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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



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COCOS ISLANDS MAGNETIC SURVEY, 1946

by

N.G. Chamberlain

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FOREWORD

This survey was done in 1946 to provide information for the preparation of more reliable maps than were then available. The information has of course been incorporated in maps prepared since 1946, but only recently it was realised that no permanent record of the survey had been made. For this reason the survey is now reported in the present form.

November 1960.

1. INTRODUCTION

The magnetic survey of the Cocos (or Cocos-Keeling) Islands, described in this report, was carried out between 28th February and 15th March, 1946. The primary purpose of the work was to observe the magnetic declination. On 3rd August 1945, in a letter to the Chief Geophysicist of the Mineral Resources Survey, it was pointed out by the Secretary of the Department of Air that the declination value for the Cocos Islands was uncertain, and that both the R.A.F. and R.A.A.F., which were at that time operating many aircraft in the vicinity, required the true value for navigation purposes. The Mineral Resources Survey possessed the necessary instruments and observers for magnetic survey work and, as a final outcome of the discussions, was requested by the South East Asia Command to make the necessary magnetic measurements on the Cocos Islands. The arrangements for air transport of personnel and equipment from Sydney to Cocos were completed by the R.A.A.F.. The forward trip was made by the R.A.F. Liberator Transport Command, and the return by the Qantas Empire Airways Service. The observations were carried out by the writer with the assistance of E. McCarthy, B.Sc. of the Radio Physics Laboratory, Sydney.

The instruments used were C.I.W. Theodolite-magnetometer No.18 and Earth Inductor No.18, Watts Vertical Intensity Variometer No.15887, and Chronometers Roskell B.78 and Brockbank and Atkins No.1437.

2. PURPOSE OF SURVEY

There is considerable discrepancy in the values of magnetic declination for the Cocos Islands as given on various charts. Some figures are quoted below :-

- (1) British Admiralty Chart No.2510, Cocos or Keeling Islands. Declination $4^{\circ}15'$ West for 1944 (decreasing slightly).
- (2) Long Range Air Navigation Chart, Sumatra; U.S. Army Map Service, Washington. Declination $4^{\circ}20'$ West. May 1942.
- (3) Survey of India. Cocos or Keeling Islands. (Survey Directorate 11th Army Group). Declination $2^{\circ}44'$ West. July 1944.
- (4) Australian Aeronautical Series. Sheet 2. 1944. Declination $5^{\circ}30'$ West for June 1942.

These figures illustrate the need which existed for a magnetic survey to resolve these differences in declination by establishing the true value.

The uncertainty with regard to the present declination of the Cocos Islands is not very surprising in view of the following circumstances :-

(a) An examination of all available published magnetic data failed to show any record of magnetic results for the Cocos Islands, and it was concluded that no land observations had previously been made there. The most recent observations made in the vicinity were ocean stations occupied during Cruise 6 of the "Carnegie" in 1920. The nearest of these to the Cocos Islands (Lat. $12^{\circ} 10'S$, Long. $96^{\circ} 50'E$) gave the following values :-

	<u>Lat.</u>	<u>Long.</u>	<u>Date</u>	<u>Declination</u>
Station 527 CV1	$10^{\circ} 16'S$.	$94^{\circ} 23' E$.	7/8/20	$4^{\circ} 01' W$.
528 CV1	$11^{\circ} 41'S$.	$93^{\circ} 22' E$.	8/8/20	$5^{\circ} 00' W$.

(b) There is a complete absence of control stations nearer than 700 miles by which to establish the secular variation appropriate to the region in question. In addition to this the secular variation for the Indian Ocean is known to be anomalous, there being a focus of rapid change between Madagascar and Fremantle, where, for the epoch 1922, the declination was changing at the rate of minus 14 minutes per year. (Note. Declination is reckoned positively from the geographic north towards the east). The rates of secular variation at the magnetic observatories at Batavia, Watheroo, and Mauritius are given below in terms of the total change in declination during the 10-year interval, 1925-1935 (Fleming and Scott, 1944):-

	<u>Lat.</u>	<u>Long.</u>	<u>Change in Declination</u> <u>1925 - 1935</u>
Batavia	$6^{\circ} 11'S$.	$106^{\circ} 49'E$.	+ $16'0$
Watheroo	$30^{\circ} 19'S$.	$115^{\circ} 52'E$.	+ $35'1$
Mauritius	$20^{\circ} 06'S$.	$57^{\circ} 33'E$.	- $1^{\circ} 50'$

It is clear that these stations will not provide a control for the secular variation at the Cocos Islands; they leave in doubt both the magnitude and direction of the variation.

