Preliminary Report of Glaciological Studies

*Kenzo FUJIWARA**, and *Yasoichi ENDO***

1. Introduction

During the traverse between Syowa Station and the South Pole in 1968–69 glaciological studies were carried out on the ice sheet of the East Antarctica with the main aim of investigating snow accumulation and snow condition. The items studied were as follows:

1) Measurements of temperature in the holes dug in the snow 10 m deep for seismic shot. The measurements were made at 23 sites (Observer: K. FUJIWARA).

2) Observations of the relief of snow surface at intervals of 2 or 4 km along the route (K. FUJIWARA).

3) Measurements of hardness and temperature on the surface layer of snow at intervals of 8 km between Syowa Station and the South Pole. In addition, measurement of density was made at intervals of 16 km between Syowa Station and the Plateau Station (M. HOSOYA, and T. ETO).

4) Measurement of snow accumulation by the snow stakes placed in 1967–68 at intervals of 2 km along the route from Syowa Station to the Plateau Station (A. KOBAYASHI, I. KAWASAKI, and K. FUJIWARA).

5) Stratigraphical studies in the 2 m pits dug at 44 sites for determining the annual snow accumulation (K. FUJIWARA).

6) Collection of snow core samples, 10 m long, taken out from the holes dug for seismic shot (K. FUJIWARA).

In this paper the results of studies on the item 1 to 5 are reported. The snow samples mentioned in item 6 were sent to the Institute of Low Temperature Science, Hokkaido University, Sapporo, and studies are now being carried out.

2. Mean Annual Air Temperature

In an ice sheet which never melts, the snow temperature at 10–15 m deep gives an approximate value of the mean annual air temperature at the surface. To obtain the annual air temperature, holes of 10 m depth were dug at 23 sites between Syowa Station and the South Pole, although at five sites the holes were shallower than 10 m.

The temperatures were determined by a thermistor thermometer, keeping

* College of General Education, Hiroshima University, Hiroshima. Member of the JARE South Pole Traverse 1968–69.

** Institute of Low Temperature Science, Hokkaido University, Sapporo. Member of the JARE South Pole Traverse 1968–69.

Table 1. Snow temperature at the depth of 10 metres.

Station No.	Bottom of holes		Date
	Depth (m)	Snow temp. (−°C)	
Syowa St.		(10.0)	
16	7.5	14.3	20 Apr. 1968
70	10.0	24.1	12 Feb. 1969
126	10.0	29.2	26 Apr. 1968
170	10.0	30.2	7 Feb. 1969
244	9.2	38.4	17 Oct. 1968
330	10.0	46.0	4 Feb. 1969
400	8.8	52.2	25 Oct. 1968
414	10.0	51.6	31 Jan. 1969
470	9.0	54.6	31 Oct. 1968
〃	10.0	54.0	28 Jan. 1969
530	6.2	56.5	5 Nov. 1968
556	10.0	57.1	24 Jan. 1969
590	6.2	60.0	9 Nov. 1968
Plateau St.		(56.6)	
687	8.9	55.5	18 Nov. 1968
747	9.9	51.2	24 Nov. 1968
777	9.5	50.5	26 Nov. 1968
807	9.5	50.3	30 Nov. 1968
837	9.6	49.9	4 Dec. 1968
867	10.0	49.4	7 Dec 1968
897	9.8	49.3	10 Dec. 1968
927	10.0	49.1	12 Dec. 1968
957	9.8	49.2	15 Dec. 1968
975	9.8	49.8	18 Dec. 1968
South Pole		(50.8)	

( ) Adopted from other studies.

enough time before final readings were taken. Care was taken not to leave boring scraps of snow at the bottom of the holes.

The temperatures are listed in Table 1, along with the mean annual air temperature at Syowa, the Plateau, and the South Pole. In Figs. 1 and 2, these snow temperatures at 10 m deep are plotted against the elevation and the distance from the coast along 43°E, respectively. As shown in Fig. 1, the decreasing in temperature with elevation was about 1.0°C/100 m on the marginal slope rising from Syowa Station (approximately sea level) up to St. 170 (2,000 m). The rate increased gradually towards the inland and attained to the value of 1.4°C/100 m in the region from St. 170 (2,000 m) to St. 414 (3,000 m). It reached 2.5°C/100 m

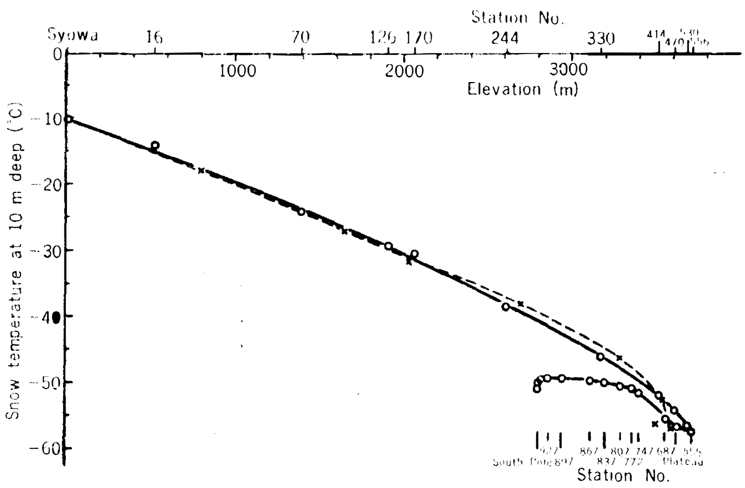

Fig. 1. Snow temperature at the depth of 10 m plotted against surface elevation. Solid line: Queen Maud Land after the JARE South Pole Traverse. Broken line: Queen Mary Land after BOGOSLOVSKI.

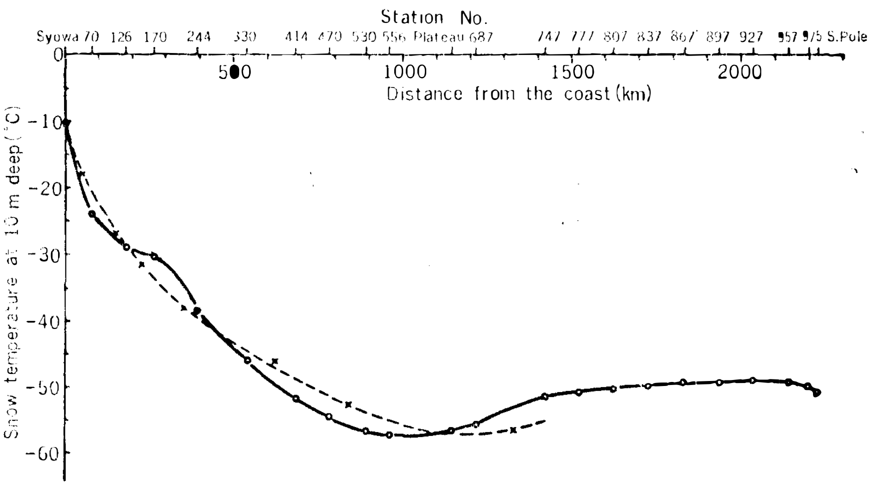

Fig. 2. Snow temperture at the depth of 10 m plotted against distance from the coast. Solid line: Queen Maud Land after the JARE South Pole Traverse. Broken line: Queen Mary Land after BOGOSLOVSKI.

between St. 414 and St. 747, where is located the highest point (St. 556) called Fuji Divide (tentative) on the traverse route. Beyond the divide, the rate decreased to 0.3°C/100 m between St. 747 (3,400 m) and the South Pole (2,800 m). Such change in the lapse rate of temperature suggests that the temperature is influenced not only by elevation but also by latitude and distance from a coast. The increase in the rate from Syowa Station to the Fuji Divide is due to the increase in latitude and distance from a coast, and the decrease from the Fuji Divide to the South Pole is due to the decrease of distance from a coast.

3. Conditions of the Snow Surface

The surface conditions of snow along the traverse route were investigated by observing surface relief, hardness, and density of snow. The results indicated that the surface conditions were distinctly different in different topographic divisions of the East Antarctic ice sheet.

3.1. Surface relief and wind directions

Roughness of snow surface and other surface conditions such as orientation and size of surface relief were measured and photographed at intervals of 2 or

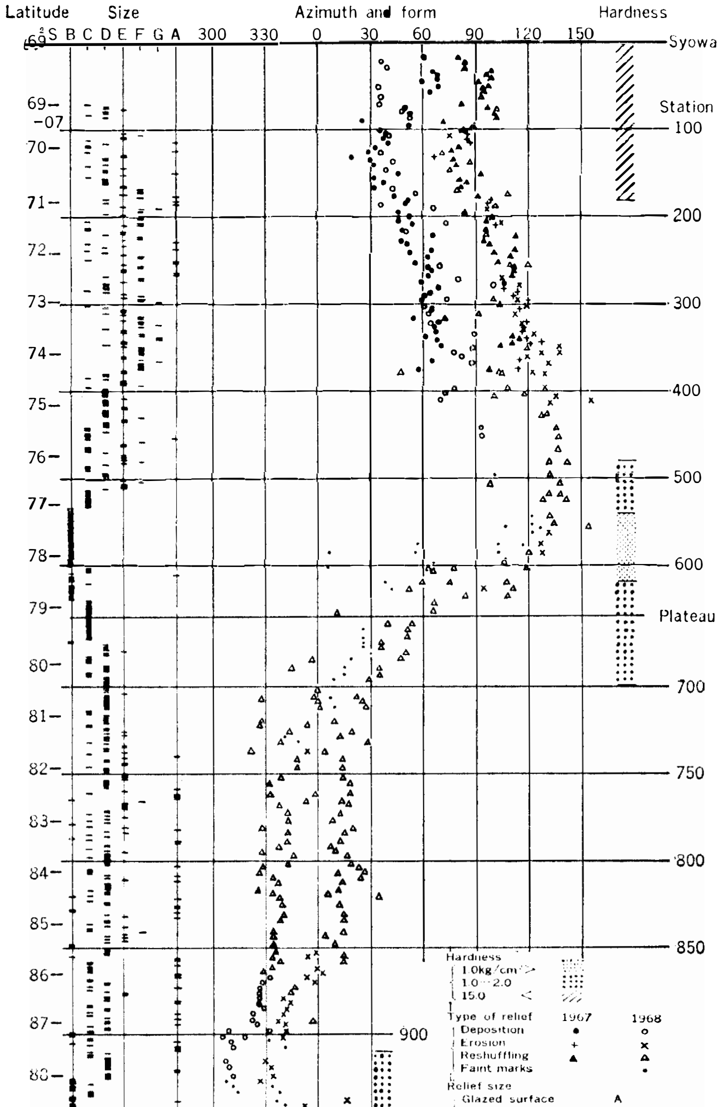

Fig. 3. Surface conditions along the traverse route.

4 km along the route (Photos 1-17). These surface features must have a close connection with the direction of the predominant wind. The observed surface reliefs can be divided into the following four types.

Deposition type :	Drift form, barchanoid, etc.
Erosion type :	Sastrugi, pit, etc.
Reshuffling type:	An elevation formed by deposition of snow on the leeward side and simultaneous erosion on the windward side.
Faint mark type:	Ripple marks, etc.

