Tides at Syowa Station

Sadakiyo HORI* and Eiichi INBE**

昭和基地における潮汐

堀　定清*・印部英一**

要　旨

1966年昭和基地においてはじめて長期間の潮汐観測に成功した．使用した験潮器は水圧式のもので，設置の状況はFig. 1およびFig. 2に示した．約一年間の観測資料のうちから独立した30日間の資料9組を選び，それぞれについて調和分解を行なった．結果はTable 1にかかげた．大潮における潮差は平均88cmで，主要な一日週潮の潮差の半日週潮のそれに対する比は1.07である．

1. Introduction

Tidal observation at Syowa Station, Antarctica, had been intended since the opening of the station in 1956. However, owing to difficulties in finding a suitable spot for installation of tide gauge, it was not executed until 1961, when the first pressure type tide gauge was installed near the station. The gauge was operated for one year, but among the data obtained only those of the first one week were fit for analysis. The results of the observation was reported by OURA and FUJINO (1965), and are quoted by the present authors in the text. In January 1966 the station was reopened after a four-year closure and a tide gauge of improved type was set on the coast near the station. The observation was continued successfully for one year and nine independent sets of one month data could be used in the harmonic analysis. The present report deals with the second observation and its results.

2. Observation

The tide gauge used was of pressure type, that is, the change of sea level was

* 海上保安庁水路部. Hydrographic Division, Maritime Safety Agency, Tsukiji 5-chome, Chuo-ku, Tokyo.

** 国土地理院. Geographical Survey Institute, Higashiyama 3-chome, Meguro-ku, Tokyo.

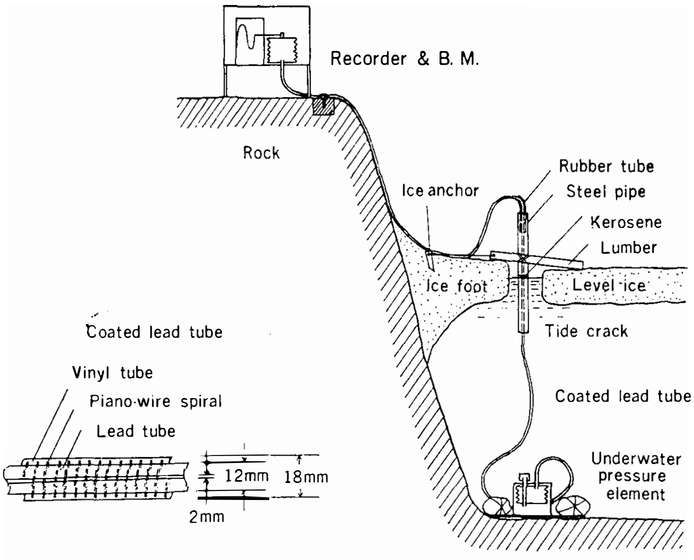

Fig. 1. Schematic representation of tide gauge installation in 1966 at Syowa Station.

