031	-007	-016	019	006	041	022	023	259
MEAN	74.2	73.0	70.9	68.3	82.6	122.3	161.5	188.9	188.5	173.0	140.2	119.3	105.6	93.7	80.9	65.3	60.2	60.8	61.1	60.1	64.0	68.7	70.9	73.4	168.6
Q	85.0	83.6	80.6	79.4	92.2	133.6	178.2	205.8	209.8	195.8	164.4	152.8	141.4	131.0	119.2	101.0	92.4	93.2	89.4	86.0	88.8	92.0	93.2	93.2	146.4
D	55.6	55.4	52.2	49.2	61.0	97.2	128.8	145.4	131.6	123.8	89.4	68.2	47.8	42.0	25.2	03.2	-01.8	04.4	03.4	15.4	28.2	29.6	30.6	39.8	185.6

HORIZONTAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON - CYCLIC VARIATIONS

H = 36,000γ (0.36 C.G.S. UNIT) +

H 11

NOVEMBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1 D	043	044	042	047	059	062	100	110	118	057	024	-001	005	005	010	002	006	001	014	018	034	031	043	040	157
2 D	036	039	040	050	047	047	124	149	119	110	102	076	040	003	027	020	-20	-12	-03	021	042	040	036	024	233
3 D	046	039	031	023	040	066	112	144	155	129	098	101	085	065	044	010	009	018	023	012	022	050	035	035	190
4	031	029	027	028	056	091	152	162	153	119	106	072	035	032	021	-001	-008	-006	018	053	029	021	025	034	191
5	042	047	037	032	057	061	135	179	141	123	090	069	076	071	062	042	050	054	050	064	069	068	070	065	171
6	061	064	055	036	052	092	141	188	220	205	149	121	083	076	073	064	044	035	036	049	059	056	084	069	188
7	065	063	058	051	061	102	153	182	190	186	171	146	121	102	086	070	068	073	078	068	087	074	084	084	149
8	084	081	071	059	070	094	149	200	216	203	172	146	112	087	081	082	083	066	051	053	069	081	084	084	167
9	080	114	111	094	119	151	179	204	217	217	203	183	163	144	123	100	081	059	056	073	090	077	076	072	170
10	077	075	069	066	091	142	179	177	185	176	156	147	122	113	099	088	079	076	079	077	084	076	091	084	143
11 Q	076	075	073	067	077	121	160	184	191	167	147	137	125	118	108	097	090	087	082	081	081	079	074	073	131
12 Q	078	072	073	075	095	134	181	224	229	207	175	145	129	124	117	108	099	093	079	072	081	082	080	085	160
13	078	077	073	068	073	105	152	190	217	216	195	189	165	147	124	103	101	088	081	084	083	080	080	079	151
14	075	083	076	060	072	119	179	219	222	185	166	123	085	073	049	037	032	052	049	059	069	072	061	069	229
15 Q	072	062	054	057	064	092	136	165	183	176	156	140	121	106	094	081	078	080	080	080	081	082	085	087	137
16	084	081	079	087	113	122	217	262	272	251	226	184	143	117	094	080	082	057	043	041	039	045	059	069	236
17	070	068	065	070	095	104	170	217	245	233	199	126	080	068	072	073	072	072	072	075	076	078	073	068	186
18	068	068	068	065	069	104	172	212	219	208	162	117	107	100	079	081	084	072	034	060	062	068	072	072	207
19	081	069	072	075	090	114	166	208	191	161	154	140	103	089	073	059	056	063	069	072	073	075	076	079	237
20 Q	069	070	071	069	084	118	153	178	183	172	163	147	126	111	106	096	091	090	087	087	082	080	083	087	124
21	086	083	078	067	070	083	119	168	166	167	168	141	091	029	-18	-27	-07	014	026	039	032	027	028	029	216
22	046	047	050	051	091	121	169	184	170	161	140	130	098	102	099	087	084	070	048	046	062	069	069	053	161
23	039	050	044	019	036	057	110	141	116	116	088	053	024	013	007	000	005	011	031	056	090	066	064	066	173
24 Q	061	055	054	049	054	078	122	156	172	178	176	165	141	113	080	061	064	079	081	074	070	069	073	075	142
25	073	070	072	069	087	129	171	223	230	215	186	137	088	062	058	053	050	047	043	043	044	049	051	078	186
26	075	075	075	076	084	108	147	163	177	214	183	156	142	136	110	097	087	091	090	098	095	084	081	062	181
27	079	076	075	069	076	104	143	128	133	137	142	140	129	113	093	083	083	080	078	083	082	077	075	082	091
28 Q	091	083	113	073	-007	-080	-105	-016	096	097	133	014	059	021	003	009	019	020	012	001	010	028	013	015	367
29	018	016	026	029	044	062	089	102	104	125	095	084	070	047	033	018	018	022	028	038	054	051	047	047	131
30 D	045	039	039	034	031	056	093	173	153	130	139	120	063	024	-018	-058	-065	-024	018	025	028	025	024	060	267
MEAN	64.3	63.8	62.4	57.2	68.3	92.0	138.9	172.5	179.4	168.0	148.8	121.6	97.7	80.4	66.3	53.8	50.5	50.9	51.1	56.7	62.6	62.0	63.2	64.0	181.1
Q	71.2	66.8	65.0	63.4	74.8	108.8	150.4	181.4	191.6	180.0	163.4	146.8	128.4	114.4	101.0	88.6	86.4	81.8	81.8	78.8	79.0	78.4	79.0	81.4	138.8
D	52.2	48.8	53.0	45.4	34.0	30.2	64.8	112.0	128.2	104.6	99.2	62.0	50.4	23.6	13.2	-3.6	-10.2	0.6	12.8	15.4	27.2	34.8	30.2	34.8	242.5

HORIZONTAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON - CYCLIC VARIATIONS

H = 36,000γ (0.36 C.G.S. UNIT) +

H 12

DECEMBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1	048	041	040	029	008	035	060	096	139	133	118	094	067	036	030	034	027	043	057	056	054	052	056	053	173
2	053	047	045	045	045	047	083	149	146	132	126	082	062	040	018	010	027	032	034	024	010	044	056	059	181
3 D	055	042	039	041	044	067	094	104	124	146	115	088	050	014	016	012	009	016	045	035	013	018	019	034	195
4	036	038	031	042	038	058	095	126	155	160	165	156	129	109	091	075	058	056	055	056	055	063	059	060	169
5 D	059	055	053	047	059	085	129	223	218	185	192	150	078	004	-72	-109	-149	-152	-151	-137	-76	004	-10	-08	425
6	-007	-001	-001	-001	010	025	022	050	078	095	103	112	106	077	061	046	040	026	035	049	056	052	052	041	167
7 Q	033	034	033	032	031	069	119	138	142	138	132	124	115	097	071	048	051	057	059	060	060	059	063	058	119
8	053	053	049	042	050	085	133	167	193	175	147	133	119	102	088	077	072	061	069	067	055	051	049	060	184
9	065	067	066	072	098	128	143	136	121	126	134	132	120	098	096	092	092	083	091	094	094	087	084	087	096
10 Q	091	086	077	081	105	133	152	155	162	163	167	160	143	124	111	101	090	087	090	079	082	092	090	090	099
11 Q	087	083	079	072	076	093	105	130	139	134	128	139	132	125	118	101	094	093	094	089	092	091	092	095	080
12	095	099	071	079	118	152	152	170	154	099	097	118	113	105	105	099	095	088	082	084	085	063	046	044	147
13	050	055	066	063	081	106	128	154	149	138	127	112	106	104	092	084	082	064	074	088	078	044	055	052	143
14 D	054	045	064	062	073	109	137	121	105	086	027	057	088	035	010	001	011	011	045	032	039	038	048	053	170
15	051	049	052	057	070	082	078	075	054	086	105	124	103	093	076	055	042	038	048	064	070	071	085	086	107
16	070	061	060	070	097	124	147	170	164	147	124	102	110	090	070	049	054	059	059	055	052	065	075	068	145
17	062	060	059	062	081	121	182	200	185	153	131	125	112	105	098	090	086	084	088	077	072	075	080	080	149
18	084	081	077	076	098	142	182	205	210	180	152	128	098	083	080	081	086	089	090	088	084	079	081	080	138
19	091	087	077	078	103	134	187	196	184	141	103	081	065	050	040	037	051	047	051	061	070	073	074	074	177
20	070	077	074	074	085	121	170	203	214	191	160	142	127	115	107	100	089	067	058	070	075	079	084	084	156
21 Q	081	082	081	080	084	118	178	225	228	211	188	170	144	127	118	114	110	107	107	104	099	098	097	096	148
22 Q	089	087	087	101	129	160	197	224	236	240	231	201	167	145	126	118	108	093	107	111	110	103	101	095	151
23	095	091	092	096	114	142	127	162	189	173	166	157	135	110	093	081	030	048	042	037	063	070	070	056	201
24	051	053	054	055	067	089	154	165	167	147	118	116	098	079	071	077	081	083	089	089	092	095	097	086	139
25	075	070	074	082	085	092	136	175	204	201	163	138	115	106	102	096	097	085	080	081	086	089	089	092	153
26	091	092	092	089	103	124	141	166	175	170	158	135	133	109	063	035	026	036	068	077	074	081	077	068	165
27 D	083	079	074	092	113	096	107	135	120	156	139	056	062	048	053	049	052	047	037	054	057	055	052	068	152
28 D	068	071	060	068	100	120	140	141	146	114	110	072	071	062	026	015	002	028	019	009	026	043	046	040	174
29	036	037	013	060	083	115	152	178	169	143	118	106	084	075	071	073	078	071	069	071	073	075	071	070	172
30	071	066	065	071	068	103	159	158	183	129	123	106	053	049	046	049	045	049	052	068	060	068	070	068	165
31	065	064	068	080	101	124	173	200	212	193	162	129	106	095	091	088	084	082	077	076	087	081	080	077	151
MEAN	64.7	62.9	60.4	73.1	77.9	103.2	134.3	157.9	163.3	151.2	136.5	127.3	103.6	84.2	69.9	60.5	55.4	54.1	57.1	60.2	62.8	66.4	67.4	66.6	161.0
Q	76.2	74.4	71.4	73.2	84.4	114.6	150.2	174.4	181.4	177.2	169.2	158.8	140.2	123.6	108.8	96.4	90.6	87.4	91.4	88.6	88.6	88.6	88.6	86.8	119.4
D	63.8	40.4	58.0	62.0	77.8	95.4	121.4	144.8	142.6	138.0	116.6	84.6	69.8	32.6	06.6	-6.4	-15.0	-10.0	-0.8	-1.6	11.8	31.6	31.0	37.4	223.2

MAGNETIC DECLINATION

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

D = W 00° + ... (IN TENTHS OF A MINUTE)

D 7 JULY 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1 Q							409	415	423	428	432	432	430	421	417	418	421	426	424	424	424	421	419	420	*043
2	419	418	418	408	390	395	405	421	428	434	431	428	428	425	424	422	423	427	427	425	421	420	419	419	046
3 Q	420	420	419	410	406	410	421	428	429	434	429	426	426	423	428	429	429	429	429	429	429	428	427	425	030
4	425	426	423	422	412	405	420	429	432	440	447	441	429	423	425										
5							421	439	439	439	439	431	426	420	418	422	426	428	427	426	427	427	426	425	
6	424	425	421	406	402	407	418	428	432	431	430	428	427	421	424	429	430	433	435	430	430	430	424	423	036
7	425	423	421	413	409	421	430	435	436	425	418	423	430	428	429	426	428	429	430	431	430	426	425	426	036
8	425	421	420	418	411	417	428	439	433	435	441	439	430	426	421	420	430	430	424	429	428	426	428	426	031
9	425	422	418	411	403	411	429	431	430	431	442	434	422	415	425	431	425	429	431	431	430	426	429	432	043
10	430	431	427	403	388	401	426	441	445	450	445	440	441	433	423	419	422	427	428	428	426	428	427	424	066
11	425	425	423	414	406	408	411	412	412	415	419	424	426	425	422	429	443	470	460	452	444	440	431	418	075
12	401	402	410	394	381	391	408	428	442	441	437	423	428	429	420	429	432	433	430	426	423	423	417	413	066
13 Q	414	414	414	407	404	409	419	426	432	435	432	432	432	432	437	431	431	432	430	427	423	419	418	418	038
14	419	423	427	418	412	425	432	432	431	427	425	424	430	432	423	426	432	432	425	430	439	423	420	421	031
15 D	416	414	414	410	405	412	431	409	412	405	433	411	460	479	464	408	340	366	354	342	378	367	370	378	204
16 D	359	359	366	357	375	394	412	431	443	447	442	431	423	412	397	398	407	411	414	413	411	412	415	414	106
17 D	411	405	395	375	366	377	405	424	433	429	424	423	416	409	411	418	433	442	432	414	413	412	397	391	109
18 D	397	386	385	357	346	348	373	408	410	422	425	425	417	411	415	429	435	425	408	404	405	406	408	405	119
19	397	394	395	390	403	417	434	438	443	444	439	427	425	417	413	411	408	419	415	417	418	416	415	414	060
20	406	407	405	396	394	406	424	434	444	441	437	432	429	420	419	422	423	418	424	422	425	423	418	414	053
21	412	410	396	397	392	407	408	433	456	456	450	444	437	432	425	424	425	432	432	426	425	422	417	415	067
22	417	415	413	397	378	384	405	435	457	464	436	437	438	435	431	429	427	431	427	426	423	417	418	416	100
23	416	419	416	396	379	405	426	433	454	445	436	435	440	433	428	429	426	427	424	426	423	416	416	415	080
24	416	417	416	407	392	405	422	445	453	450	440	441	435	431	435	431	434	431	418	424	422	418	416	410	067
25 D	410	414	410	394	376	390	419	444	451	446	441	429	425	417	416	418	423	429	413	417	416	417	412	421	088
26	418	410	400	388	381	392	416	437	458	462	448	440	432	427	426	425	419	425	420	419	418	418	417	420	089
27	417	412	410	398	388	392	408	422	436	440	436	431	431	419	417	420	427	427	426	426	424	425	423	420	059
28	425	423	418	404	391	395	418	435	447	450	445	437	436	429	420	420	430	429	423	422	423	420	420	423	065
29 Q	418	420	418	403	394	397	409	423	436	430	424	418	420	412	413	419	428	428	427	428	428	427	426	421	052
30 Q	423	420	419	410	403	412	431	437	438	430	436	432	436	434	427	429	434	433	431	429	427	429	428	427	040
31	427	428	424	419	420	429	438	442	448	437	425	419	414	420	421	425	429	428	429	431	430	424	420	428	040
MEAN	435.8	413.9	411.7	400.8	393.3	402.1	417.9	430.1	437.5	437.7	434.8	430.2	429.7	425.4	423.0	422.9	424.0	427.5	423.9	422.5	422.4	420.2	418.2	417.5	63.1
Q	418.8	418.5	417.5	407.5	401.8	407.0	417.8	425.8	431.6	431.4	430.6	428.0	428.8	424.4	424.4	425.2	428.6	429.6	428.2	427.4	426.2	424.8	423.6	422.4	40.6
D	398.6	395.6	394.0	378.6	373.6	384.0	408.0	423.2	429.8	429.8	433.0	423.8	428.2	425.6	420.6	414.2	407.6	414.6	404.2	398.0	404.6	402.8	400.4	401.8	125.2

MAGNETIC DECLINATION

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

D = W 00° + ... (IN TENTHS OF A MINUTE)

D 8 AUGUST 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1	430	430	423	417	403	400	413	420	426	419	411	412	417	414	417	424	432	429	431	433	433	429	429	429	039
2	427	418	419	409	392	405	421	442	451	445	434	427	423	420	418	419	426	424	426	424	429	429	424	426	066
3	422	424	419	407	396	402	421	435	448	436	429	424	419	412	412	420	427	429	429	429	421	420	420	420	054
4	422	420	413	396	391	401	418	424	446	457	449	428	421	420	418	420	425	422	427	430	430	425	426	424	074
5	423	421	418	401	401	418	433	442	445	445	439	429	420	414	411	413	421	422	423	428	430	430	430	428	053
6	424	420	411	395	391	401	430	451	454	452	440	429	424	421	430	428	424	411	410	428	425	428	425	427	068
7	424	421	413	392	383	396	426	450	463	462	450	437	432	422	419	417	419	424	428	423	429	431	431	427	092
8	423	421	412	397	397	414	442	458	459	448	441	431	422	421	419	418	430	432	431	432	431	431	431	423	073
9	422	421	419	400	392	413	429	450	460	461	450	442	438	421	412	412	421	417	413	414	420	426	428	424	073
10	423	421	414	396	389	404	429	448	451	451	449	441	433	431	424	428	432	434	429	423	430	431	430	431	051
11	430	426	421	409	395	404	424	441	451	452	439	420	416	419	422	423	422	432	432	432	431	430	429	426	065
12 Q	428	424	422	420	413	425	439	442	437	439	436	433	424	420	422	425	431	433	434	432	430	427	418	422	036
13 Q	425	424	423	416	421	428	440	450	452	443	432	423	429	430	433	433	434	436	436	433	430	426	425	424	040
14 Q	424	423	416	405	404	412	431	452	459	456	442	435	430	428	435	441	442	441	437	434	432	430	425	424	060
15	423	423	422	422	421	424	434	442	447	439	434	432	424	423	425	434	442	442	435	434	426	425	421	414	034
16 D	413	417	422	407	413	431	439	452	*439	*439	445	427	421	392	405	415	406	407	408	417	414	410	414	405	056
17 D	393	392	376	357	345	353	387	413	428	434	419	426	421	406	396	403	405	418	424	424	422	418	417	414	099
18	410	407	399	387	393	408	422	443	463	455	453	450	431	422	412	419	424	424	423	424	421	417	415	417	081
19	416	411	401	387	385	398	414	432	442	449	444	429	425	423	421	425	433	429	423	423	425	423	418	416	072
20 D	417	416	406	386	399	426	436	462	462	458	454	449	442	432	428	433	436	433	430	427	424	420	418	417	087
21 D	416	407	407	401	399	417	424	436	434	424	422	426	426	426	424	426	426	425	426	421	426	427	419	419	049
22	418	417	416	400	397	405	417	438	452	449	444	439	438	429	428	428	428	427	429	428	426	419	419	419	059
23 D	420	419	418	416	394	410	424	446	461	459	445	448	444	429	420	425	428	420	424	427	427	425	425	420	078
24	420	419	411	398	383	381	398	419	436	444	444	437	435	424	418	418	426	429	429	429	428	427	426	420	071
25	424	424	422	408	398	407	416	436	456	458	456	446	435	425	414	413	420	428	431	429	431	432	430	428	065
26	429	427	421	406	399	409	430	449	456	454	451	450	440	427	419	423	429	434	432	435	436	451	450	430	062
27 Q	429	426	421	405	392	399	415	429	447	453	449	440	427	414	411	421	433	435	433	432	433	431	430	428	064
28 Q	429	427	420	411	409	419	435	447	454	447	445	439	394	421	420	429	437	438	438	438	437	436	430	428	049
29	429	428	424	420	418	422	438	446	451	448	440	429	420	395	391	411	431	431	437	438	440	444	446	437	068
30	431	429	426	420	416	428	436	446	457	452	439	429	420	411	411	413	421	427	431	434	432	431	430	429	049
31	429	427	421	410	400	412	429	446	448	431	422	417	412	408	413	422	430	432	430	429	428	430	429	429	056
MEAN	422.4	420.3	415.4	403.3	397.7	408.8	425.5	441.5	449.5	447.1	440.2	433.0	425.9	419.4	417.7	421.9	427.1	427.9	428.0	428.5	428.3	427.7	426.1	423.4	59.2
Q	427.0	424.8	420.4	411.4	407.8	416.6	432.0	444.0	449.8	447.6	440.8	434.0	420.8	422.6	424.2	429.8	435.4	436.6	435.6	433.8	432.4	430.0	435.6	425.2	55.6
D	411.8	410.2	405.6	393.4	390.0	407.4	422.0	441.8	446.3	443.8	437.0	435.2	430.8	417.0	414.6	420.4	420.2	420.6	422.4	423.2	422.6	420.0	418.6	415.0	73.8

MAGNETIC DECLINATION

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

D = W 00° + ... (IN TENTHS OF A MINUTE)

D 9

SEPTEMBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1	429	429	424	419	419	429	444	458	467	458	448	440	432	425	419	409	410	417	419	420	420	429	424	429	059
2	432	426	414	390	378	387	416	442	454	458	448	432	420	412	415	429	434	431	428	426	425	422	428	421	092
3	429	422	417	411	421	441	459	464	464	452	442	433	420	412	417	420	430	420	410	425	430	432	430	420	063
4 D	415	429	410	377	379	392	408	425	440	440	441	432	422	420	410	406	410	419	411	412	415	422	432	428	094
5	420	414	405	383	386	406	430	447	459	459	444	430	420	410	412	424	425	421	421	422	430	435	430	423	086
6	425	413	413	391	384	410	433	450	461	461	457	451	436	421	420	429	432	432	431	431	432	431	431	430	087
7 Q	426	422	416	407	402	410	429	442	455	451	452	445	434	422	421	431	430	431	432	433	432	432	431	430	060
8 Q	429	426	421	411	411	433	465	480	487	476	465	452	432	411	410	421	432	434	436	435	432	430	425	429	083
9 Q	427	422	420	404	412	432	445	456	461	460	448	442	433	432	432	433	434	436	437	434	432	431	427	428	065
10 Q	431	430	424	420	422	437	455	466	471	462	453	441	420	413	435	442	446	443	441	439	437	431	426	427	061
11	431	430	424	412	408	423	444	459	461	454	451	448	439	424	427	434	439	441	440	439	434	432	430	424	043
12	418	414	412	411	405	416	431	442	453	460	445	432	420	414	421	427	430	433	437	436	434	433	432	432	057
13	430	424	422	422	423	436	444	451	461	460	451	442	423	417	428	440	442	441	442	440	437	432	430	422	050
14	424	421	422	422	432	449	461	462	463	466	451	435	423	418	422	435	440	433	436	433	432	431	426	423	054
15	424	423	422	413	412	425	442	453	470	461	451	442	422	422	432	441	433	428	432	432	433	432	430	424	065
16	422	412	403	401	403	412	439	443	456	461	453	443	432	429	428	432	434	434	433	435	434	432	431	428	052
17	431	431	432	432	418	422	427	432	438	444	442	440	422	422	430	433	435	440	439	434	429	424	424	430	037
18	422	423	421	412	411	427	444	451	452	452	451	446	437	432	428	432	434	433	432	432	432	432	425	422	056
19	412	412	414	398	384	408	440	456	461	456	453	449	433	424	429	433	434	432	432	432	432	432	432	433	089
20 D	434	434	434	417	404	404	424	437	443	445	442	415	404	413	403	412	414	410	412	413	432	412	422	432	073
21 D	421	423	412	393	382	384	416	426	441	451	451	442	432	424	424	419	412	414	422	422	422	422	417	423	084
22 D	429	422	421	403	394	386	412	442	450	454	452	442	423	422	416	422	427	431	430	425	425	423	423	422	088
23	423	423	423	414	409	422	444	449	445	448	444	427	416	414	422	427	422	422	413	421	416	420	414	422	045
24	422	423	417	411	403	413	423	432	432	441	443	434	420	412	422	422	422	423	422	421	422	422	423	429	055
25 D	432	427	431	430	418	422	424	430	422	430	425	422	413	412	412	408	405	408	411	414	413	415	413	418	031
26	421	416	415	420	422	430	442	440	432	427	422	411	396	412	424	431	422	424	423	426	424	421	422	425	056
27	422	424	424	422	422	424	430	433	424	422	417	414	414	420	423	423	423	432	427	427	424	426	424	424	028
28	424	424	419	412	412	412	419	422	422	424	430	427	422	427	432	432	432	427	419	424	432	431	429	427	021
29 Q	423	427	432	427	430	436	444	448	449	432	422	417	412	413	427	432	433	433	434	435	433	432	432	431	040
30	432	431	429	424	421	427	434	440	442	442	436	433	426	421	421	422	422	424	426	427	423	426	429	427	036
MEAN	425.3	423.2	419.8	410.0	407.6	418.5	435.6	445.9	451.2	450.2	444.3	435.3	423.3	419.0	422.1	426.7	427.9	428.3	427.6	428.2	428.3	427.5	426.4	426.1	60.3
Q	427.2	425.4	422.6	413.8	415.4	429.6	447.6	458.4	464.6	456.2	448.0	439.3	426.2	418.2	425.0	431.8	435.0	435.4	436.0	435.2	433.2	431.2	428.2	429.0	60.1
D	426.2	427.0	421.6	404.0	395.4	397.6	416.8	432.0	439.2	444.0	442.2	430.6	418.8	418.2	413.0	413.4	413.6	416.4	417.2	417.2	421.4	418.8	421.4	424.6	74.0

MAGNETIC DECLINATION

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

D = W 00° + ... (IN TENTHS OF A MINUTE)

