ROYAL OBSERVATORY, HONG KONG.

TECHNICAL NOTES, NO. 3.

FOGS AT WAGLAN ISLAND, AND THEIR RELATIONSHIP TO FOGS IN HONG KONG HARBOUR.

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by
K. R. HUNG.
(Technical Officer)

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CONTENTS

FOGS AT WAGLAN ISLAND,

AND THEIR RELATIONSHIP TO FOGS IN HONG KONG HARBOUR.

Introduction.

This note describes the result of a study of fog occurences at Waglan. The aim of the investigation was to determine the conditions most favourable for fog formation at Waglan and the relationship between fogs at Waglan Island and fogs in the harbour area of Hong Kong.

Waglan, in spite of its short distance from Hong Kong Harbour, may experience quite different weather, especially during the Spring, when fog is most frequent and persistent and constitutes the greatest hazard to flying and shipping.

Fogs at Waglan are of the sea-fog type, caused by warm moist air blowing over a relatively colder sea surface. Whenever the general wind flow is favourable, the fog drifts through the Lyemun Pass into the harbour and often seriously interrupts both air and sea traffic. As fog is always first observed at Waglan, conditions there may give a certain amount of warning of subsequent developments in the harbour area.

PART I. Waglan Fogs.

1. Data.

Description of the Island.

Waglan is an island, situated in 22° 11' N., and 114° 18' E., being half a mile long, north-northeast and south-southwest, and about a hundred and twenty yards wide; it is divided into two parts by a small boat passage. (1)

The instrument screen is placed 196 feet above mean sea level on the summit of the southern part.

Observational data.

a. Data refer to two periods, 1919-1933 and 1948-1950. The records for 1934-1947 are missing. They were either lost during the war or no observations were made.

b. All statistics in this paper, except the total hours of fog at Waglan and the figures used in Part II, are based on fog-days.

c. Any day with half an hour or more fog observed is described as a fog-day.

d. The figure used for both wind force and direction in the tables showing their relationship to fog are mean values for that fog-day.

e. During the pre-war period 1919-1933, observations were made four-hourly throughout the twenty-four hours and during the postwar period 1948-1950, three-hourly from 0200 to 1700 hours local standard time.

2. Monthly and Annual Distribution.

From 1919-1933 and from 1948-1950, fog was never observed from September through November and rarely from June through August, Winter and Spring being the most favourable seasons.

Table I. — Duration (nearest hours) of Fog for each month 1919-1933.
x Records missing.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1919	101	20	208	36	-	6	-	-	-	-	-	-	371
1920	49	34	124	80	24	-	x	-	-	-	-	16	327
1921	5	11	41	78	-	4	-	-	-	-	-	19	158
1922	23	118	69	74	10	-	-	-	-	-	-	-	294
1923	11	63	54	87	-	-	-	-	-	-	-	-	215
1924	x	x	x	x	x	x	2	-	-	-	-	-	-
1925	23	-	60	67	101	-	x	x	-	-	-	-	251
1926	10	40	102	124	75	25	-	-	-	-	-	34	410
1927	52	130	121	139	76	-	-	-	-	-	-	-	518
1928	69	34	140	33	1	-	-	-	-	-	-	-	277
1929	19	47	109	25	13	-	-	4	-	-	-	65	282
1930	14	145	122	108	4	-	-	-	-	-	-	10	403
1931	103	69	109	148	63	3	-	1	-	-	-	3	499
1932	-	11	56	164	4	-	-	4	-	-	-	19	258
1933	21	52	134	108	15	-	-	-	-	-	-	-	330
Total	500	774	1449	1271	386	38	2	9	-	-	-	166	4595
Mean	36	55	103	91	27	3	.1	.6	-	-	-	11	
Max.	103	144	208	164	101	25	2	4	-	-	-	65	

Table I shows the total duration of fog for each month, more than half the total being accounted for by March and April. These two months average about a hundred hours each, approximately one-seventh of the whole month. If we consider the number of fog-days in these two months as shown in Table II, expectation would be about one in three.

Table II — Number of Fog-days at Waglan, 1919-1933.
x Records missing.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1919	9	2	18	4	-	1	-	-	-	-	-	-	34
1920	4	5	12	8	5	-	x	-	x	-	-	2	36
1921	1	2	7	7	-	1	-	-	-	-	-	3	21
1922	3	9	6	10	2	-	-	-	-	-	-	-	30
1923	2	7	6	11	-	-	-	-	-	-	-	-	26
1924	x	x	x	x	x	x	1	-	-	-	-	-	-
1925	3	0	8	8	8	-	x	x	-	-	-	-	27
1926	2	8	10	16	9	5	-	-	-	-	-	4	54
1927	5	11	11	13	9	-	-	-	-	-	-	-	49
1928	8	5	13	6	1	-	-	-	-	-	-	-	33
1929	3	5	7	3	4	-	-	1	-	-	-	5	28
1930	3	10	9	13	1	-	-	-	-	-	-	2	38
1931	11	10	11	19	8	1	-	1	-	-	-	1	62
1932	-	2	7	14	2	-	-	1	-	-	-	2	28
1933	2	8	11	12	1	-	-	-	-	-	-	-	34
Total	56	84	136	144	50	8	1	3	-	-	-	19	501
Mean	4.0	6.0	9.7	10.3	3.6	0.6	0.1	0.2	-	-	-	1.4	35.8
% Freq.	11	17	27	28	10	2	.2	1	-	-	-	4	

In the months of December and January fog is not often observed. The reason is that during this time of the year, the tropical air rarely reaches the China Coast with the Asiatic High dominating the region.

During the months February, March and April, the Asiatic High is not as strong as in December and January. Tropical air more frequently reaches the China Coast, and usually results in fog forming. In the latter part of Spring and the whole of Summer, equatorial or tropical air predominates, but since the sea temperature for most of the China Sea is higher than the dew point, fog rarely forms. Farther north, where the sea temperature is lower, cooling from below takes place. If such cooling is pronounced, fog will be seen in the Summer months.