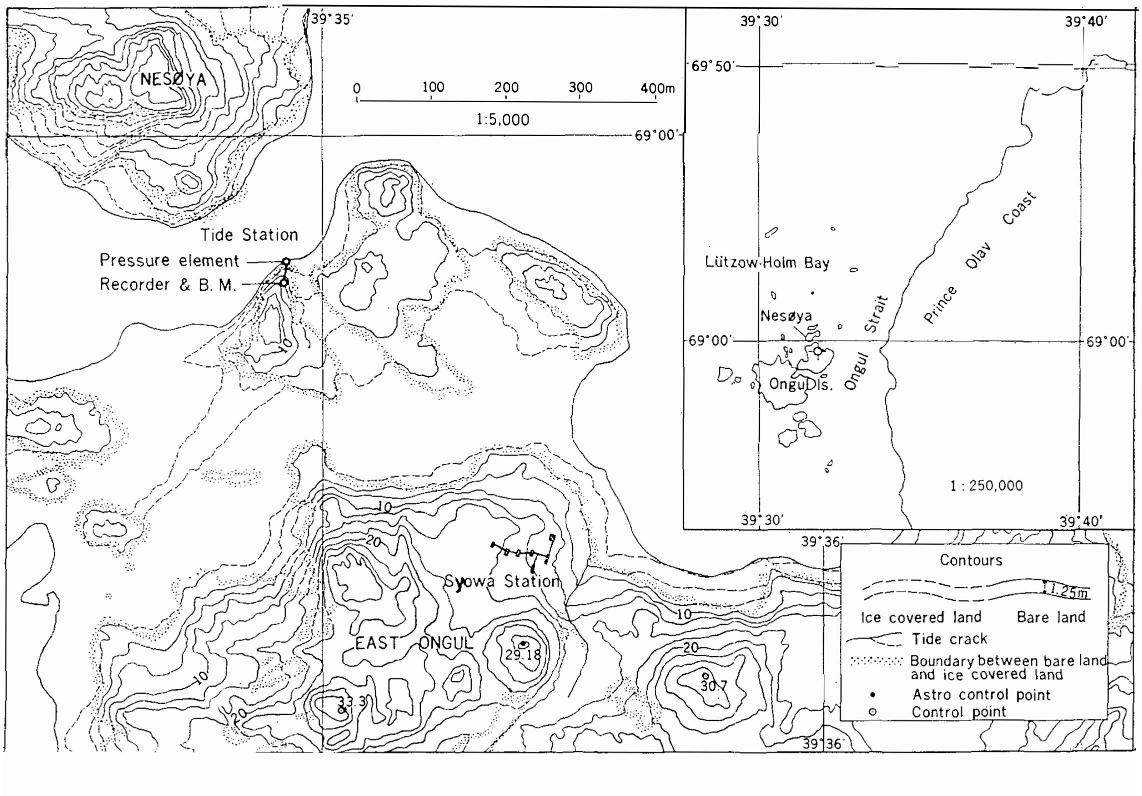

Fig. 2. Location of tide gauge in 1966 at Syowa Station.

detected as a pressure change of air inside a bellows in a bell submerged to the sea bottom and the pressure change was transmitted to another bellows in the recorder on shore through a lead tube which was protected against ice with spiral wire and vinyl tube. The movement of the bellows was enlarged and recorded on a strip chart by a pen with red ink. The chart was driven by a clock which was wound at regular intervals by an electric-motor and power of the motor was supplied from dry cells.

A spot on the coast 500 meters northwest of the station, East Ongul Island, was chosen for the tide station where bare rocks were not too far from the tide crack to connect with the lead tube and where a wintering member could reach easily for maintenance. Installation of the tide gauge is shown schematically in Fig. 1. The underwater pressure element (bell) was set through the tide crack where the water depth was about five meters. The recorder was fixed on a bare rock, about six meters above the sea surface, and about thirty meters from the tide crack. Location of the tide station, as shown in Fig. 2, was 69°00.1′S and 39°34.9′E.

Calibration of the tide gauge was made by measuring the vertical distance between a fixed point on shore and the sea surface, and the ratio of record to the actual range was determined to be 1/244 (1mm/2.4cm).

Maintenance of the instrument during the one-year operation was done by one of the present authors (INBE) who stayed on the island for the year.

3. Analysis

The data obtained by one-year observation include several discontinuances caused by troubles of the clock and by failures in supplying a new roll of strip chart to the recorder. From the data obtained nine sets of thirty-day continuous record were chosen to be analysed. Processing and analysis of the data were carried out at the Hydrographic Division by the method prepared for their electronic cumputor, HYPAC103. Results of analysis are given in Table 1 together with values obtained from the observation in 1961 (OURA and FUJINO, 1965) and with those of Molodezhnaya Station (SHAMONT′YEV, 1965) which is about 160 miles east-northeast from Syowa Station (69°00.2′S, 39°35.2′E). As shown in Table 1, the constants, both amplitudes and lags, obtained for each month are in good agreement for most of the dominant component tides (M_2, S_2 and O_1) and show relatively larger scattering around the mean values for other components. However, recently it has been made clear, from analysis for the eleven stations along the Japanese coast, that differences such as given in the table usually arise among the constants computed for different month of a year althouth they are not so systematic to be easily explained and that the mean value of constants for each component approximates very closely to the value obtained from one-year data (AKAGI, 1968, personal communication).