While the immediate purpose of the survey was to determine the declination because of its practical importance, the position of the Cocos group at a considerable distance from any land mass makes it a favourable place for a complete absolute station. If reoccupied at intervals it should be a useful addition to the existing network of Island stations which are essential for the general study of terrestrial magnetism and the construction of magnetic charts.

3. DESCRIPTION OF SURVEY

The Cocos group consists of five main islands and many smaller ones arranged in typical atoll formation around a central lagoon (Plate 4). They are composed of coral sand and limestone, rise to an average elevation of 3 to 4 feet above sea level, and are for the most part thickly covered with coconut palms. Two absolute stations were established, one on West Island and the other on Direction Island. The former is to be regarded as the main station, the second being largely intended as a check. In each case the absolute sites were checked for possible magnetic disturbances by variometer readings, the results of which appear on Plates 1 and 2 together with station descriptions and plans showing connections and true bearings to fixed objects.

Additional variometer observations were made on West Island, Direction Island, and Home Island.

4. RESULTS OF ABSOLUTE OBSERVATIONS

(1). West Island

West Island, the largest island of the group, was almost entirely taken up by the air strip and many R.A.F. buildings and camps. A cleared area in the southern portion provided the only suitable location for the absolute station. Sun observations for latitude were impossible because of the proximity of the sun to the Zenith at meridian passage. For the latitude determination, observations were made on four stars, two to the north and two to the south. Azimuth and longitude were obtained from sun observations. The declination was observed on 28th February, readings being taken at ten-minute intervals between 09.30 and 18.00 hrs. LMT. The resulting diurnal variation curve is given on Plate 3. The horizontal intensity (H) and inclination (I) were observed on 2nd March. In the results given below (Table 1) I is shown negative, in accordance with the usual convention, because the total field is directed upwards. The correction factors of September 1944 have been applied to the observed mean of day values to make the reduction to International Magnetic Standard. The vertical intensity Z is derived from the product $H \tan I$.

(2). Direction Island

Direction Island is situated on the northern edge of the atoll. The existence of the Cable and Wireless Station as a permanent establishment may make this site a more convenient one for reoccupation than the station on West Island which is at present only temporarily occupied by the Royal Air Force. The western tip of the island provided the only clear area suitable for the observations. Azimuth and longitude were determined by sun observations, the latitude figure used being taken from the most recent Admiralty Chart (1944). A broken magnetometer suspension prevented the completion of two full sets of observations, and the results include five declination determinations but only two each for horizontal intensity and inclination.

In taking the mean declination, only the first three values have been included so as to obtain a better distribution over the diurnal variation curve.

5. VARIOMETER OBSERVATIONS

In addition to the absolute observations, a variometer survey was carried out to obtain more information on the distribution of vertical intensity. It was thought that any magnetic anomaly discovered might be associated with the geological structure forming the foundation of the atoll. It is interesting to note that the subsidence theory of atoll formation which was propounded by Darwin in 1889 was mainly based on his examination of the Cocos Islands. The theory assumes first the existence of an island formed by a volcanic peak rising above the ocean surface, providing conditions suitable for the growth of coral to form a reef around it. Subsidence of the island takes place, but at a sufficiently slow rate for the growth of coral to maintain the reef at sea level and preserve roughly the shape of the original island. The extent to which the subsidence continued is doubtful, drilling operations on atolls having failed to reach the foundations below the coral rock.

The presence of a magnetic anomaly at the Cocos Islands is evident from a comparison of the vertical intensity at the two absolute stations. There is a difference of approximately 140 gammas between the West Island and Direction Island values, the northern station having the higher value. (Here and in the following treatment of the variometer work, only the numerical value of Z is taken into account. Z is directed upwards and, according to the strict sign convention, all Z values would be negative for the region in question). The normal Z gradient of about 17 gammas per mile decreasing northwards, which would be expected in the neighbourhood of the Cocos Islands, would give a difference of 130 gammas, but of opposite sense to that observed.