Table 2, Fig. 3, and General map inside of the back cover, respectively give the orientation, size, and type of surface relief, observed along the traverse route. As shown in Fig. 3, in the region from Syowa Station to 75°S, the surface relief is mostly of deposition, erosion, and reshuffling type and is fairly large in size (40-70 cm in height). A characteristic of surface relief in this region is that its orientations are different with the deposition and erosion types. Relief of the deposition type is oriented parallel to the contour lines while relief of the erosion type is oriented 40° off the direction of the maximum slope (see General map). Therefore, the winds giving rise to the two kinds of relief deviate in direction by $50^\circ(=90^\circ-40^\circ)$ from each other. It is highly probable that surface relief of the deposition type is formed by cyclonic storms while that of the erosion type is formed by katabatic winds. If this be correct, it would turn out that the influence of cyclonic storms is not confined to the marginal slope but extends into the interior as far as latitude 75°S.

On the antarctic plateau between 75°S and 81°S, relief of the deposition and erosion types was very obscure and no relief higher than 40 cm was found. Near the Fuji Divide, snow surfaces become so smooth that only faint marks like ripples were observed. Beyond the Fuji Divide, the direction of the maximum slope shifts from NNE to SW and so does also the wind direction. In this gently sloping region between 75°S and 81°S, the winds must be mild throughout the year.

Between 81°S and 86°S, no relief other than the reshuffling type was found. The relief was not higher than 40 cm and oriented in two directions of NNE and NNW.

To the south of 86°S, three types of relief, the deposition, the erosion, and the faint marks were observed, disappearing the reshuffling type. The relief was less than 30 cm in height and it changed remarkably in type and size at various portions of the undulations of ice sheet ; on the top of the undulations, glazed surfaces were formed, whereas relief of the deposition and erosion types were formed on the bottom.

The angle of deviation between the directions of wind and maximum slope ranges from 60° to 90° in the region extending between 86°S and the South Pole.

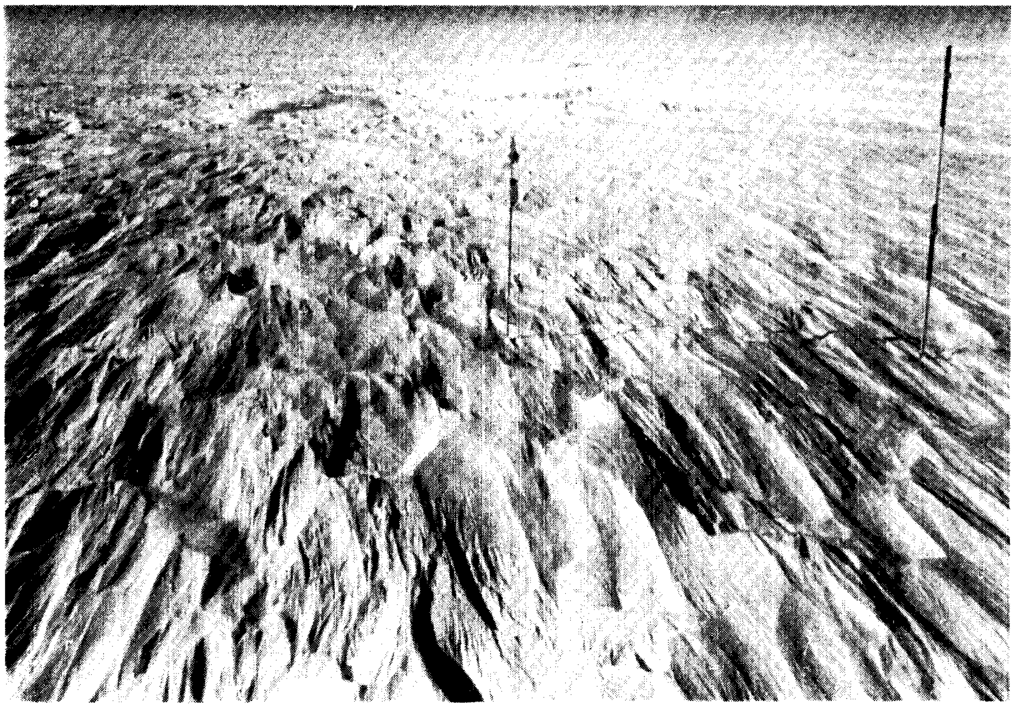

Photo 1. Sastrugi, like a fine split, in the initial stage of development (at St. 144).

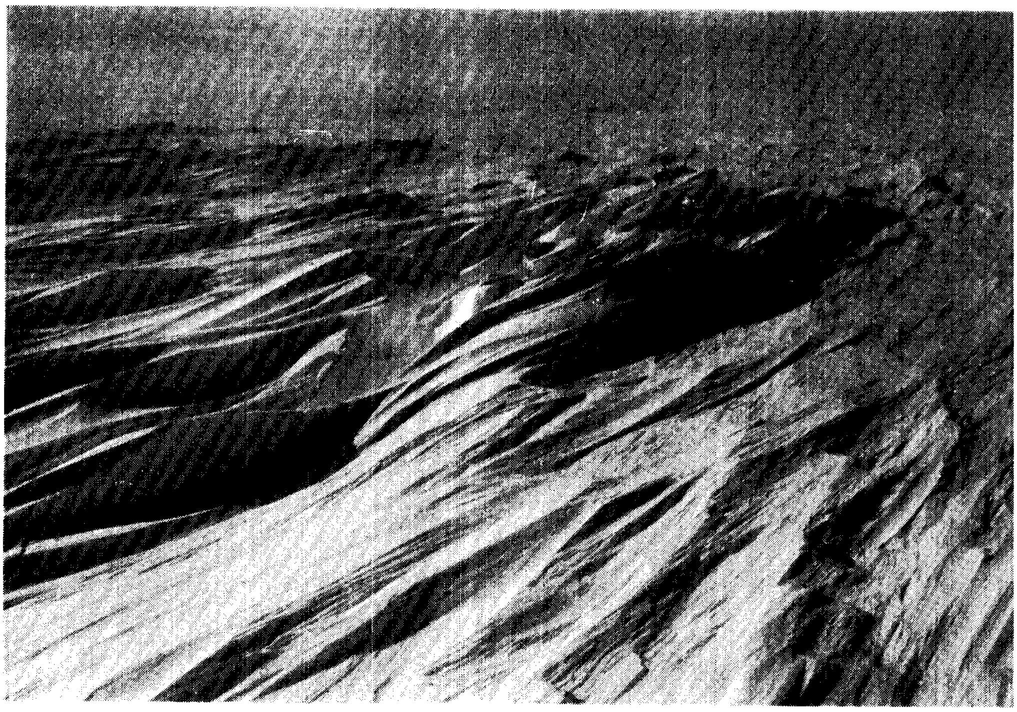

Photo 2. Severe sastrugi carved by a strong wind (at St. 178).

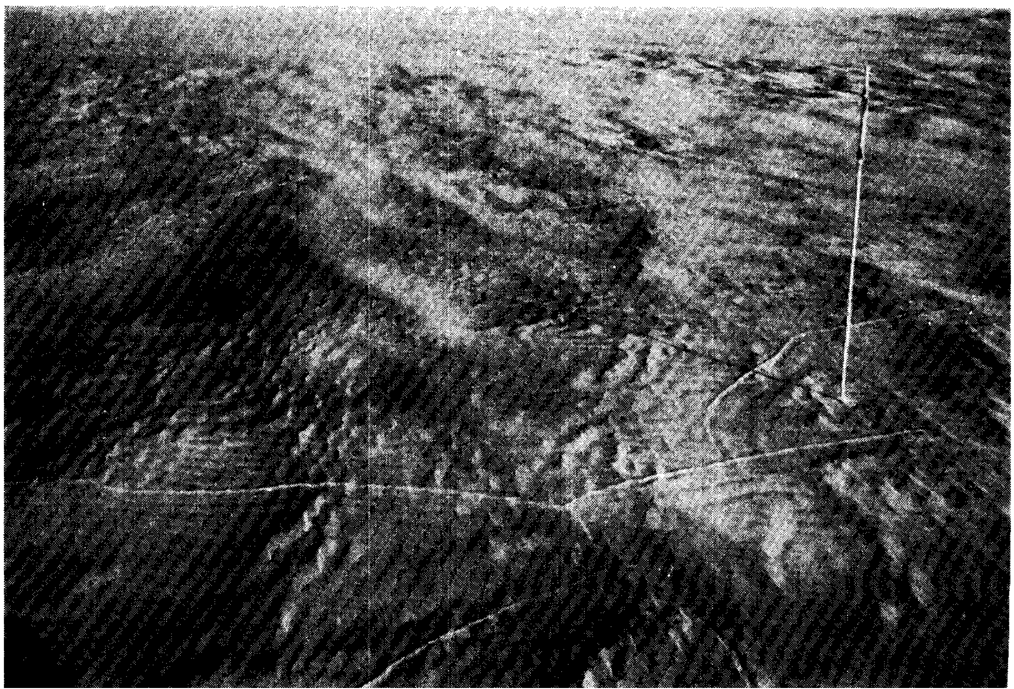

Photo 3. Glazed surface with polygonal pattern of cracks (at St. 186).

Photo 4. The prominent sastrugi with a hard surface. It was so large that the vehicle could not go over it (at St. 222).

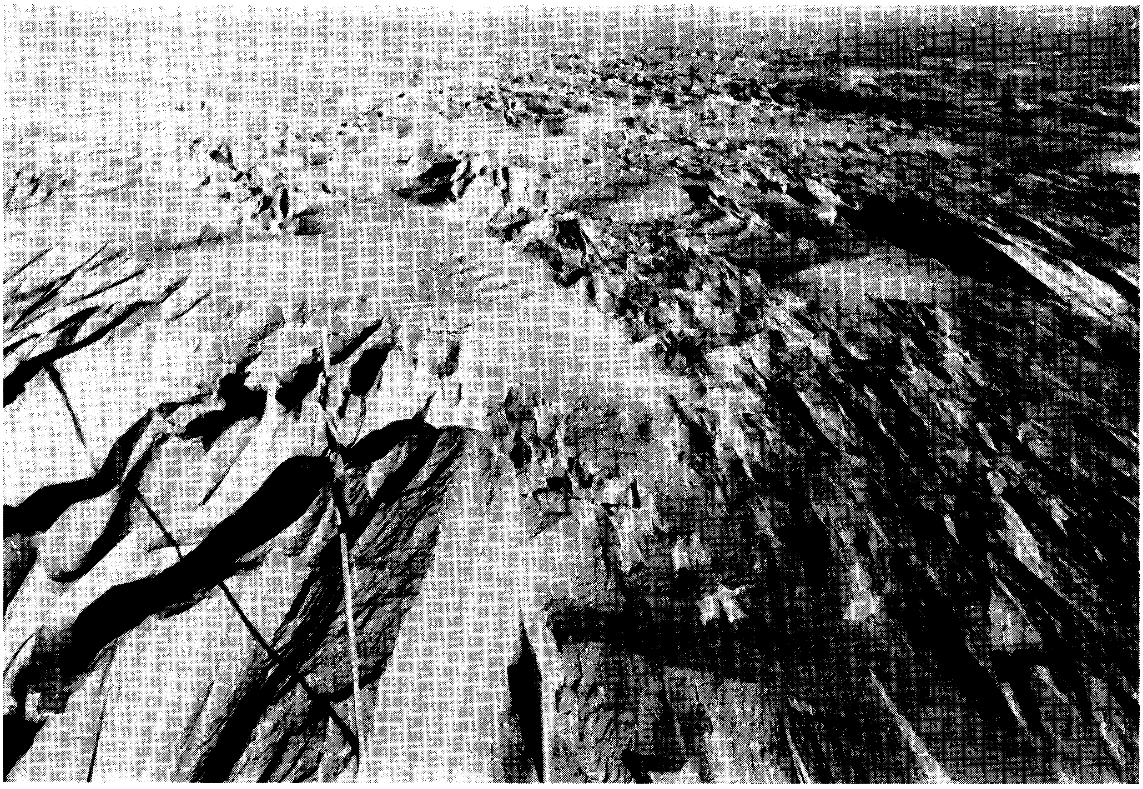

Photo 5. Reshuffling type of surface relief. Carving of sastrugi and formation of soft barchan on its lee-side (at St. 272).