Table III shows the average duration of fog periods for each month. It can be seen that although conditions favourable to fog occur less frequently in February than in March and April, once established they are more persistent then than in the other two months, with February showing a comparatively higher average duration.

Table III.— Average Duration (nearest hours) of fog periods for each month, 1919-1933. x Records missing.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1919	14	7	8	9	-	6	-	-	-	-	-	-
1920	5	5	10	10	5	-	x	-	x	-	-	16
1921	5	3	4	11	-	2	-	-	-	-	-	10
1922	4	14	10	8	5	-	-	-	-	-	-	-
1923	4	5	8	6	-	-	-	-	-	-	-	-
1924	x	x	x	x	x	x	2	-	-	-	-	-
1925	8	-	6	10	13	-	x	x	-	-	-	-
1926	5	6	9	8	11	6	-	-	-	-	-	8
1927	13	14	12	11	8	-	-	-	-	-	-	-
1928	7	11	9	4	1	-	-	-	-	-	-	-
1929	6	16	27	6	3	-	-	4	-	-	-	16
1930	7	29	6	8	4	-	-	-	-	-	-	5
1931	9	7	8	6	6	3	-	1	-	-	-	3
1932	-	5	7	12	1	-	-	4	-	-	-	9
1933	11	7	12	11	15	-	-	-	-	-	-	-
Total	98	129	136	120	72	17	2	9	-	-	-	67
Mean	7	9	10	9	5	1	.1	.6	-	-	-	4

Table IV shows the longest fog periods recorded each month from 1919-1933, with the absolute maximum occurring in March, 1920. This fog was unbroken from the morning of 8th March to the morning of 12th March. (2) This spell will be described in a later paragraph.

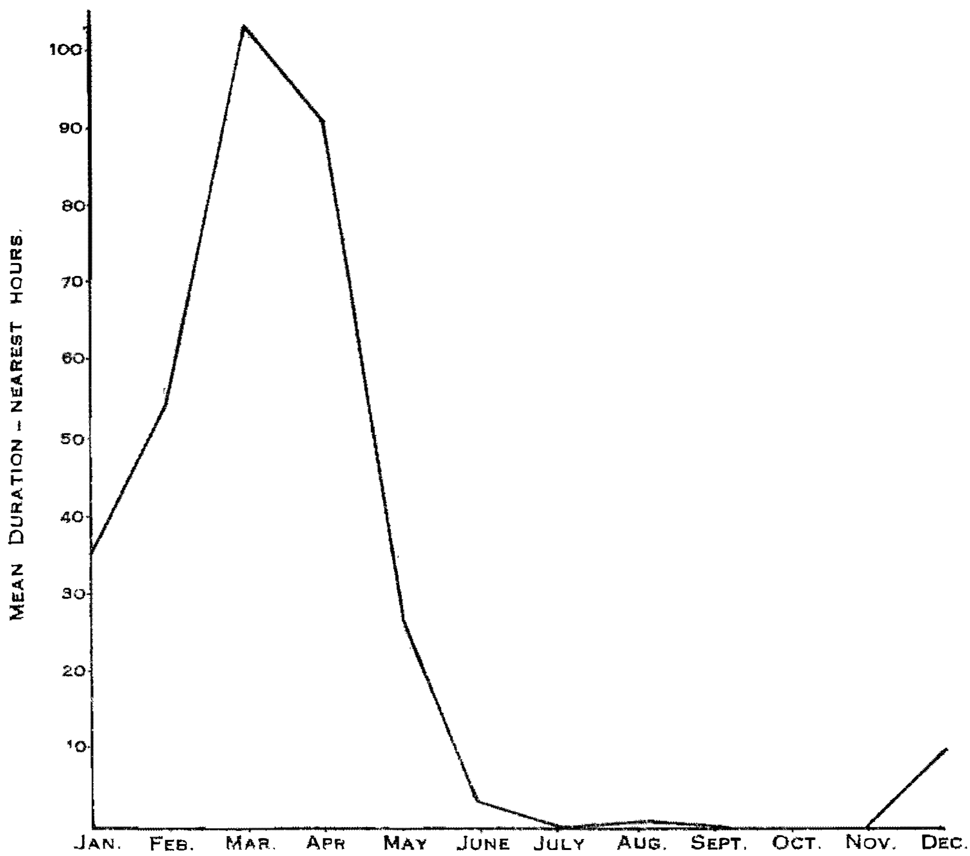

Fig. 1. Monthly distribution of Fogs at Waglan, 1919-1933.