A complete investigation of the anomaly would require variometer traverses across the centre of the atoll. The depth of water in the lagoon made these impracticable, and readings had to be confined to the islands forming the outer edge of the atoll.

Variometer observations were made on West Island, Direction Island, and Home Island, but Horsburgh Island and South Island were not accessible during the time spent on the survey. The variometer results are expressed in gammas as relative to a base station situated on West Island, and have been reduced to a common epoch. On Direction Island and Home Island the presence of buildings tended to restrict the work.

Two E-W traverses (AB and CD, Plate 4) were made across West Island; the readings were taken at 100-yard intervals. Over the limited distances through which it was possible to extend these traverses, the resulting vertical intensity profiles show no marked east-west gradient (Plate 5).

A north-south traverse with readings every quarter mile was taken, starting from the northern tip of West Island. These readings together with those taken on Home Island and Direction Island are shown on Plate 4.

To the profile plotted from the north-south traverse of West Island have been added the readings taken on Home Island and Direction Island, so as to give north-south distribution of vertical intensity assuming a negligible east-west gradient. The graph has been extended to the south by using the mean value of the readings along Traverse CD. The procedure may not be justified, but the result is interesting in suggesting that the north-south profile consists of two maxima superimposed on the normal gradient represented by the line O-O'.

From the variometer results it is concluded that -

- (a) There is a magnetic anomaly of about 250 gammas in vertical intensity;
- (b) The extent of the anomaly coincides approximately with the size of the atoll.

As the islands appear to be composed entirely of coral sand and limestone, the magnetic anomaly is good evidence of an underlying volcanic formation as would be required, on Darwin's theory, for the origin of the atoll.

6. REFERENCES

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|--------------------------------|------|-----------------------------------------------------------------------------------------------------------|
| CHAPMAN, S. and BARTELS, J., | 1940 | GEOMAGNETISM,
1, 114. |
| FLEMING, J.A. and SCOTT, W.E., | 1944 | List of geomagnetic observatories
and thesaurus of values.
<u>Terr. Magn. atmos. Elect.</u> 49 (2). |

TABLE 1 : WEST ISLAND

<u>LATITUDE</u>	<u>Date</u>	<u>Star</u>	<u>Obs. Latitude</u>
	27/2/46	Canopus	12° 12.2
	27/2/46	Castor	12.6
	27/2/46	E. Argus	12.0
	5/3/46	Pollux	<u>12.1</u>
		Mean=	<u>12° 12.2</u>

AZIMUTH AND LONGITUDE

<u>Date</u>	<u>Azimuth of Fixed Mark</u>	<u>Longitude E. of G.</u>
27/2/46 p.m.	168° 10.5	96° 49.7
27/2/46 "	168° 10.8	96° 49.5
28/2/46 a.m.	168° 10.9	96° 49.7
28/2/46 "	<u>168° 10.6</u>	<u>96° 49.6</u>
Mean	168° 10.7	96° 49.6

HORIZONTAL INTENSITY

<u>Date</u>	<u>L.M.T. h. m.</u>	<u>Obs. Values</u>
2/3/46	09 48	32911 gammas
"	10 41	900
"	13 56	881
"	14 40	886
"	15 54	854
"	16 51	<u>859</u>
	Mean	<u>32882</u>

INCLINATION

2/3/46	09 06	- 45° 20'4
	11 23	19.1
	13 26	19.2
	15 19	21.7
	17 28	<u>20.9</u>
	Mean	- 45° 20'3

Mean of day values

<u>Element</u>	<u>Date</u>	<u>Obs. Mean of Day</u>	<u>Corrected to I.M.S.</u>
D	28/2/46	- 3° 05'4	- 3° 05'8
H	2/3/46	32882 gammas	32862 gammas
I	2/3/46	-45° 20'3	-45° 20'0
Z	2/3/46	= H tan I	= 33247 gammas