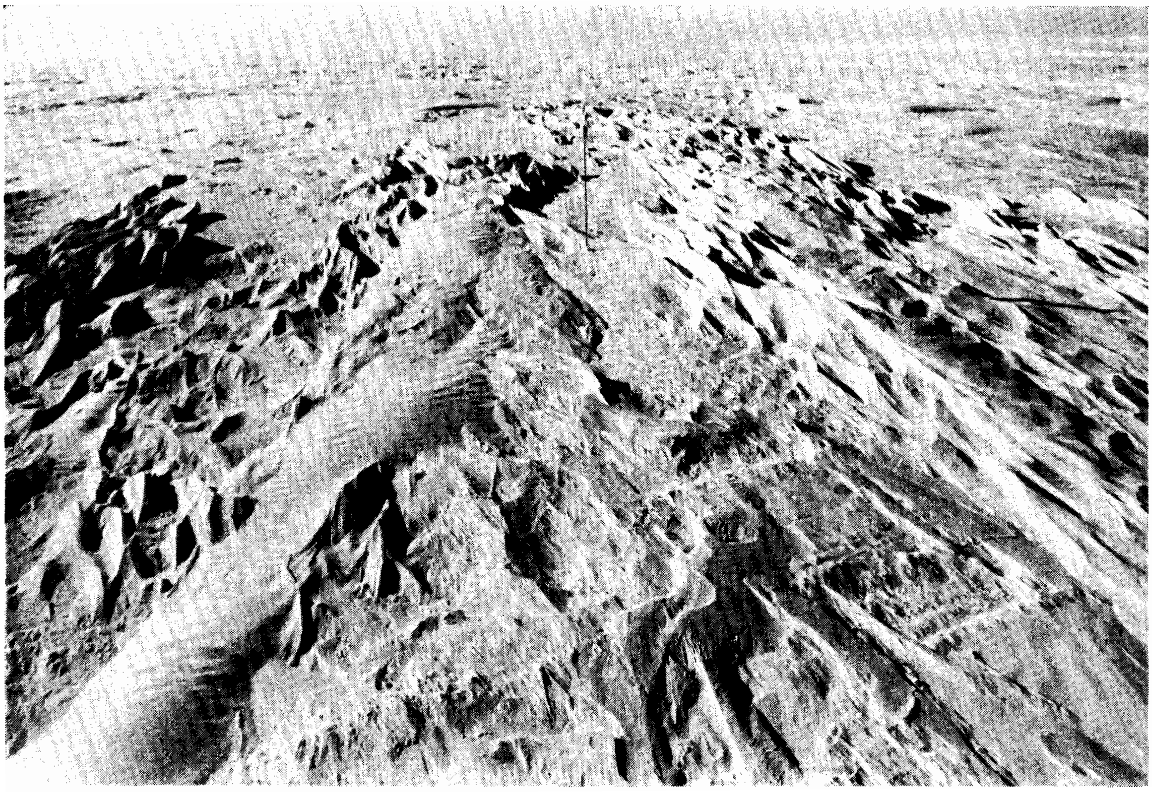

Photo 6. Reshuffling type of surface relief. Thin sastrugi and narrow banks are moving leeward on the smooth surface of compact snow (at St. 346).

Photo 7. Reshuffling type of surface relief. Wearing of sastrugi and expansion of thin friable banks with ripple marks (at St. 418).

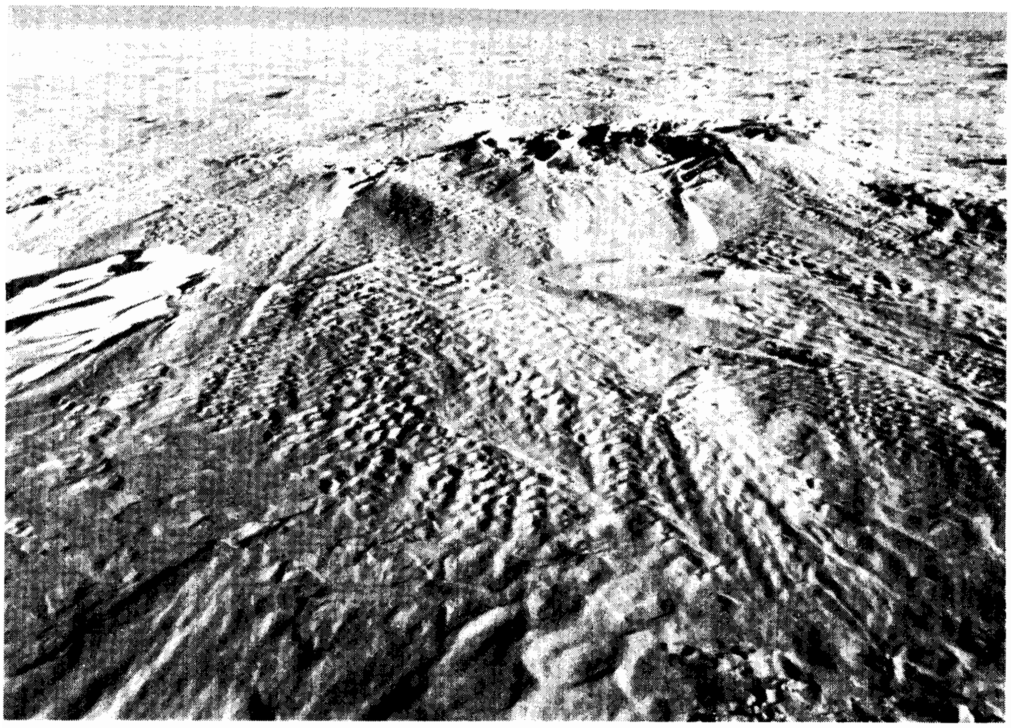

Photo 8. Smooth surface marked with Y-shaped ripples and senile sastrugi scattered on them (at St. 548).

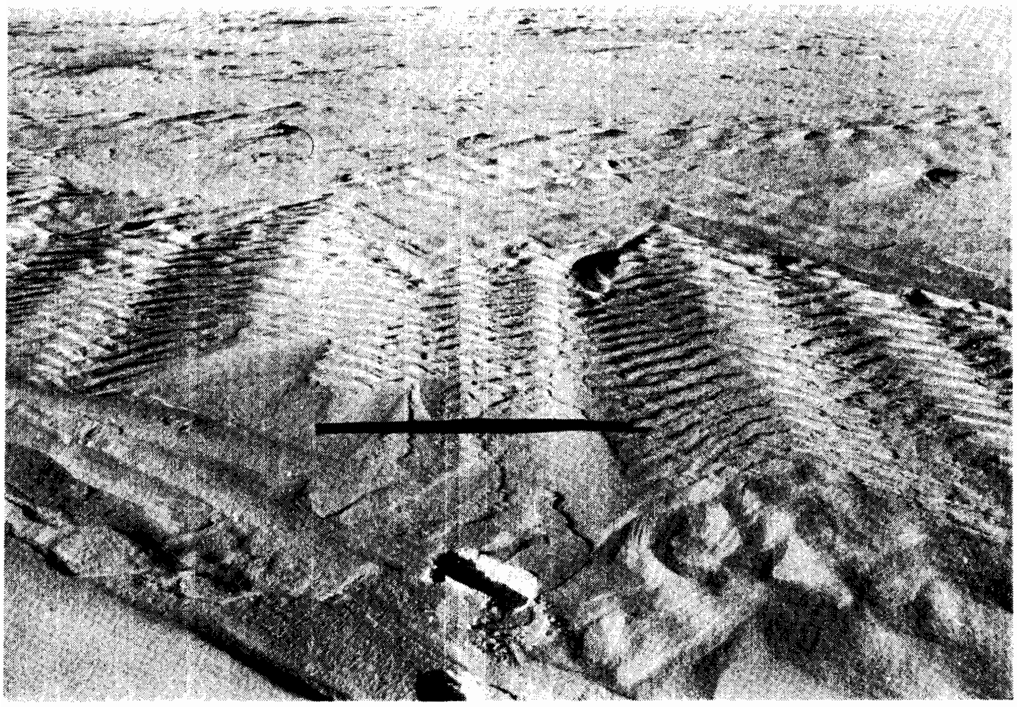

Photo 9. Typical Y-shaped ripples, interlacing and aligned along axes parallel to the wind direction, at the Fuji Divide (at St. 556).

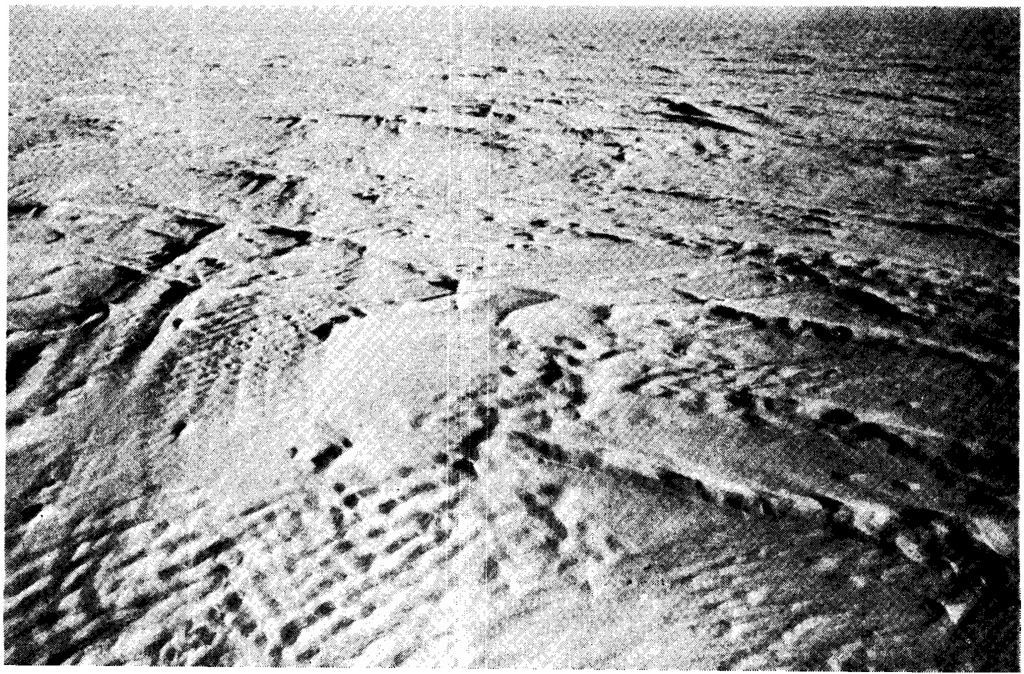

Photo 10. Complicated surface relief indicating three wind directions near the Fuji Divide (at St. 586).