Table 1. Harmonic constants of the principal components tides at Syowa Station obtained from nine independent data sets of 30 days.

	Epoch 1966	K_1	O_1	P_1	Q_1	M_2	S_2	K_2	N_2	S_0***
Amplitude (cm)	Feb. 2	23.7	25.1	7.9	8.2	24.0	21.6	5.9	4.0	594.4
	March 4	21.2	24.9	7.1	6.5	24.9	20.5	5.6	5.4	587.8
	April 3	23.5	25.3	7.8	6.0	24.9	20.3	5.6	5.1	590.8
	May 3	23.7	25.6	7.9	4.9	24.6	19.3	5.3	5.1	599.7
	June 2	21.7	25.0	7.3	4.8	23.8	18.9	5.1	4.4	609.2
	Aug. 11	22.2	23.9	7.4	7.1	22.8	18.5	5.1	4.0	590.3
	Oct. 6	17.9	24.0	6.0	5.3	23.5	19.1	5.2	4.2	592.3
	Nov. 5	19.7	24.5	6.6	5.4	23.9	19.0	5.2	4.0	597.5
	Dec. 11	21.2	24.7	7.1	4.5	23.5	19.9	5.4	4.3	592.4
	Mean	21.6	24.8	7.2	5.9	24.0	19.7	5.4	4.5	594.9
	1961*	20.4	21.5	6.8	—	17.9	20.2	5.5	—	
	Molod.**	21.8	21.8	7.3	4.4	19.0	18.5	5.0	3.8	
Lag (°)	Feb. 2	4.6	351.6	4.6	350.5	161.9	180.6	180.6	158.2	
	March 4	358.4	352.3	358.4	333.5	166.2	184.2	184.2	156.5	
	April 3	353.9	352.7	353.9	327.4	167.0	184.2	184.2	151.8	
	May 3	359.9	350.5	359.9	331.6	164.1	182.0	182.0	147.3	
	June 2	359.2	348.8	359.2	343.0	161.5	179.3	179.3	154.7	
	Aug. 11	4.6	349.9	4.6	351.9	163.9	178.9	178.9	146.0	
	Oct. 6	0.3	352.3	0.3	331.5	163.3	175.9	175.9	150.3	
	Nov. 5	353.2	352.7	353.2	330.2	162.6	174.8	174.8	142.8	
	Dec. 11	359.8	349.7	359.8	341.5	165.7	179.5	179.5	140.6	
	Mean	359.3	351.2	359.3	337.9	164.0	179.9	179.9	149.8	
	1961*	351	337	351		154	171	171		
	Molod.**	3.5	350.1	3.5	350.1	159.8	177.1	177.1	159.8	

* From Feb. 28 to March 7. OURA and FUJINO (1965).

** Molodezhnaya Station. SHAMONT'YEV (1965).

*** 30-day mean sea level below bench mark (cm).

4. Tidal Characteristics

Some tidal characteristics of the station derived from Table 1 are as follows:

Mean spring range, $2(H_m + H_s)$: 88cm

Ratio of principal diurnal range to semi-diurnal,
$(H_o + H')/(H_m + H_s)$: 1.07

Time of high water of principal lunar semi-diurnal (M_2) after upper and lower transit of the Greenwich meridian (in lumar hours) : 2.9

The type of tide at Syowa Station is similar to those observed at other stations on the Indian Ocean coast, namely, Molodezhnaya, Gauss and Wilks stations. For the convenience of reference, tidal constants of 37 stations on the Antarctic coast and the southern islands are extracted from the Special Publication No. 26 of the International Hydrographic Bureau and listed in Table 2.