TABLE 2 : DIRECTION ISLAND

AZIMUTH AND LONGITUDE

<u>Date</u>	<u>Azimuth of Fixed Mark</u>	<u>Longitude E. of G.</u>
8/3/46 p.m.	333° 18!9	96° 52.4
"	18.9	52.1
9/3/46 a.m.	19.2	52.4
"	<u>18.3</u>	<u>52.9</u>
Mean	333° 18.8	96° 52.4

DECLINATION

<u>Date</u>	<u>L.M.T.</u>	<u>Obs. Values</u>	<u>Reduced to I.M.S.</u>
	<u>h. m.</u>		
8/3/46	15 31	-02° 52.6	
9/3/46	10 34	-03° 04.9	
9/3/46	12 11	-02° 57.9	
10/3/46	09 58	-03° 00.8	
10/3/46	10 14	<u>-03° 00.2</u>	
	Mean	-02° 58.4	-02° 58.8

HORIZONTAL INTENSITY

<u>Date</u>	<u>L.M.T.</u>	<u>Obs. Values</u>	<u>Reduced to I.M.S.</u>
	<u>h. m.</u>		
9/3/46	10 57	33219 gammas	
"	11 49	<u>22</u> "	
	Mean	33220 "	33200 gammas

INCLINATION

<u>Date</u>	<u>L.M.T.</u>	<u>Obs. Values</u>	<u>Reduced to I.M.S.</u>
	<u>h. m.</u>		
9/3/46	09 59	-45° 10.2	
"	12 47	<u>09.6</u>	
	Mean	-45° 09.9	-45° 09.6

VERTICAL INTENSITY

9/3/46	Z	=	H tan I	=	33386 gammas
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MAGNETIC STATION AT WEST ISLAND : COCOS ISLANDS.

Latitude : $12^{\circ} 12'.2$ S.

Longitude : $96^{\circ} 49'.6$ E.

Occ. Feb. 27th - Mar. 5th 1946. Obs. NGC & EMCC.

The station was established near the edge of the cleared ground forming the overshoot area to the south of the airstrip proper, approx. 90 ft. from the ocean beach, in line with the eastern edge of the bitumen road parallel to and on the west of the airstrip, 943 ft. from the nearest corner of the bitumen taxi strip, 258.8 ft. from the NW corner of nearby High Freq. Direction Finder hut, marked by a brass screw set in the centre of concrete block, 12" long, 4" diam. left 1" above surface.

True Bearings.

Mast behind Flight Control Tower $149^{\circ} 33'.4$
(1700 yds. approx.)