D 10

OCTOBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1 D	432	427	431	422	412	412	413	411	424	432	415	412	411	414	417	419	422	422	420	420	421	429	423	423	035
2	423	423	423	424	424	436	451	456	450	443	442	432	424	427	434	436	436	433	432	431	430	425	424	423	048
3 D	427	431	432	431	436	441	442	442	441	444	441	424	413	412	414	422	416	416	412	412	411	405	412	412	046
4 D	405	408	409	403	403	412	433	442	434	435	438	432	405	405	422	422	421	425	424	423	420	418	417	418	031
5	418	419	417	409	412	421	440	445	438	426	416	410	402	407	420	418	418	411	413	419	424	416	425	426	048
6 D	421	419	413	397	390	402	412	426	429	425	424	427	414	415	422	413	414	420	424	425	423	422	422	423	049
7	425	426	424	421	422	429	439	442	441	434	428	421	418	415	428	434	434	433	432	432	431	431	428	426	032
8	428	431	430	421	417	426	439	441	433	434	441	440	432	432	434	433	432	432	432	433	432	432	432	432	028
9	432	433	432	434	431	433	435	433	432	431	429	425	417	418	428	432	432	432	432	432	432	432	432	432	025
10 Q	432	432	432	433	435	436	432	432	433	434	432	428	425	430	439	442	439	433	432	434	434	433	432	432	018
11 Q	432	433	435	433	428	424	419	412	414	415	420	421	422	429	437	412	437	432	433	433	432	432	432	432	030
12	433	436	434	433	433	434	443	443	436	430	430	432	432	432	439	441	441	434	434	432	431	431	433	433	018
13 Q	437	439	438	423	432	435	442	442	440	443	443	437	432	433	445	445	442	438	436	437	433	433	435	431	020
14	437	438	436	436	431	439	447	451	452	450	440	433	432	431	438	441	433	431	429	429	424	425	427	423	031
15	432	431	430	428	425	432	440	451	450	442	438	430	424	422	435	439	434	433	435	433	432	432	427	431	038
16 Q	432	432	432	425	430	444	456	461	456	445	434	430	423	423	429	435	433	432	434	435	434	436	434	433	039
17	430	432	432	431	438	444	443	440	438	427	421	430	433	438	445	442	439	435	434	436	431	431	423	428	038
18	431	424	434	437	445	458	446	445	434	423	412	426	431	429	431	434	428	426	430	432	425	422	424	423	047
19	431	432	432	429	423	425	435	438	438	438	433	432	435	438	442	467	432	431	432	433	432	431	431	429	028
20	433	435	439	438	434	426	422	426	428	423	416	413	420	431	438	435	431	431	432	432	436	433	433	436	030
21	440	441	442	442	442	434	432	438	448	444	442	442	440	434	442	442	434	432	432	434	434	433	433	438	020
22	435	443	444	445	447	433	423	422	431	429	427	419	411	410	411	413	413	423	428	429	431	425	425	425	045
23	429	432	423	413	412	415	424	438	445	445	438	433	434	437	438	437	433	432	433	436	435	434	434	433	038
24	436	439	442	442	440	435	442	436	429	426	418	413	414	417	427	436	433	433	436	437	436	434	435	439	029
25	442	443	442	437	425	425	427	424	426	427	414	418	431	438	438	433	426	429	431	432	434	439	441	434	032
26	434	441	441	444	437	426	415	413	420	429	437	437	433	435	429	431	426	423	428	425	428	430	432	432	039
27	432	435	438	443	438	429	437	436	435	435	435	438	440	433	433	435	434	432	432	432	433	433	433	433	014
28 Q	435	437	443	456	456	449	443	434	424	419	413	421	429	427	433	440	434	433	436	437	436	437	439	441	047
29	442	444	449	459	461	460	454	450	444	440	434	435	441	442	442	440	434	432	435	438	439	437	441	445	029
30	422	457	463	460	458	449	437	431	431	432	432	436	446	447	449	445	436	436	431	426	420	423	424	426	056
31 D	439	447	457	455	448	431	421	420	424	418	417	415	416	429	433	426	417	420	413	420	407	418	423	433	061
MEAN	430.9	433.6	434.5	432.4	431.1	432.1	435.0	436.2	435.4	432.8	429.0	427.2	425.2	426.8	432.7	433.6	430.2	429.2	429.6	430.2	429.1	428.8	429.2	429.8	35.1
Q	433.6	434.6	436.0	434.0	436.2	437.6	438.4	436.2	433.4	431.2	428.4	427.4	426.2	428.4	436.6	434.8	437.0	433.6	434.2	435.2	433.8	434.2	434.4	433.8	30.8
D	424.8	426.4	428.4	421.6	417.8	419.6	424.2	428.2	430.4	430.8	427.0	422.0	411.8	417.0	421.6	420.8	418.0	420.6	418.6	420.0	416.4	418.4	419.4	421.8	44.0

MAGNETIC DECLINATION

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

D = W 00° + ... (IN TENTHS OF A MINUTE)

D 11

NOVEMBER 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1 D	440	442	445	447	446	441	429	431	442	415	408	401	402	410	422	417	412	416	422	418	426	435	436	442	060
2 D	451	454	459	447	443	425	430	418	420	420	415	421	419	422	437	429	413	413	410	421	416	421	423	421	058
3 D	427	433	435	442	438	429	418	418	415	404	394	411	422	423	426	425	425	421	420	426	425	424	426	431	053
4	431	434	442	445	442	430	439	442	439	429	415	409	417	429	433	430	419	419	426	425	419	422	424	428	043
5	429	441	443	445	437	423	412	407	405	413	401	397	412	414	425	428	429	431	432	435	436	437	436	440	056
6	443	445	437	443	445	439	422	426	435	432	417	417	418	426	433	431	423	422	428	432	432	432	432	434	037
7	439	441	442	439	433	424	428	434	434	432	432	432	433	432	434	435	432	432	433	436	436	438	431	441	020
8	442	445	444	441	435	429	419	427	426	413	403	412	423	432	436	441	434	432	429	433	435	440	442	442	044
9	442	442	443	452	457	448	436	440	439	429	419	421	424	432	441	441	437	432	433	438	436	432	433	432	046
10	431	435	441	445	444	444	445	446	428	431	433	439	442	443	448	445	442	437	437	436	435	431	433	432	021
11 Q	434	442	445	450	451	450	444	456	439	433	433	429	430	435	445	445	439	436	437	435	433	432	431	433	024
12	433	435	441	446	445	439	424	417	420	426	430	427	430	438	445	447	441	440	442	438	433	432	432	432	035
13	436	443	446	456	466	462	449	439	427	423	418	422	425	437	448	449	445	445	440	440	433	431	427	436	052
14	435	438	444	453	467	472	462	451	436	419	412	406	411	426	440	438	430	433	432	432	430	423	425	433	070
15 Q	436	438	443	448	453	450	442	431	423	424	422	422	427	431	438	440	433	432	432	432	432	432	434	438	025
16	441	445	451	449	461	456	440	425	416	412	412	414	422	430	436	440	433	424	426	425	423	423	432	440	049
17	445	450	454	468	469	446	440	432	429	417	415	414	415	430	439	440	433	432	434	437	437	439	440	442	066
18	440	440	445	457	457	443	432	426	415	403	408	412	416	420	434	432	432	433	424	428	431	432	433	435	073
19	439	442	445	451	452	443	433	426	411	410	417	423	428	432	433	432	426	432	432	432	433	433	433	434	055
20 Q	441	443	441	445	445	442	444	449	444	441	436	432	432	433	442	444	436	433	439	441	438	440	439	438	021
21	442	444	446	447	451	458	464	469	453	443	437	420	410	412	415	419	414	421	425	426	423	422	422	425	067
22	438	443	446	454	464	460	455	446	438	428	424	420	420	435	442	441	437	433	430	426	431	432	434	436	053
23	428	429	424	428	426	425	415	417	423	424	424	429	425	429	429	428	423	422	424	427	427	430	432	432	015
24 Q	438	442	442	442	442	439	434	438	441	438	433	430	430	431	432	436	432	432	433	432	432	432	432	439	018
25	444	449	451	452	452	446	439	435	426	424	424	413	412	420	433	438	431	430	432	432	431	431	434	442	046
26	442	446	450	451	451	445	443	444	445	436	423	428	427	429	434	433	434	429	432	436	436	436	430	426	031
27	431	433	437	441	448	446	443	446	442	442	442	442	442	442	445	441	434	433	434	433	430	429	435	433	028
28 D	426	444	447	431	421	422	422	435	430	407	402	394	412	418	420	424	422	421	422	421	425	424	423	429	085
29	435	441	445	442	444	436	430	429	428	415	402	410	416	419	428	431	424	427	423	429	429	430	427	427	046
30 D	434	441	442	443	449	449	444	440	430	428	422	403	403	415	422	429	414	417	421	421	422	421	416	425	060
MEAN	437.1	441.3	443.9	446.7	447.8	442.0	435.9	434.7	429.3	422.8	419.1	418.3	421.5	427.5	434.5	435.0	429.3	428.7	429.5	430.8	430.2	430.5	430.9	433.9	45.2
Q	436.4	440.0	442.4	446.2	447.2	444.0	437.6	438.2	433.4	432.4	430.8	428.0	429.8	433.6	440.4	442.4	436.2	434.6	436.6	435.6	433.6	433.6	436.6	436.0	46.0
D	435.6	442.8	445.6	442.0	439.4	433.2	428.6	428.4	423.4	414.8	408.2	406.0	411.6	417.6	425.4	424.8	417.2	417.6	419.0	421.4	422.8	425.0	424.8	429.0	63.2

MAGNETIC DECLINATION

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

D = W 00° + ... (IN TENTHS OF A MINUTE)

D 12

DECEMBER 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1	429	441	450	445	440	436	425	421	421	418	411	408	413	422	431	425	423	431	432	432	428	426	426	430	049
2	433	433	439	441	441	432	432	432	424	416	415	412	423	419	424	425	431	432	427	421	423	426	431	432	039
3 D	433	440	443	445	444	438	428	426	416	405	392	386	390	403	419	423	424	423	427	421	413	412	420	421	066
4	433	435	437	457	463	462	451	445	443	441	428	419	416	423	432	435	431	431	431	432	432	432	432	432	057
5 D	436	441	441	440	448	448	444	448	433	419	411	403	394	384	400	417	416	400	386	386	391	403	418	426	072
6	431	433	433	432	438	438	441	444	443	432	422	420	414	414	424	432	430	429	428	431	432	431	431	431	034
7 Q	425	426	430	433	429	429	434	441	442	442	436	425	416	419	428	435	428	430	432	432	432	430	429	427	029
8	430	432	436	435	440	438	436	441	447	445	442	440	423	423	434	440	438	433	433	434	433	424	423	429	028
9	434	438	445	453	459	465	468	467	465	463	461	447	438	432	436	436	432	433	432	432	432	430	429	432	052
10 Q	432	435	440	445	450	448	438	435	438	441	444	439	439	436	440	441	437	433	434	438	433	432	432	434	020
11 Q	438	441	442	444	451	450	438	434	440	448	449	435	431	432	436	440	433	435	433	435	435	432	432	442	024
12	439	438	442	450	458	453	439	421	413	419	433	435	436	433	438	441	436	433	431	432	428	421	413	421	049
13	428	436	447	454	458	451	449	443	437	441	441	434	433	438	445	442	436	434	430	431	428	418	415	428	057
14 D	439	444	452	466	471	451	436	419	406	411	413	415	419	415	425	424	421	423	425	427	423	423	423	429	080
15	436	443	448	452	459	456	439	430	435	440	438	428	421	422	427	431	425	421	424	430	429	430	431	432	047
16	434	440	445	456	465	457	448	443	440	439	432	432	430	420	424	429	424	431	428	429	426	429	432	429	064
17	433	439	445	454	461	462	454	444	438	432	432	426	421	425	437	440	436	434	433	433	431	431	435	438	043
18	441	441	443	448	451	447	442	441	434	433	429	418	413	421	434	435	435	434	434	437	436	432	434	437	039
19	441	447	450	453	449	435	424	412	410	414	412	412	413	420	428	429	428	432	431	432	432	432	433	439	051
20	443	445	446	451	452	451	445	431	432	433	427	424	426	429	438	441	441	433	432	434	434	432	437	441	031
21 Q	442	443	445	449	452	449	437	425	424	432	433	422	424	432	440	445	442	441	438	438	437	436	435	435	037
22	437	441	445	457	459	454	445	437	444	441	426	417	419	433	444	445	442	437	440	441	439	434	432	436	046
23	435	442	449	459	462	458	439	442	449	461	457	446	433	429	438	448	449	437	432	436	432	426	422	412	056
24	420	437	443	450	450	444	444	433	431	429	411	423	423	424	431	435	430	431	432	431	431	432	434	436	047
25	450	450	451	454	463	457	444	440	443	438	426	421	426	433	440	440	435	434	431	431	434	438	440	444	047
26	446	451	452	460	464	450	424	420	434	428	420	412	428	429	427	435	431	430	429	433	433	432	431	434	066
27 D	447	450	458	469	473	447	432	425	433	441	420	418	428	421	428	427	429	430	425	421	422	426	430	435	078
28 D	441	437	444	443	465	454	434	433	440	438	416	409	421	431	430	429	428	429	420	421	421	421	423	430	069
29	435	445	451	458	463	441	426	418	421	429	428	413	418	435	436	432	429	428	430	432	432	432	432	437	064
30	438	442	444	449	455	451	433	415	418	425	426	420	418	439	436	440	428	426	426	430	428	432	432	436	047
31	441	443	447	455	470	464	440	418	420	420	404	400	409	421	438	440	432	432	432	432	432	434	436	440	078
MEAN	436.1	440.3	444.6	450.2	454.9	448.9	439.0	433.0	432.7	432.7	426.9	421.3	421.2	424.4	431.9	434.7	431.6	430.3	429.0	430.0	429.0	428.0	429.1	432.4	50.5
Q	434.8	437.2	440.4	445.6	448.2	446.0	438.4	434.4	437.6	440.8	437.6	427.6	425.8	430.4	437.6	441.2	436.4	435.2	435.4	436.8	435.2	432.8	432.0	434.8	33.2
D	439.2	442.4	447.6	452.6	460.2	447.6	434.8	430.2	425.6	422.8	410.4	406.2	409.8	410.8	420.4	424.0	423.6	421.0	416.6	415.2	414.2	417.0	422.8	428.2	73.0

VERTICAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

Z 7 JULY 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1 Q							067	064	058	047	043	051	049	043	044	048	051	052	051	051	051	051	051	052	29
2	053	053	056	057	057	064	065	063	061	056	049	044	042	042	048	049	051	051	051	051	051	051	051	051	31
3 Q	051	C52	051	050	055	057	051	045	040	037	038	042	037	038	044	048	051	051	051	051	051	049	051	052	25
4	051	053	053	051	051	052	054	054	051	053	051	051	042	046	049										20
5							064	063	062	061	053	048	044	040	045	048	051	051	050	049	050	051	050	051	33
6	051	050	048	048	052	051	049	050	047	044	037	038	035	034	044	045	049	050	048	048	048	048	047	048	22
7	048	048	048	047	051	057	059	048	044	053	056	050	042	041	040	044	049	048	047	048	047	048	048	048	25
8	048	048	049	048	052	054	059	051	044	053	057	050	041	041	040	044	048	048	048	048	048	047	048	048	23
9	048	048	048	048	048	053	057	057	057	046	045	034	024	054	035	042	044	045	047	047	045	046	048	048	45
10	047	048	046	038	051	067	068	054	051	039	031	037	041	038	041	044	048	048	048	048	048	049	048	048	41
11	051	051	053	054	055	054	067	068	058	048	045	044	045	042	044	048	048	051	047	044	042	041	043	042	42
12	042	044	045	044	048	054	055	051	038	026	015	013	027	039	041	044	046	047	046	046	046	047	047	047	47
13 Q	049	049	049	048	056	068	072	070	065	068	056	053	054	053	049	048	049	050	048	048	048	045	049	051	28
14	051	051	051	054	061	064	064	056	049	049	046	040	038	041	043	045	048	049	048	048	049	048	048	050	30
15 D	050	051	052	051	054	050	041	038	032	029	053	058	057	054	051	045	044	047	043	034	041	040	041	047	34
16 D	048	051	050	051	064	074	077	074	064	057	048	035	030	029	033	041	048	049	048	050	051	051	051	051	59
17 D	049	051	051	051	059	063	063	064	058	054	051	051	049	044	048	051	047	048	044	041	042	039	040	041	56
18 D	047	044	048	049	060	076	093	090	069	065	051	039	036	038	043	044	050	049	049	050	051	050	051	051	68
19	051	052	053	054	061	064	057	054	055	049	048	048	047	045	044	046	048	050	050	049	049	049	051	050	26
20	048	049	051	051	057	062	059	057	061	064	058	053	051	048	047	048	049	049	049	049	049	049	048	048	20
21	051	051	050	051	057	068	061	061	059	052	047	048	045	047	044	044	050	049	048	048	047	048	048	049	29
22	051	051	051	045	047	051	059	065	067	056	052	053	051	048	046	046	048	049	049	048	047	047	047	048	25
23	049	048	049	047	053	064	067	074	063	048	040	045	044	047	049	051	051	051	051	050	051	051	052	052	33
24	051	053	052	050	055	060	061	062	055	048	047	045	046	046	048	049	050	049	049	049	049	048	049	050	24
25 D	051	052	048	052	059	058	062	062	056	046	039	037	037	039	049	052	051	049	049	049	049	049	050	050	34
26	050	050	050	046	056	059	066	064	051	042	040	042	037	037	044	047	048	049	048	047	046	047	047	048	41
27	048	047	048	046	049	055	066	063	052	040	040	037	037	045	047	047	048	049	048	048	046	047	048	048	38
28	048	047	049	046	052	055	062	059	056	056	059	059	056	050	045	048	050	050	049	049	049	048	049	050	20
29 Q	049	049	050	047	041	036	033	028	027	027	031	035	036	034	043	049	049	049	048	048	047	047	047	048	25
30 Q	049	050	049	050	054	059	059	058	056	053	054	055	053	046	041	045	047	048	047	047	047	047	047	047	21
31	048	047	048	048	052	056	053	043	041	030	032	028	030	039	041	043	047	047	047	047	046	047	047	047	32
MEAN	29.2	49.6	49.9	49.0	54.0	58.8	61.0	58.4	53.1	48.2	45.5	43.3	42.0	41.5	44.2	46.4	48.6	49.1	46.9	46.3	47.7	47.5	48.1	48.7	33.2
Q	49.5	50.0	49.8	48.6	51.5	55.0	56.4	53.0	49.2	46.4	44.4	47.2	45.8	42.8	44.2	47.6	49.4	50.0	49.0	49.0	48.8	47.8	49.0	50.0	25.6
D	49.0	45.8	45.8	50.8	59.2	64.2	62.2	65.8	55.8	50.2	48.4	44.0	41.8	40.8	44.8	46.6	48.0	48.4	46.6	44.8	46.8	45.8	46.6	48.0	50.2

VERTICAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON-CYCLIC VARIATIONS

Z 8 AUGUST 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1	046	047	045	044	041	041	038	038	038	036	037	041	045	045	044	049	050	049	048	047	047	047	046	047	21
2	046	047	047	050	057	063	070	069	068	059	055	054	047	044	043	047	049	048	047	047	047	047	046	047	33
3	047	047	046	044	049	051	048	052	050	045	041	034	031	034	037	045	047	047	046	045	044	044	044	046	26
4	047	047	047	044	049	057	065	066	061	050	041	034	040	043	044	044	047	047	046	046	045	044	044	045	38
5	045	045	045	044	048	044	041	033	028	034	037	037	038	040	040	046	047	047	046	047	047	047	047	047	24
6	047	045	046	044	046	056	063	062	057	055	046	040	041	037	037	038	043	043	044	044	043	044	044	044	29
7	043	043	041	037	047	063	067	066	060	056	046	047	046	037	034	040	044	045	045	045	045	045	045	044	36
8	044	046	044	040	041	044	050	044	037	038	043	045	044	043	042	044	046	047	046	045	045	044	046	047	17
9	047	047	045	042	044	045	036	035	034	033	032	043	040	038	040	041	044	044	044	045	045	044	044	044	16
10	047	049	047	043	047	055	054	052	050	045	044	044	044	043	041	043	047	046	045	045	045	045	045	046	
11	044	045	047	045	044	044	043	045	050	051	041	039	047	045	043	044	045	048	047	047	047	046	046	047	18
12 Q	048	048	048	050	057	067	071	067	062	061	055	052	046	042	044	045	047	048	047	047	046	046	047	047	33
13 Q	048	048	048	048	051	054	052	051	047	044	038	037	039	038	041	043	044	045	044	044	044	044	044	045	19
14 Q	046	047	046	045	048	049	055	054	044	038	034	034	035	038	042	044	045	045	045	045	044	044	045	046	28
15	045	045	046	048	047	045	042	035	032	035	043	043	041	035	040	043	045	044	042	042	041	041	041	042	18
16 D	045	047	046	042	048	052	055	059	058	051	040	042	034	032	036	043	043	045	044	044	045	043	045	045	50
17 D	044	042	045	045	061	074	070	071	061	054	045	042	040	039	038	041	044	045	045	049	048	046	045	045	45
18	047	048	048	051	051	055	056	051	053	038	039	031	023	025	033	039	043	044	044	045	044	044	044	046	37
19	048	048	048	049	052	058	058	062	056	051	042	038	040	042	042	045	046	045	044	044	045	045	045	045	28
20 D	047	048	048	036	049	061	065	061	066	048	039	042	043	038	039	042	046	045	045	045	045	045	045	046	45
21 D	045	048	048	048	054	057	053	044	045	049	050	050	048	049	049	049	048	047	047	048	046	046	046	048	30
22	048	047	048	045	051	053	057	058	059	057	056	052	053	051	051	048	048	048	048	046	045	045	045	046	26
23 D	048	048	049	049	049	048	048	048	050	044	043	037	036	035	036	039	045	045	046	045	045	045	045	046	23
24	048	048	047	047	052	062	067	067	067	066	064	059	054	059	048	048	048	048	048	047	046	045	046	046	27
25	048	048	048	045	046	048	045	048	045	042	044	042	039	038	039	044	047	048	048	048	048	048	048	049	14
26	049	049	048	046	055	067	072	069	052	040	039	038	035	035	038	044	046	048	047	046	046	045	046	048	40
27 Q	048	049	048	047	052	058	058	058	053	040	033	032	031	028	029	043	046	046	046	047	046	045	045	046	33
28 Q	047	046	045	045	049	051	051	050	044	040	036	039	036	031	035	042	045	045	045	045	044	044	044	045	22
29	045	045	045	045	044	045	044	045	038	022	015	012	015	019	029	041	045	044	044	044	045	045	045	044	38
30	042	043	042	045	049	055	049	051	055	049	045	042	036	035	035	039	044	045	045	045	044	044	044	044	24
31	044	042	042	041	044	048	041	030	025	022	026	029	032	035	038	042	045	044	043	043	042	043	043	043	27
MEAN	46.2	46.5	46.2	45.0	49.1	53.9	54.3	52.9	49.8	44.9	41.4	40.4	39.3	38.5	39.6	43.4	45.8	46.0	45.5	45.5	45.1	44.8	45.0	45.7	28.8
Q	47.4	47.6	47.0	47.0	51.4	55.8	57.4	56.0	50.0	44.6	39.2	38.8	37.4	35.4	38.2	43.4	45.4	45.8	45.4	45.6	44.8	44.6	45.0	45.8	27.0
D	45.8	46.6	47.2	44.0	52.2	48.4	58.2	56.6	56.0	49.1	43.4	42.6	40.2	38.6	39.6	42.4	45.2	45.4	45.4	46.2	45,8	45.0	45.2	46.0	38.6

VERTICAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES UNCORRECTED FOR NON - CYCLIC VARIATIONS

Z 9 — SEPTEMBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1	043	042	043	044	045	047	045	047	041	035	036	038	035	032	032	035	041	042	043	042	042	044	042	043	18
2	043	044	044	039	049	058	062	056	055	055	058	047	042	039	042	045	045	044	044	044	043	042	043	042	29
3	042	042	043	045	054	056	058	056	051	046	042	032	027	029	033	039	043	032	042	043	042	042	041	040	37
4 D	039	042	040	039	051	059	054	051	044	051	048	034	031	035	039	040	042	044	048	044	043	044	044	043	46
5	044	042	042	039	052	064	061	062	056	050	045	042	040	039	041	045	045	044	044	044	044	044	043	044	28
6	042	043	043	041	049	051	042	044	048	048	039	039	037	037	039	044	045	045	045	044	044	043	043	044	22
7 Q	044	045	044	043	042	042	045	049	052	055	052	047	042	038	039	044	044	045	045	045	044	043	044	045	22
8 Q	045	045	045	045	049	052	051	050	043	033	030	032	026	022	029	039	042	043	044	043	042	042	042	042	35
9 Q	045	045	045	042	048	048	047	051	052	045	042	039	040	042	041	042	043	044	044	049	042	042	042	042	18
10 Q	045	045	045	046	048	046	037	027	023	019	019	018	016	022	032	039	042	041	040	041	042	040	041	042	36
11	046	044	045	044	048	052	052	051	045	042	045	040	036	032	039	042	043	042	042	041	041	041	042	043	27
12	043	045	046	044	048	049	044	043	042	039	038	029	034	035	039	043	042	042	044	042	041	042	042	042	26
13	043	045	045	045	048	045	038	036	033	029	029	031	023	027	035	039	040	041	041	042	041	040	040	042	28
14	042	043	045	046	051	052	039	033	026	021	019	018	019	020	029	037	039	039	038	039	039	039	039	041	41
15	042	042	042	042	046	045	046	048	048	039	037	036	032	032	039	042	042	040	042	040	039	039	041	040	25
16	042	042	042	045	049	046	046	045	048	042	036	037	032	032	035	039	040	041	039	039	039	040	041	040	23
17	042	042	043	041	042	042	041	041	042	035	035	035	035	038	039	043	042	041	040	039	038	039	039	039	15
18	042	045	045	041	043	045	042	039	042	048	049	046	042	039	039	041	042	042	041	039	040	040	040	042	19
19	042	042	042	040	049	062	061	055	045	045	044	039	043	039	041	043	043	042	042	042	042	040	042	043	41
20 D	045	045	043	042	042	047	054	057	056	056	049	042	041	041	043	045	045	045	043	042	045	042	043	045	33
21 D	043	045	043	043	053	056	063	076	069	072	062	053	043	043	042	042	042	043	044	043	041	042	043	046	49
22 D	046	048	049	046	049	058	078	066	069	069	056	046	039	040	039	043	043	043	042	042	043	042	043	042	47
23	043	045	045	042	044	050	049	049	049	052	051	046	042	043	044	045	043	043	044	043	041	041	042	043	15
24	045	045	045	045	051	056	060	060	056	056	047	039	036	038	043	044	043	044	043	044	044	043	045	046	43
25 D	047	046	046	047	046	040	033	025	020	029	031	030	033	036	040	043	042	043	043	043	042	041	043	045	33
26	045	046	046	046	045	042	038	032	030	030	029	029	026	033	039	041	041	041	042	041	041	040	042	042	26
27	043	045	046	045	041	042	041	040	041	046	047	045	042	042	043	043	042	042	042	041	040	040	039	042	15
28	043	043	043	043	046	047	046	045	045	045	043	041	041	046	045	043	043	043	043	043	043	044	042	043	13
29 Q	044	044	043	043	044	043	043	046	044	045	045	040	040	042	044	044	043	043	041	042	042	041	042	043	12
30	044	044	044	043	044	047	047	047	048	047	041	037	036	040	043	044	044	043	043	043	040	041	043	043	12
MEAN	45.5	44.0	44.1	43.2	47.2	49.6	48.8	47.5	45.4	44.1	41.5	37.6	35.1	35.8	38.9	42.6	42.5	42.6	42.4	42.3	41.6	41.4	41.9	42.6	27.8
Q	46.6.	44.6	44.4	43.8	46.2	46.2	45.4	44.6	42.8	39.4	37.6	35.2	33.4	33.2	37.0	41.6	42.8	43.2	42.8	44.0	42.4	41.6	42.2	42.8	24.6
D	44.0	45.2	44.2	43.4	48.2	52.0	56.4	55.0	51.6	54.8	49.2	41.0	37.4	39.0	40.6	42.6	42.8	43.6	43.0	42.8	41.8	42.2	43.2	44.2	41.0

VERTICAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES UNCORRECTED FOR NON - CYCLIC VARIATIONS

Z 10 — OCTOBER 1959

DATE \ U.T.	0 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14	14 15	15 16	16 17	17 18	18 19	19 20	20 21	21 22	22 23	23 24	RANGE
1 D	044	044	046	043	047	047	047	046	053	047	050	050	046	047	046	043	043	043	042	043	041	043	042	043	18
2	044	044	044	045	046	047	048	047	048	047	046	036	034	038	042	041	040	040	040	040	039	040	040	042	23
3 D	044	045	045	046	045	040	032	029	036	037	031	029	026	030	036	040	040	039	038	040	037	037	037	040	22
4 D	041	041	041	044	047	050	045	047	047	050	046	039	037	037	039	040	042	042	041	041	040	040	041	042	20
5	043	044	045	044	044	044	043	041	041	040	037	036	038	039	040	041	042	042	040	041	040	038	039	040	11
6 D	040	040	041	041	049	055	056	057	058	051	054	050	043	044	044	041	042	044	042	041	039	041	041	042	33
7	043	044	044	042	044	043	043	037	035	039	034	029	028	030	036	040	040	040	040	040	038	037	040	040	24
8	041	042	043	041	044	046	040	034	034	036	043	045	045	045	044	041	040	040	040	041	039	039	040	040	17
9	041	041	041	041	035	033	031	030	034	040	042	036	034	040	043	042	041	041	041	040	038	039	039	039	15
10 Q	040	041	042	041	040	037	037	040	040	043	045	042	039	038	041	041	039	037	040	040	038	038	038	040	11
11 Q	040	041	042	040	041	040	040	040	044	048	054	054	051	050	049	044	042	040	040	040	040	040	040	041	19
12	042	042	043	044	044	044	040	035	033	030	030	030	031	034	037	038	038	037	038	038	037	037	038	039	16
13 Q	041	042	042	043	045	046	047	046	049	047	050	046	045	047	049	045	043	042	043	043	042	042	043	044	12
14	045	046	046	046	045	043	042	041	043	041	042	043	041	039	043	044	043	043	044	043	042	043	044	045	14
15	047	047	047	047	045	043	039	037	038	036	039	034	034	036	043	043	042	043	043	043	042	042	043	043	16
16 Q	044	046	047	047	050	047	046	043	039	036	036	034	035	035	039	040	040	042	042	042	043	043	042	042	22
17	044	043	046	044	043	043	040	040	040	043	044	048	044	044	043	043	043	043	042	040	039	040	043	043	17
18	046	047	047	047	050	043	035	033	029	033	040	041	040	040	040	042	040	040	042	042	043	042	043	044	35
19	044	044	046	045	043	044	043	044	044	045	044	043	*043	*044	044	043	040	042	043	043	042	042	043	044	8
20	044	044	044	043	043	039	040	040	043	045	047	047	047	048	047	048	043	043	043	043	043	044	044	044	14
21	046	045	047	048	047	042	042	044	045	044	044	047	044	044	046	046	046	046	043	044	043	043	043	043	10
22	043	043	043	043	037	034	030	031	030	032	040	042	040	041	047	046	041	043	043	040	040	040	040	041	22
23	040	041	041	041	044	047	047	047	047	045	048	048	045	046	044	043	041	041	040	041	040	041	041	042	10
24	044	040	044	041	037	034	029	022	027	033	036	036	033	035	040	040	038	039	040	040	041	040	040	040	22
25	041	041	041	041	044	042	040	041	044	040	040	041	046	045	044	041	041	044	044	044	044	044	045	046	16
26	045	045	044	045	046	045	047	052	053	055	055	050	044	044	044	044	041	042	044	041	044	042	045	045	21
27	045	046	047	046	041	040	041	041	042	045	045	051	048	045	042	042	041	041	042	042	041	041	042	042	17
28 Q	044	042	048	042	033	037	023	023	025	026	027	030	032	031	038	041	039	039	041	041	041	042	042	042	21
29	039	039	045	045	042	038	036	033	037	035	038	038	039	041	041	041	041	041	042	042	042	042	042	042	15
30	046	046	045	042	038	033	029	023	024	030	034	043	044	041	042	038	038	041	042	042	041	042	041	044	30
31 D	045	046	046	042	034	026	025	031	034	039	038	039	044	044	046	043	041	042	042	042	042	042	042	042	27
MEAN	43.1	43.3	44.3	43.6	43.0	41.6	39.5	38.6	39.9	40.6	42.1	41.2	40.0	40.7	42.4	42.1	41.0	41.4	41.5	41.3	40.7	40.8	41.4	42.1	18.6
Q	42.6	42.4	44.2	42.6	41.8	41.4	38.6	38.4	39.4	40.0	42.4	41.2	39.4	40.2	43.2	42.2	40.6	40.0	41.2	41.2	40.8	41.0	41.0	41.8	17.0
D	42.8	43.2	43.8	43.2	44.4	43.6	41.2	41.6	45.6	44.8	43.8	41.4	39.2	40.4	42.2	41.4	41.6	42.0	41.0	41.4	39.8	40.6	40.6	41.8	24.0

VERTICAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON - CYCLIC VARIATIONS

Z 11 NOVEMBER 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1 D	046	047	047	045	045	044	038	039	033	039	041	040	039	042	045	044	044	044	045	044	045	047	046	046	25
2 D	045	045	043	043	046	048	047	046	042	042	043	043	041	043	043	041	040	039	039	041	041	042	044	044	19
3 D	047	045	045	043	039	033	029	032	025	027	032	039	042	041	041	040	038	040	040	042	039	042	039	043	28
4	044	045	046	044	035	028	026	029	031	034	033	038	043	045	044	041	039	041	041	038	041	041	041	042	25
5	043	045	044	041	039	027	025	023	033	038	037	04C	040	039	042	042	041	042	041	040	042	042	042	044	25
6	044	044	043	044	041	033	031	039	039	036	037	042	048	047	044	042	041	042	042	042	041	041	044	044	20
7	044	044	044	044	043	041	040	039	040	041	039	039	042	042	042	042	040	041	041	041	041	041	041	042	08
8	044	045	045	044	047	045	041	041	044	039	036	042	049	048	047	044	041	041	042	042	041	041	042	042	15
9	042	042	042	042	041	033	030	032	031	027	029	035	037	039	042	040	038	038	039	038	038	040	040	041	19
10	042	044	044	042	040	034	039	037	034	035	036	038	040	039	039	038	037	037	038	038	039	039	039	040	13
11 Q	041	041	042	039	045	042	040	039	034	037	037	036	037	037	040	039	037	037	038	037	039	040	040	041	14
12 Q	042	044	045	043	036	031	027	030	027	028	033	035	039	041	042	040	038	038	039	037	038	039	039	039	21
13	041	042	042	045	045	039	034	029	025	026	027	029	036	040	042	039	036	036	035	036	036	037	039	040	23
14	040	043	045	044	045	038	028	022	021	024	023	028	034	039	040	037	035	036	037	037	036	037	039	039	31
15 Q	039	041	041	041	040	035	024	022	022	026	028	029	032	034	036	036	035	035	037	037	036	036	036	037	25
16	039	040	040	040	035	026	016	011	012	017	023	030	036	036	039	038	035	036	036	036	036	037	039	040	31
17	040	040	041	040	033	023	015	015	015	023	027	028	031	036	039	035	032	033	035	035	036	037	039	040	30
18	040	040	040	041	033	024	021	022	022	023	031	033	036	039	042	040	039	040	037	037	037	039	039	040	25
19	040	040	040	041	039	033	029	028	024	029	038	043	045	043	043	041	039	040	041	039	039	016	040	041	24
20 Q	043	043	043	043	045	045	044	044	041	040	043	041	043	044	043	041	040	040	041	041	041	042	042	043	06
21	044	044	044	045	049	052	049	043	038	035	034	032	035	039	041	041	040	044	046	043	042	043	043	044	23
22	046	046	045	046	047	042	038	040	040	036	036	038	044	048	046	043	041	042	041	042	043	045	046	049	17
23	048	047	047	048	043	039	036	042	045	042	044	049	048	048	047	043	042	042	041	041	043	044	043	045	20
24 Q	047	049	046	047	047	046	046	046	046	042	038	038	044	049	048	044	042	042	043	043	043	044	044	046	14
25	046	046	049	046	044	038	032	029	028	033	033	035	039	048	048	044	042	043	048	042	042	044	045	045	25
26	046	046	046	044	041	034	029	032	032	027	029	035	034	037	041	040	040	042	042	043	044	046	044	045	28
27	044	042	042	044	047	044	044	050	046	043	041	037	039	042	041	037	036	037	038	039	040	042	042	044	19
28 D	049	051	050	051	053	057	063	053	044	040	039	041	044	046	045	044	043	044	045	043	042	044	044	045	56
29	046	046	041	044	039	037	036	040	039	037	044	045	045	044	045	044	042	044	043	044	042	042	044	045	16
30 D	047	047	046	046	049	045	042	032	031	034	029	032	039	041	042	043	039	041	042	042	043	044	045	047	28
MEAN	43.6	44.1	43.9	43.7	42.4	37.8	34,6	34.2	32.8	33.3	34.6	37.3	36.7	41.9	42.6	40.8	39.1	39.9	40.4	40.0	40.1	40.5	41.7	42.8	22.4
Q	42.4	43.6	43.4	42.6	42.6	39.8	36.2	36.2	34.0	34.6	35.8	35.8	39.0	41.0	41.8	40.0	38.4	38.4	39.6	39.0	39.4	40.2	40.2	41.2	16.0
D	46.8	47.0	46.2	45.6	46.4	45.4	43.8	40.4	35.0	36.4	36.8	39.0	41.0	42.6	43.2	42.4	40.8	41.6	42.2	42.4	42.0	43.8	43.6	45.0	31.2

VERTICAL COMPONENT OF TERRESTRIAL MAGNETIC FIELD

MEAN VALUES FOR PERIODS OF SIXTY MINUTES
UNCORRECTED FOR NON - CYCLIC VARIATIONS

Z 12 DECEMBER 1959

DATE \ U.T.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	RANGE
1	052	052	052	052	051	048	052	045	041	038	033	034	039	042	044	041	044	041	041	041	043	041	043	045	26
2	046	046	045	044	046	047	046	045	045	044	046	049	052	050	049	046	045	046	045	044	044	044	046	048	16
3 D	041	042	049	049	044	039	037	037	034	030	032	038	041	044	047	045	047	047	046	044	043	041	041	048	28
4	050	049	050	053	052	049	045	042	042	039	030	025	029	034	040	041	041	041	042	043	042	043	044	045	39
5 D	046	045	045	044	043	037	032	030	035	046	037	040	041	044	048	046	044	043	041	041	042	045	049	050	39
6	050	050	052	051	051	053	056	053	048	047	042	038	037	039	041	041	040	040	040	041	042	042	044	045	34
7 Q	044	044	044	044	042	041	043	045	046	048	047	042	041	043	046	046	042	043	043	044	044	044	045	046	10
8	046	046	048	048	050	046	046	042	043	046	046	042	040	041	045	045	042	043	043	043	042	043	045	045	15
9	045	045	048	046	046	047	045	045	048	055	053	046	043	045	045	045	042	043	044	045	042	044	045	046	16
10 Q	046	046	048	049	046	047	044	045	046	055	049	046	043	044	045	045	043	043	044	045	042	044	046	046	15
11 Q	042	042	043	047	049	045	037	038	049	059	057	049	049	045	046	045	043	043	043	045	044	043	044	045	28
12	046	046	048	046	042	037	032	029	035	051	059	050	046	045	046	045	042	043	042	045	042	043	044	045	36
13	047	047	050	048	045	043	045	040	042	050	051	047	045	047	047	045	042	042	042	043	042	042	044	046	18
14 D	049	047	048	046	042	034	028	030	034	042	047	039	035	038	042	042	040	041	041	042	041	042	042	044	29
15	045	046	046	046	042	038	042	045	050	050	044	037	034	031	035	038	038	040	038	041	041	042	042	043	24
16	044	042	044	044	038	026	020	014	019	027	032	030	027	029	036	039	038	038	039	040	039	040	041	042	34
17	042	044	044	042	038	029	016	013	017	030	030	025	029	033	037	037	036	037	038	038	038	039	041	041	32
18	041	041	042	041	035	033	034	029	030	035	033	029	030	029	038	033	035	036	037	037	037	037	038	038	17
19	040	041	041	037	029	020	022	017	025	029	025	028	030	034	037	037	036	039	038	038	037	037	038	041	26
20	042	041	041	039	038	037	028	021	030	028	025	025	029	032	037	037	037	037	037	037	037	037	039	038	20
21 Q	041	041	040	039	037	025	013	008	017	017	026	028	041	042	042	039	038	037	037	036	037	037	038	038	41
22 Q	038	039	039	037	031	022	012	011	014	011	011	021	032	040	039	037	034	034	034	034	037	036	037	038	36
23	038	038	040	041	037	029	024	020	020	025	018	025	034	037	041	037	034	031	034	037	036	037	038	040	24
24	041	042	041	038	040	032	022	027	029	032	020	030	037	042	042	040	037	038	034	039	040	041	042	044	29
25	046	040	041	041	042	041	033	031	034	026	022	027	032	035	036	033	032	033	034	035	036	036	037	035	24
26	039	039	039	039	036	033	029	034	039	031	026	035	042	040	040	042	039	037	037	039	039	040	039	042	21
27 D	043	043	043	042	035	028	024	024	039	037	025	039	043	041	042	038	037	039	039	037	040	041	042	044	29
28 D	044	044	043	043	039	031	027	028	031	036	035	039	043	044	044	042	042	041	043	041	040	041	043	044	24
29	046	047	046	046	047	033	030	029	039	036	033	036	042	046	048	043	042	043	044	043	043	044	044	046	24
30	047	046	046	045	044	039	032	035	039	045	042	044	048	053	048	045	044	044	044	044	044	044	046	048	27
31	048	048	048	047	047	039	020	023	024	027	020	031	040	044	047	044	043	043	044	045	044	045	045	046	31
MEAN	44.4	44.1	45.0	44.4	42.1	37.0	32.8	31.5	35.0	37.8	35.4	36.0	38.5	40.4	42.6	41.3	40.0	40.2	40.3	40.9	40.6	41.1	42.3	43.6	26.2
Q	42.2	42.4	42.8	43.2	41.0	36.0	29.8	29.4	34.4	38.0	38.0	37.2	41.2	42.8	43.6	42.4	40.0	40.0	40.2	40.8	40.8	40.8	42.0	42.6	26.0
D	44.6	44.2	45.6	44.8	40.6	33.8	29.6	29.8	34.6	38.2	35.2	39.0	40.6	42.2	44.6	42.6	42.0	42.2	42.0	41.0	41.2	42.0	43.4	46.0	29,8

DAILY MEANS AND EXTREMES OF HORIZONTAL COMPONENT

H = 36,000γ (0.36 C.G.S. UNIT) + ...

1959		JULY					AUGUST					SEPTEMBER			
DATE		Max	Min	Mean	Ci		Max	Min	Mean	Ci		Max	Min	Mean	Ci
1	Q	179	052*		0.2		203	046	092	1.0		203	008	073	1.1
2		159	040	076	0.8		160	011	074	0.9		304	005	076	1.2
3	Q	189	057	102	0.1		200	046	092	1.0		246	-54	083	1.4
4		242	057*		0.8		221	046	090	1.0	D	173	-101	-02	1.8
5		153	064*		0.9		258	065	100	0.6		206	-005	069	1.3
6		209	072	170	0.6		195	-11	092	1.1		183	018	076	0.9
7		216	064	105	0.8		254	039	098	1.0	Q	210	041	093	0.4
8		233	064	101	0.8		181	053	088	0.8	Q	211	048	097	0.6
9		177	057	091	0.9		238	005	079	1.1	Q	210	062	108	0.2
10		221	057	110	0.8		215	037	086	0.8	Q	242	068	127	0.4
11		182	028	104	1.4		215	048	100	0.4		244	054	109	0.9
12		213	019	090	1.1	Q	238	037	106	0.2		249	052	112	0.8
13	Q	192	035	091	0.6	Q	195	068	104	0.3		226	062	122	0.7
14		195	003	087	0.9	Q	285	076	124	0.3		245	055	097	1.1
15	D	332	-522	-77	2.0		261	044	108	1.2		263	046	110	1.1
16	D	038	-192	-37	1.4	D	234	-136	091*	2.0		208	027	095	0.9
17	D	261	-119	045	1.9	D	089	-108	-13	1.8		243	027	106	1.2
18	D	104	-160	-19	2.0		109	-014	034	1.2		237	036	105	1.2
19		167	-08	053	1.2		158	020	079	1.1		211	033	094	1.2
20		144	017	059	1.0	D	307	032	104	1.4	D	199	-29	067	1.6
21		201	031	084	0.9	D	274	028	091	1.3	D	131	-35	040	1.9
22		187	040	087	0.8		187	058	089	1.1	D	180	079	047	1.7
23		152	029	090	0.7	D	257	033	082	1.2		158	-13	066	1.2
24		218	029	085	1.2		222	048	091	1.1		171	-02	058	1.2
25	D	212	019	075	1.2		227	048	097	0.9	D	186	-29	050	1.2
26		187	022	075	1.1		173	054	100	0.4		151	027	064	1.2
27		241	031	083	1.1	Q	199	068	109	0.2		175	022	070	1.1
28		152	039	076	0.7	Q	217	049	114	0.1		173	036	084	0.9
29	Q	210	041	089	0.5		216	066	114	0.7	Q	200	056	096	0.5
30	Q	188	044	099	0.1		200	036	092	0.6		229	041	094	0.9
31		210	039	086	0.9		274	044	113	0.6					
MEAN			074		0.95				091	0.88				083	1.06
DAYS			28	28	31				31	31				30	30

1959		OCTOBER					NOVEMBER					DECEMBER			
DATE		Max	Min	Mean	Ci		Max	Min	Mean	Ci		Max	Min	Mean	Ci
1	D	195	002	063	1.3	D	144	-13	038	1.3		168	-05	059	1.1
2		207	040	090	1.0	D	197	-36	048	1.6		182	001	059	1.2
3	D	198	-40	060	1.5	D	174	-16	058	1.4	D	177	-18	052	1.5
4	D	132	031	043	1.3		175	-16	053	1.3		177	008	082	0.7
5		206	-43	059	1.3		194	023	073	1.1	D	256	-169	028	1.7
6	D	127*	-10	046	1.5		220	032	088	1.1		142	-25	047	0.9
7		204	035	095	0.9		198	049	101	0.7	Q	145	026	076	0.3
8		201	054	092	0.3		214	047	103	0.6		221	037	090	0.3
9		189	060	105	0.3		221	051	124	0.7		157	061	100	0.3
10	Q	190	068	112	0.2		204	061	109	0.6	Q	174	075	113	0.2
11	Q	244	076	119	0.2	Q	195	064	107	0.1	Q	149	069	103	0.2
12		267	068	133	0.4	Q	227	067	118	0.2		187	040	101	1.0
13	Q	235	088	131	0.2		216	065	119	0.8		165	022	090	1.1
14		256	051	117	0.8		253	024	095	1.2	D	159	-11	056	1.4
15		215	070	111	1.0	Q	189	052	101	0.1		134	027	071	1.1
16	Q	197	061	114	0.1		273	037	119	0.5		189	044	089	1.0
17		328	059	128	1.0		244	058	106	0.5		206	057	103	0.3
18		335	044	101	1.2		224	017	101	0.9		211	073	110	0.5
19		187	049	097	0.9		215	052	100	0.5		211	034	090	0.8
20		228	077	109	0.4	Q	186	062	109	0.1		213	057	109	0.3
21		254	066	124	0.4		183	-33	069	1.0	Q	225	077	127	0.1
22		254	005	091	1.2		197	036	094	1.0	Q	236	085	140	0.4
23		209	037	091	0.5		168	-05	054	1.4		212	011	102	1.3
24		234	066	114	0.3	Q	183	041	096	0.2		188	049	095	0.9
25		157	075	084	1.2		227	041	097	0.6		221	068	109	0.4
26		158	-13	069	1.2		239	058	113	0.7		186	021	099	1.2
27		147	054	081	0.7		152	061	098	0.8	D	186	034	079	1.4
28	Q	-236	077	126	0.0	D	228	-139	029	1.7	D	167	-07	067	1.4
29		212	081	123	0.2		146	015	053	0.8		202	030	087	0.9
30		256	001	121	1.3	D	188	-81	048	1.4		204	039	083	0.8
31	D	216	-43	064	1.5							213	062	108	0.4
MEAN				097	0.78				087	0.83				110	0.81
DAYS				31	31				30	30				31	31

DAILY MEANS AND EXTREMES IN DECLINATION

D = −00° + ... (IN TENTHS OF A MINUTE)

1959		JULY					AUGUST					SEPTEMBER			
DATE		Max	Min	Mean	Ci		Max	Min	Mean	Ci		Max	Min	Mean	Ci
1	Q	433	390*		0.2		437	398	422	1.0		468	409	430	1.1
2		436	390	420	0.8		456	390	424	0.9		466	374	424	1.2
3	Q	436	406	424	0.1		448	394	422	1.0		468	405	430	1.4
4		449	396		0.8		461	387	423	1.0	D	450	356	416	1.8
5		445			0.9		449	396	424	0.6		464	378	423	1.3
6		436	400	425	0.6		458	390	424	1.1		467	380	429	0.9
7		440	404	426	0.8		469	377	426	1.0	Q	459	399	430	0.4
8		442	411	427	0.8		463	390	428	0.8	Q	489	406	437	0.6
9		445	402	426	0.9		462	389	425	1.1		466	401	434	0.2
10		451	385	427	0.8		435	384	428	0.8	Q	472	411	438	0.4
11		479	404	427	1.4		458	393	426	0.4		465	422	435	0.9
12		445	379	419	1.1	Q	448	412	428	0.2		461	404	429	0.8
13	Q	440	402	424	0.6	Q	455	415	431	0.3		466	416	436	0.7
14		436	405	426	0.9	Q	462	402	432	0.3		468	414	436	1.1
15	D	522	318	403	2.0		451	417	430	1.2		475	410	433	1.1
16	D	451	345	406	1.4	D	459	403	419	2.0		465	413	430	0.9
17	D	472	363	411	1.9	D	438	339	404	1.8		449	412	431	1.2
18	D	455	336	402	2.0		464	383	422	1.2		461	405	433	1.2
19		448	388	417	1.2		453	379	421	1.1		463	374	430	1.2
20		444	391	420	1.0	D	465	378	430	1.4	D	449	376	421	1.6
21		457	390	424	0.9	D	443	394	421	1.3	D	456	372	421	1.9
22		469	369	423	0.8		455	396	425	1.1	D	462	374	425	1.7
23		457	377	423	0.7	D	467	389	428	1.2		451	406	425	1.2
24		456	389	425	1.2		446	375	421	1.1		451	396	423	1.2
25	D	457	369	419	1.2		460	395	428	0.9	D	434	403	419	1.2
26		466	377	422	1.1		459	397	433	0.4		444	388	423	1.2
27		443	384	420	1.1	Q	454	390	426	0.2		440	412	424	1.1
28		454	389	424	0.7	Q	457	408	430	0.1		433	412	424	0.9
29	Q	443	391	419	0.5		456	388	430	0.7	Q	451	411	431	0.5
30	Q	440	400	427	0.1		459	410	429	0.6		451	415	429	0.9
31		451	411	427	0.9		455	399	424	0.6					
MEAN				420.8	0.95				425.3	0.88				428.3	1.06
DAYS				28	31				31	31				30	30