Photo 11. Friable bank abrased diagonally by a weak wind (at St. 636).

Photo 12. Wearing down of surface relief by wind erosion (at St. 702).

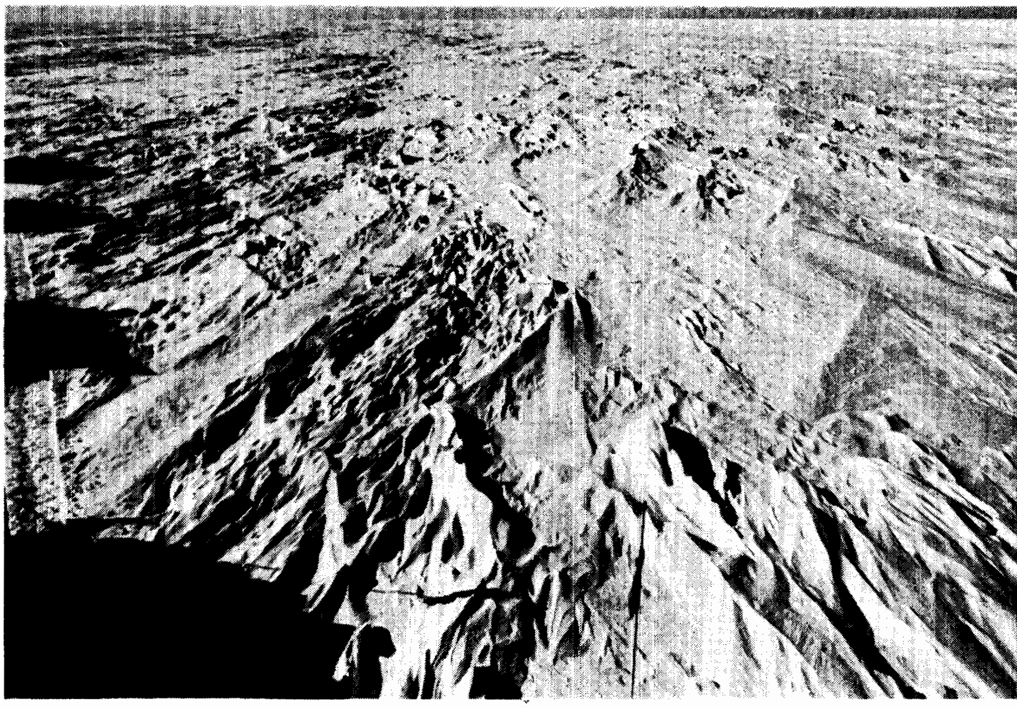

Photo 13. Pitted patterns developed on a smooth surface (at St. 723).

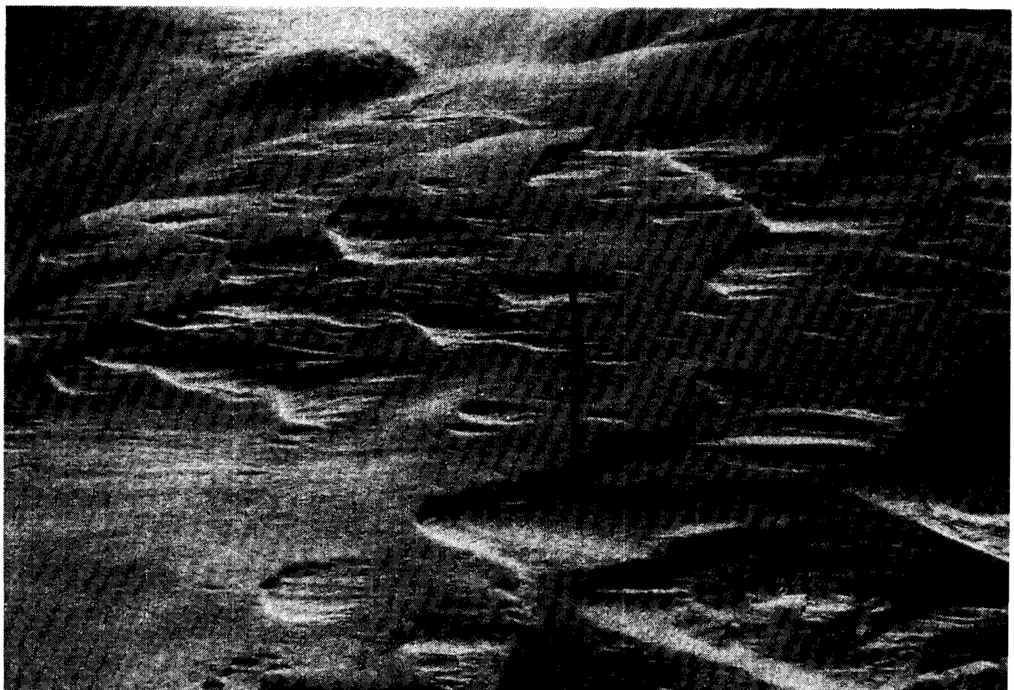

Photo 14. Two types of surface relief, deposition and erosion, showing the wind directions in crossing (at St. 772).

Photo 15. Zonal alignment of a smooth surface (toward lower half of the photograph) and a gullied surface (the distant view), according to the undulated topography of ice sheet (at St. 793).

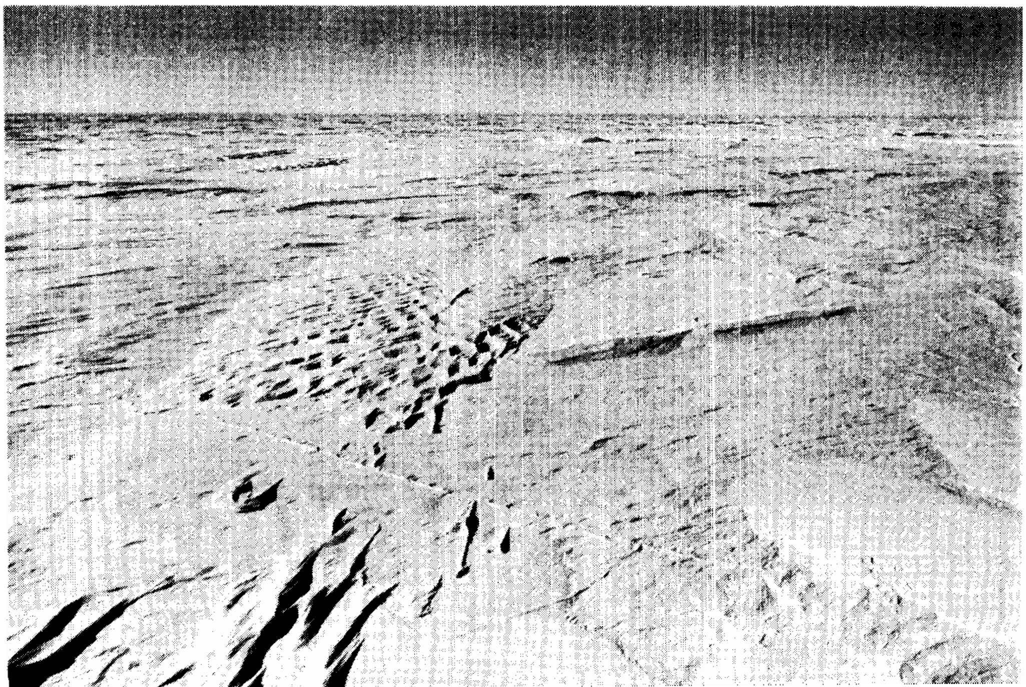

Photo 16. Very thin barchanoia moving on a smooth surface, to the leeward (at St. 857).

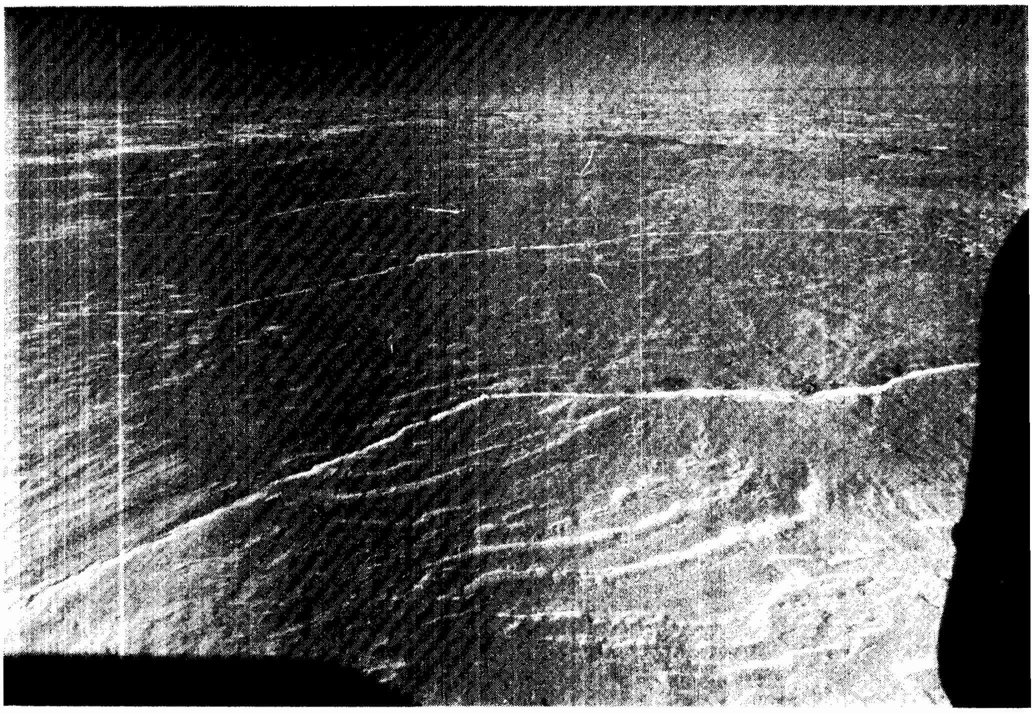

Photo 17. Parallel pattern of cracks on a smooth surface (at St. 910).