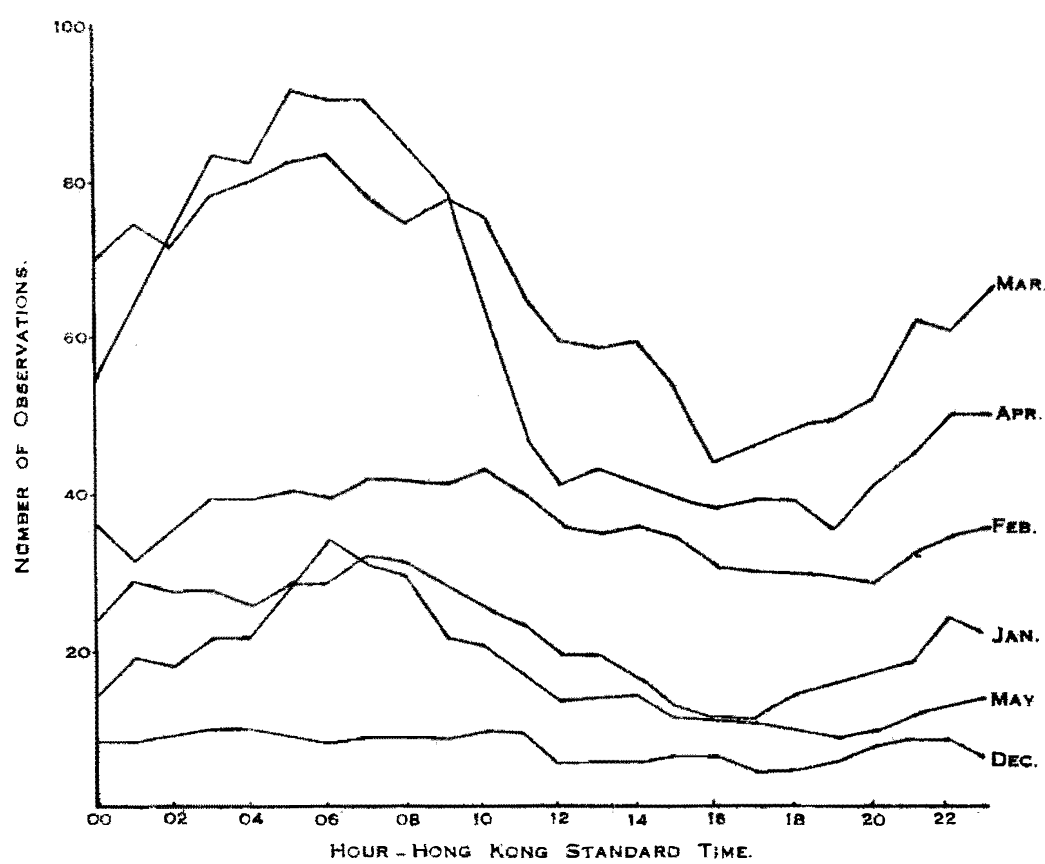

Fig. 2. Diurnal Variation of Fogs in different months, Waglan. 1919 - 1933.

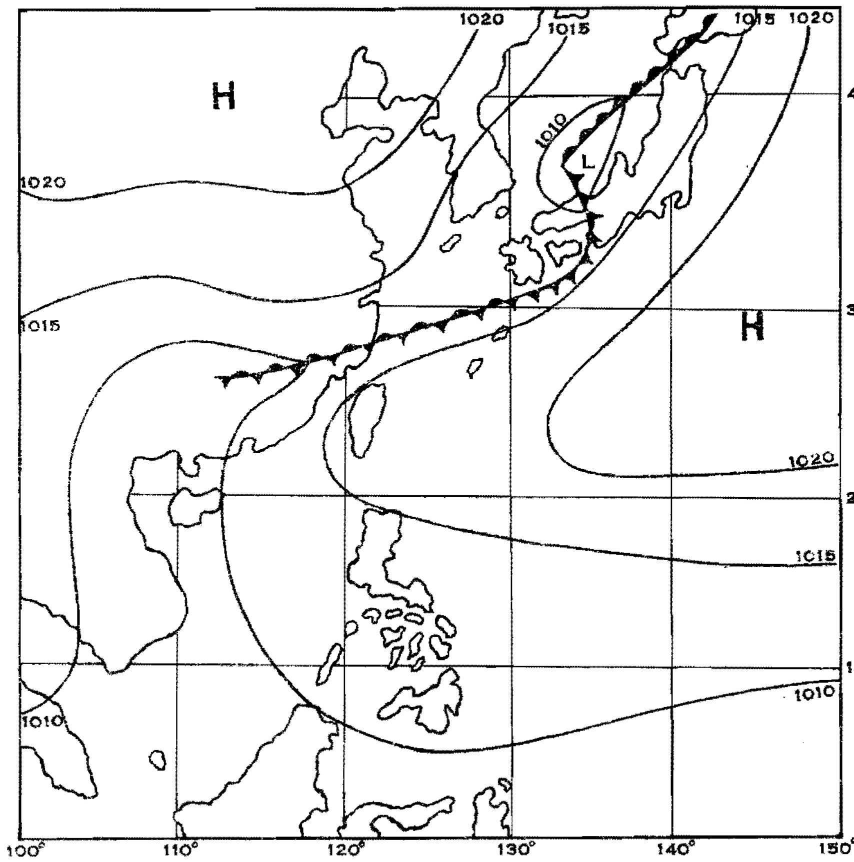

Fig. 3. Example of typical fog-forming weather pattern.
2100 hr. H. K. S. T. 8th March, 1919.