1959		OCTOBER					NOVEMBER					DECEMBER			
DATE		Max	Min	Mean	Ci		Max	Min	Mean	Ci		Max	Min	Mean	Ci
1	D	438	403	420	1.3	D	457	394	426	1.3		452	403	428	1.1
2		464	416	433	1.0	D	461	403	427	1.6		442	403	428	1.2
3	D	449	403	425	1.5	D	445	392	423	1.4	D	449	383	421	1.5
4	D	444	413	420	1.3		448	405	429	1.3		471	414	436	0.7
5		449	401	420	1.3		449	393	425	1.1	D	451	379	418	1.7
6	D	432	383	418	1.5		450	413	431	1.1		446	412	431	0.9
7		444	412	429	0.9		442	422	434	0.7	Q	443	414	430	0.3
8		442	414	432	0.3		447	403	431	0.6		450	422	435	0.3
9		438	413	430	0.3		461	415	437	0.7		472	422	444	0.3
10	Q	442	424	433	0.2		445	424	438	0.6	Q	451	431	438	0.2
11	Q	442	412	427	0.2	Q	451	427	439	0.1	Q	453	429	439	0.2
12		447	429	435	0.4	Q	451	416	435	0.2		461	412	433	1.0
13	Q	449	429	437	0.2		468	416	439	0.8		460	403	437	1.1
14		461	430	436	0.8		473	403	435	1.2	D	478	398	429	1.4
15		457	419	434	1.0	Q	456	431	435	0.1		461	414	434	1.1
16	Q	461	422	436	0.1		461	412	432	0.5		478	414	436	1.0
17		451	413	434	1.0		478	412	437	0.5		463	420	438	0.3
18		451	404	431	1.2		463	390	430	0.9		451	412	435	0.5
19		448	420	434	0.9		461	406	432	0.5		458	407	430	0.8
20		442	412	430	0.4	Q	451	430	440	0.1		453	422	437	0.3
21		451	431	438	0.4		472	405	434	1.0	Q	457	420	437	0.1
22		448	403	427	1.2		467	414	438	1.0	Q	461	415	439	0.4
23		450	412	432	0.5		437	412	426	1.4		465	409	441	1.3
24		442	413	432	0.3	Q	446	428	436	0.2		451	404	433	0.9
25		444	412	432	1.2		456	410	434	0.6		467	420	440	0.4
26		447	408	430	1.2		453	422	437	0.7		469	403	435	1.2
27		445	431	435	0.7		452	424	439	0.8		482	404	435	1.4
28	Q	460	413	436	0.0	D	459	374	423	1.7	D	472	403	432	1.4
29		461	432	443	0.2		446	400	438	0.8		471	407	433	0.9
30		468	412	438	1.3	D	457	397	427	1.4		459	412	433	0.8
31	D	464	403	427	1.5							473	395	433	0.4
MEAN				431.1	0.78				433.2	0.83				433.8	0.81
DAYS				31	31				30	30				31	31

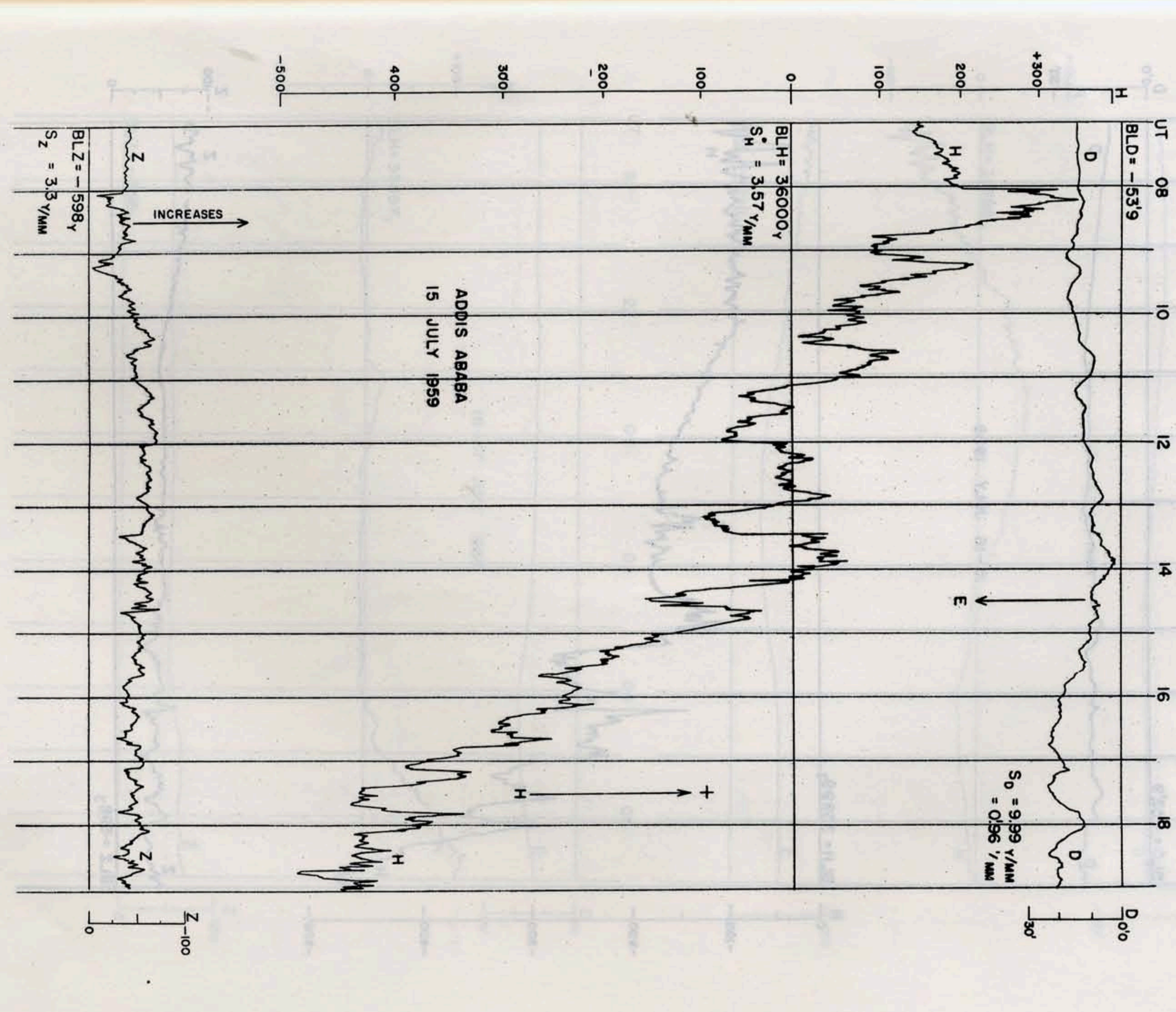
DAILY MEANS AND EXTREMES OF VERTICAL COMPONENT

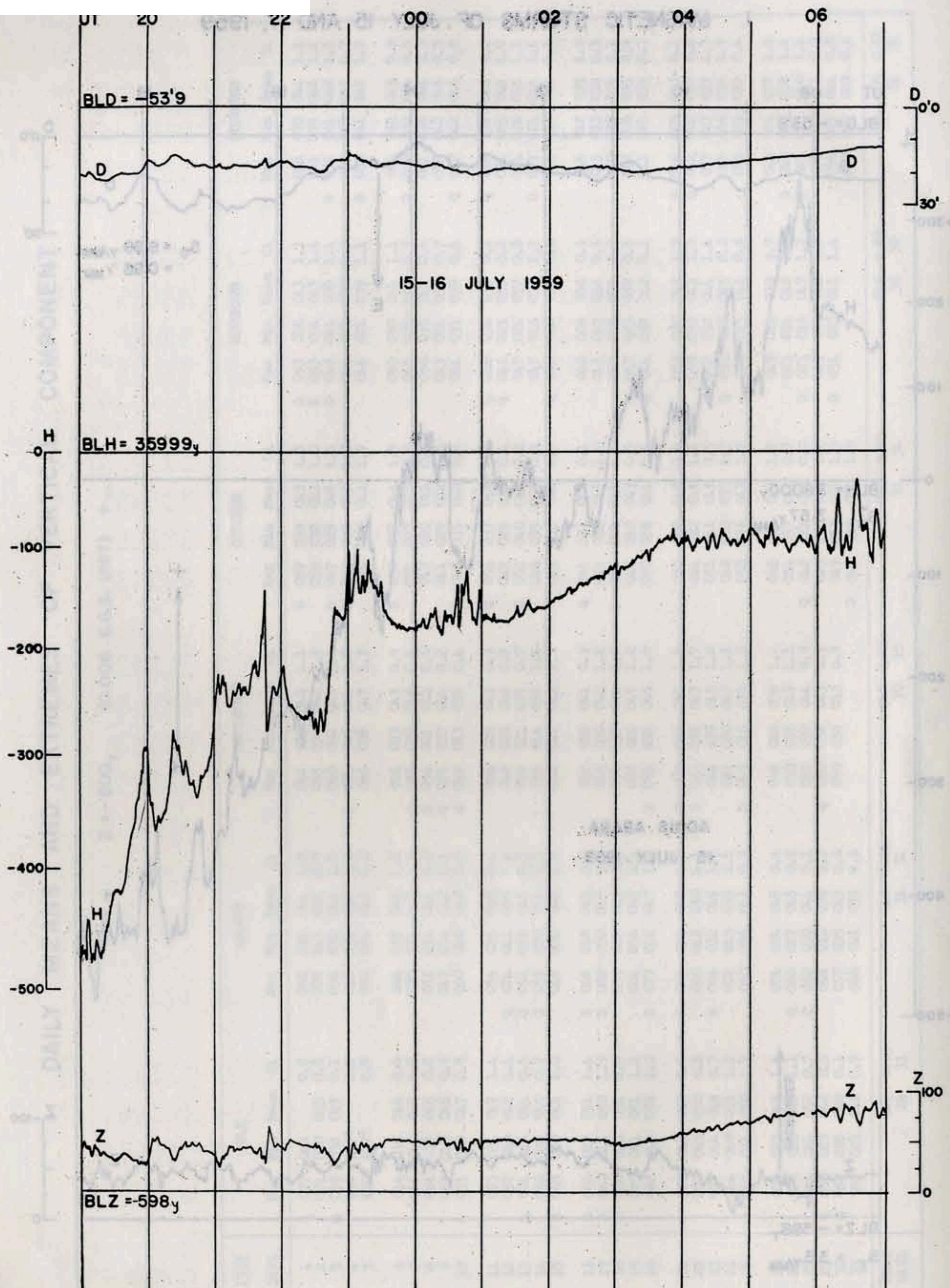
$Z = -600_{\gamma}$ (0.006 C.G.S. UNIT) + ...

1959 DATE		JULY Max	JULY Min	JULY Mean	JULY Ci		AUGUST Max	AUGUST Min	AUGUST Mean	AUGUST Ci		SEPTEMBER Max	SEPTEMBER Min	SEPTEMBER Mean	SEPTEMBER Ci
1	Q	077	048		0.2		052	031	044	1.0		048	030	041	1.1
2		071	040	053	0.8		076	043	052	0.9		065	036	047	1.2
3	Q	057	032	049	0.1		056	030	044	1.0		060	024	043	1.4
4		057	037*		0.8		069	031	048	1.0	D	071	025	044	1.8
5		070*	037*		0.9		050	026	043	0.6		066	038	047	1.3
6		054	032	046	0.6		066	037	046	1.1		055	033	043	0.9
7		066	041	048	0.8		070	034	047	1.0	Q	058	036	045	0.4
8		061	038	048	0.8		051	034	044	0.8	Q	056	021	041	0.6
9		063	018	046	0.9		047	030	042	1.1	Q	055	037	044	0.2
10		071	030	047	0.8		060	040	046	0.8	Q	049	013	036	0.4
11		073	031	049	1.4		054	036	045	0.4		056	029	043	0.9
12		057	010	042	1.1	Q	074	041	050	0.2		042	026	042	0.8
13	Q	074	046	054	0.6	Q	054	035	045	0.3		059	021	035	0.7
14		068	038	050	0.9	Q	058	030	044	0.3		055	014	036	1.1
15	D	068	030	046	2.0		048	030	042	1.2		052	027	041	1.1
16	D	086	027	051	1.4	D	068	018	045	2.0		052	029	041	0.9
17	D	069	013	050	1.9	D	082	037	049	1.8		045	030	040	1.2
18	D	098	030	054	2.0		059	022	043	1.2		056	037	042	1.2
19		067	041	051	1.2		064	036	047	1.1		070	029	045	1.2
20		068	048	052	1.0	D	077	032	047	1.4	D	065	032	046	1.6
21		070	041	050	0.9	D	061	031	048	1.3	D	085	036	050	1.9
22		070	045	050	0.8		068	042	050	1.1	D	083	036	049	1.7
23		077	044	052	0.7	D	055	032	045	1.2		054	039	045	1.2
24		064	040	051	1.2		072	045	053	1.1		063	020	047	1.2
25	D	068	034	050	1.2		050	036	046	0.9	D	049	016	039	1.2
26		074	033	048	1.1		074	034	048	0.4		048	022	039	1.2
27		071	033	048	1.1	Q	060	027	045	0.2		050	035	043	1.1
28		064	044	052	0.7	Q	052	030	044	0.1		050	037	044	0.9
29	Q	050	027	042	0.5		048	010	038	0.7	Q	050	038	043	0.5
30	Q	059	038	050	0.1		057	033	045	0.6		050	038	043	0.9
31		057	025	044	0.9		048	021	039	0.6					
MEAN				049	0.95				046	0.88				043	1.06
DAYS				28	31				31	31				30	30

1959 DATE		OCTOBER Max	OCTOBER Min	OCTOBER Mean	OCTOBER Ci		NOVEMBER Max	NOVEMBER Min	NOVEMBER Mean	NOVEMBER Ci		DECEMBER Max	DECEMBER Min	DECEMBER Mean	DECEMBER Ci
1	D	057	039	045	1.3	D	053	028	043	1.3		056	030	044	1.1
2		055	032	042	1.0	D	053	034	043	1.6		055	039	046	1.2
3	D	047	025	048	1.5	D	049	021	039	1.4	D	052	024	042	1.5
4	D	052	032	043	1.3		046	021	039	1.3		062	023	042	0.7
5		046	035	041	1.3		046	021	039	1.1	D	050	011	042	1.7
6	D	070	037	041	1.5		050	030	041	1.1		066	032	045	0.9
7		051	027	037	0.9		045	037	041	0.7	Q	049	039	044	0.3
8		047	030	041	0.3		050	035	043	0.6		051	036	044	0.3
9		044	029	038	0.3		043	024	037	0.7		058	042	046	0.3
10	Q	046	035	040	0.2		044	031	039	0.6	Q	057	042	046	0.2
11	Q	056	037	043	0.2	Q	046	032	039	0.1	Q	064	036	046	0.2
12		045	029	038	0.4	Q	046	025	037	0.2		061	025	044	1.0
13	Q	052	040	045	0.2		047	024	037	0.8		054	036	045	1.1
14		049	035	043	0.8		047	016	035	1.2	D	053	024	041	1.4
15		049	033	042	1.0	Q	043	018	034	0.1		056	032	041	1.1
16	Q	051	029	042	0.1		040	009	032	0.5		046	012	035	1.0
17		051	034	043	1.0		043	013	032	0.5		045	013	034	0.3
18		056	021	041	1.2		043	018	035	0.9		042	025	035	0.5
19		048	040	043	0.9		047	023	037	0.5		042	016	033	0.8
20		050	036	044	0.4	Q	044	038	042	0.1		041	021	035	0.3
21		050	040	045	0.4		053	030	042	1.0	Q	046	005	033	0.1
22		044	022	040	1.2		050	033	043	1.0	Q	042	006	030	0.4
23		051	041	043	0.5		052	032	044	1.4		037	013	033	1.3
24		042	020	037	0.3	Q	051	037	045	0.2		045	016	036	0.9
25		052	036	043	1.2		050	025	041	0.6		045	021	035	0.4
26		062	041	046	1.2		049	021	039	0.7		045	024	037	1.2
27		054	037	043	0.7		053	034	042	0.8	D	048	019	038	1.4
28	Q	042	021	036	0.0	D	071	015	047	1.7	D	047	023	040	1.4
29		045	030	040	0.2		049	033	042	0.8		051	027	041	0.9
30		049	019	039	1.3	D	051	023	041	1.4		056	029	044	0.8
31	D	049	022	040	1.5							048	017	040	0.4
MEAN				042	0.78				040	0.83				040	0.81
DAYS				31	31				30	30				31	31