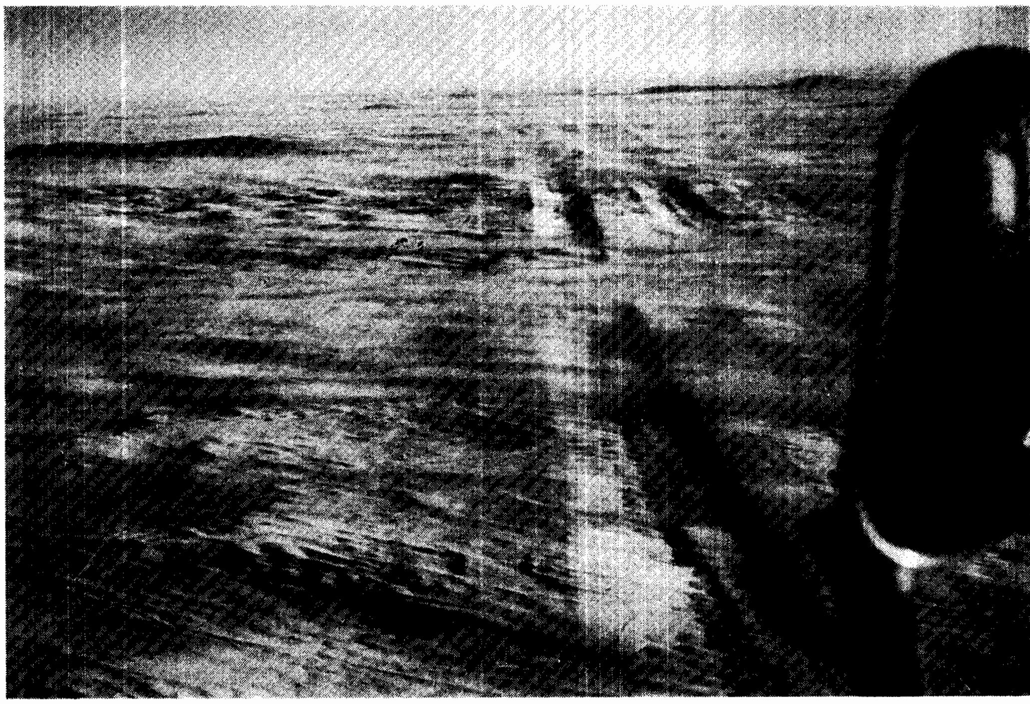

Photo 18. Distinct tracks of the caterpillars of a vehicle of the previous year remain on a glazed surface (at St. 186).

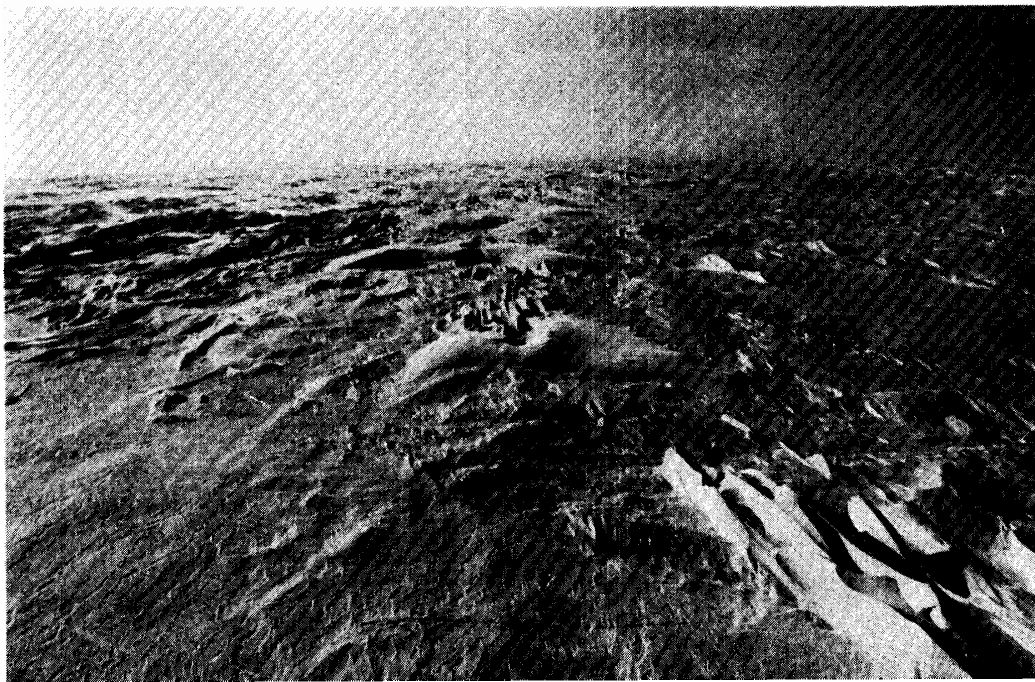

Photo 19. The vehicle tracks intermittently covered with moving barchans (at St. 344).

Photo 20. Faint mark of tracks of the vehicle near the Fuji Divide (at St. 548).

Photo 21. Well-developed hoarfrost crystals by sublimation (at St. 690).

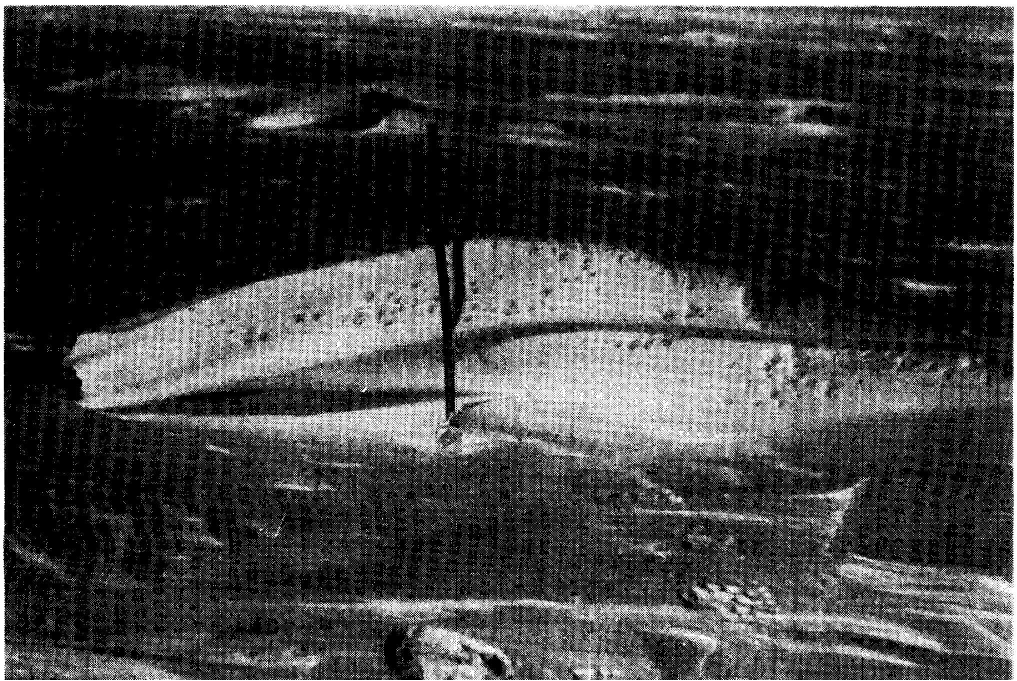

Photo 22. A mature sastrugi in the bending stage, on which layers of hoarfrost crystals were blown by winds of moderate intensity (at St. 776).

Table 2. Snow accumulation at stakes and surface conditions.

Symbols of snow accumulation
- A : The period between Jan. 1968 and Oct.—Nov. 1968.
- B : The period between Oct.—Nov. 1968 and Jan. 1969.
- C : One year from Jan. 1968 to Jan. 1969.

Symbols of surface-relief size
- A : Glazed surface.
- B : Smooth surface with some faint marks.
- C : Less than 10 cm in mean height.
- D : 10 to 20 cm in mean height.
- E : 20 to 40 cm in mean height.
- F : 40 to 70 cm in mean height.
- G : More than 70 cm in mean height.

Symbols of surface-relief type
- d : Deposition type.
- e : Erosion type.
- r : Reshuffling type.
- m : Faint marks.

Values with parentheses were measured by the JARE traverse 1967-68.

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
16	523	167.0		−20.0				(61d, 80r)
18	584	103.5			45.5			
20	630							
22	720	118.0	61.0	−19.0	42.0			36d, 84r
24	784	90.3			60.7			
26	838	117.8			40.2			
28	892	120.0	41.5	6.0	47.5			40d, 84r
30	937	92.0			61.0			
32	969		62.0					(66d, 99r)
34	1006	112.2			56.8			
36	1042	103.5	54.5	− 7.5	47.0			(69d, 96r)
38	1073	111.8	41.2	− 1.3	41.2			
40	1098	78.5	59.0	17.5	71.5			(69d, 99r)
42	1128	103.4	58.0	− 6.4	51.6			
44	1150	116.7			41.3			
46	1178	117.5	62.5	−24.5	38.0			(60d, 92r)
48	1193	114.8			45.7			
50	1203	87.5	63.5	9.0	72.5			(69d, 97e)
52	1214	104.0	59.5	− 5.0	54.5			34d, 94r
54	1249	134.9	17.0	3.1	20.1			

Station No.	Eleva-tion	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
56	1268	121.5	43.0	− 7.5	35.5			(64d, 94r)
58	1279	94.8	74.5	− 4.3	70.2			
60	1321	106.4	55.0	− 5.4	49.6			(36d, 89r)
62	1327	95.4			60.6			35d, 93r
64	1343	119.5	34.0	2.5	36.5			(56d, 103r)
66	1360		41.5					
68	1377	119.7			39.8			
70	1393	172.0		10.0			C	34d, 82r
72	1418	119.0	41.0	−10.0	31.0		D	
74	1445	117.0	47.5	5.5	53.0		D	(50d, 97r)
76	1472	111.7	42.5	− 6.7	35.8		E	
78	1487	119.5	65.5	− 9.0	56.5		D	47d, 102r
80	1510	121.5	53.5	− 6.0	47.5		D	
82	1529	127.8	47.0	− 6.8	40.2		C	(53d, 100r)
84	1560	148.2	2.5	− 1.7	0.8		D	
86	1558	141.6	28.0	−10.6	12.4			52d, 102r
88	1578	144.0	15.0	− 1.5	13.5			
90	1604	160.0	10.0	− 7.0	3.0			(25d, 72r)
92	1606	142.5	28.5	−12.0	16.5			
94	1623	148.4	21.0	− 0.4	20.6			
96	1639	146.6	31.0	− 5.6	25.4			(42d, 89r)
98	1659	158.5	19.5	− 8.5	11.0			
100	1675	166.5	19.0	− 6.5	12.5			(36d, 83r)
102	1683	168.0	7.0	3.0	10.0			
104	1697	155.4					E	(39d, 86e)
106	1715	160.3	21.5	− 6.3	15.2		F	41d, 76e
108	1730	172.6	6.5	2.4	8.9		E	
110	1745	150.5	31.0	− 9.5	21.5		E	(38d, 85e)
112	1779	126.2	48.5	− 4.0	44.5		E	
114	1800	148.4	28.0	− 5.9	22.1		C	(40d, 87e)
116	1812	152.7	40.5	−13.7	26.8		A	
118	1846	186.0	− 3.5	− 4.0	− 7.5		D	
120	1875	176.5	5.0	− 1.5	3.5		C	(33d, 80r)
122	1881	144.0					C	
124	1893	183.7	− 4.5	− 5.7	−10.2		A	(29d, 76r)
126	1913	178.2	− 2.0	− 8.2	−10.2		C	36d, 71r)
128	1915	150.5	24.5	− 4.5	20.0		E	