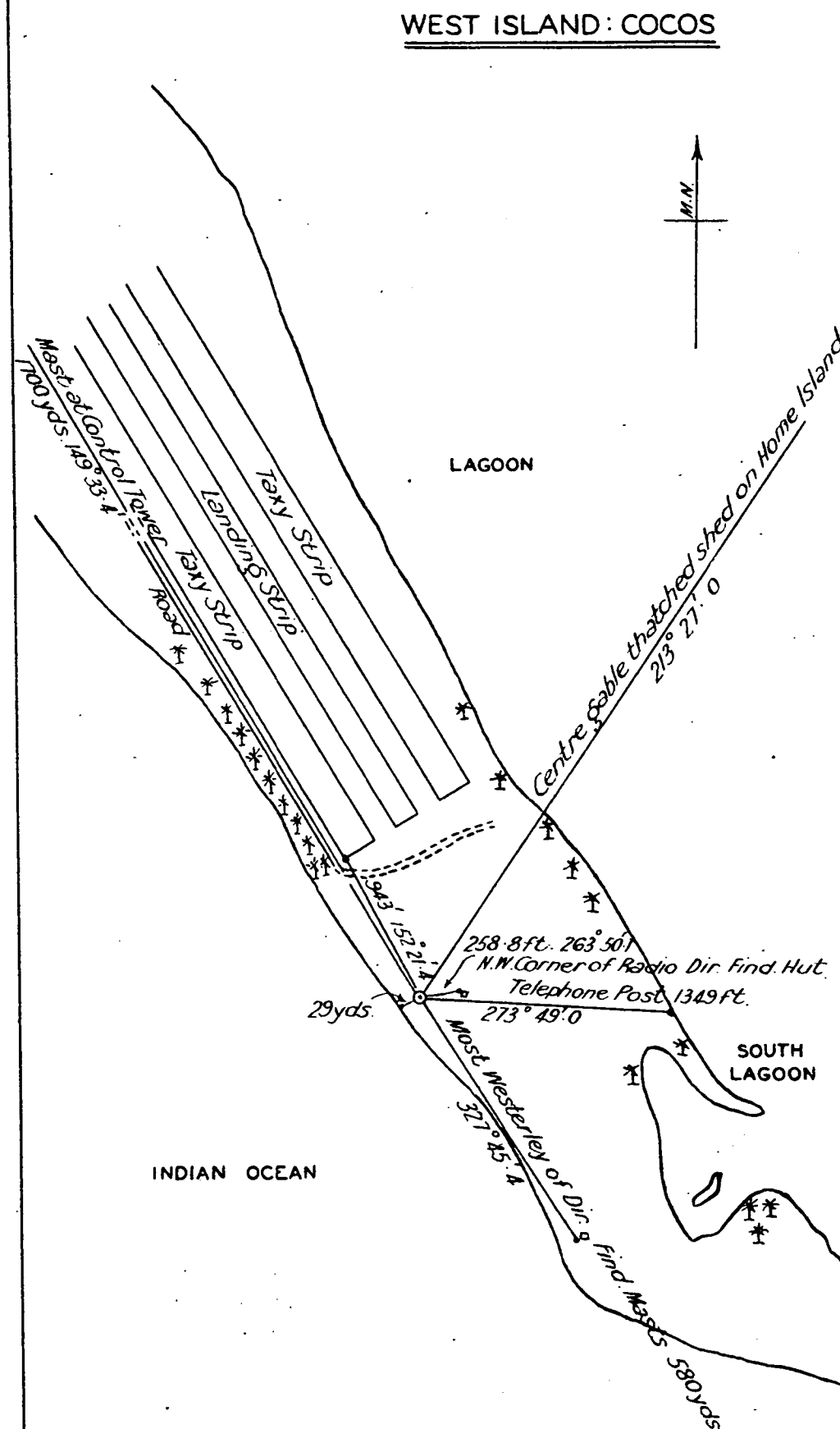
Nearest corner of bitumen Taxi Strip (943 ft.) $152^{\circ} 21'.4$

Centre of gable of thatched shed on HOME ISLAND. $213^{\circ} 27'.0$

NW corner of High Freq. Dir. Find. hut (258.8 ft.) $263^{\circ} 50'.1$

Lower end of telephone post on edge of lagoon, (1349 ft.) $273^{\circ} 49'.0$

Most westerly of four High Freq. Dir. Find. masts (580 yds. approx.) $327^{\circ} 45'.4$