I. MAGNETIC STORMS OF JULY 15 AND 17, 1959

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20
22
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02
04
06
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30'
15–16 JULY 1959
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Z
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0
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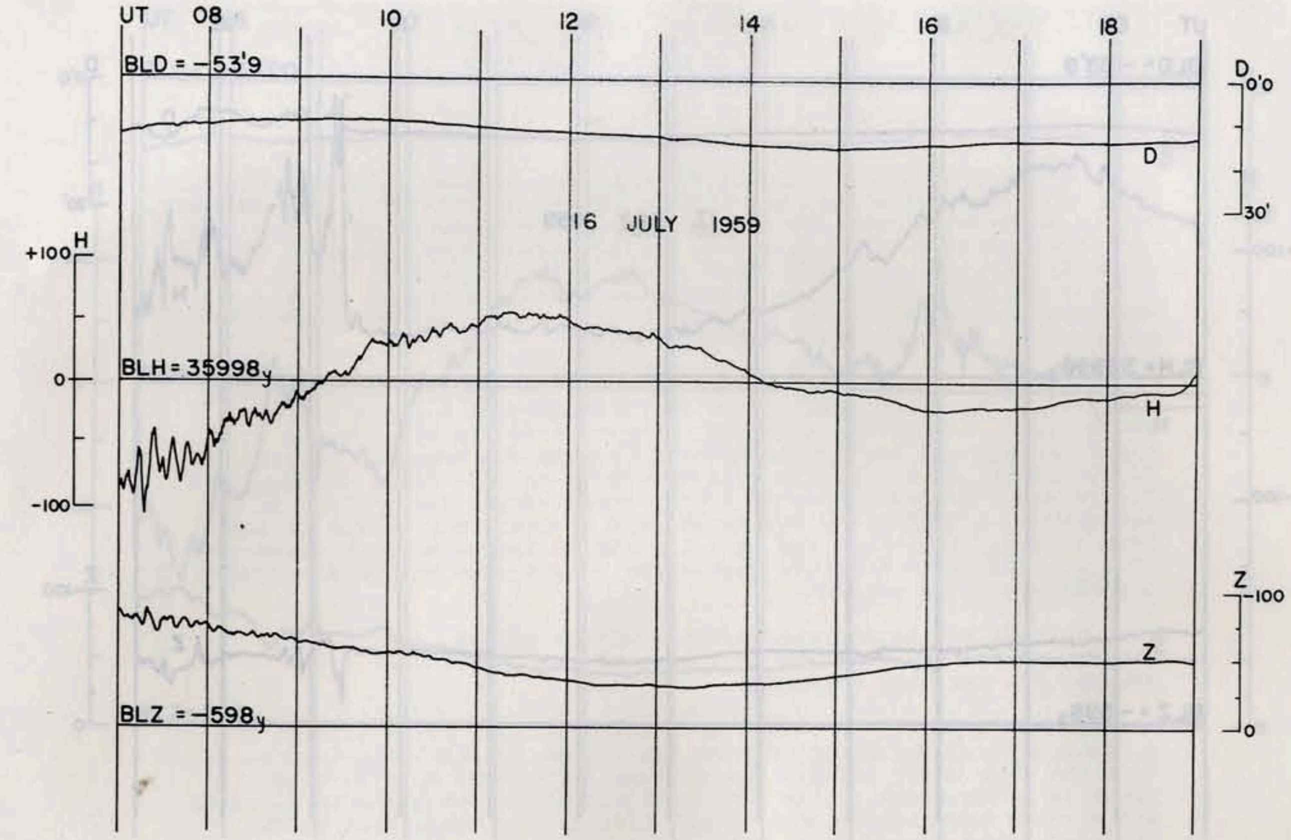
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30'
16 JULY 1959
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0
−100
BLH = 35998γ
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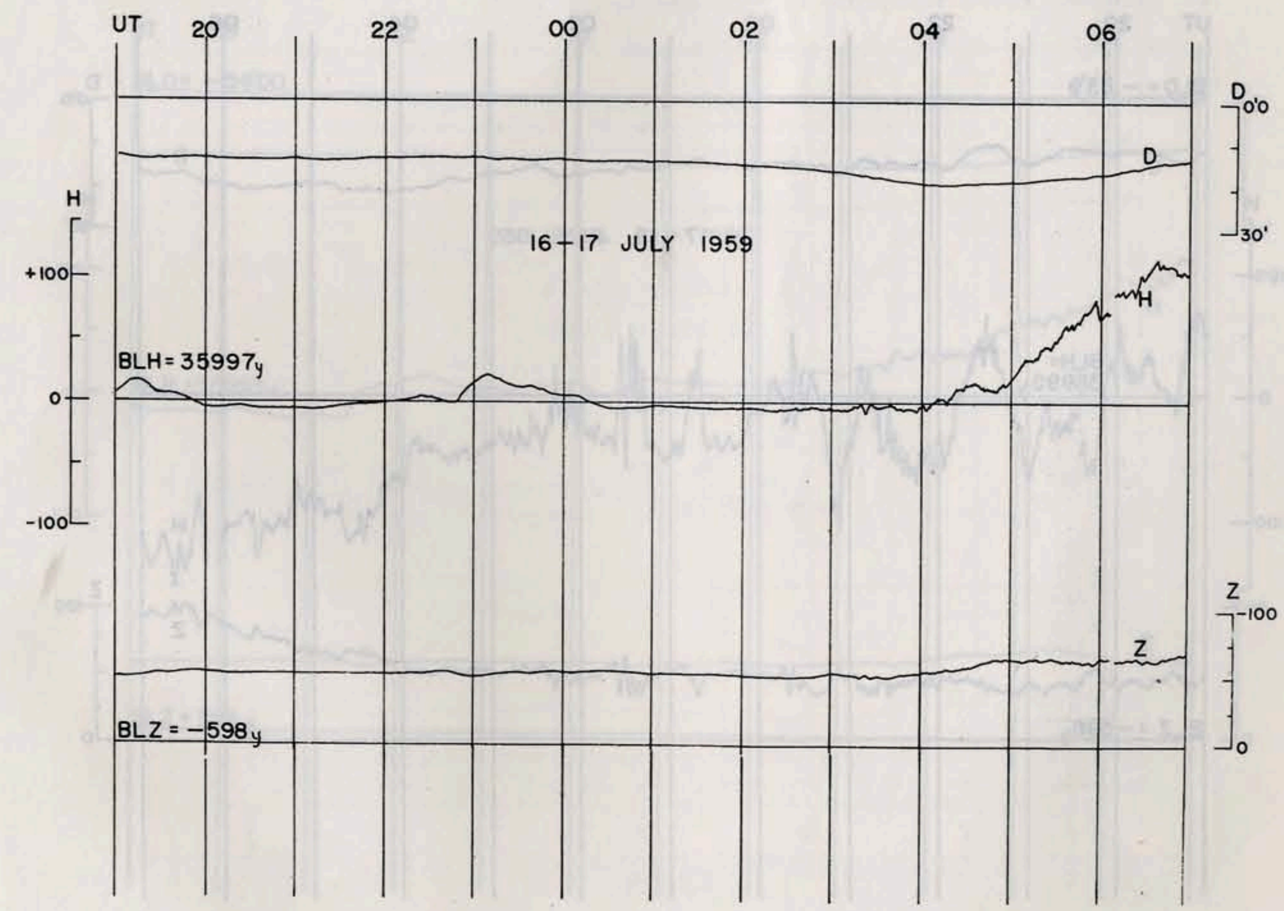
100
0
BLZ = −598γ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00
02
04
06
D
0'0
30'
16–17 JULY 1959
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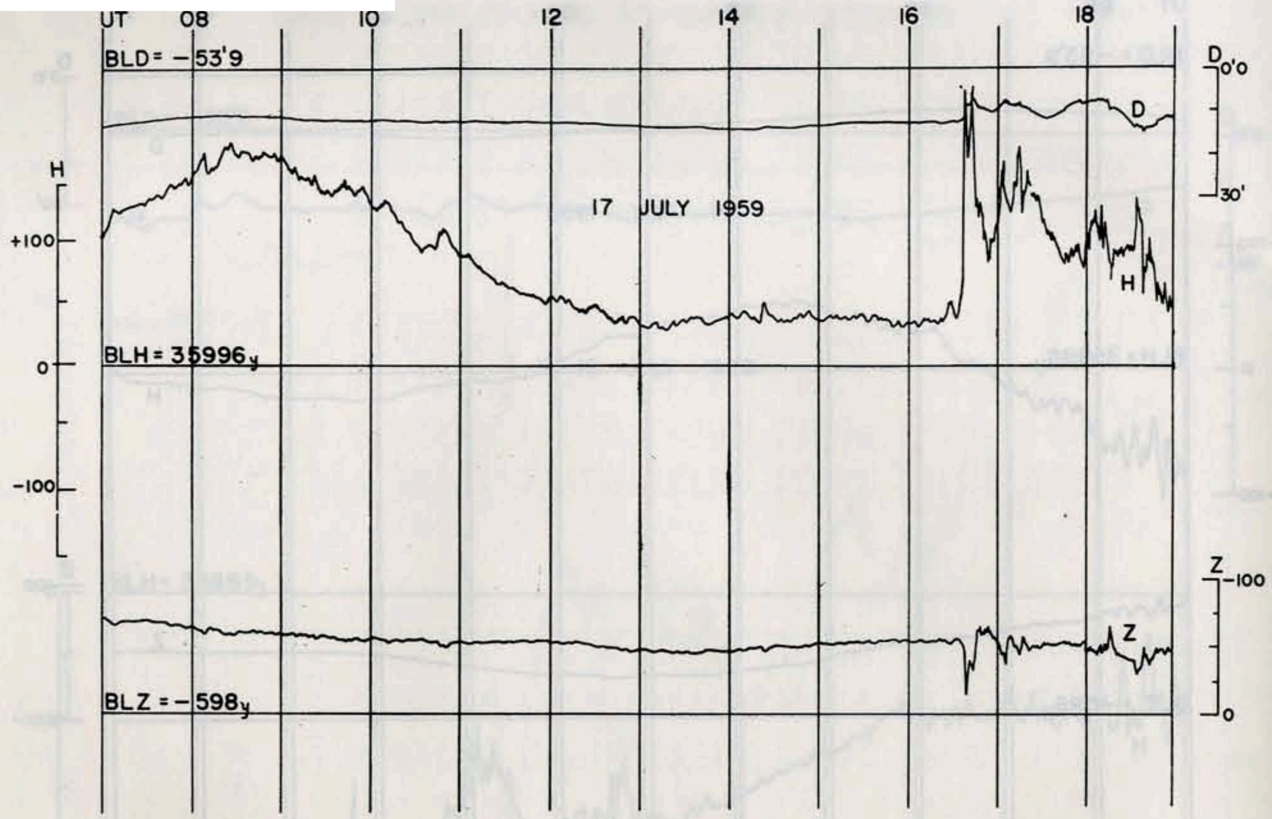
+100
0
−100
BLH = 35997γ
Z
100
0
BLZ = −598γ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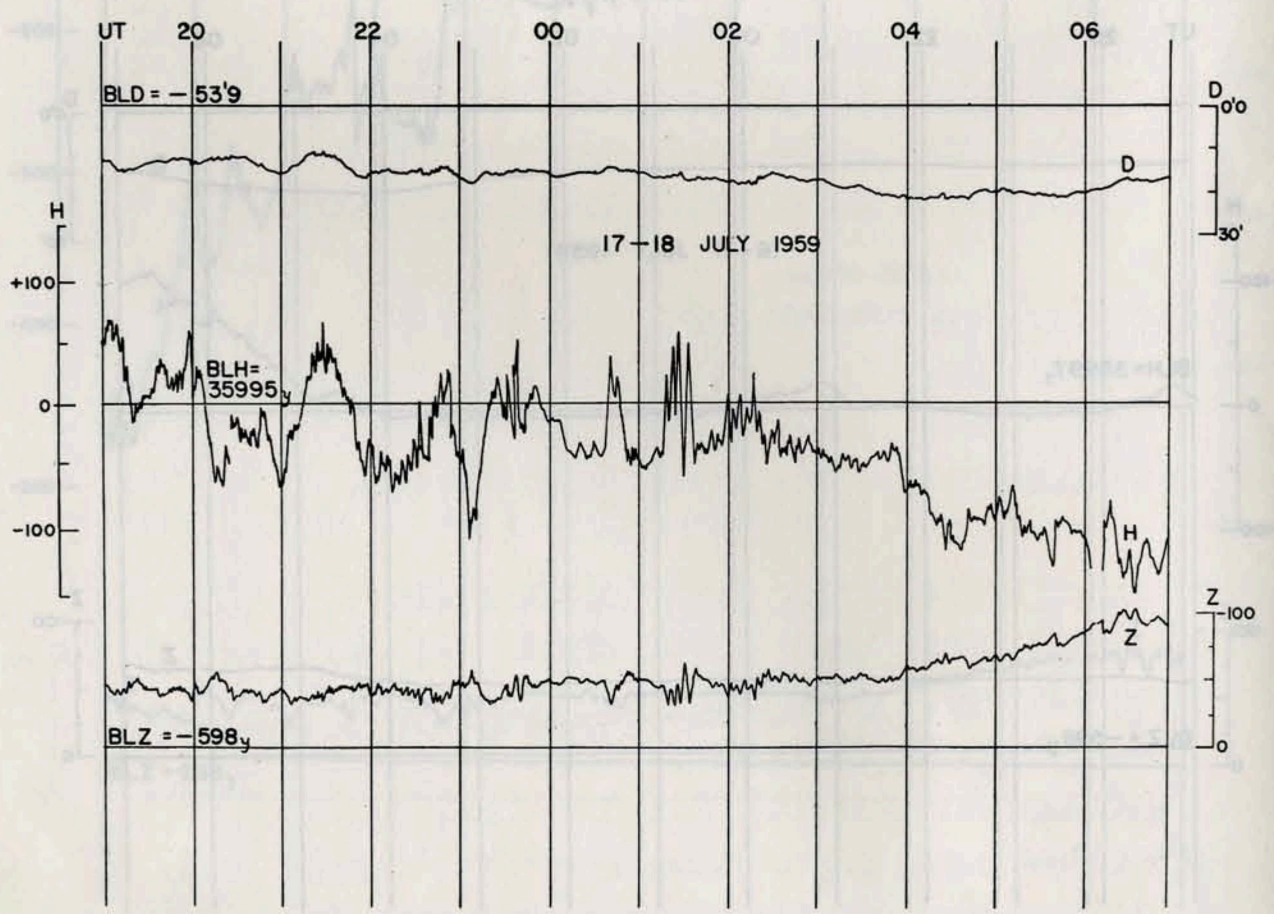
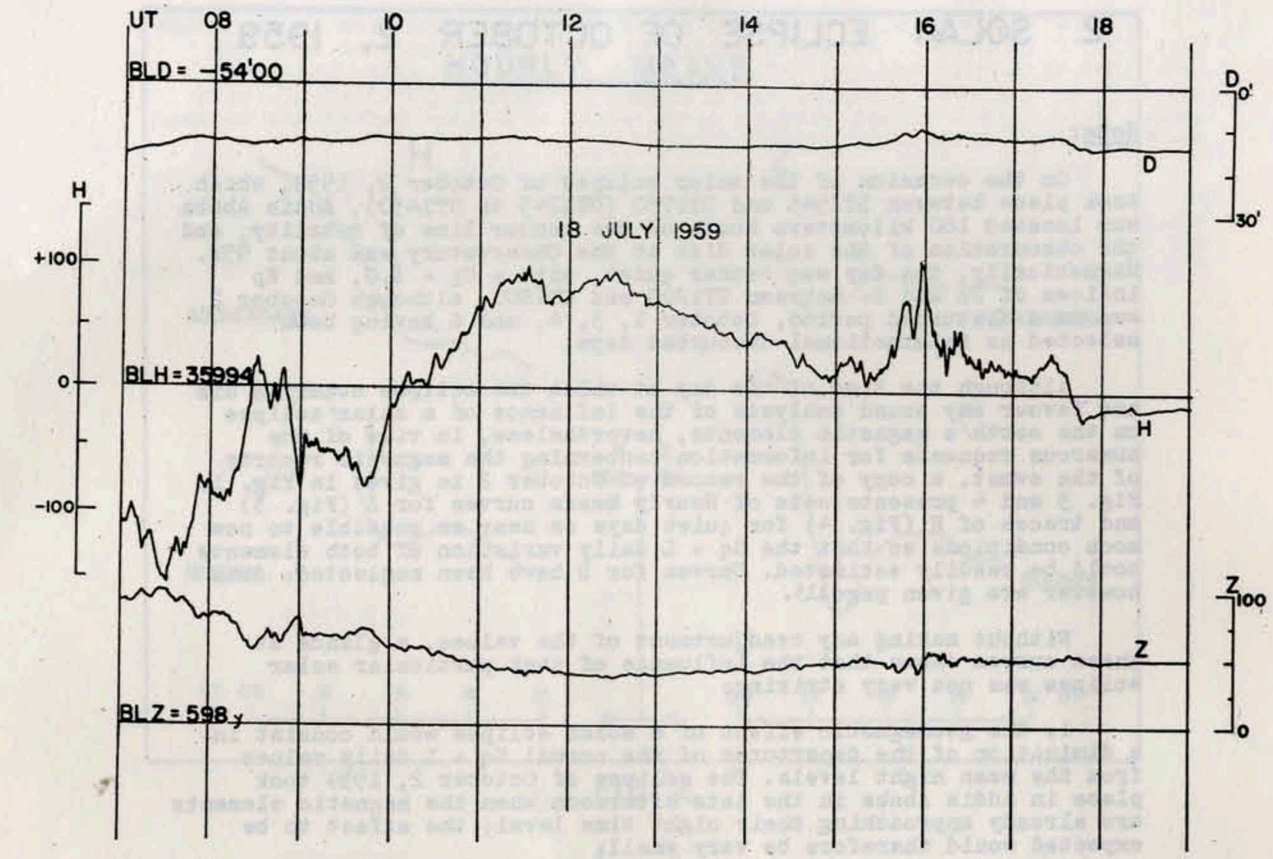
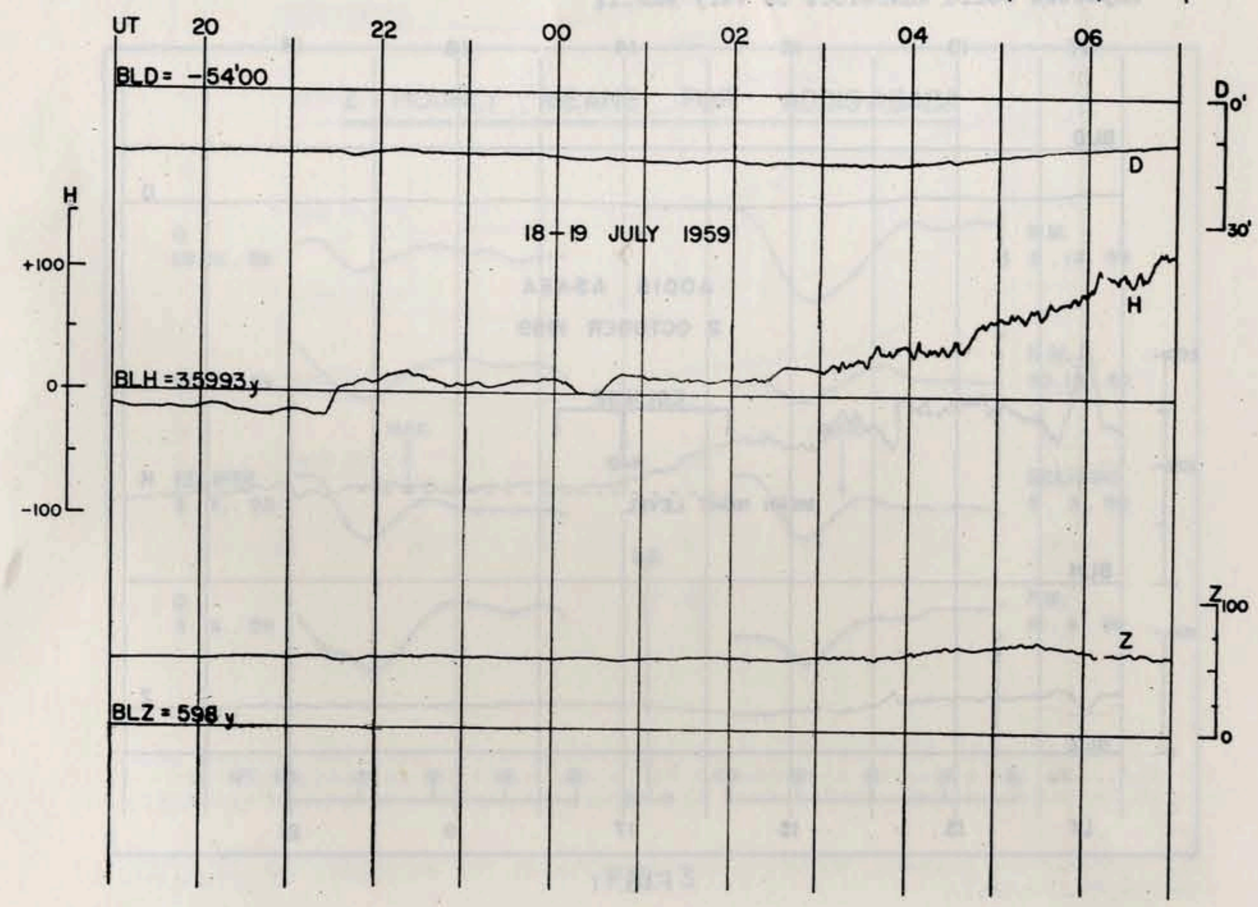
D 0'0
30'
D
H
+100
0
−100
17 JULY 1959
H
BLH = 35996 γ
Z −100
Z
0
BLZ = −598 γ


UT 20 22 00 02 04 06
BLD = −53'9
D 0'0
30'
D
H
+100
0
−100
17 – 18 JULY 1959
BLH = 35995 γ
H
Z −100
Z
0
BLZ = −598 γ


UT 08 10 12 14 16 18
BLD = −54'00
D 0'
30'
D
H
+100
0
−100
18 JULY 1959
BLH = 35994
H
Z 100
Z
0
BLZ = 598 γ


UT 20 22 00 02 04 06
BLD = −54'00
D 0'
30'
D
H
+100
0
−100
18 – 19 JULY 1959
H
BLH = 35993 γ
Z 100
Z
0
BLZ = 598 γ

2. SOLAR ECLIPSE OF OCTOBER 2, 1959

Note:

On the occasion of the solar eclipse of October 2, 1959, which took place between LT1545 and LT1750 (UT1245 to UT1450), Addis Ababa was located 160 kilometers North of the center line of totality, and the obscuration of the solar disk at the Observatory was about 95%. Magnetically, the day was rather quiet, with a $C_i = 1.0$, and Kp indices of 2o and 2+ between UT1200 and UT1800, although October 2 was in a disturbed period, October 1, 3, 4, and 6 having been selected as international disturbed days.

Although the time of the day at which the eclipse occurred did not favour any sound analysis of the influence of a solar eclipse on the earth's magnetic elements, nevertheless, in view of the numerous requests for information concerning the magnetic records of the event, a copy of the record of October 2 is given in Fig. 1. Fig. 3 and 4 presents sets of Hourly Means curves for Z (Fig. 3) and traces of H (Fig. 4) for quiet days as near as possible to new moon conditions so that the Sq + L daily variation of both elements could be readily estimated. Curves for D have been neglected; data however are given page115.

Without making any readjustment of the values, a glance at these curves shows that the influence of that particular solar eclipse was not very striking:

1. the geomagnetic effect of a solar eclipse would consist in a diminution of the departures of the normal Sq + L daily values from the mean night levels. The eclipse of October 2, 1959 took place in Addis Ababa in the late afternoon when the magnetic elements are already approaching their night time level; the effect to be expected would therefore be very small;

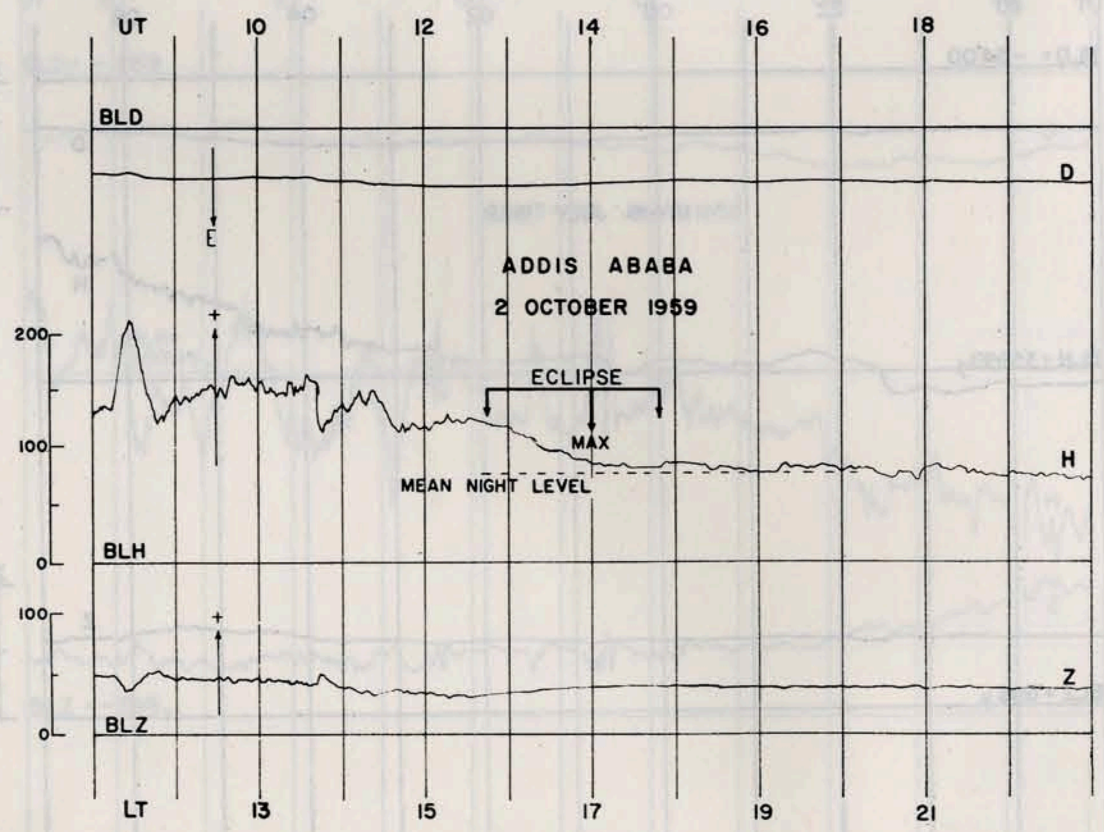


FIG. 1

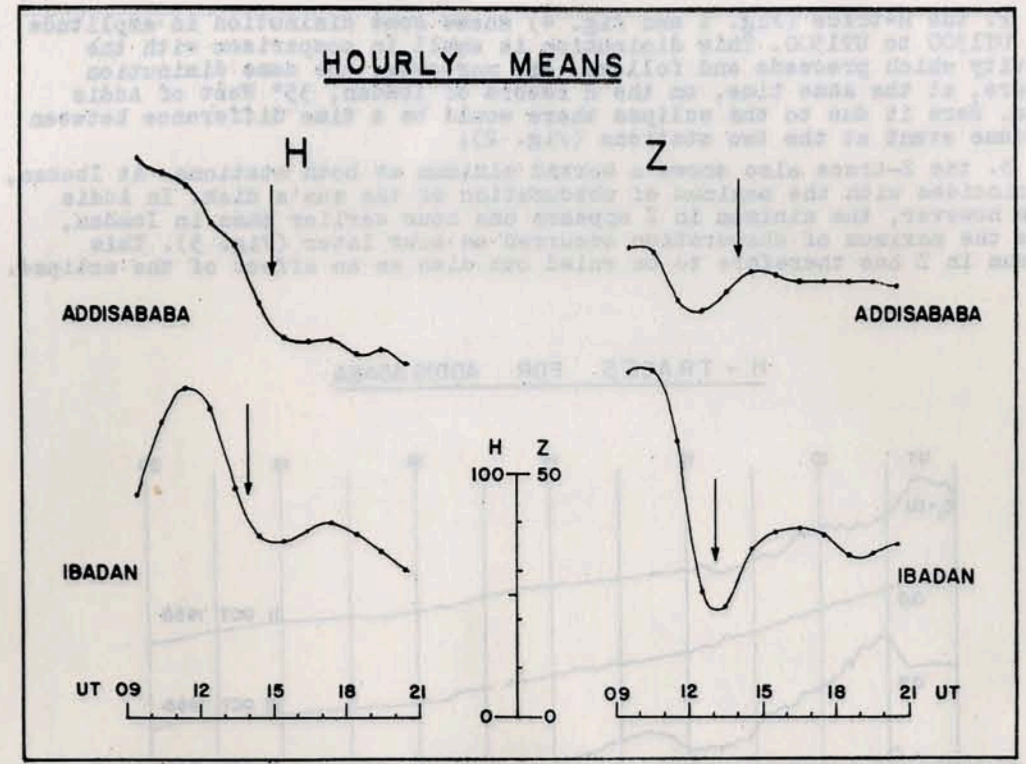


FIG. 2

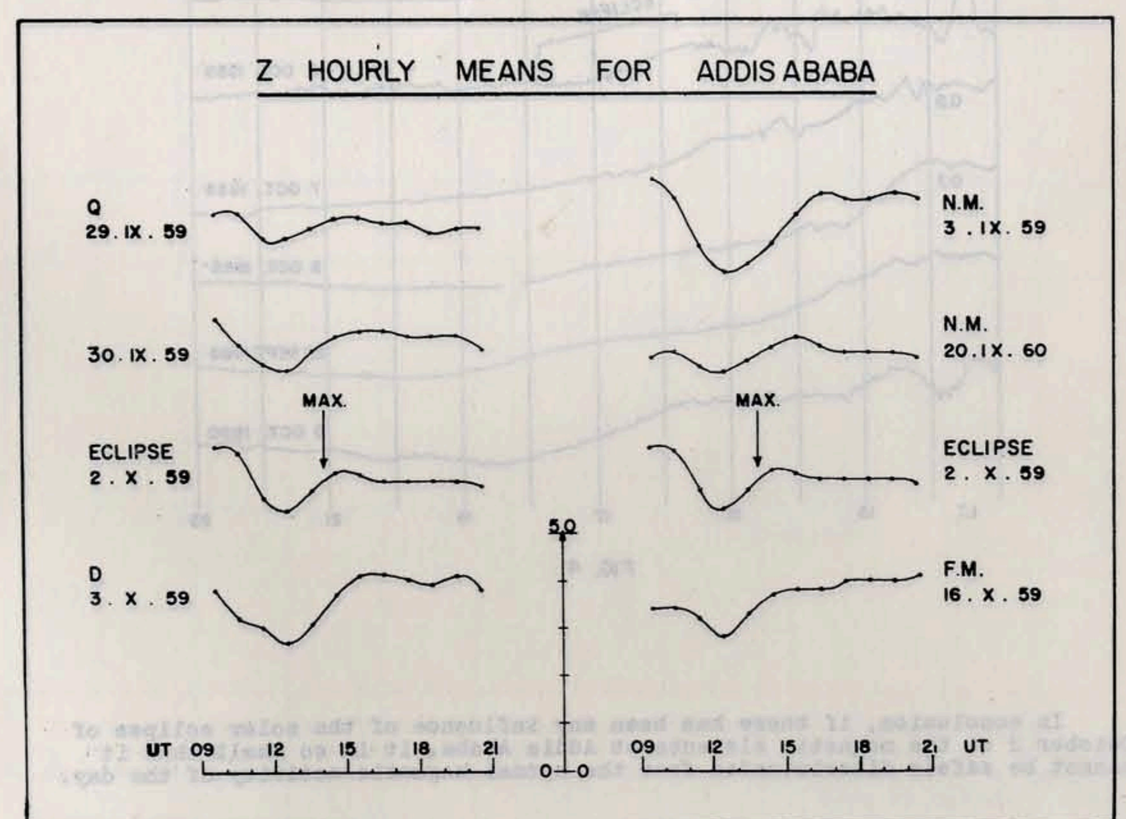


FIG. 3

2. the H-trace (Fig. 1 and Fig. 4) shows some diminution in amplitude from UT1300 to UT1500. This diminution is small in comparison with the activity which preceeds and follows, and moreover, the same diminution appears, at the same time, on the H record of Ibadan, 35° West of Addis Ababa. Were it due to the eclipse there would be a time difference between the same event at the two stations (Fig. 2);

3. the Z-trace also shows a marked minimum at both stations. At Ibadan, it coincides with the maximum of obscuration of the sun's disk. In Addis Ababa however, the minimum in Z appears one hour earlier than in Ibadan, while the maximum of obscuration occurred an hour later (Fig. 3). This minimum in Z has therefore to be ruled out also as an effect of the eclipse.