Station No.	Eleva-tion	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
130	1923	114.3	− 1.5	1.2	− 0.3		E	(19d, 66e)
132	1942	165.1	− 1.0	− 4.6	− 5.6		D	
134	1932	142.5					D	(30d, 77r)
136	1933	165.0	9.0	− 4.0	5.0			43d, 87r
138	1949	153.2	32.0	− 6.2	25.8	5		
140	1961	118.0	49.0	− 7.0	42.0	3	D	(32d, 79r)
142	1976	170.0	− 4.5	0	− 4.5	50	C	
144	1982	151.0	27.0	− 4.0	23.0	5	E	
146	1984	165.3	− 1.0	− 5.3	− 6.3	46	D	39d, 75r
148	1987	154.8	− 2.0	− 3.8	− 5.8	28	D	
150	2001	154.2	− 1.5	10.3	8.8	95	A	(46d, 93r)
152	2001	151.7	11.5	− 4.7	6.8	52	E	
154	2005	106.0	53.0	0	53.0	0	C	
156	2005	165.3	9.5	−10.8	− 1.3	20	D	(32d, 81r)
158	2023	153.6	9.0	− 7.6	1.4	60	D	
160	2032	144.0	31.5	−10.5	21.0	31	D	(38d, 85r)
162	2045	136.5	27.7	− 5.2	22.5	25	D	
164	2060	138.3	29.5	− 5.8	23.7	10	E	
166	2052	137.7	23.5	− 5.2	18.3	2	E	(32d, 81e)
168	2054	132.8	34.5	−10.3	24.2	5	F	43d, 80r
170	2062	102.5	76.0	−14.5	61.5	0	F	(44d, 91r)
172	2069	158.3	17.0	− 7.3	9.7	10	F	56d, 109r
174	2044	169.8	− 3.0	− 4.8	− 7.8	50	E	
176	2081	165.5	− 2.0	− 2.5	− 4.5	45	A	(44d, 91r)
178	2075	105.2	64.5	− 6.2	58.3	5	F	
180	2087	161.2	4.0	− 4.2	− 0.2	40	D	(52d, 99e)
182	2113	149.2			18.0	80	A	
184	2152	140.1	27.0	− 6.1	20.9	5	D	(50d, 97e)
186	2172	168.8	− 2.0	− 4.8	− 6.8	95	A	36d, 101r
188	2183	168.8	5.0	− 5.8	− 0.8	25	E	
190	2210	154.0		− 7.0		0	G	66d, 97e
192	2236	196.0	−26.0	− 7.0	−33.0		F	
194	2253	137.6			29.4	0	F	
196	2275	161.0			4.0	75	D	(46d, 83r)
198	2295	176.5	− 2.0	− 3.5	− 5.5	15	E	
200	2312	160.2	− 1.0	2.8	1.8	28	F	(52d, 99r)
202	2311	116.8			45.7	0	F	

Station No.	Eleva-tion	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
204	2332	176.2	− 1.5	− 6.2	− 7.7	70	C	(46d, 96r)
206	2342	166.3	5.0	− 5.8	− 0.8		F	73d, 103e
208	2348	124.0	47.5	− 9.5	38.0	0	F	(54d, 101e)
210	2359	152.5	9.5	1.3	10.8	50	E	
212	2373	162.0	− 1.0	− 3.0	− 4.0	58	C	
214	2394	179.8	− 0.5	− 3.8	− 4.3	43	C	(49d, 96r)
216	2407	131.5	−14.7	− 3.0	−11.7	5	E	51d, 96r
218	2420	125.8	19.0	14.2	33.2	5	E	
220	2427	164.7			13.3	30	D	(66d, 113r)
222	2444	160.5	7.0	− 7.5	− 0.5		F	
224	2460	145.8	2.0	10.2	12.2		F	
226	2478					50	E	(48d, 95r)
228	2490	179.4	− 1.0	− 4.4	− 5.4	93	A	
230	2517	159.4	●	− 3.4	− 3.4	90	C	(51d, 98r)
232	2523	142.0			9.0	20	E	
234	2535	167.8	3.0	− 4.8	− 1.8	35	D	
236	2548	153.0	3.0	− 4.0	− 1.0	95	A	(65d, 112r)
238	2569	149.9	− 1.5	− 2.9	− 4.4	75	C	
240	2590	166.0	− 1.0	− 3.0	− 4.0	43	D	(53d, 100r)
242	2607	129.1	− 1.5	16.9	15.4		E	
244	2617	113.7	47.5	11.7	35.8	0	F	(63d, 110r)
246	2622	111.4	50.0	5.6	55.6	5	F	
248	2626	122.2	− 5.0	49.8	44.8	95	C	
250	2654	156.4	− 2.0	7.6	5.6	90	A	(56d, 103r)
252	2681	142.3	0	8.7	8.7	60	A	
254	2708	155.9	− 1.5	8.1	6.6	30	E	70d, 110r, 120r
256	2710	127.2	37.0	6.8	43.8	10	F	(63d, 110r)
258	2719	130.8	21.5	11.7	33.2	0	F	
260	2727	155.0	− 2.0	13.5	11.5	0	E	(65d, 112r)
262	2734	105.0	53.0	10.0	63.0	0	E	
264	2721	157.0	8.5	− 7.5	1.0	90	A	
266	2780	166.0	− 0.5	− 1.0	− 1.5	65	A	(63d, 110r)
268	2790	155.3	6.5	4.2	10.7	20	D	
270	2802	152.4	31.5	− 9.9	21.6	5	F	80d, 106e, 170e
272	2805	122.8	41.5	− 2.3	39.2	20	F	
274	2804	95.0	39.0	16.0	55.0	20	E	(59d, 106r)
276	2822	146.9	15.0	− 2.9	12.1	30	D	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
278	2837	134.8	34.5	0.2	34.7	20	D	100r, 115e
280	2841	143.8	− 4.0	− 3.8	− 7.8	55	D	(69d, 116e)
282	2860	120.2	16.0	4.8	20.8	16	D	
284	2887	175.0	− 0.5	− 2.1	− 2.6	95	C	
286	2921	155.0	− 1.5	− 2.0	− 3.5	50	D	(64d, 114e)
288	2936	192.2	− 0.5	− 2.2	− 2.7	30	E	
290	2942	151.6	29.0	2.4	31.4	5	F	(62d, 112e)
292	2938	62.0	70.5	23.0	93.5	60	E	
294	2967	173.5	− 0.5	− 1.5	− 2.0		F	74d, 100r, 114e
296	2966	147.4	19.0	21.6	40.6	50	F	(60d, 120e)
298	2979	134.3	12.5	19.7	32.2	50	G	
300	3003	162.0	59.0	−56.0	3.0	30	G	61d, 104r, 119e
302	3018	122.2	50.0	− 5.2	44.8	90	C	
304	3038	160.2	− 1.0	− 1.8	− 2.8	70	D	
306	3042	116.7	50.0	− 2.2	47.8	25	E	(65d, 115e)
308	3046	167.5	0	8.5	8.5	45	E	
310	3054	138.9	40.0	1.1	41.1	5	D	64d, 91r, 113e
312	3054	111.0	33.5	35.5	69.0	0	E	
314	3059	157.8	− 1.5	− 2.3	− 3.8	30	F	
316	3069	127.0	26.0	− 2.5	23.5	30	F	(55d, 72r)
318	3087	159.8	− 1.5	− 2.8	− 3.8	37	E	
320	3094	182.4	2.5	− 2.4	0.1	20	F	(69d, 119e)
322	3120	115.0	44.0	− 4.0	40.0	20	F	65d, 119e
324	3143	172.0	− 1.0	− 3.0	− 4.0	55	G	
326	3150	153.7	4.5	− 1.7	2.8	50	F	(67d, 117e)
328	3163	132.6	7.5	9.9	17.4	80	D	
330	3177	143.6	12.5	0.9	13.4	45	E	(67d, 117e)
332	3180	148.0	− 1.5	14.0	12.5	20	E	
334	3194		6.5			50	F	89d, 124e
336	3204	131.0	23.0	5.0	28.0	40	F	(61d, 111r)
338	3210	90.0	42.5	20.0	62.5	5	G	
340	3220	123.2	− 8.0	36.8	24.8	45	G	(69d, 115r, 119e)
342	3228	136.3	− 2.0	10.7	8.7	95	E	
344	3247	153.2	− 1.0	7.8	6.8	65	E	111r, 128e
346	3263	142.2	15.5	− 4.7	10.8	46	D	(71d, 104r, 121e)
348	3278	157.9	0.5	− 0.4	0.1	20	E	
350	3275	104.5	43.0	−13.5	56.5	5	F	88d, 120r, 138e