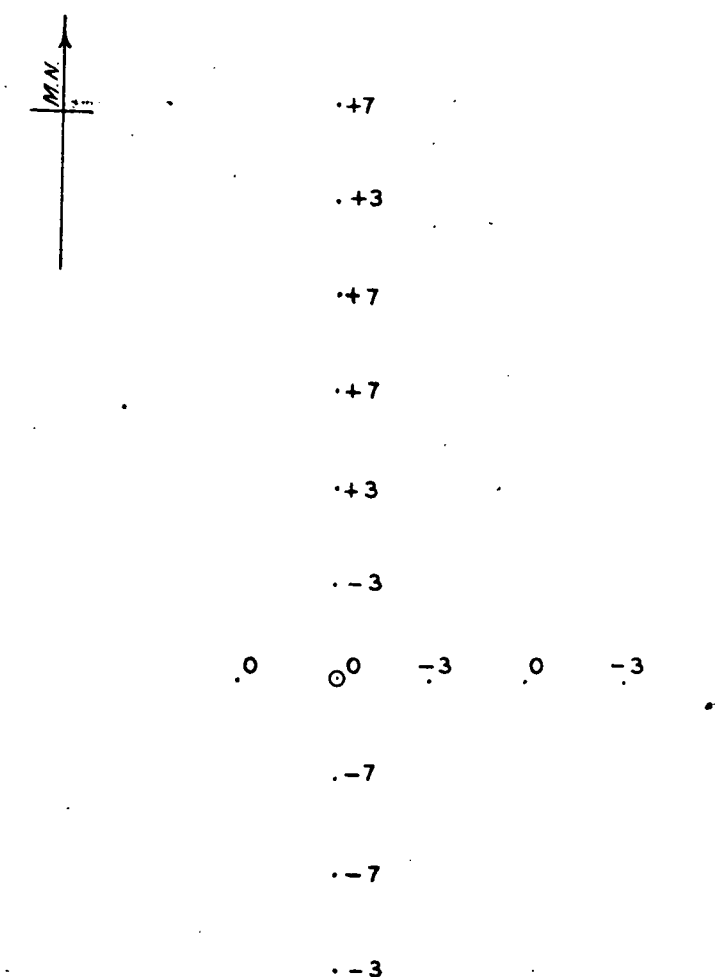


WEST ISLAND: COCOS

VARIOMETER RESULTS SHOWING VARIATIONS OF Z IN GAMMAS IN VICINITY OF THE

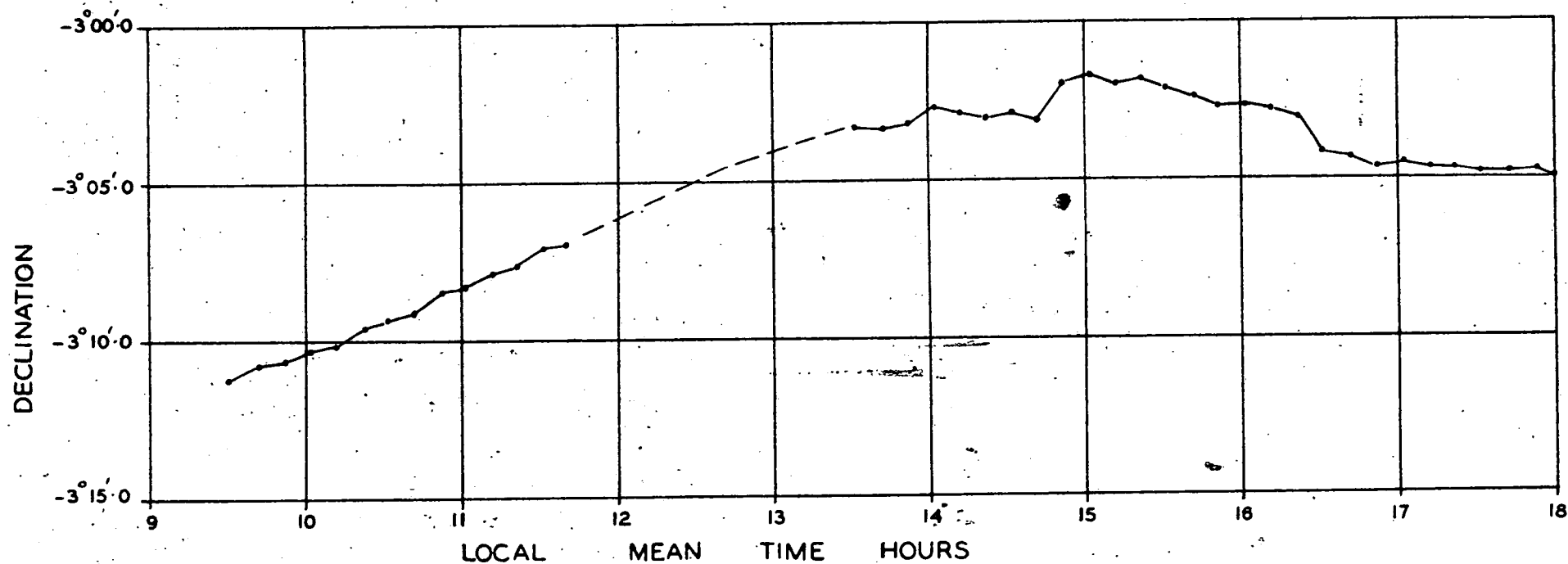
MAGNETIC STATION

Scale. 1" = 100 Ft.



COCOS WEST ISLAND. (LAT. 12° 12' 2" S. LONG. 96° 49' 6")

28TH. FEB. 1946





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SHOWING SITES OF ABSOLUTE AND VARIOMETER STATIONS, &
VARIOMETER TRAVERSES.