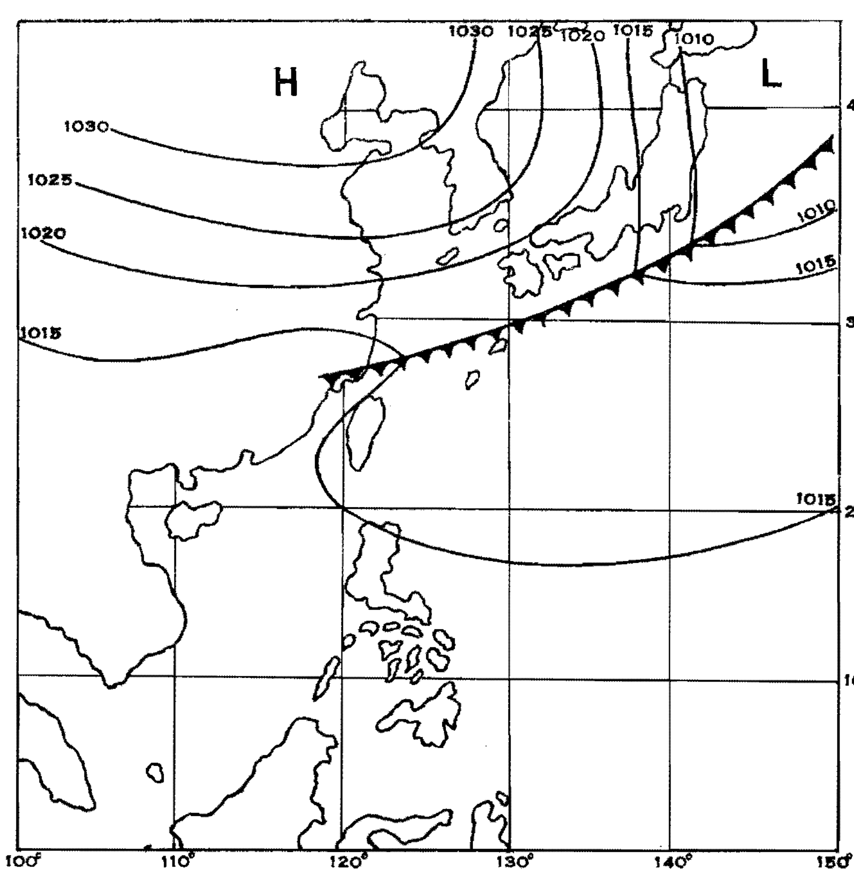

Fig. 4. Example of typical fog-forming weather pattern.
2100 hr. H. K. S. T. 23rd Feb., 1929.

Table IV — Longest fog period (nearest hours) for each month, 1919-1933. x Records missing.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year.
1919	31	14	47	20	-	6	-	-	-	-	-	-	47
1920	11	19	95	24	15	-	x	-	x	-	-	16	95
1921	5	9	15	23	-	3	-	-	-	-	-	13	23
1922	10	78	33	51	5	-	-	-	-	-	-	-	78
1923	8	23	19	39	-	-	-	-	-	-	-	-	39
1924	x	x	x	x	x	x	2	-	-	-	-	-	-
1925	10	-	13	33	37	-	x	x	-	-	-	-	37
1926	9	12	16	25	26	15	-	-	-	-	-	28	28
1927	21	39	41	37	25	-	-	-	-	-	-	-	41
1928	13	21	35	9	1	-	-	-	-	-	-	-	35
1929	14	20	92	11	7	-	-	4	-	-	-	39	92
1930	9	63	69	28	4	-	-	-	-	-	-	6	69
1931	25	20	45	15	27	3	-	1	-	-	-	3	45
1932	-	9	17	57	2	-	-	4	-	-	-	14	57
1933	13	16	33	23	15	-	-	-	-	-	-	-	33
Max.	31	78	95	57	37	15	2	4	-	-	-	39	95

3. Diurnal Variation.

Fig. 2 shows the diurnal variation of fog. In the months June to December, fog was observed too infrequently for significant diurnal patterns to appear. The curves of the other five months show a marked maximum occurring at about sunrise, the reason being that as soon as the sun's rays become active they create instability between the saturated air in the fog layer and the unsaturated air above it and convection begins at the upper surface of the fog layer. As soon as the process goes a little further, sufficient warming of the successive cold damp layers takes place to tend to dissolve the fog.

4. Fog in Relation to Wind and Sea Temperature.

Tables V, VI and VII show the relationship between fog and the wind direction and force, and the difference between air and sea temperature during fog.

Fog is liable to form along the S. China Coast in spring when tropical air which has travelled over warm seas to the east or south reaches the cooler waters of the coastal current. Typical synoptic situations favourable for the formation of fog are illustrated in Figs. 3 and 4. One might expect, therefore, that fogs would occur most frequently with south-east winds.

From the tables, however, we notice that fogs are most often associated with winds of force 2 and 3 and with wind directions from between the north and east. This is due to the orographic effect of the coast line; the east or southeast winds are deflected to the left on approaching the China Coast and tend to reach Waglan from northeast.

If we study the column of mean values of air temperature minus sea temperature in Table VII, we find there is a very slight difference between the air and the sea temperature for air from the north to east and a greater contrast for air from a southerly direction. This is because air from the northeast would have been travelling recently in the same direction as the sea current, resulting in only a slight contrast in air and sea temperature; whereas an air from the south would be much warmer and the contrast would naturally be greater.

Table V — Observations of Fog for all months in respect to Wind Direction and Force, Waglan, 1919-1933 and 1948-1950.

Dir. / Force	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	22
1	4	3	4	3	4	2	5	2	1	1	1	-	-	1	-	3	-	34
2	33	16	35	11	26	6	7	11	6	2	1	1	2	3	4	4	-	168
3	34	39	47	23	28	8	10	11	4	-	1	-	1	1	2	7	-	216
4	5	12	24	18	16	1	3	3	1	-	-	-	-	-	-	1	-	84
5	1	-	1	13	11	-	-	-	-	-	-	-	-	-	-	-	-	26
6	-	-	-	1	4	1	-	-	-	-	-	-	-	-	-	-	-	6
7	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Total	77	70	111	69	90	18	25	27	12	3	3	1	3	5	6	15	22	557

Table VI — The effect of wind force on the difference between Air Temperature and Sea Temperature. (1948-1950).

Wind Force (Beaufort Scale)	No. of Observations of Fog	Mean Values of Air Temperature minus Sea Temperature
0	3	2.5
1	2	1.5
2	31	0.6
3	26	0.7
4	4	-1.0
5	2	-1.5

Table VII — The effect of wind direction on the difference between Air Temperature and Sea Temperature. (1948-1950).

Wind Direction	No. of Observations of Fog	Mean Values of Air Temperature minus Sea Temperature
N	6	0.9
NNE	10	0.4
NE	17	0.4
ENE	5	-0.5
E	21	0.2
ESE	1	2.0
SE	3	2.0
SSE	-	-
S	1	5.0
SSW	-	-
SW	-	-
WSW	-	-
W	-	-
WNW	-	-
NW	1	2.0
NNW	-	-

From the same column under Table VI, it will be noticed that the mean values of air temperature minus sea temperature decrease with the wind force, whereas Petterssen and Taylor agree that in conditions of sea fog, the stronger the wind the higher the air temperature relative to sea temperature (3, 4). Taylor's observations were made on board the whaler "Scotia" out in the open Atlantic, near the Great Bank, with only a few feet separating the air and sea thermometers. At Waglan, on the other hand, the air temperature is taken at a point two hundred feet above the level of the sea, and thus in strong winds the mechanical turbulence caused by the sheer cliff on the windward side of the island is enough to establish a local moist adiabatic lapse rate between the sea surface and two hundred feet, in contrast to the general inversion caused by the surface cooling. It can be seen that with strong winds, although the temperature of the air in contact with the sea may be higher than the sea temperature, the temperature as recorded on the top of the island may be lower. On the other hand in the case of calm or slight wind, the inversion would remain without distortion and higher air temperatures would be expected. Hence the results in no way contradict those obtained by Taylor under different circumstances.