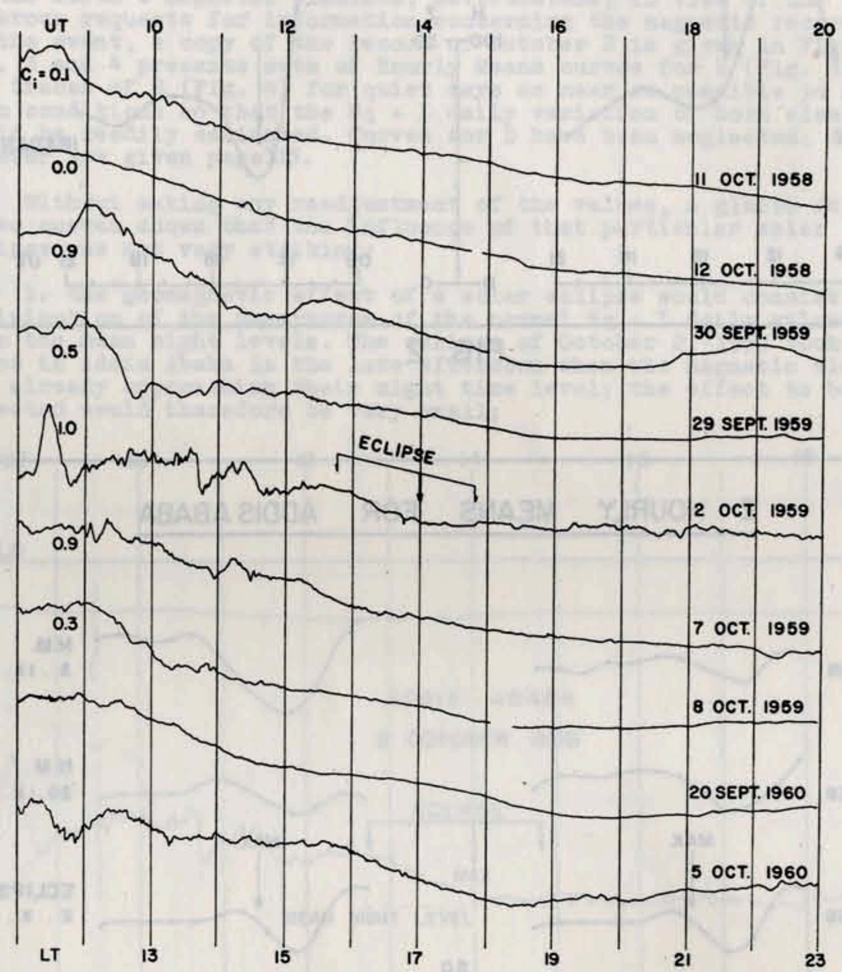


FIG. 4

In conclusion, if there has been any influence of the solar eclipse of October 2 on the magnetic elements at Addis Ababa, it is so small that it cannot be safely discriminated from the normal magnetic activity of the day.

(The Director is grateful to Dr. C.A. Onwumichelli for supplying the magnetic records of Ibadan).

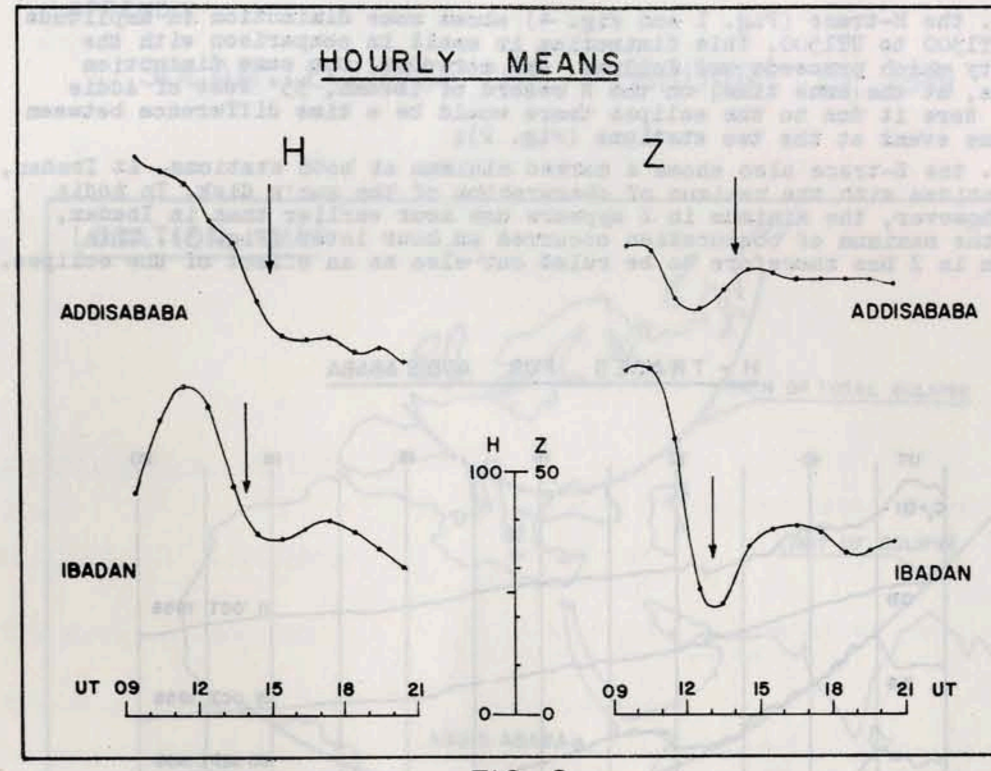
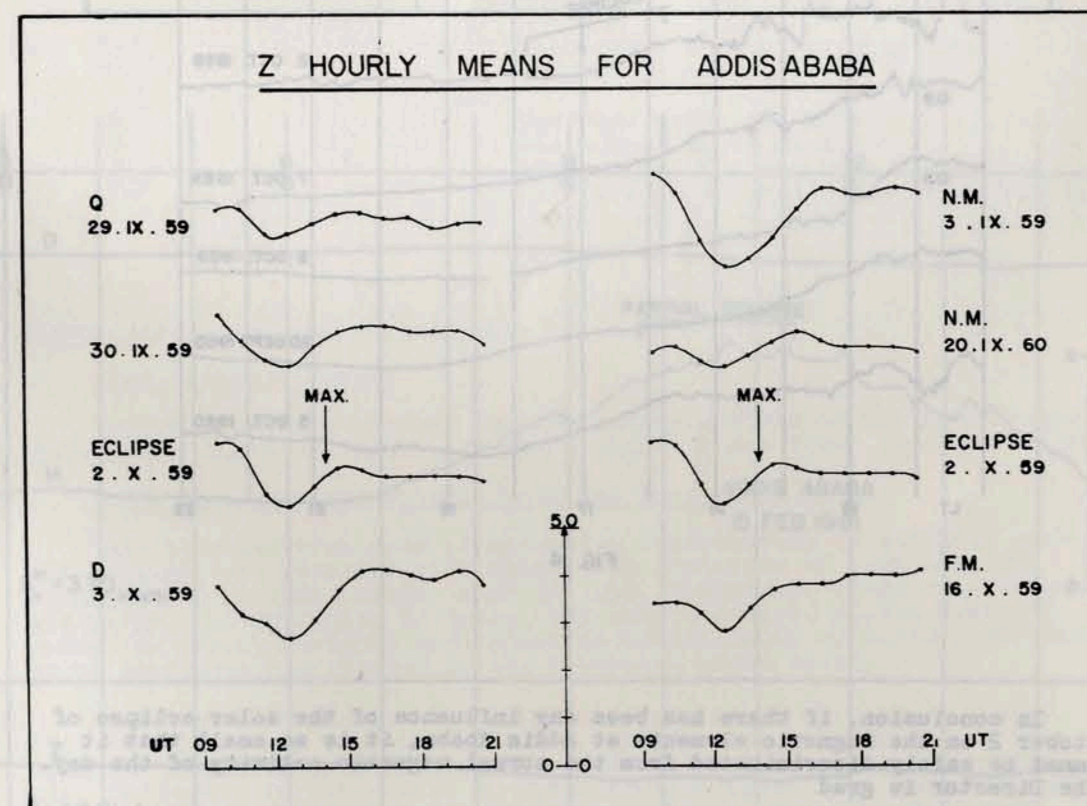


FIG. 2



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H - TRACES FOR ADDIS ABABA

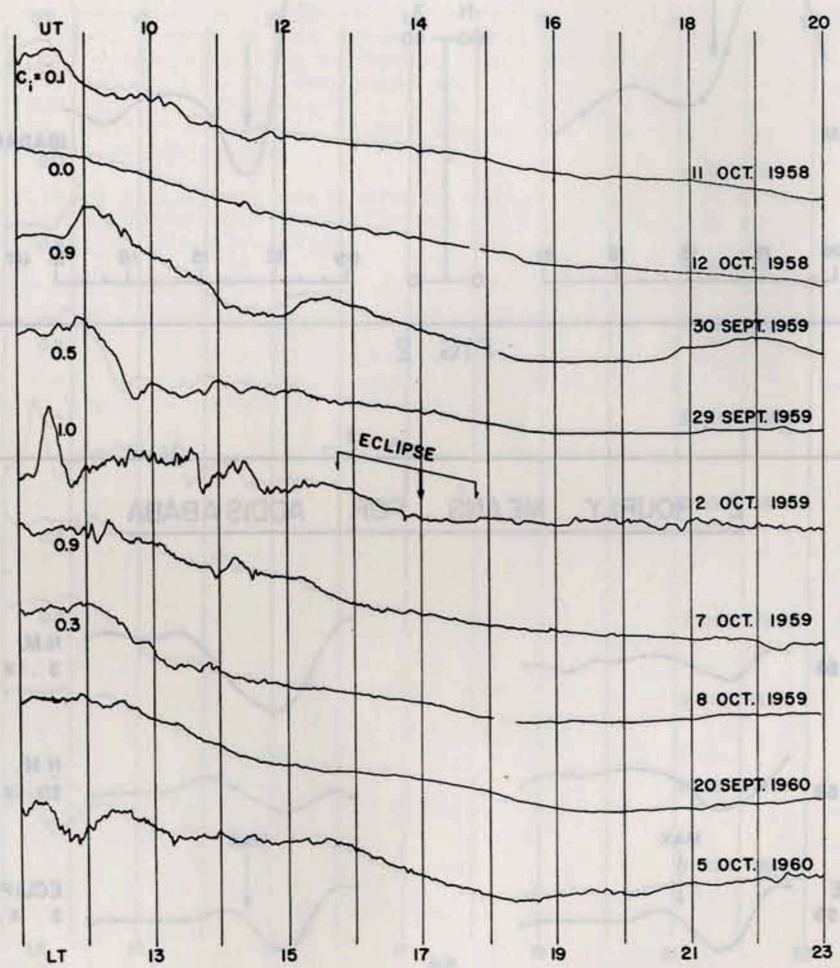

FIG. 4

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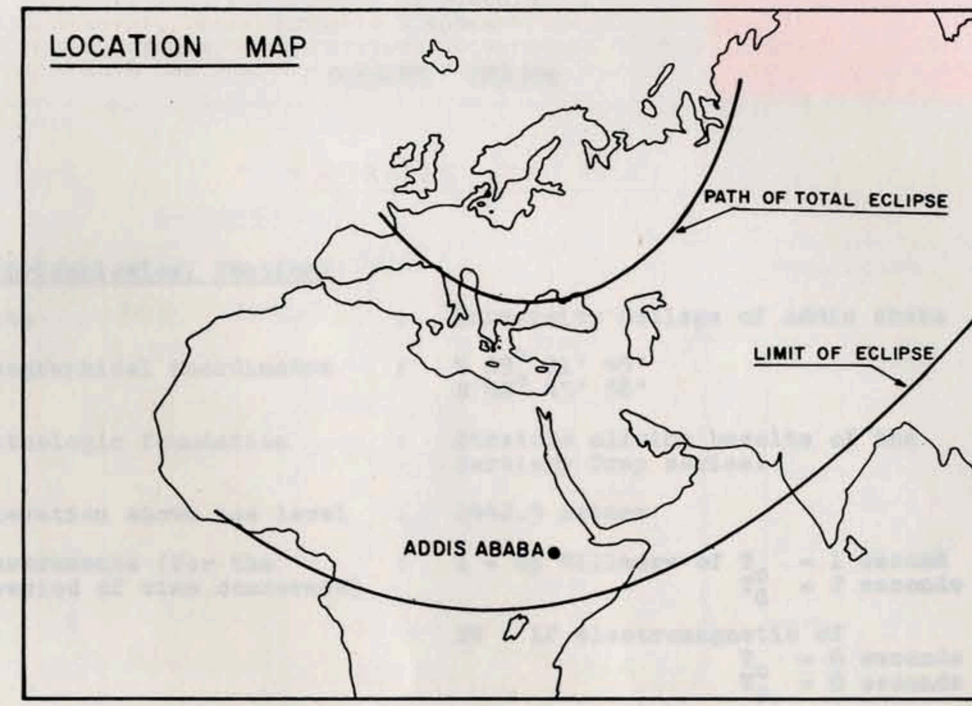
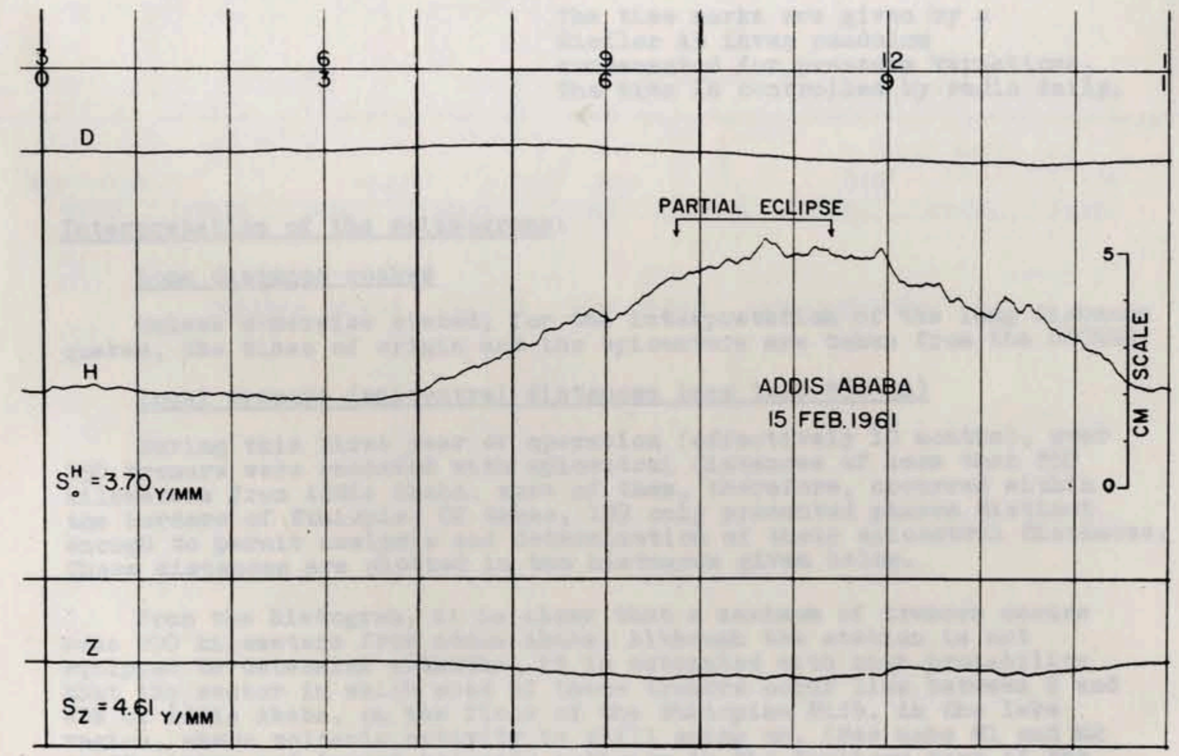
(The Director is grateful to Dr. C.A. Onwumichelli for supplying the magnetic records of Ibadan).

APPENDIX

SOLAR ECLIPSE OF FEBRUARY 15, 1961





Seismological Report July-December 1959

SEISMOLOGICAL REPORT

JULY-DECEMBER 1959

PIERRE GOUIN

The Seismological Station:

Site	:	University College of Addis Ababa
Geographical coordinates	:	N 09° 01' 45" E 38° 45' 56"
Lithologic foundation	:	Stratoid olivine basalts of the Tertiary Trap series.
Elevation above sea level	:	2442.5 meters
Instruments (for the period of time concerned)	:	Z = Sp Willmore of T_o = 1 second, T_G = 2 seconds EW = LP electromagnetic of T_o = 6 seconds, T_G = 8 seconds Photographic recorder with time-base of 30 mm/minute The time marks are given by a Riefler A3 invar pendulum compensated for pressure variations. The time is controlled by radio daily.

Interpretation of the seismograms:

Long distance quakes

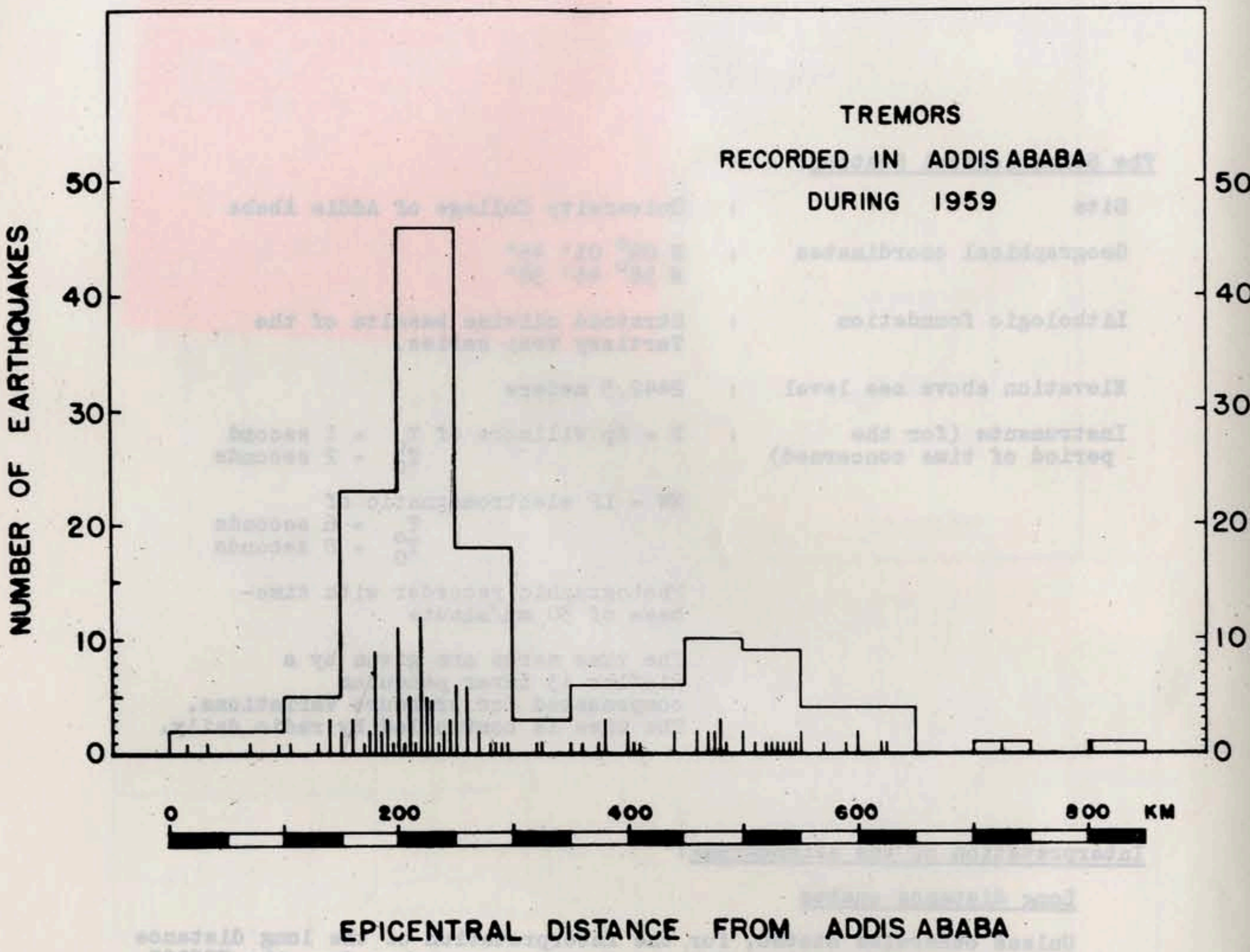
Unless otherwise stated, for the interpretation of the long distance quakes, the times of origin and the epicenters are taken from the USC&GS.

Local tremors (epicentral distances less than 850 km)

During this first year of operation (effectively 10 months), over 250 tremors were recorded with epicentral distances of less than 850 kilometers from Addis Ababa; most of them, therefore, occurred within the borders of Ethiopia. Of these, 139 only presented phases distinct enough to permit analysis and determination of their epicentral distances. These distances are plotted in the histogram given below.

From the histogram, it is clear that a maximum of tremors occurs some 200 kilometers from Addis Ababa. Although the station is not equipped to determine azimuths, it is estimated with high probability that the sector in which most of these tremors occur lies between S and WSW of Addis Ababa, on the floor of the Ethiopian Rift, in the lake region, where volcanic activity is still going on. (See maps M1 and M2 on "Faulting and recent volcanic activity in the Southern part of the main Ethiopian Rift", by Mohr. Bull. of the Geoph. Obs., Vol. 2, no.1, Addis Ababa, June 1960).

Tremors forming the secondary maximum around 500 kilometers, are most probably from the region of Harrar, due east of the station, and the region of Adoua, due North of Addis Ababa.



NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		Lat.	Long.	EPICENTER Region
257	1/7		iP	11-00-06			
258	1/7		iP	11-29-43			
259	1/7		iP,	19-02-39			D = abt. 220 km.
			S,	03-05			
260	1/7		iP,	21-17-46.5			D = abt. 180 km.
			iS,	18-07			
261	2/7	11-34-20	iP'	11-52-47	20S	178½W	h = abt. 650 km. Fiji Islands.
262	2/7		i	17-04-34			
263	2/7		iP	17-29-32.5			
				53.0			
264	2/7			23-27-31			
			i	-54			
265	3/7		iP	12-48-31			
266	3/7	17-55-29	iP'	18-14-36.5	16S	172½E	h = 200 km. Mag. 6¼ New Hebrides region.
			i	15-19			
267	5/7		i	09-55-11			
268	5/7		i	13-23-03			
269	6/7	09-10-17	iP	09-23-28	26½S	61½W	h = 600 km. M = 6½ Chaco Prov. Argentina.
			iPP	27-50			
			iS	33-14			
			(SP)	36-08			
270	6/7	09-23-27	i(P)	09-36-08			Second shock, Chaco Prov. Argentina.
			iS	46-22			
				49-18			
				50-16			
271	6/7		iP,	22-20-02			D = abt. 220 km.
			S,	-28			
272	7/7		i	14-34-20			
273	7/7		i	23-19-12.5			
			i	16			
274	9/7		iP,	12-42-18			
			S,	(43)			
275	9/7	16-05-18	i	16-20-16	20½S	68W	h = 100 km. M = 6¼ Chile-Bolivia border
			PPP	26-40			
			(S)	33-38			
276	9/7		i	05-22-44			
			i	23-48			
			i	-56			
277	11/7	12-01-36	P	12-11-46	36S	78E	M = 6¼ - 6½ Indian Ocean.
			S	20-03			
278	12/7	00-24-22	iP'	00-43-15	19½S	177½W	h = 400 km. M = 6¼ Fiji Islands.
279	12/7		iP,	19-06-10			D = abt. 175 km.
			iS,	-31			
280	14/7		iP	10-48-24			
281	14/7		iP	11-02-52			
282	14/7	22-31-22	eP	22-43-45	½°N	120°E	Near N. Coast of Celebes.
283	15/7		iP	07-25-41			
284	16/7		iP	01-15-05			
			(S)	16-21			
285	16/7		i	19-32-40.5			
286	17/7		iP,	08-55-49			D = abt. 405 km.
			iS,	56-37			
287	17/7		iP,	15-49-33			
			i(S),	56			
288	18/7		iP,	01-59-09			D = abt. 200 km.
			S,	33			
289	18/7	03-51-58 (BCIS)	iP	03-57-11	29½N	51E	Iran
290	18/7		iP	12-29-39			
			i(S)	30-06			
291	18/7		i	19-30-12			
292	18/7		iP	20-06-57.5	15½N	120½E	Lucon, P.I.
			PP	10-045			
			S	17-16			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		Lat.	Long.	EPICENTER Region
293	19/7		i	03-53-12			
294	19/7	15-06-10	iP'	15-24-29	15S	70½W	h = 200 km.
			i	25-08			Peru
			ipPP	25-56			
			(SKSS)	31-00			
			i	34-26			
			i	35-26			
295	20/7	02-41-04	iP	02-51-55	6S	111E	h = 500 km.
			S	03-00-51			Sea of Java
296	21/7	07-43-13	iP'	08-02-29	14½S	167½E	New Hebrides
297	22/7		iP,	03-28-06			D = 200 km.
			Sn	24			
			S,	31			
298	22/7	11-15-33	iP	11-28-24	2N	126½E	Molluca Passage
299	22/7	19-24-17	iP	19-36-45	53N	153E	h = 650 km.
							Sea of Okhotsk
300	22/7	23-02-07	iP'	23-21-15	5S	152½E	h = 60 km.
							New Britain
301	23/7		iP,	01-20-37			D = abt. 400 km.
				21-15			
			S,	21-28			
302	23/7	14-56-45	iP'	15-16-27	24½S	176W	h = 60 km.
							Tonga Islands
303	23/7		iP,	19-37-11			D = abt. 200 km.
			iS,	-35			
304	24/7	07-19-45	iP	07-24-585	31N	50½E	Iran
		(BCIS)					
305	24/7	16-17-43	iP	16-27-11	24½N	94½E	h = 160 km.
		(BCIS)					India-Burma Border
306	24/7	23-03-08	iP	23-15-47	56½S	28½W	Sandwich Islands
307	26/7	17-07-03	iP	17-13-44	40.8N	27½E	NW Turkey
		(BCIS)					
308	28/7	01-14-12	iP	01-28-14			Coast of Peru
		(BCIS)					
309	29/7		iP	00-39-34			D = abt. 1200 km.
			S	41-10			
310	29/7	00-30-54	iP''	00-49-26	18½S	178W	h = 650 km.
							Fiji Islands
311	30/7		eP	04-45-34			D = abt. 620 km.
			iS	46-47			
			Mew	47-00			
			Mz	50-00			
312	31/7	10-28-04	P	10-34-24	38½N	49E	Caspian Sea
		(BCIS)					
313	31/7	19-53-02	iP	20-00-55	38½N	70E	Tadzhik U.S.S.R.
314	1/8		(P)	10-54-06			
			(S)	55-09			
315	4/8	08-02-17	iP'	08-20-48	20½S	178W	h = 600 km.
							Fiji Islands
316	4/8		i(P)	11-28-40			
			(S)	29-38			
317	5/8		P	05-29-24	12½N	125E	Samar P.I.
318	5/8		iP,	09-04-15			
			(S,)	-37			
319	8/8		iP,	07-50-14			D = abt. 140 km.
			iS,	-31			
320	9/8		P	02-48-05	2N	128E	Halmahera
321	9/8		iP	04-54-42			
322	9/8		iP	11-19-46			D = abt. 2200 km.
			S	23-20			
323	9/8		iP,	16-06-36			
			(S,)	07-31			
324	12/8		iP	04-11-01			
			i	18-46			
			i	21-21			
325	12/8	09-58-22	P'	10-17-58	16½S	177½W	Fiji Islands
326	13/8	00-32-55	iP	00-39-39			Caspian Sea
327	13/8		iP,	00-57-04			
			(S.)	-23			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		Lat.	Long.	EPICENTER Region
328	14/8	04-39-07	iP	04-51-575	120½E	125½E	Molucca Passage
329	14/8		iP,	17-18-02			D = abt. 410 km.
			S,	50			
330	15/8	08-57-04	iP	09-09-13	23N	121E	Formosa (8900 km)
				13-02			
			ScS	19-50			
			SS	24-47			
			h	48-12			
331	15/8	13-14-26	iP'	13-34-11	21S	174W	Tonga Islands
332	16/8		i	06-12-34			
			i	13-02			
333	16/8		iP	09-32-56			D = abt. 800 km.
			S	34-32			
			h	34-54			
334	16/8		iP	21-40-20			
335	18/8	00-33-43	iP	00-45-58	22N	121½E	Near S.Coast of
							Formosa
336	18/8	06-37-13	iP'	06-56-17	44½N	111W	Yellowstone Park,
				56-45			Wyoming, U.S.A.
			PP	57-43			
			SKS	07-03-40			
				05-01			
			SS	14-22			
				50-20			
337	18/8	07-56-18		08-15-16			Yellowstone after
							shock
338	18/8	22-04-01	iP	22-11-15			D = 4120 km.
							Albania
339	20/8	12-20-08	iP	12-30-25	29S	78E	Indian Ocean
			i	30-31			
			i	31-12			
340	23/8		iP	08-16-54			
			(S)	18-14			
341	23/8		iP	08-49-35			
			(S)	50-55			
342	23/8	22-21-30	iP	22-30-04	35½N	3W	Mediterranean Sea
			PP	31-43			
			PPP	32-01			
343	23/8		eP	22-47-29			D = abt. 2950 km.
				48-085			
			S	51-44			
				52-28			
344	24/8	01-26-12	iP	01-29-25	4¼S	34E	Tanganyika
		(BCIS)	i	-34			
			(S)	31-44			
				33-06			
345	24/8		i	08-23-41			
			i	24-20			
346	24/8	21-30-46	iP	21-50-29	10½S	161E	Solomon Islands
			PP	51-42			
347	25/8		eP	14-43-47			
				-59			
			(S)	44-59			
348	25/8		i	14-53-43			
			i	54-43			
349	26/8		i(P)	08-08-31			Explosion?
							D less than 20 km.
350	26/8	08-25-30	iP'	08-44-41	18N	94½W	Mexico
351	26/8	10-27-41	iP'	10-47-57	51N	132W	S. Queen Charlotte
							Islands.
352	26/8		i	11-04-13			
353	27/8		iP	20-32-44			
			i	33-19			
				-30			
				34-00			
354	28/8		i	00-03-10			
			i	03-29			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		Lat.	Long.	EPICENTER Region
355	28/8		i(P)	04-56-09			
			(S)	57-26			
356	29/8	17-03-10	iP	17-14-26	52N	106½E	Lake Baikal, U.S.S.R.
			i	34			
				15-18			
			PP	17-03			
			S	23-59			
357	30/8	03-24-54	eP	03-33-(29)	35½N	3W	N. of Spanish Morocco
				34-20			
				51-30			
358	30/8	21-45-07	iP	21-55-12	36½S	78½E	Indian Ocean
				-24			
				56-02			
			S	22-03-28			
359	30/8		i	23-04-28			
360	31/8		iP,	09-50-16			D = abt. 160 km.
			S,	-35			
361	31/8		iP,	22-42-05			D = 180 km.
			Sn	42-21			
			S,	42-27			
362	1/9		iP,	04-58-18			D = 160 km.
			S.	-37			
363	1/9	11-37-42	iP	11-44-47	41½N	20E	Adrauic Sea
			S	50-31			
			L	52-58			
				57-56			
				12-01-21			
364	2/9		P,	15-31-36			Harar Region (felt)
			S,	32-22			
365	2/9		iP,	18-25-12			D = abt. 440 km.
			S*	25-59			
			S,	26-05			
366	3/9	06-27-30	iP	06-40-13	4½S	123E	Celebes Islands
			SKS	50-37			
			S	50-47			
367	4/9		iP,	19-36-31			D = 380 km.
			Sn	-53			
			S,	37-16			
368	5/9	23-05-00	iP'	23-23-37	18S	178½W	h = 500 km.
							Fiji Islands
369	6/9	00-27-59	iP	00-41-14	5½N	126½E	Philippines Is.
370	6/9		iP,	10-08-33			D = abt. 480 km.
			S*	09-13			
			S,	09-28			
371	8/9		iP,	00-14-05			D = 380 km.
			(S,)	-59			
372	8/9	10-03-27	iP	10-16-45	36½N	140E	h = 100 km.
							Honshu, Japan.
373	8/9	13-12-04	iP	13-22-48			South Atlantic O.
374	8/9	10-19-39	i(sP)	19-33-485	42½N	142½E	Japan
375	8/9		i(P)	22-21-03			
			i	-13			
			S	23-45			
376	10/9	05-35-04	P'	05-53-54	6½S	154½E	Solomon Islands
			PP	55-01			
377	10/9		iP,	13-08-325			D = abt. 95 km.
			S,	-445			
378	10/9		i	14-05-294			
			i	-314			
			i	-355			
379	11/9		i	21-02-02			
			i	-10			
380	12/9	01-53-47	P'	02-12-58	3S	146½E	Bismark Sea
381	12/9		P,	18-46-15			D = abt. 320 km.
			S,	-42			
382	12/9	21-19-57	iP	21-27-220	36N	71E	h = 200 km.
			pP	28-085			Hindu Kush
				28-375			
			PP	29-005			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		Lat.	Long.	EPICENTER Region
383	13/9	19-15-52	iP	19-24-10	39½N	74½E	Kirghiz S.S.R.
384	13/9	22-40-36	iPKP	22-54-12	1N	129E	Halmahera Is. Region
385	14/9		i	01-41-45			
				42-48			
386	14/9	13-15-49	iP'	13-35-39	24S	176½W	Tonga Islands
			i	36-00			
387	14/9	14-09-39	eP'	14-29-135	28½S	177W	Kermadec Islands
			PKS	33-45			
			PPS	45-04			
			h	15-29			
388	14/9	14-58-40	eP'	15-18-13			After shock
			i	-22			Kermadec Islands
389	14/9	17-06-15	eP'	17-25-45			After shock
			i	-54			Kermadec Islands
390	14/9	22-23-53	eP'	22-43-31			After shock
							Kermadec Islands
391	15/9	05-59-42	iP'	06-19-10			After shock
			i	-19			Kermadec Islands
392	15/9	06-17-28	eP'	06-37-04			After shock
							Kermadec Islands
393	15/9	11-05-33	iP'	11-24-01	21½S	179½W	Fiji Islands h = 600 km.
			PP	27-16			
				31-59			
394	16/9	05-13-50	iP	05-19-50	35½N	26E	Near Crete S.
			i	20-18			
395	16/9		e	05-27-41			
			i	28-30			
396	16/9	15-57-03	iP'	16-16-525	28½S	176W	Kermadec Islands
397	16/9		eP	17-22-41			
			(S)	29-04			
398	16/9		iP	17-58-57			
399	16/9		i	18-16-04			
400	16/9		e	19-21-38			
401	16/9		iP,	21-42-50			D = abt. 500 km.
			S,	43-49			
402	17/9	14-36-11	eP'	15-55-46	28½S	176W	Kermadec Islands
403	18/9		eP	02-13-33			D = 5250 km.
							North of Morocco
404	18/9		e	02-31-(07)			
405	20/9		P,	16-07-25			D = abt. 490 km.
			S,	08-22			
406	21/9	12-19-30	iPP	12-29-38	40N	74½E	Kirghiz SSR.
407	21/9	13-09-36	eP	13-22-10	10S	120E	Sumba Islands
			i	-33			
408	21/9		e	14-35-28			
409	22/9		e	06-46-23			
			e	48-35			
			i	49-52			
410	23/9	10-38-59	eP	10-51-08	83½N	113½E	North Polar Region
411	24/9	05-43-38	iP	05-55-46			
412	24/9		eP,	22-28-30			D = abt. 130 km.
			S,	-46			
413	25/9	00-14-30	iP	00-26-33	9S	113½E	Off Coast of Java
				-52			
				27-17			
414	25/9	02-36-48	iP	02-49-26	22N	122E	Off Coast of
				52-10			Formosa
			S	59-32			
415	25/9		e	19-47-08			
416	25/9		e	20-17-24			
			i	-36			
			i	-47			
417	26/9	08-20-51	iP'	08-40-03	43½N	128½W	Off Coast of
							Oregon U.S.A.
418	26/9		e	20-01-12			
419	27/9	10-20-18	eP	10-33-37	5½S	129½E	Banda Sea
420	27/9		P,	11-06-25			D = abt. 295 km.
				-43			
			S,	-49			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		EPICENTER Lat.	Long.	Region
421	27/9		iP	12-25-22			
				-41			
422	27/9		P,	16-19-18			D = abt. 200 km.
			S,	20-02			
423	28/9		iP	04-19-08			
				-28			
424	28/9	04-20-27	eP	04-33-14	26½N	128E	Okinawa
425	28/9		i	05-41-32			
426	28/9		eP	10-22-17			
427	28/9		e	12-55-56			D = abt. 480 km.
			i(P,)	56-02			
			(Sn)	-28			
			(S,)	-58			
428	28/9		P,	19-20-14			D = abt. 180 km.
			Sn	-30			
			S,	-36			
429	28/9		P,	20-09-26			D = abt. 150 km.
			(S,)	-41			
430	29/9		iP	05-24-49			
			(S)	26-26			
431	29/9		eP	06-25-07			
			(S)	27-11			
432	29/9		i	09-15-02			
433	29/9	15-31-57	iP'	15-51-38	29S	176½W	Kermadec Islands
434	29/9		iP,	16-46-23			D = abt. 250 km.
			S,	-53			
435	30/9		iP,	03-33-34			D = abt. 190 km.
			iS,	-47			
436	30/9		eP	10-30-10			
			i	-12.5			
437	30/9		iP,	12-33-06			D = abt. 250 km.
				-32			
			(S,)	-36			
438	30/9		iP,	12-34-56			
			M	35-30			
439	30/9		eP,	13-21-05			D = abt. 225 km.
			iS,	-28			
440	1/10	20-25-58	iP'	20-45-19	18S	168E	New Hebrides
441	1/10		e	03-46-48			
			iP,	46-525			
			(S,)	47-48			
			Mz	48-05			
442	1/10		iP	04-44-20			D = 3600 km.
443	1/10		iP,	16-37-29			
			(S,)	-57			
				38-02			
444	2/10		iP,	21-22-28			D = abt. 105 km.
			S,	-42			
445	5/10	17-56-25	e	18-08-32	84N	113E	North Polar
			i	08-345			Region
446	5/10	18-27-47	P	18-39-58	83½N	112½E	Arctic Ocean
447	5/10	20-34-04	iP	20-41-11	41N	20E	Albania
448	6/10	05-44-37	eP	05-56-52	½N	122½E	h = 200 km.
							Celebes Islands
449	6/10		iP	10-42-43			
450	7/10		e	07-25-08			
			i	25-17			
			M	25-57			
451	7/10	08-30-41	iP	08-37-49	41N	20E	Albania
			S	43-19			
452	9/10		e	03-35-08			
			e	-14			
			i	-27			
453	9/10		eP	17-09-333			
			i	09-518			
			e	12-55			
454	9/10		i	23-29-38			
			e	30-29			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		EPICENTER Lat.	Long.	Region
455	10/10		i	20-17-39			
456	11/10		i	00-47-13			
457	11/10		i	01-22-53			Very nearby shock
			i	23-00			
458	11/10		i	01-26-39			Very nearby shock.
			M	-45			Max. displacement of
							the Z-trace = 60 mm.
459	11/10		i	01-28-54			Very nearby shock
460	12/10		e	00-34-32			
			i	34-36			
			(S)	35-09			
461	12/10		e	01-13-13			
462	12/10	03-21-52	iP	03-32-03	2N	98½E	Sumatra
			PcP	32-44			
			i	33-03			
463	12/10		iP	04-44-03			D = abt. 500 km.
			S	45-02			
			M	45-10			
464	12/10		i	08-16-37			
465	14/10	09-56-29	iP	10-09-10			D = 9600 km.
							Ryukyu Islands
466	14/10		iP,	20-32-18			D = abt. 190 km.
			S,	-41			
467	15/10	06-15-32	iP	06-27-56	½N	120½E	Celebes
			S	38-15			
				38-26			
			ScS	39-00			
468	17/10		iP,	15-14-05			
			S,	(20)			
469	17/10		iP,	19-49-08			D = abt. 240 km.
			S,	49-37			
470	17/10		P,	20-53-53			D = abt. 175 km.
			S,	54-14			
471	18/10		e	19-53-01			
472	18/10		iP,	22-53-59			D = abt. 160 km.
			S,	54-19			
473	19/10		iP'	08-47-10	27½S	177W	Kermadec Islands
474	19/10	15-55-30	iP	16-08-07	54½S	29W	Sandwich Islands
			S	18-43			
475	19/10		P,	21-43-43			D = abt. 185 km.
			S,	44-05			
476	20/10		iP,	03-12-16			D = abt. 140 km.
			S,	12-33			
477	22/10		i	13-55-09			
478	23/10	16-54-23	eP	17-00-42	33½N	59E	E. Iran
479	24/10		i	16-16-32			
480	24/10	23-40-34	iP	23-48-38	41½N	70E	Kazakh, S.S.R.
			PP	50-18			
481	25/10	06-51-09	iP	07-02-26			D = abt. 7900 km.
							North of Azores
482	25/10	15-57-51	iP	16-04-07	39N	42E	E. Turkey
483	26/10	07-35-12	iP	07-48-385	37½N	142½E	E. Japan
			PP	52-335			
				53-01			
			S	59-21			
484	27/10		i	03-28-10			
485	27/10		P	07-06-28			Kuriles Islands
			PP	10-31			
			S	17-32			
486	27/10		i	15-26-21			
487	28/10		e	13-35-47			
488	29/10	14-19-51	eP'	14-39-26	29½S	176½W	Kermadec Islands
			PP	42-10			
			SKSP	51-47			
489	30/10	04-00-26	iP	04-13-08	66N	136½E	Yakutska, S.S.R.

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		EPICENTER Lat.	Long.	Region
490	30/10	06-24-38	(P)	06-37-42	7S	123½E	Flores Sea
491	30/10	07-04-48	iP'	07-23-38	19S	177½W	Fiji Islands h = 450 km.
492	30/10	11-27-33	P	11-40-33			Sandwich Islands
493	30/10	13-58-25	eP'	14-18-07	23½S	175½W	Tonga Is. Region
494	30/10	21-37-35	iP'	21-56-11	19S	177½W	Fiji Islands. h = 600 km.
495	31/10	04-27-12	iP'	04-46-01	16½S	178W	Fiji Islands. h = 450 km.
496	31/10		i	17-07-05			
497	31/10		e	19-59-31			
498	1/11		e	12-26-53			
499	1/11		e	16-00-57			
500	2/11		iP,	11-24-18			D = abt. 140 km.
			S,	-35			
501	2/11	13-15-40	P	13-25-20	21½N	92½E	Pakistan-Burma Border
502	2/11		iP,	13-42-51			D = abt. 490 km.
			(S,)	43-49			
503	2/11		iP,	14-39-11			D = abt. 210 km.
			S,	-37			
504	2/11		iP,	14-59-33			D = abt. 210 km.
			S,	15-00-00			
505	2/11		eP,	15-03-45			D = abt. 210 km.
			S,	04-12			
506	2/11		e	16-35-01			
			i	35-55			
507	2/11	20-03-32	eP'	20-22-09	5½S	151½E	New Britain
508	2/11	21-53-05	eP'	22-12-52	23½S	175½W	Tonga Islands
509	3/11	00-32-19	iP	00-45-17	3½N	126½E	Molucca Passage
510	3/11	09-40-05	iP	09-51-49	10½S	111E	S. Java
			S	10-01-36			
511	3/11		iP,	18-19-57			D = abt. 210 km.
			S,	20-24			
512	3/11		iP,	20-15-29			
			S,	(-56)			
513	4/11		eP,	21-18-49			D = abt. 400 km.
			S,	19-37			
514	5/11	10-59-40	eP	11-06-19			Chagos Archipelago
515	5/11	11-50-17	eP'	12-09-38	13S	166½E	h = 100 km.
							New Hebrides
516	5/11	14-59-37	iP	15-11-56	30N	129E	h = 250 km.
							Ryukyu Islands
517	6/11	11-43-06	iP'	12-02-49	24S	174½W	Tonga Islands
518	6/11		e	15-34-10			
			i	34-32			
519	6/11		eP,	21-05-52			
			i(S,)	06-51			
520	7/11	02-32-07	iP	02-40-12	36½N	2½E	Coast of Algeria
521	7/11		iP	07-48-28			
522	7/11		i	11-55-45			
			i	56-31			
524	7/11		i	15-24-35			
			i	24-43			
525	7/11		iP	16-46-04			
			i	47-07			
526	7/11		e	19-54-22			
			i	54-28			
			i(S,)	55-26			
527	7/11	22-16-15	eP'	22-36-00	23½S	175½W	Tonga Islands
528	8/11	13-54-55	iP	14-08-13	44N	140½E	Japan
			S	18-53			
529	8/11		iP,	16-50-17			
			(S,)	51-08			
530	10/11	20-56-12	P	21-05-47	36N	89E	N.Thibet
531	11/11		e	04-31-28			
532	11/11		P,	07-20-(02)			D = abt. 475 km.
			S,	-58			

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533	11/11		P,	08-10-41			D = abt. 70 km.
			S,	-50			
534	11/11		eP,	18-55-22			
			i	56-04			
535	11/11		iP,	23-58-00			
			i	-59			
536	12/11		iP,	12-14-38			D = abt. 215 km.
			S,	15-04			
537	12/11		eP	15-48-14			D = abt. 530 km.
			S	49-17			
538	13/11		iP	08-55-08			D = abt. 3400 km.
			i	-29			
539	13/11		iP	09-26-37			
540	13/11		e	20-24-21			
			iS,	25-20			
541	14/11		i	10-50-50			
542	15/11	10-25-03	iP	10-33-25	38N	74½E	Tadzhik S.S.R.
543	15/11	17-08-41	iP	17-15-23.5	37.8N	20.5E (BCIS)	W. Coast of Greece
544	16/11		eP,	09-52-33			D = abt. 185 km.
			S,	-56			
545	16/11	10-21-17	iP	10-32-05	1N	26½W	Mid-Atlantic
546	16/11		i	20-42-18			
			iS,	-26			
547	16/11	23-43-40	eP	23-56-30	4N	126½E	Talaud Islands
548	17/11	02-32-37	eP	02-39-27	11S	66½E	Indian Ocean
			i	-29			
549	17/11		i(P,)	11-21-30			
			iS,	-34			
550	17/11		iP,	12-40-03			
			(S,)	40-54			
551	19/11		e	09-26-21			
				26-46			
552	19/11	11-08-32	eP·	11-23-04	5½S	146E	N. Coast of New Guinea
			PP	27-33			
			S	33-39			
553	19/11	14-00-24	eP	14-06-59	38½N	26E	W.Coast of Turkey
			i	07-63			
554	19/11		e	19-27-07			
			i	28-04			
555	19/11		iP,	22-26-18			D = abt. 220 km.
			S,	-44			
556	20/11	15-16-45	iP'	15-36-36	15½S	174W	Samoa Islands
557	20/11	19-29-38	eP	19-40-28	1N	26½W	Mid-Atlantic
			e	-35			
558	21/11		i	08-30-06			
559	21/11		i	16-03-48			
			i	-50			
560	21/11		e	23-08-30			
561	21/11		eP,	23-42-30			D = abt. 180 km.
			S,	-51			
562	22/11		e	10-15-23			
563	22/11		e	10-26-48			
564	22/11		iP,	11-10-00			D = abt. 245 km.
			S,	-29			
565	22/11		iP,	11-13-08			D = abt. 260 km.
			S,	-39			
566	22/11		e	17-41-58			
567	22/11	19-34-35	eP'	19-53-09	21½S	178½W	h = 550 km.
							Fiji Islands
568	23/11		i	01-24-09			
			i	24-32			
569	23/11		i	15-31-02			Nearby shock or explosion
570	23/11		i	19-02-22			
571	24/11	20-06-35	P	20-18-34	7½N	37W	D = 8750 km.
572	25/11		i	05-44-16			
			i	44-50			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		EPICENTER Lat.	Long.	Region
573	25/11	19-04-20	eP	19-17-12	6N	127E	Philippines
574	26/11		P,	02-38-58			D = abt. 525 km.
			S,	40-00			
575	26/11	07-06-19	eP	07-17-10	5½S	102½E	Sumatra
			S	25-58			
576	26/11	07-39-49	eP'	07-59-52	15½S	175W	Samoa Islands
577	26/11	16-06-03	iP'	16-25-56			Tonga Islands
578	26/11		iP,	19-51-51			D = abt. 225 km.
			S,	52-18			
579	26/11	23-09-23	iP	23-20-16	5½S	103E	Near Sumatra
			PcP	20-32			
			S	29-04			
			SS	33-22			
580	27/11	00-22-30	iP	00-29-07	38½N	20½E	Greece
581	27/11	(00-26-19)	iP	00-32-56	38½N	20½E	Greece
582	28/11	12-34-53	e(P')	12-53-55	28½S	71W	Chile
			i	54-29			
583	1/12		e	12-42-41			
			i	-46			
584	1/12	12-38-46	iP	12-45-29	38N	21½E	W. Coast of
			S	50-55			Greece
585	1/12	12-51-58	iP	12-58-42	38N	21E	Greece after
							shock
586	2/12	07-02-52	iP'	07-20-49	9S	80W	Off Coast of Peru
			PP	22-56			
587	2/12		i	07-39-55			
588	2/12	07-30-05	e	07-40-48	5S	104E	h = 150 km.
							Sumatra
589	2/12	09-34-00	iP	09-46-42	1S	123E	Celebes
			S	57-12			
590	4/12		i	09-07-16			
			i	-21			
591	6/12		i	05-17-05			
			i	-13			
592	6/12		i	05-17-44			Very near
593	7/12		e	02-59-31			
594	7/12	03-01-44	iP'	03-20-18	18S	178W	h = 600 km.
							Fiji Islands
595	7/12		e	13-27-12			
			i	-17			
596	8/12	04-30-16	eP	04-42-47	1S	124E	Celebes
597	8/12		i	08-52-22			
598	8/12		e	09-41-18			
599	8/12	12-20-55	eP	12-29-16	37½N	72½E	Afghanistan
600	8/12	12-50-45	eP	12-56-41			S. Iran
			S	13-01-52			
				06-42			
				08-35			
601	8/12	13-33-59	iP	13-40-32	42N	44½E	Georgia, S.S.R.
602	8/12		eP	18-11-(08)			D = abt. 725 km.
			iS	12-34			
603	9/12		i	01-32-59			
604	9/12		iP	16-59-56			
605	9/12		i	19-27-58			
606	11/12	00-31-40	eP	00-44-58	5S	130E	Banda Sea
607	11/12	01-38-33	eP'	01-58-18	23S	175W	Tonga Islands
608	11/12	10-07-12	eP'	10-27-08	23S	175W	Tonga Islands
			e	-43			
609	11/12		e	15-03-12			
610	12/12		e	06-32-02			
611	12/12		eP,	09-01-(59)			
			iS,	02-18			
612	13/12		e	15-02-56			
613	13/12	17-36-07	iP'	17-56-00	18S	173½W	Tonga Islands
614	13/12		P,	19-34-43			D = abt. 180 km.
			S,	35-04			
615	14/12		i	09-33-24			