5. Mean Sea Level

Owing to the intermissions of observation invariability of recording level was not secured throughout the year, so the values of mean sea level for each period of continuous recording were determined and averaged after being weighted with duration of each period. The results of computation is as follows, where numerals are the vertical distances in cm measured from the bench mark by the recorder.

Period (1966)	Duration (month)	Mean sea level
Feb. 2～July 1	5	596.4
Aug. 11～Sept. 9	1	590.3
Oct. 6～Dec. 4	2	594.9
Dec. 11～Jan. 9	1	592.4
	Average (weighted)	594.9

Values for each monthly mean sea level are also given in the last column of Table 1.

According to the measurement of difference in height between the bench mark and a control point, height of which refers to the mean sea level determined in 1957 by observation of a rather short period, the bench mark is 573 cm above the mean sea level so that there exist 22 cm of difference between two reference levels.

Table 2. Tidal constituents on the Antarctic coast and the southern islands.*

No.	Region	Station	Position	H_m	k_m	H_s	k_s	H'	k'	H_0	k_0	Co-tidal hour**	$\frac{H'+H_0}{H_m+H_s}$	$2(H_m+H_s)$
				cm	°	cm	°	cm	°	cm	°	h		cm
1	Ross Island	Scott Base	77°52′S 166°48′E	4	338	3	249	29	351	31	3	0.2	8.93	13
2	Ross Island	Cape Armitage	77°49′S 166°45′E	5	10	3	272	24	14	24	0	1.2	5.95	15
3	Ross Island	Cape Evans	77°38′S 166°33′E	5	22	3	265	23	10	23	2	1.6	5.98	15
4	Ross Island	Cape Royds	77°34′S 166°10′E	6	5	2	27	21	12	20	0	1.1	4.87	17
5	Campbell Island		52°33′S 169°09′E	40	43	11	43	5	344	2	339	1.1	0.12	102
6	Auckland Island		50°52′S 166°05′E	36	9	11	23	3	40	6	54	1.2	0.18	93
7	Macquarie Island		54°31′S 158°50′E	28	13	8	42	9	33	8	9	1.8	0.47	71
8	Adélie Coast	Cape Denison	67°00′S 142°40′E	28	332	13	27	31	3	30	343	1.6	1.46	83
9	Adélie Coast	Port Martin	66°50′S 141°25′E	26	335	14	22	31	353	32	346	1.8	1.58	80
10	Adélie Coast	Pointe Geologie	66°40′S 140°01′E	26	342	14	28	29	8	29	348	2.1	1.47	80
11	Adélie Coast	Rocher X	66°20′S 136°42′E	30	353	16	43	26	22	27	6	2.7	1.15	92
12	Budd Coast	Wilks Station	66°15′S 110°31′E	28	1	17	61	25	355	26	343	4.6	1.16	89
13	Wilhelm II Coast	Gauss Station	66°02′S 89°38′E	23	19	12	101	19	7	21	0	6.6	1.15	70
14	Heard Island		53°01′S 73°23′E	25	342	10	42	15	262	10	247	6.5	0.72	69
15	Kerguelen Island	Port-aux-Francais	49°21′S 70°13′E	52	322	24	17	7	211	3	173	6.0	0.13	153
16	Kerguelen Island	Betsy Cove	49°09′S 70°12′E	44	9	25	52	4	289	7	292	7.6	0.16	136
17	Kerguelen Island	Observatory Bay	49°25′S 69°53′E	49	324	29	10	6	215	2	140	6.1	0.10	156
18	Enderby Land	Molodezhnaya Station	67°41′S 45°47′E	19	160	19	177	22	4	22	350	2.2	1.16	75
19	Enderby Land	Syowa Station	69°00′S 39°35′E	24	164	20	180	22	359	25	351	2.9	1.07	88
20	South Georgia	Moltke Harbour	54°31′S 36°00′W	23	213	12	236	5	52	10	18	9.5	0.45	69
21	South Georgia	King Edward Cove	54°17′S 36°30′W	24	202	12	224	5	50	10	15	9.1	0.43	73
22	South Georgia	Leith Harbour	54°08′S 36°41′W	28	191	12	221	4	64	9	27	8.8	0.34	79
23	Luitpold Coast	Shackleton Base	77°59′S 37°10′W	62	201	45	222	20	368	28	338	9.2	0.45	213