5. Foggy Spell from 8th-12th March, 1920. (94 hrs. 30 mins.)

Visibility and temperature were not recorded then, and it is therefore difficult to describe this spell in detail. However, an attempt will be made to describe the general situation.

2100 hr., 7th March. An anticyclone is moving eastward across Japan, with a ridge of high pressure extending southwestward to South China and the northern part of the China Sea, a situation highly favourable for a rise in dew point along the China Coast. (Fig. 5).

2100 hr., 8th March. The high has spilt and a depression is developing in the region of the Bonins. Southerly stream dominates the China Sea. (Fig. 6).

2100 hr., 9th March to 2100 hr., 10th March. The depression has moved NE and intensified and the trough from Indo-China has advanced more northwards. Warm frontogenenesis has taken place and the China Coast is now under the influence of tropical air even more favourable for fog. The fog at Waglan is denser. However, the Asiatic High is moving SE behind a depression crossing the Sea of Okhotsk. (Figs. 7 and 8).

2100 hr. 11th March. The Asiatic high continues to advance. The associated cold front which passed Waglan at 0540 hr. on the 12th finally cleared the fog. (Figs. 9 and 10).

Throughout the fog spell, pressure at Waglan remained steady with the wind from between north and north-northeast, averaging Beaufort force three; except that on the 11th, while the fog was getting thinner, there was calm for some hours; the wind shifted to south force three at 1800 hr. at the approach of the cold front. At 0600 hr. on the 12th, after the front had passed, the wind freshened from northeast.

Gap Rock, which is only about twenty-five miles southwest of Waglan, experienced a comparatively small number of hours of fog in the whole period.

The explanation of this lies in the steep gradient of sea surface temperature along the China Coast, Waglan lying within the narrow belt of cold water hugging the Coast and Gap Rock outside it.

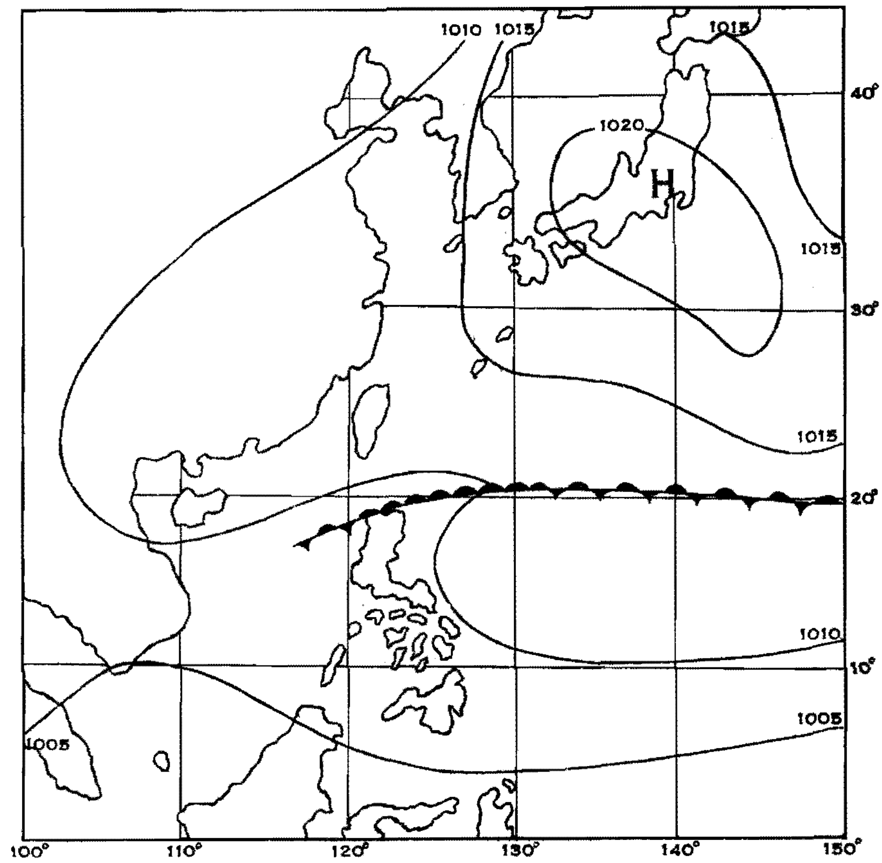

Fig. 5. 2100 hr. (Hong Kong Standard Time) 7th March, 1920.