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		EPICENTER Lat.	Long.	Region
616	14/12	17-58-31	eP	18-11-00	5N	126E	S.Mindanao P.I.
			i	11-01			
			SKS	21-18			
			S	21-32			
617	14/12	21-49-10	eP	22-01-56	1N	125E	Celebes
618	14/12	22-00-50	ePP	22-20-07	52½N	168W	Aleutians
			i	-40			
619	14/12	23-21-56	iP	23-34-43	59½S	31W	Sandwich Islands
			(PP)	37-48			
			PPP	40-18			
			iS	45-46			
620	15/12	10-47-42	eP	10-55-21	37N	70E	Hindu Kush
621	15/12	12-15-45	iP	12-28-35	59S	24W	Sandwich Islands
622	15/12		e	19-51-41			
623	16/12		e(P,)	16-37-37			
			(S,)	38-16			
624	16/12		eP,	23-37-28			D = abt. 375 km.
			S,	38-12			
625	17/12		e	17-56-46			
			i	57-58			
626	17/12		e	18-13-26			
627	17/12		iP,	21-06-56			D = abt. 485 km.
			S,	07-53			
628	18/12		i	06-07-36			
629	18/12	09-57-07	eP'	10-16-09	18S	178½E	h = 600 km.
							Fiji Islands
630	18/12		i	10-26-39			
631	18/12	16-24-50	e	16-43-52	53N	168½W	Fox Islands -
							Aleutians
632	20/12	12-53-37	eP	13-06-31	10½N	126½E	Mindanao
633	21/12	10-20-33	eP'	10-40-23	27½S	176W	Kermadec Islands
634	21/12	11-19-14	iP	11-22-32	14N	52E	Gulf of Aden
			i	24-22			
			iS	24-58			
			i	26-37			
			i	32-02			
635	21/12		e	12-12-06			
			i	-14			
636	21/12		e	13-56-45			
			i	57-01			
637	22/12		iP	00-12-57			Gulf of Aden
			h	16-55			
638	22/12		iP	03-07-51			
				08-14			
			i	08-27			
639	22/12		iP	03-51-37			
			i	-46			
640	23/12		iP	07-32-01			
			i	-09			
			(S)	37-53			
641	23/12		iP	09-04-42			
642	23/12	09-28-56	eP	09-36-06	38N	14½E	Sicily
			i	-16			
			i	-23			
			i	37-01			
643	23/12		e	13-17-35			
			e	-47			
644	23/12		i	13-57-12			
645	23/12	13-59-02	eP'	14-18-42	27½S	176W	Kermadec Islands
646	23/12		ei	16-38-39			
				39-02			
647	23/12		i	17-39-14			
648	23/12		eP	21-45-44			
649	24/12		iP	01-24-13			
650	24/12		e	05-44-45			
651	24/12		e	07-26-43			
652	24/12	13-08-34	eP	13-21-29	9N	126½E	Philippine
			i	-46			Islands

NO.	DATE 1959	ORIGIN TIME U.T.	PHASE		Lat.	Long.	EPICENTER Region
653	24/12		i	17-20-01			
654	25/12	10-18-35	e	10-37-14	25½S	67W	Chile-
			e	-47			Argentina
655	25/12		ei	11-36-38			
656	26/12	18-19-10	eP'	18-38-24	59½N	151½W	Alaska
			i	-36			
657	26/12	22-02-35	eP	22-16-35	53N	160E	Kamchatka
			ePP	20-36			
658	26/12		e	22-39-11			
659	27/12	12-39-09	eP	12-52-19	28S	63W	h = 650 km.
			ePP	55-46			Argentina
660	27/12	15-52-55	iP	16-06-48	56N	162½E	Kamchatka
			PP	10-51			
661	27/12		e	19-03-23			
662	28/12		iP	02-19-36			
663	28/12	07-20-32	iP	07-34-35	52½N	160E	Kamchatka
			PP	38-38			
664	28/12		i	10-01-07			
			i	-14			
665	28/12		i	13-31-50			
			i	32-12			
666	28/12		i	15-50-04			
667	29/12		iP,	10-26-38			D = abt. 220 km.
			Sn	27-04			
			S,	27-13			
668	29/12	17-14-40	e	17-34-27	21½S	174W	Tonga Islands
			iP'	-28			
669	29/12		iP	22-50-34			
670	29/12		iP	23-21-38			
671	30/12		ei	07-54-19			
672	30/12		e	13-33-54			
673	31/12		iPn	15-12-05			D = 520 km.(S,-P,)
			iP,	-36			French Somaliland
			Sn	13-175			(Felt in Djibouti)
			S,	-37			
674	31/12		iP,	15-29-30			D = 545 km.
			i	30-25			French Somaliland
			iS,	30-34			
675	31/12	20-52-55	eP	21-03-32	37½N	25W	Azores
			i	-42			
676	31/12		i	21-39-35			D = 535 km.
			iP,	39-43			French Somaliland
			S,	40-46			

METEOROLOGY

JULY - DECEMBER 1959

METEOROLOGICAL DATA

M 7

JULY 1959

DATE	TEMPERATURE °C Max.	Min.	Mean	P_a mmHg Mean	R.H. % Mean	WIND m / sec. Max.	Mean	θ°	SUNSHINE Cal/cm²	Hrs	RAIN mm
1	19.5	8.8	12.7	576.8	75	6.6	1.70		313	1.8	2.4
2	18.8	10.5	13.8	576.4	70	5.0	2.06		517	3.1	2.0
3	17.2	11.2	13.4	575.7	77	6.6	1.60		342	0.6	6.0
4	17.2	11.1	13.9	576.2	78	5.0	1.60		258	0.8	3.0
5	19.8	11.2	14.6	576.7	75	4.7	1.63		465	2.9	5.0
6	19.8	10.1	13.9	576.7	70	3.5	1.55		513	6.1	7.0
7	21.2	8.8	15.6	576.2	72	5.6	1.75		570	7.2	0.0
8	21.3	10.0	15.9	576.2	68	4.6	1.78		571	8.4	0.0
9	20.7	10.3	14.1	576.1	74	4.9	1.91		303	7.1	0.0
10	17.6	11.0	13.0	576.1	76	6.6	1.55		301	0.2	1.8
11	20.3	10.8	14.5	575.8	74	5.3	1.77		375	2.8	19.0
12	19.9	11.2	14.0	575.9	76	5.9	1.67		427	2.9	4.0
13	19.6	11.8	13.9	575.7	72	6.9	1.95		333	2.6	2.4
14	16.3	11.3	12.6	575.8	77	5.3	2.00		191	0.3	29.2
15	16.3	10.5	13.2	575.1	82	3.7	1.75		208	0.0	3.5
16	15.4	10.7	12.9	575.2	81	4.0	1.33		219	0.1	2.9
17	15.8	11.0	12.3	575.7	78	4.4	1.90		202	0.1	17.9
18	19.5	10.0	13.4	576.0	68	5.5	2.05		400	1.8	0.0
19	19.9	9.2	14.0	576.1	66	6.9	1.75		451	5.3	9.8
20	19.8	9.9	14.0	576.0	75	4.6	1.76		404	2.4	6.0
21	16.8	9.3	13.0	576.2	85	4.6	1.65		310	0.9	1.8
22	20.5	8.7	14.1	576.1	75	6.2	1.75		407	3.3	0.0
23	18.5	9.6	13.6	576.1	85	4.7	1.70		207	2.4	1.5
24	16.4	10.8	12.0	576.2	85	3.4	1.30		265	0.3	26.5
25	17.7	10.5	13.6	575.2	80	5.3	2.15		341	0.7	2.6
26	18.3	11.2	14.4	575.1	80	4.6	1.70		329	1.4	1.0
27	20.1	10.0	13.7	575.1	80	5.3	1.50		463	4.7	0.0
28	19.8	11.0	14.6	575.2	80	5.9	2.24		434	2.6	0.0
29	17.5	10.3	13.4	575.6	83	4.3	1.36		320	1.9	1.3
30	19.0	9.8	14.0	575.6	87	5.3	1.51		416	2.9	16.5
31	18.3	11.8	13.7	575.2	90	3.3	1.20		230	0.6	20.5
SUM											199.8
MEAN	18.7	10.4	13.7	575.9	77.2	5.1	1.71		358	2.5	

θ = Wind direction from 0 to 360°, clockwise, from North.

METEOROLOGICAL DATA

M 8

AUGUST 1959

DATE	TEMPERATURE °C Max.	Min.	Mean	P_a mmHg Mean	R.H. % Mean	WIND m / sec. Max.	Mean	θ°	SUNSHINE Cal/cm²	Hrs	RAIN mm
1	16.2	11.2	13.5	575.5	95	4.3	1.18		200	0.0	24.5
2	19.0	9.8	14.7	575.4	85	4.4	1.49		414	4.7	2.3
3	19.5	10.9	14.7	575.3	75	3.3	1.56		553	6.7	8.0
4	21.2	10.8	15.7	575.2	75	5.0	1.70		566	8.2	0.0
5	19.0	11.0	14.5	575.4	80	6.2	2.00		313	2.1	2.5
6	16.8	10.3	13.3	575.7	92	4.0	1.48		219	0.0	35.6
7	20.5	9.1	13.1	575.1	85	5.3	1.61		437	4.5	16.5
8	20.0	10.7	14.8	575.5	80	4.4	1.40		495	6.0	9.5
9	19.1	10.1	14.4	575.8	80	4.7	1.67		457	4.1	15.4
10	18.5	9.8	13.5	576.0	85	5.6	1.55		298	1.4	24.5
11	16.7	8.7	12.4	576.0	90	5.3	1.80		308	2.4	19.0
12	19.3	8.2	13.0	575.6	85	7.0	1.89		345	2.9	8.5
13	20.2	10.4	13.8	575.4	83	5.3	1.50		363	1.0	10.0
14	17.8	9.9	12.5	575.0	95	6.2	1.80		421	2.0	0.0
15	18.1	8.7	12.5	574.9	85	4.6	1.62		326	2.9	9.2
16	18.4	9.4	12.7	575.2	80	6.6	2.05		310	1.4	14.3
17	17.3	9.9	12.7	575.0	85	4.2	1.27		265	0.8	1.5
18	19.0	8.5	13.5	574.8	80	4.4	1.70		334	3.6	1.2
19	18.1	7.7	12.2	574.9	85		1.45*		304	2.6	9.4
20	17.4	10.0	12.8	575.3	90	4.2	1.55*		227	1.2	8.5
21	14.4	10.6	12.1	575.6	95	4.7	1.30		127	0.0	5.8
22	17.0	10.6	12.3	575.1	90	4.3	1.50		280	0.6	11.0
23	18.2	9.9	13.2	575.6	90	4.5	1.40		371	1.4	20.0
24	19.0	8.0	13.2	575.5	80	4.3	1.70		391	5.5	4.0
25	16.6	10.2	12.6	575.4	85	5.0	1.43		239	0.3	10.0
26	16.3	9.0	12.1	575.1	90	3.1	1.30		281	1.4	28.0
27	19.8	8.5	12.7	575.3	85	5.6	1.90		394	2.1	2.7
28	19.0	10.0	13.6	575.5	80	6.2	1.71		381	2.1	1.8
29	20.0	7.4	14.0	575.1	80	4.0	1.30		333	5.7	0.0
30	18.5	9.1	14.2	574.9	85	4.3	1.65		328	4.7	0.0
31	20.2	10.1	14.4	574.4	80	5.0	1.81		348	4.3	6.0
SUM											319.7
MEAN	18.4	9.6	13.4	575.3	84.5	4.9	1.59		343	2.8	

O = Wind direction from 0° to 360°, clockwise, from North.

METEOROLOGICAL DATA

M 9

SEPTEMBER 1959

DATE	TEMPERATURE °C			P_a mmHg	R.H. %	WIND m / sec.			SUNSHINE		RAIN mm
	Max.	Min.	Mean	Mean	Mean	Max.	Mean	θ°	Cal/cm²	Hrs	
1	19.0	11.7	15.0	574.2	80	3.7	1.25	Wind Direction Indicator installed 20.IX.59	391	4.3	0.2
2	18.9	11.7	15.0	573.7	85	5.6	1.66		333	2.1	0.6
3	13.6	11.8	12.6	574.4	95	2.7	1.26		175	0.0	47.2
4	17.5	11.6	13.6	575.2	95	5.9	1.80		275	0.5	36.0
5	18.3	10.8	13.3	575.1	90	4.7	1.53		369	1.7	4.0
6	18.0	8.0	13.6	574.9	90	3.6	1.32		374	7.5	10.0
7	19.0	11.0	14.1	575.0	80	4.7	1.45		331	3.4	8.8
8	17.5	11.5	12.9	574.9	85	3.3	1.31		232	0.6	3.2
9	20.1	9.4	14.6	574.5	80	3.9	1.38		401	3.3	0.0
10	19.7	8.5	14.6	574.5	85	5.3	1.32		449	4.9	4.0
11	19.7	11.2	13.5	574.7	85	5.6	1.56		341	3.0	9.4
12	17.9	10.4	13.8	574.9	85	4.7	1.28		306	0.8	45.2
13	18.0	9.6	12.8	575.4	85	9.1	1.63		387	4.5	13.4
14	19.2	8.0	13.7	575.5	75	5.9	1.91		488	5.4	1.0
15	20.2	8.4	14.9	575.5	70	4.7	1.86		591	9.8	0.0
16	19.8	8.8	14.0	575.7	75	4.5	1.66		449	5.7	1.0
17	20.1	9.5	14.0	575.9	80	9.1	1.95		543	6.5	0.0
18	18.4	10.2	14.2	576.2	85	5.6	1.72		463	5.3	7.9
19	17.5	9.0	14.2	575.9	82	4.0	1.87		354	3.0	12.0
20	19.2	7.0	14.7	575.6	85	5.9	1.75	119	467	4.5	1.0
21	19.5	7.6	13.2	576.1	75	6.2	1.81	81	465	6.1	11.2
22	20.6	7.0	12.2	577.3	75	5.9	1.98	95	576	5.9	29.5
23	19.0	9.2	12.8	577.5	75	4.6	1.89	93	435	3.3	0.0
24	21.4	7.5	14.6	576.1	70	5.9	2.28	98	536	6.4	0.0
25	21.3	9.0	14.8	575.4	69	6.6	2.26	108	633	9.1	0.0
26	21.5	8.5	14.6	576.2	72	5.8	2.03	104	583	8.3	0.0
27	20.3	8.7	14.9	576.5	75	5.9	1.84	91	497	7.7	4.8
28	19.0	8.1	14.8	575.7	75	3.3	1.64	119	413	3.5	0.0
29	19.8	8.5	14.2	575.1	83	4.4	1.37	158	359	4.0	5.8
30	18.8	10.5	13.9	575.7	87	3.3	1.41	121	318	2.7	0.6
SUM											256.8
MEAN	19.1	9.4	14.0	575.4	80.9	5.1	1.67	106	418	4.5	

θ = Wind direction from 0° to 360°, clockwise, from North.

METEOROLOGICAL DATA

M 10

OCTOBER 1959

DATE	TEMPERATURE °C			P_a mmHg	R.H. %	WIND m / sec.			SUNSHINE		RAIN mm
	Max.	Min..	Mean	Mean	Mean	Max.	Mean	θ°	Cal/cm²	Hrs	
1	17.0	10.8	13.7	576.0	90	3.8	1.52	107	266	2.1	2.0
2	20.1	8.1	14.2	576.0	82	5.3	1.83	94	496	7.5	0.0
3	20.2	9.4	15.0	576.1	77	5.6	1.68	115	502	6.7	0.0
4	21.0	8.2	15.4	575.7	72	5.9	1.81		557	7.7	0.0
5	21.2	11.4	16.2	575.9	63	6.5	1.64		452	6.3	0.0
6	21.5	9.4	16.6	575.6	68	7.5	2.17	126	673	8.3	0.0
7	20.1	11.0	15.2	575.1	75	6.5	1.72	117	342	4.0	0.0
8	21.0	8.2	15.0	575.3	70	6.2	2.20	105	513	9.1	0.0
9	20.6	7.3	14.6	576.4	65	7.5	2.15	120	522	10.9	0.0
10	20.7	6.5	14.2	576.3	60	8.5	2.42	97	616	11.0	0.0
11	21.1	5.5	13.1	575.9	71	5.4	1.57	112	530	6.7	0.0
12	20.0	10.7	14.1	575.4	75	5.6	1.78	111	402	3.9	0.0
13	19.8	8.4	14.3	575.5	80	5.9	1.95	117	340	4.1	0.0
14	21.0	7.6	14.5	576.2	65	7.3	2.23	90	631	11.0	0.0
15	21.5	5.7	12.0	576.3	60	5.6	2.20	99	480	7.6	0.0
16	20.5	7.4	14.1	576.1	60	4.3	1.72	87	489	7.1	0.0
17	24.7	8.5	16.7*	576.0	59	5.0	1.94	100	453	7.2	0.0
18	21.2	8.3	15.0*	575.4	60	4.8	1.76	97	448	5.2	0.0
19	19.3	3.5	15.6*	575.3	58	5.9	1.50	80	408	6.7	0.0
20	20.3	9.9	15.3	575.5	56	7.6	2.79	110	512	6.4	0.0
21	21.0	5.6	15.1	576.0	58	6.5	2.19	85	602	9.0	0.0
22	20.3	5.5	14.2	575.8	68	4.8	2.26	112	545	8.5	0.0
23	20.8	7.5	15.8	575.1	62	5.8	2.20	111	461	8.8	0.0
24	19.3	8.3	14.6	576.1	75	4.8	1.48	148		4.3	0.0
25	17.9	11.3	14.5	576.8	82	4.9	1.57	144	298	2.6	3.2
26	20.1	7.8	14.4	576.4	65	6.2	2.21	104	530	9.5	0.0
27	19.5	5.4	13.6	576.1	60	6.5	2.37	80	597	11.4	0.0
28	22.4	5.5	15.4	576.2	58	7.2	2.28	108	596	10.3	0.0
29	21.9	6.5	15.1	576.0	60	7.3	3.59	97	581	10.4	0.0
30	21.4	6.8	15.3	576.0	48	7.4	2.27	109	623	10.7	0.0
31	21.8	6.4	15.1	575.8	58	7.1	2.40	128	527	8.0	0.0
SUM											5.2
MEAN	20.7	8.0	14.8	575.9	66.5	6.1	2.05	107	500	7.5	

θ = Wind direction from 0° to 360°, clockwise, from North.

METEOROLOGICAL DATA

M 11 — NOVEMBER 1959

DATE	TEMPERATURE °C Max.	Min.	Mean	P_a mmHg Mean	R.H. % Mean	WIND m/ sec Max.	Mean	θ°	SUNSHINE Cal/cm²	Hrs.	RAIN mm
1	21.2	8.2	15.5	575.7	50	8.4	3.13	94	587	10.7	0.0
2	21.2	6.4	15.0	575.9	47	5.9	2.36	94	613	10.5	0.0
3	21.5	5.2	13.8	575.8	55	4.8	2.10	102	537	9.6	0.0
4	210	4.6	13.7	575.7	58	4.4	2.03	138	564	9.4	0.0
5	20.6	5.3	14.2	575.8	55	6.0	2.24	117	602	10.5	0.0
6	20.1	4.0	13.2	575.5	50	6.0	2.49	95	610	10.7	0.0
7	21.0	4.2	13.5	576.5	50	6.8	2.71	106	613	10.9	0.0
8	21.1	5.2	13.6	576.3	60	6.9	2.72	111	602	10.8	0.0
9	20.3	7.4	13.2	576.3	65	6.4	2.41	120	532	10.2	0.0
10	20.6	5.8	13.7	575.8	65	7.3	2.58	95	570	10.1	0.0
11	20.1	2.4	12.7	575.3	53	6.0	2.38	101	598	11.1	0.0
12	19.9	4.2	13.2	575.7	50	6.0	2.16	113	610	11.2	0.0
13	20.7	3.5	12.8	575.5	55	5.3	1.89	95	604	11.1	0.0
14	21.1	4.0	13.6	575.5	55	6.8	2.14	120	601	11.0	0.0
15	22.0	4.2	14.9	575.7	55	6.8	2.09	115	559	10.1	0.0
16	21.5	5.7	14.7	575.4	60	6.9	2.51	125	524	10.1	0.0
17	21.3	6.4	14.3	574.9	65	6.6	2.18	141	542	10.5	0.0
18	21.3	8.0	15.3	575.2	65	6.1	2.29	126	522	8.5	0.0
19	21.3	7.6	14.8	575.5	75	6.0	1.87	163	414	8.1	0.0
20	19.8	9.6	14.6	575.4	78	6.3	2.14	117	404	3.5	0.0
21	20.3	6.2	13.8	575.4	69	7.8	2.47	110	518	10.1	0.0
22	21.1	6.4	14.2	576.2	62	6.8	2.52	111	505	10.6	0.0
23	21.2	4.2	13.0	576.3	55	7.0	2.43	96	610	11.1	0.0
24	20.8	2.4	12.8	575.7	53	7.4	2.44	106	594	11.2	0.0
25	21.2	3.0	13.1	575.4	60	6.8	2.70	100	573	11.0	0.0
26	21.6	6.1	14.5	575.9	47	6.0	2.38	88	575	10.7	0.0
27	22.7	3.8	14.6	576.2	50	6.1	1.93	91	600	11.1	0.0
28	23.9	6.0	16.2	576.2	63	4.8	2.03	88	519	10.2	0.0
29	23.1	7.6	16.1	576.3	65	5.1	1.69	119	485	9.1	0.0
30	21.9	7.4	13.7	576.3	75	6.9	2.10	139	401	7.8	0.0
SUM											0.0
MEAN	21.2	5.5	14.1	575.8	58	6.4	2.30	111	553	10.1	

θ = Wind direction from 0° to 360°, clockwise, from North.

METEOROLOGICAL DATA

M 12 — DECEMBER 1959

DATE	TEMPERATURE °C Max.	Min.	Mean	P_a mmHg Mean	R.H. % Mean	WIND m / sec Max.	Mean	θ°	SUNSHINE Cal/cm²	Hrs.	RAIN mm
1	18.9	10.9	13.9	576.3	90	6.0	2.16	133	257	2.2	2.5
2	20.1	10.5	14.0	576.5	75	7.8	2.35	108	462	8.8	0.0
3	20.8*	4.2*	13.8*	576.6	62	7.3	2.31	92	566	11.1	0.0
4	20.5*	2.8*	13.6*	576.2	57	4.8	1.97	93	581	11.1	0.0
5	21.6	5.3	13.4	575.9	65	6.0	1.98	102	522	10.3	0.0
6	22.1	3.5	12.3	575.7	70	7.8	2.33	87	588	10.4	0.0
7	20.2	2.0	11.9	576.2	70	5.1	2.04	103	568	10.3	0.0
8	19.8	3.5	11.3	576.1	70	5.6	2.08	103	557	10.1	0.0
9	20.2	2.5	12.7	576.0	55	6.3	2.12	131	582	10.9	0.0
10	19.8	5.6	13.7	575.5	66	6.0	2.06	108	502	9.5	0.0
11	20.4	5.3	13.0	575.7	73	5.7	2.23	103	418	5.3	0.0
12	20.7	6.0	14.4	575.6	68	7.0	2.64	103	555	10.6	0.0
13	21.5	7.1	15.0	575.6	68	6.2	2.49	106	500	9.8	0.0
14	21.5	7.5	14.5	575.5	63	6.8	2.40	138	575	10.8	0.0
15	20.0	6.3	13.9	575.1	57	7.3	2.62	93	570	10.8	0.0
16	19.5	4.0	12.8	576.4	58	6.0	2.57	111	578	10.5	0.0
17	21.8	4.1	13.0	577.0	58	7.9	2.27	94	570	10.7	0.0
18	22.2	5.5	14.4	576.5	51	5.6	2.10	119	568	11.0	0.0
19	22.0	6.0	14.7	576.2	60	4.8	2.05	121	521	10.3	0.0
20	22.0	5.7	14.2	576.1	60	6.4	2.20	88	544	10.7	1.0
21	22.0	4.3	13.6	576.0	70	5.4	2.11	118	582	10.6	0.0
22	21.4	4.1	13.4	576.2	69	6.0	2.01	103	594	10.4	0.0
23	21.2	2.6	11.8	576.3	65	7.3	2.28	120	578	9.9	0.0
24	20.6	1.6	11.9	576.7	50	6.1	2.10	88	573	10.9	0.0
25	21.7	3.0	12.4	576.2	52	6.0	2.04	110	588	10.9	0.0
26	21.6	3.0	13.0	576.2	60	5.7	1.88	93	532	10.4	0.0
27	22.7	6.4	15.1	575.8	60	5.3	1.94	70	516	10.1	0.0
28	22.5	6.9	14.1	575.4	70	5.1	1.64	79	462	4.7	0.0
29	20.3	7.8	14.0	576.2	73	5.5	2.00	130	475	7.6	0.0
30	22.0	7.2	14.8	576.2	70	4.4	1.67	115	454	5.6	0.0
31	21.2	11.3	15.4	575.8	65	4.6	1.72	127	432	4.5	0.0
SUM											3.5
MEAN	21.1	5.5	13.6	576.1	64	6.1	2.14	106	528	9.4	

θ = Wind direction from 0° to 360°, clockwise, from North.