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
352	3284	136.9	− 1.0	25.1	24.1	25	F	
354	3294	150.5	21.5	3.0	24.5	17	F	
356	3314	169.0	− 1.5	− 1.0	− 2.5	50	F	78d, 128e, 138e
358	3332	153.1	5.0	− 3.1	1.9	35	F	
360	3333	133.8	14.0	8.7	22.7	20	E	82d, 120e
362	3335	174.5	− 2.0	− 0.5	− 2.5	35	E	
364	3351	156.0	− 2.0	0.5	− 1.5	55	F	(65d, 115e)
366	3353	142.9	25.5	0.1	25.6	40	G	
368	3362	157.7	0	− 2.7	− 2.7	41	F	88d, 132e
370	3371	160.0	2.0	5.5	7.5	20	F	
372	3387	184.4	− 0.5	28.9	28.4	20	F	
374	3399	153.0	7.0	6.0	13.0	35	F	(58d, 98r, 114e)
376	3407	115.0	− 1.0	28.0	27.0	35	E	48r, 103r, 123e
378	3416	166.0	10.0	− 3.6	6.4	33	E	
380	3423	159.7	5.0	3.3	8.3	20	D	102r, 130e
382	3437	147.5	16.0	− 3.5	12.5	30	D	
384	3437	141.5	12.0	4.5	16.5	25	C	
386	3434	131.4	24.0	− 2.4	21.6	25	D	
388	3447	136.0	24.5	− 1.0	23.5	25	E	
390	3450	138.3	−16.5	13.7	− 2.8	20	E	
392	3457	140.0	−14.0	3.0	17.0		E	
394	3461	136.5	13.5	7.5	21.0		F	
396	3475	156.6	0	3.4	3.4		C	
398	3480	156.0	5.5	1.5	7.0		D	78d, 108r, 130e
400	3478	150.3	4.5	7.2	11.7	20	D	
402	3483	163.4	1.5	− 3.4	− 1.9		D	73d, 118r
404	3483	143.4	9.0	12.1	21.1	25	D	
406	3495	119.4	28.5	8.1	36.6	30	D	100r, 136e
408	3500	160.9	1.0	− 0.9	0.1	20	E	
410	3499	159.6	− 1.5	− 0.1	− 1.6		D	70d, 156e
412	3505	147.3	8.0	− 0.3	7.7		D	
414	3519	145.0	11.0	0	11.0	20	D	132e
416	3513	151.8	17.5	− 1.3	16.2	10	D	
418	3514	148.9	5.0	6.1	11.1		E	
420	3529	143.0	30.0	0	3.0		E	
422	3526	148.8	8.5	8.7	17.2	30	D	
424	3537	154.5	8.5	2.0	10.5		D	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
426	3543	151.8	10.0	3.2	13.2		D	130r
428	3546	157.8	1.0	3.2	4.2		D	128r
430	3547	139.6	8.0	10.4	18.4	25	F	
432	3548	135.3	27.5	− 2.3	25.2		E	
434	3544	149.5	5.0	7.5	12.5	≀	E	
436	3548	146.8	19.5	2.7	22.2	30	D	
438	3549	152.9	14.0	0.1	14.1		D	
440	3556	158.3	1.5	3.2	4.7		D	
442	3555	151.8	7.0	4.2	11.2		C	93d, 136r
444	3556	164.8	1.0	3.2	4.2		C	
446	3559	138.8	14.5	1.2	15.7		D	
448	3569	137.9	18.0	− 0.9	17.1		C	
450	3584	138.2	8.0	3.8	11.8		C	
452	3591	150.2	− 3.0	4.8	1.8		C	93d, 138r
454	3594	140.4	15.0	2.6	17.6		A	
456	3591	142.5	0	14.0	14.0		C	
458	3594	158.8	3.0	2.2	5.2	Faint trace under thin snow cover.	F	
460	3604	145.5	− 1.5	7.5	6.0		E	
462	3612	145.2	8.0	3.2	4.8		E	
464	3613	132.7	13.0	6.3	19.3		C	
466	3614	145.2	9.5				C	137r
468	3616	147.5	8.0	3.5	11.5		C	
470	3613	149.0	0	15.5	15.5		D	
472	3617	139.6	16.5	− 2.1	14.4		E	
474	3622	130.8	21.0	0.2	21.2		E	
476	3624	151.0	15.5	3.5	19.0		F	
478	3629	128.8	22.5	1.7	24.2		E	
480	3635		17.5				F	
482	3639	129.5	5.0	7.5	12.5		E	132r, 142r
484	3642	139.9	12.0	2.9	9.1		D	
486	3632	139.1	18.0	5.9	23.9		C	
488	3637	149.0	6.0	2.0	8.0		C	
490	3642	139.0	11.0	0.5	11.5		C	
492	3640	148.7	1.5	0.8	2.3		C	
494	3645	140.0	11.5	− 3.5	8.0		D	
496	3646	145.7	14.5	− 1.2	14.3		D	102m, 132r
498	3652	146.8	8.5	1.7	11.2		D	

Station No.	Eleva-tion	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
500	3652	141.6	3.0	9.7	12.4	Faint trace under thin snow cover.	D	
502	3648	147.2	12.0	− 0.2	11.8		E	
504	3653	143.0	13.5	1.5	12.0		E	
506	3655	144.0	4.0	6.0	10.0		F	98r, 138r
508	3672	132.2	10.0	16.8	26.8		E	
510	3672	138.6	10.0	2.9	12.9		E	
512	3675	141.2	14.0	3.8	17.8		D	
514	3673	149.0	12.5	2.0	14.5		C	
516	3674	146.3	14.0	2.7	16.7		C	
518	3675	130.8		0.2			C	132r, 139r
520	3673	133.4	−18.5	21.6	13.1		C	
522	3683	148.3	1.0	1.7	2.7		C	
524	3694	150.3	10.0	0.3	10.7		C	129r, 142r
526	3691	145.6	10.0	− 1.6	8.4		C	
528	3694	146.1	3.5	7.9	11.4		C	
530	3696	152.5	1.5	2.0	3.5		C	
532	3699	156.2	0	1.8	1.8		C	
534	3702	159.8	3.0	1.2	4.2		B	
536	3698	146.0	8.0	4.0	12.0		B	
538	3693	152.5	4.0	9.0	13.0		B	
540	3710	146.5	14.5	− 3.5	11.0		B	
542	3709	134.4	13.0	5.6	18.6		B	
544	3704	143.6	12.0	− 0.6	11.4		B	122m, 132r
546	3708	136.5	19.0	− 5.5	13.5		B	
548	3712	142.6	5.0	4.4	9.4		B	
550	3714	123.2	25.0	− 2.2	21.8		B	
552	3713	139.0	20.5	− 8.0	12.0		B	122m, 135r
554	3714	144.0	16.0	− 3.0	13.0		B	
556	3717	137.8	14.0	0.2	14.2		B	106m, 127m, 154r
558	3715	143.8	15.5	− 1.3	14.2		B	
560	3714	139.0	14.0	− 1.0	13.0		B	
562	3712	145.5	16.0	− 0.5	15.5		B	122m, 132e
564	3712	143.6	1.0	11.4	12.4		B	
566	3709	134.6	9.0	4.4	13.4		B	
568	3711	120.5	29.0	4.5	33.5		B	
570	3710	125.8	12.5	16.7	29.2		B	
572	3708	143.5	6.0	1.5	7.5		B	

Station No.	Eleva-tion	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
574	3707	147.5	2.5	5.5	8.0		B	
576	3702	151.0	11.0	0	11.0		B	57m, 102m, 117m, 127e
578	3704	151.2	7.0	4.8	11.8		B	
580	3705	137.7	10.0	3.3	13.3		B	
582	3704	153.5	18.0	− 4.5	13.5		B	
584	3702	151.8	16.0	0.2	16.2		B	
586	3698	163.5	2.0	9.5	11.5		B	6m, 55m, 102m, 120r, 128e
588	3693	155.7	10.0	− 1.7	9.3		B	
590	3694	156.4	3.5	1.1	4.6		B	
592	3685	146.5	6.5	1.0	7.5		B	
594	3683	159.0	6.0	0	6.0		B	
596	3681	150.4	14.0	0.6	14.6		B	
598	3682	159.0	7.0	− 1.0	6.0		B	66m, 106r
600	3679	138.8	19.5	3.7	22.2		B	
602	3677	141.2			15.8		B	6m, 63r, 78r, 118r
604	3679	141.8	16.0	7.2	23.2		C	
606	3674	152.2	4.0	3.8	7.8		C	66r
608	3670	149.6	11.0	− 0.6	10.4		C	
610	3670		8.5			Faint trace under thin snow cover.	B	
612	3668	148.5	13.0	− 2.5	10.5		A	
614	3667	133.7	10.0	12.3	22.3		B	
616	3665	146.3	11.0	7.7	18.7		B	
618	3662	138.1	0.5	14.4	14.9		B	
620	3659	139.7	14.0	3.3	17.3		B	38m, 60r, 76r, 108r
622	3653	146.2	14.0	1.8	15.8		C	
624	3650		15.5	5.8			B	
626	3649	147.5	4.5	− 1.0	10.0		B	
628	3650	147.0	11.5	− 1.5	10.5		B	42m, 52r 94e, 111r
630	3654	145.0	15.0	− 0.1	13.5		B	
632	3648	136.6	18.5	− 0.1	18.4		B	
634	3647	150.9	2.5	2.6	5.1		B	
636	3647	133.5	16.5	3.0	19.5		B	84r, 108r
638	3639	150.0	14.0	− 1.0	13.0		B	
640	3629	145.5	11.0	3.0	14.0		B	
642	3628	147.5	12.0	3.5	15.5		B	
644	3622	128.0	32.0	− 5.0	27.0		C	66r
646	3613		9.0				C	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
648	3617	161.5	6.5	−4.0	2.5		C	
650	3619	141.0	13.0	1.0	14.0		C	
652	3616	151.4	21.0	−8.4	12.4		C	
654	3618	157.5			11.5		C	
656	3613	158.0	19.0	−8.0	11.0		C	11r, 66r
658	3609	182.5	2.5	2.5	5.0		C	
660	3613	153.0	5.5	3.5	9.0		C	
662	3618	147.5	8.5	3.0	11.5		C	
Plateau St. (663)	3624							
664	3619	133.5		0.5			C	40r, 54r
665	3615	175.0		0			C	
666	3621	141.6		3.4			C	
667	3616	144.5		5.5			C	26m, 51r
668	3614	172.5		3.5			C	
669	3609	153.2		−2.2			C	
670	3599	135.8		0.2			C	
671	3603	178.0		1.0			C	
672	3609	151.0		4.0			C	26m, 51r
673	3604	168.0		5.0			C	
674	3592	166.2		−4.2			B	
675	3584	134.3		1.7			B	26m, 36r
676	3584	146.5		4.5			D	
677	3583	144.4		12.6			D	26m, 36r
678	3582	156.0		3.0			D	
679	3581	177.5		−7.5			D	
680	3579	137.5		1.5			E	
681	3576	133.6		−0.6			D	30m, 50r
682	3574	107.2		6.8			D	
683	3574	180.0		−1.0			C	
684	3569	131.2		−0.2			C	357r, 19m, 47r
685	3570	135.0		2.0			C	
686	3568	131.2		−1.2			C	
687	3563	151.7		−1.7			C	
688	3562	146.3		−9.3			D	
689	3557	128.5		13.5			D	345r, 15m, 35r
690	3559	141.5		−1.5			D	
691	3554	147.5		−0.5			D	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
692	3558	140.0		− 1.0			C	
693	3561	143.3					C	15m, 35r
694	3564	147.6		0.4			C	
695	3571	130.5		18.5			D	
696	3553	156.0		− 1.0			D	9m, 29r
697	3553	156.0		− 1.0			D	
698	3539	156.2		17.8			D	
699	3545	155.3		− 1.3			D	
700	3545	161.4		3.6			D	0r
701	3544	168.4		− 0.4			D	
702	3538	159.4		− 0.4			D	
703	3535	164.0		− 9.0			D	
704	3530	179.0					E	
705	3532	164.5		− 0.5			D	
706	3526	158.6		27.4			D	328r, 358r, 7m, 22r
707	3518	172.0		2.0			D	
708	3517	163.5		4.5			D	0r, 25r
709	3518	158.8		− 0.8			D	
710	3515	152.5					D	
711	3505	184.0		0			D	
712	3497	155.2		− 0.2			D	1r, 9m, 27r
713	3487	148.5		− 2.5			D	
714	3490	146.5		− 0.5			C	
715	3488	170.5		− 0.5			C	
716	3486	146.9		0.1			C	
717	3481	150.0					D	
718	3471	174.0		0			D	
719	3467	158.7		− 4.7			D	
720	3466	142.8		0.2			D	328r, 9r
721	3467	161.3		− 0.3			D	
722	3466	151.4		0.6			C	327r, 354r
723	3468	162.5		−11.5			C	
724	3467	182.0		0			D	
725	3461	166.3		− 0.3			D	
726	3457	164.7		1.3			E	344m, 19r
727	3460	163.4		2.6			D	
728	3459	149.5		− 0.5			E	