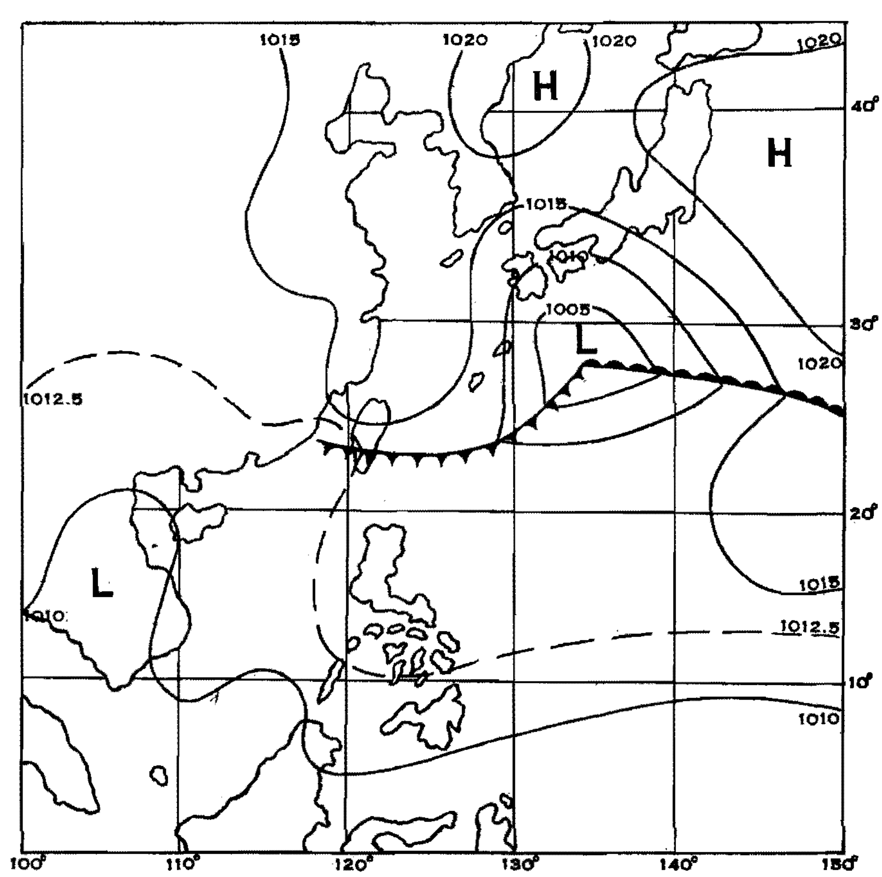

Fig. 6. 2100 hr. (Hong Kong Standard Time) 8th March, 1920.

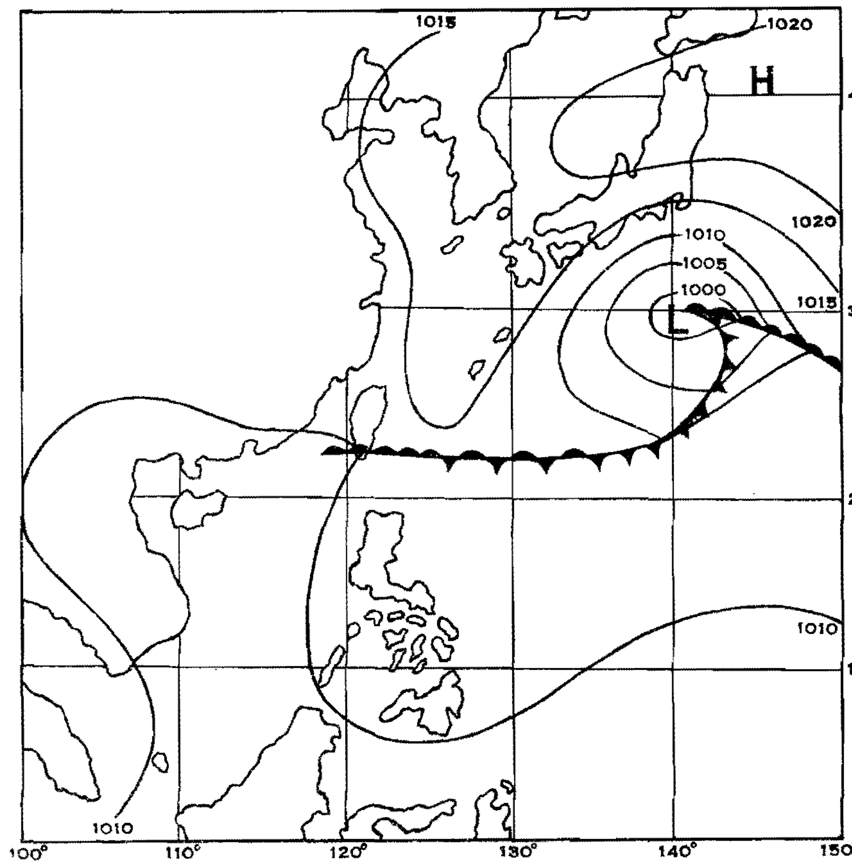

Fig. 7. 2100 hr. (Hong Kong Standard Time) 9th March, 1920.

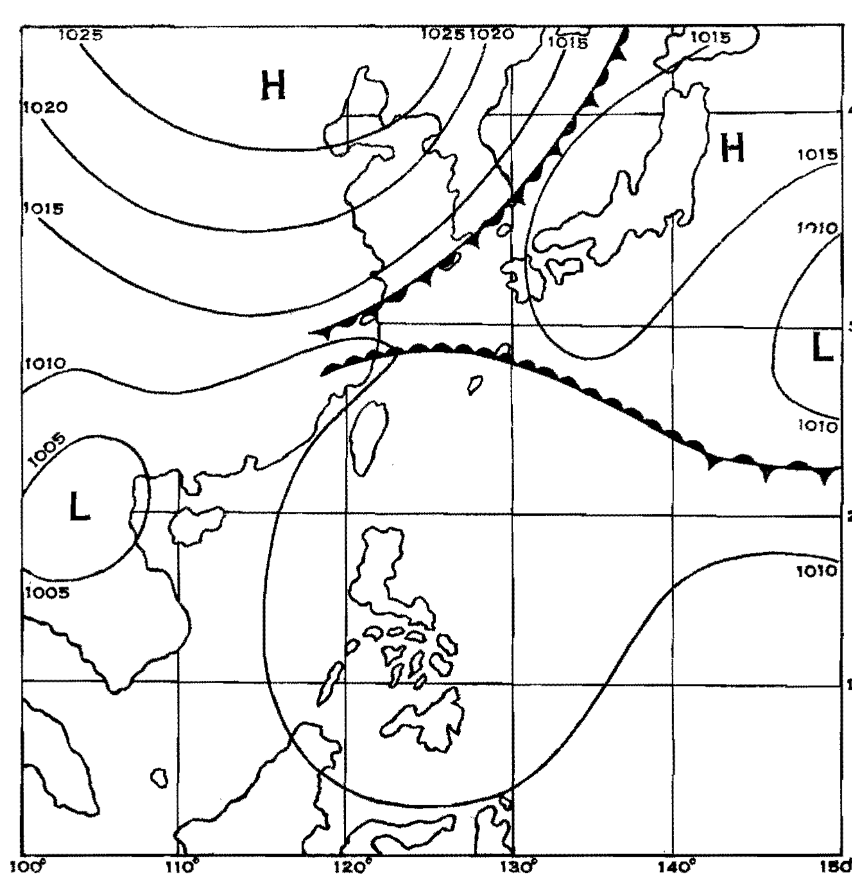

Fig. 8. 2100 hr. (Hong Kong Standard Time) 10th March, 1920.