No.	Region	Station	Position	H_m	k_m	H_s	k_s	H′	k′	H_0	k_0	Co-tidal hour**	$\frac{H'+H_0}{H_m+H_s}$	$2(H_m+H_s)$
24	Antarctic Peninsula	Bahia Esperanza	63°18′S 56°55′W	61	162	42	198	40	0	41	333	9.2	0.78	207
25		Hope Bay	63°24′S 56°59′W	63	150	38	189	38	339	42	334	8.8	0.81	200
26		Punta Observatorio	64°15′S 62°58′W	27	204	18	289	31	26	3	21	11.0	0.73	91
27		Puerto Melchior	64°20′S 62°59′W	28	163	20	246	31	12	31	359	9.6	1.31	94
28		Nansen Island	64°33′S 61°57′W	38	162	24	237	37	7	34	357	9.5	1.14	124
29		Lemaire Channel	64°47′S 62°43′W	27	164	21	244	32	12	30	0	9.7	1.29	96
30		Puerto Neko	64°48′S 62°23′W	28	190	20	274	33	34	32	16	10.5	1.33	97
31		Puerto Charcot	65°04′S 64°02′W	22	163	19	255	32	7	30	2	9.7	1.48	83
32		Port Circoncision	65°10′S 64°14′W	20	161	17	266	31	21	29	16	9.7	1.63	74
33		Stella Creek	65°15′S 64°16′W	24	161	21	266	39	21	33	5	9.7	1.61	90
34		Ferin Head	66°01′S 65°21′W	17	153	17	266	32	19	29	8	9.5	1.78	68
35		Lent Island	66°53′S 66°48′W	15	146	16	276	32	24	25	7	9.4	1.84	61
36		Palmer Peninsula	68°11′S 67°00′W	15	134	19	287	29	24	24	8	9.1	1.59	67
37		Bahia Margarita	68°12′S 67°00′W	14	134	19	288	28	24	23	7	9.0	1.59	65
38		Marguerite Bay	68°12′S 67°03′W	14	137	20	287	31	23	25	77	9.1	1.67	67
39		Barry Island	68°08′S 67°05′W	16	132	20	291	33	28	25	10	8.9	1.64	71

* Values of harmonic constants were taken from the Special Publication No. 26 of the International Hydrographic Bureau, except that for Enderby Land.

** Numerals indicate time of high water of the principal lunar semidiurnal tide (M_2) in lunar hours after upper and lower transit of the Greenwich meridian.

Acknowledgements

The authors are indebted to the members of the seventh Japanese Antarctic Research Expedition for their cooperation in installation and maintenance of the tide gauge. They also wish to express their hearty thanks to the members of the Oceanographic Section of Hydrographic Division who helped them in data processing and computation.

References

OURA, H. and K. FUJINO (1965): Tides at Syowa Station. Antarctic Rec., **24**, 14–17.

SHAMONT′YEV, V. A. (1965): Resul′tay nablyudeniy za prilivo-otlivnymi yavleniyami v rayone statsii Molodezhnoy. [Results of observations on tidal phenomena in the Molodezhnaya Station area.] Trudy Sovet. Antarct. Exped. [Pap. Soviet Antarct. Exped.], **44**, 115–123.

(*Received May 8, 1968*)