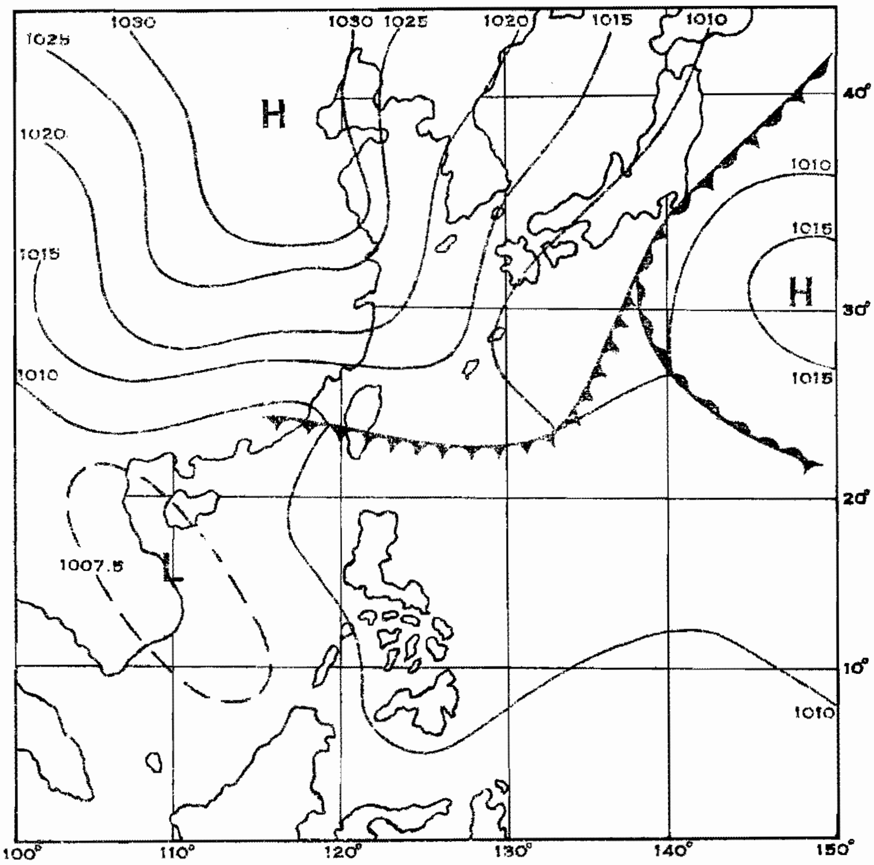

Fig. 9. 2100 hr. (Hong Kong Standard Time) 11th March, 1920.

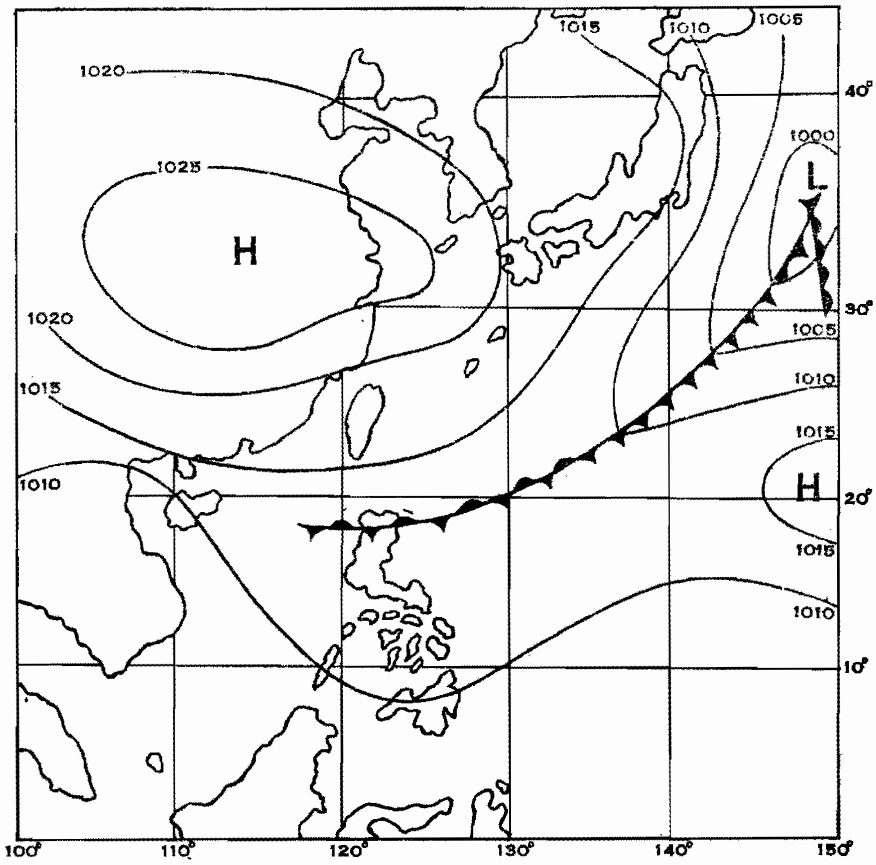

Fig. 10. 2100 hr. (Hong Kong Standard Time) 12th March, 1920.

PART II. The Relationship between Fogs observed at the Royal Observatory and Kai Tak Airfield and Waglan Fogs.

1. Data.

The Royal Observatory is located on a hill 109 feet above sea level on Kowloon Peninsula. It is exposed to all directions being about half a mile from the water front to the south, east and west, and about three miles from the Kowloon range to the north.

Kai Tak Airfield, which is about three miles northeast of the Royal Observatory, lies on the northern shore of Kowloon Bay, being flanked in the other directions by an arc of hills.

At the Royal Observatory only "days with fog" were recorded in the pre-war period while in the postwar period hourly observations of visibility and weather were made both at the Observatory and at Kai Tak Airfield. It is therefore rather difficult to relate the Waglan figures to those of the Observatory and Kai Tak. A further difference in the observations is that during the period 1919-1933 fog was recorded at Waglan whenever any atmospheric obscurity reduced the visibility to one mile or less, whereas at the Observatory and Kai Tak visibility of 1000 yards or less was the criterion.

2. Comparative Observations.

Table VIII – Number of Fog-days at Hong Kong Royal Observatory, 1919-1932.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1919	10	2	19	5	1	-	-	-	-	-	-	1	38
1920	4	5	11	11	7	-	-	-	-	-	-	2	40
1921	1	3	13	8	1	-	-	-	-	-	-	1	27
1922	1	11	11	10	1	-	-	-	-	-	-	0	34
1923	3	1	6	5	3	-	-	-	-	-	-	1	19
1924	5	7	2	13	0	-	-	-	-	-	-	2	29
1925	1	1	9	5	6	-	-	-	-	-	-	2	24
1926	2	5	6	8	7	-	-	-	-	-	-	2	30
1927	0	7	8	8	7	-	-	-	-	-	-	1	31
1928	4	4	10	3	0	-	-	-	-	-	-	1	22
1929	2	5	6	2	4	-	-	-	-	-	-	6	25
1930	3	9	7	5	0	-	-	-	-	-	-	2	26
1931	8	6	9	8	6	-	-	-	-	-	-	0	37
1932	2	3	7	13	0	-	-	-	-	-	-	3	28
Total	46	69	124	104	43	-	-	-	-	-	-	24	410
Mean	3.3	4.9	8.8	7.4	3.1	-	-	-	-	-	-	1.7	29.3

Table VIII shows the number of fog-days recorded at the Royal Observatory for the period 1919-1932. We notice that February, March and April are again the three months with most fog, and only a few cases were observed during the months June through November.

A separate table (IX) for Waglan, Hong Kong Royal Observatory, and Kai Tak during the period 1948-1950 is included here to enable direct comparison with Kai Tak, for which no pre-war records are available..

Table IX – Number of Fog-days at Waglan, Royal Observatory and Kai Tak, 1948-1950.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Waglan	12	20	16	12	4	-	-	-	-	-	-	4	68
R.O.	11	13	9	8	1	-	-	-	-	-	-	1	43
K.T.	3	11	7	4	1	-	-	-	-	-	-	1	27

From the table, we find that 43 fog-days were recorded at the Royal Observatory and 27 days at Kai Tak, as against 68 days at Waglan.

When a fog drifts in through the Lyemoon Pass from Waglan, it will mostly be blown westwards by the prevailing easterly wind in the harbour, and often crosses the tip of Kowloon Peninsula, reducing visibility at the Royal Observatory. On the other hand for fog to drift into the head of Kowloon Bay and over Kai Tak the wind in the harbour must be southeast. However this direction is critical for the passage of the fog through Lyemoon, since the eastern end of Hong Kong Island then exerts a blocking effect with the result that fog no longer enters the harbour. (Table X).

At Waglan, during the years 1948-1950, there was a total of 216 observations of fog; of which 141 were with visibility below 220 yards, 49 below 1,100 yards and only 26 between 1,100 yards and 1½ miles.

At the Royal Observatory there were 88 observations of fog during the years 1948-1950; of these 51 were associated with an easterly wind. The wind force varied from calm to force 5, with a maximum frequency for force 3 and 4, showing that fog observed at the Royal Observatory is still of the sea fog type like those at Waglan.

Table X – Number of fog observations with respect to wind direction for Waglan, Royal Observatory and Kai Tak (1948-1950).

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm	Total
Waglan	27	27	51	25	49	7	8	3	3	-	-	-	-	-	1	3	12	216
R. O.	11	-	3	3	51	5	1	-	-	-	-	1	1	-	-	1	11	88
K. T.	-	-	-	-	1	1	4	5	-	-	-	-	-	-	-	1	30	42

Table XI – Observations of fog for all months for Waglan, Royal Observatory and Kai Tak with respect to wind force. (1948-1950).

Force	0	1	2	3	4	5	Total
Waglan	12	17	80	92	12	3	216
R. O.	22	10	13	19	17	6	88
K. T.	30	5	4	3	-	-	42

From Table X, of 42 observations of fog at Kai Tak, 30 were accompanied by calm, and almost all the rest occurred with wind from the southeast quadrant. Again, we notice that out of 42 observations of fog, 21 gave visibility between 1,100 yards and 1½ miles. This shows well that the fog that drifts in from Waglan seldom sweeps onto Kai Tak Airfield, passing rather across the entrance of Kowloon Bay.

The diurnal maximum of fog frequency at Waglan occurs at about 0600 hr. (Fig. 2), whereas at both the Royal Observatory and Kai Tak it is at 0800 hr. This shows that usually fog develops first at Waglan and about two hours later is sighted within the harbour, where thereafter the fog tends to dissipate due to two process acting together or separately – (a) Increased mechanical turbulence due to obstacles in the path of the wind; (b) Increased convective turbulence due to the ground being warmer than the sea. In each case the turbulence tends to mix the fog-laden air with drier air above, and so disperses the fog.

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