Station No.	Eleva-tion	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
729	3457	174.2		−2.2			D	341m, 12r
730	3463	158.3		16.7			D	
731	3449	148.7		1.3			D	
732	3446	160.0		0			C	339r, 349m, 29r
733	3440	159.4		−6.4			D	
734	3436	162.0		2.0			E	
735	3432	165.3					E	
736	3429	134.2		1.8			D	
737	3420	161.4		12.4			D	322r, 354e, 4r
738	3416	181.0		3.0			E	
739	3417	151.7		−0.7			C	
740	3413	145.0		−10.0			A	
741	3406	183.0		−3.0			E	
742	3407	167.2		−1.2			D	348r, 14r
743	3401	146.5		−1.5			D	
744	3391	143.3		−0.3			E	
745	3394	159.0		10.0			E	
746	3402	162.5		−0.5			C	
747	3407	153.6		−0.6			D	348r, 14r
748	3404	160.3		0.3			D	
749	3411	159.7		−0.3			D	
750	3412	150.5		0.5			B	
751	3402	150.8		0.8			E	
752	3399	155.5		5.5			E	339r, 14r
753	3402	158.7		8.7			E	
754	3404	155.5		5.5			D	
755	3407	156.2		6.2			D	
756	3405	159.0		1.0			D	332r, 18r
757	3404	161.0		−1.0			D	
758	3399	162.3		−2.3			D	
759	3402	169.0		−1.0			A	
760	3397	160.4		−0.4			E	
761	3399	158.0		2.0			C	
762	3392	149.0		11.0			A	333r, 359e, 18r
763	3391	156.0		4.0			A	
764	3384	157.0		3.0			A	
765	3369	159.4		0.6			B	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
766	3371	180.4		− 0.4			F	353e, 13r
767	3379	181.5		− 0.5			E	
768	3373	157.4		− 0.4			E	338r, 17r
769	3372	180.4		2.6			E	
770	3374	160.5		− 0.5			E	
771	3370	150.0		0			D	
772	3370	159.0		1.0			D	
773	3372	152.8		− 0.8			C	343r, 13r
774	3368	186.4		− 0.4			D	
775	3368	158.4		1.1			E	
776	3368	160.8		− 0.8			D	
777	3362	155.7		− 0.2			C	343r, 8r
778	3353	160.3		− 0.3			D	
779	3362	160.3		0.3			B	
780	3363	159.3					C	
781	3361	161.8		0.2			E	330r, 20r
782	3356	161.5		− 1.5			A	
783	3353	157.0		− 1.0			D	
784	3351	163.3		− 1.3			E	344m, 15r
785	3349	182.3		− 0.3			C	
786	3352	171.4		0.6			D	
787	3348	171.4		− 0.4			B	
788	3343	159.7		0.3			C	
789	3337	162.5		2.5			A	342m, 12r
790	3317	160.0		0			A	
791	3313	177.5		− 0.5			D	
792	3312	160.3		− 0.3			D	337r, 7r
793	3307	156.7		0.7			C	
794	3306	171.0		0			D	
795	3300	152.0		− 0.5			E	328r, 10r
796	3299	160.0		0			D	
797	3299	170.7		5.3			D	
798	3298						C	346r, 16r
799	3292	173.4		− 0.4			D	
800	3298	172.0		0			D	
801	3296	160.0		0			E	343r, 19r
802	3290	172.4		− 0.4			D	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
803	3288	115.0		0			D	
804	3294	171.5		0.5			A	329m, 23r
805	3298	147.5		0.5			C	
806	3298	162.5		−2.5			C	
807	3291			0			C	326r, 11e, 26r
808	3291	148.0		0			D	
809	3292	179.8		0.2			A	
810	3288	163.5		− 9.5			D	334m, 22e
811	3290	149.0		− 1.0			E	
812	3290	153.2		− 0.2			A	
813	3282	158.7		6.3			D	337m, 13e
814	3276	164.5		5.5			D	
815	3271	155.4		0.6			D	
816	3271	160.2		− 0.2			D	
817	3263	154.5		6.5			C	326r, 11r
818	3260	161.4		− 1.4			D	
819	3257	151.0		9.0			D	334r, 5r
820	3257	166.0		− 1.0			C	
821	3253	147.5		2.5			B	
822	3249	180.2		− 0.2			A	338r, 34r
823	3248	174.5		0.5			C	
824	3245	154.0		1.0			D	
825	3249	174.8		0.2			D	340r, 12e
826	3254	160.0		0			A	
827	3357	160.2		− 0.2			A	
828	3253	155.0		0			B	
829	3248	150.0		0			B	
830	3237	149.0		1.0			A	
831	3234	112.0		0			D	340m, 14r
832	3220	155.0		0			E	
833	3207	172.0		0			A	
834	3197	168.2		− 6.2			D	338r, 14r
835	3191	162.5		0.5			D	
836	3194	140.0		0			C	
837	3194	173.7		0.3			D	
838	3197	155.2		− 0.2			E	
839	3195	144.8		− 0.2			C	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
840	3191	145.2		0.2			C	
841	3187	185.6		0.4			F	334r, 14r
842	3190	155.0		0			E	
843	3189	182.0		0			D	334r, 4r
844	3188	154.6		0.4			E	
845	3188	155.8		−0.8			D	
846	3188	170.5		−0.5			E	
847	3186	160.5		−0.5			D	
848	3184	160.0		0			B	
849	3180	163.4		−0.4			B	
850	3169	165.3		−0.3			D	334r, 9r
851	3166	171.0		−1.0			D	
852	3163	176.8		−0.8			D	
853	3157	174.5		0.5			D	335r, 359e
854	3155	177.8					D	
855	3154	165.5		−0.5			B	334r, 354e, 14r
856	3154	154.3		0.7			A	
857	3152	161.0		−1.0			A	
858	3146	184.5		−0.4			C	339r, 14r
859	3147	168.0		−1.0			C	
860	3148	156.3		−1.3			A	
861	3147	158.0		2.0			C	
862	3142	163.5		−0.5			C	333r, 0e
863	3137	160.0		0			C	
864	3135	165.0		0			C	330r, 2e
865	3132	145.2		−0.2			A	
866	3122	159.0		0.6			A	
867	3116	158.6		1.4			A	332d, 353e
868	3107	170.0		0			C	
869	3105	173.4		3.6			C	
870	3102	153.0		0			D	328d, 358e
871	3109	153.7		1.3			D	
872	3107	180.8		−0.8			C	
873	3103	154.5		1.1			A	326d, 346r
874	3090	160.2		−0.2			C	
875	3080	167.5		0.5			D	
876	3076	184.0		1.0			E	326d, 344r

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes A	Snow accumulation at stakes B	Snow accumulation at stakes C	Survival rate of track	Microrelief of snow surface Size	Microrelief of snow surface Direction and type
	m	cm	cm	cm	cm	%		
877	3079	165.8		− 0.8			E	
878	3079	155.3		− 0.3			D	
879	3072	117.0		1.0			D	326d, 340e
880	3065	181.2		− 0.2			D	
881	3064	150.2		4.8			A	
882	3058	169.7		12.3			A	326d, 344e
883	3044	172.0		0			C	
884	3033	180.5		1.5			C	
885	3030	158.8		1.2			D	330d, 342e
886	3028	160.5		− 0.5			D	
887	3027	159.2		0.8			C	
888	3016	185.0		− 1.0			A	323d, 340e
889	3005	143.6		1.4			C	
890	2995	155.8		− 0.8			D	
891	2994	150.7		− 0.7			A	
892	2980	155.2		4.8			D	322d, 337e, 357r
893	2981	177.3		− 2.3			D	
894	2974	145.5		− 0.5			A	325d, 341e
895	2955	158.0		2.0			C	
896	2952	172.8		0.2			D	
897	2945	163.2		1.8			D	
898	2945	180.6		− 0.6			C	309d, 332d, 342e
899	2946	171.4		− 0.4			B	
900	2953	165.0		− 1.0			B	
901	2946	170.0		0			B	305d, 318d, 340e
902	2933	165.0		0			C	
903	2933	161.2		− 0.2			C	
904	2944	144.8		0.2			A	310d, 331m
905	2939	169.2		− 1.2			B	
906	2944	160.3		− 0.3			C	
907	2945	160.9		− 0.9			A	311d, 341m
908	2942	159.2		0.8			A	
909	2938	162.0		0			A	
910	2916	108.5		− 0.5			C	
911	2909	159.0		2.0			D	
912	2920	146.5		1.5			C	
913	2932	154.0		0			C	
914	2926	164.0		1.0			D	

Station No.	Eleva-tion	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
915	2910	160.0		0			D	307d, 330e
916	2904	160.0		1.0			D	
917	2901	160.0		0			D	
918	2897	156.0		0			D	
919	2899	162.8		0.2			D	309d, 333e
920	2913	146.0		−1.0			A	
921	2906	169.5		0.5			A	
922	2894	154.5		0.5			A	
923	2873	169.2		0.8			D	
924	2866	169.7		0.3			D	311d, 334e
925	2859	168.8		0.2			D	
926	2855	152.5		−0.5			B	
927	2859	141.5		0			B	307m, 327e
928	2859	142.0		1.0			B	
929	2868	170.5		−0.5			C	
930	2857	149.5		0.5			B	311m, 334m
931	2859	149.0		1.0			B	
932	2867	150.5		−0.5			B	
933	2874	152.7		0.3			C	314m, 338m
934	2863	149.6		0.4			C	
935	2856	150.8		−0.8			C	
936	2841	165.0		0			B	
937	2814	160.3		−0.3			B	
938	2819	179.5		0.5			B	336m, 16e
939	2815	170.3		−0.3			A	
940	2807	150.0		0			B	
941	2818	156.0					B	342m, 352e
942	2820	150.0		0			B	
943	2827	159.4		0			A	
944	2829	167.0		0			A	
945	2832	157.8		2.2			C	
946	2823	174.7		0.3			C	342d, 352e
947	2807	159.4		0.6			B	
948	2807	149.7		0.3			B	
949	2810	154.5		0.5			C	324m, 348e, 6d.
950	2802	160.0		0			B	
951	2791	160.0		0			B	

Station No.	Elevation	Height of stakes in the return trip	Snow accumulation at stakes			Survival rate of track	Microrelief of snow surface	
			A	B	C		Size	Direction and type
	m	cm	cm	cm	cm	%		
952	2792						B	339m, 3e
953	2792	155.3		− 0.3			B	
954	2802	115.2		− 0.2			C	
955	2811	147.0		0			B	
956	2811	160.4		− 0.4			B	
957	2816	160.0		0			B	328m, 348e
958	2823	145.3		− 0.3			C	
959	2832	149.3		0.7			B	
960	2818	149.4		0.6			B	328d, 3e
961	2818	149.0		1.0			C	
962	2823	153.3		− 0.3			C	
963	2813	154.4		0.6			B	
964	2810	160.4		0.4			B	
965	2818	165.3		0.3			C	322d, 345e
966	2823	164.5		− 0.5			C	
967	2831	137.6		− 0.5			B	
968	2814	139.9		− 0.1			B	
969	2813	157.0		0			B	
970	2819	156.0		0			C	318m, 338e, 0d
971	2826	150.5		− 0.5			C	
972	2819	153.9		1.1			B	
973	2809	154.2		0.8			B	
974	2811	160.0		0			C	
975	2801						C	320d, 334e, 2d
976	2806	155.0					B	
977	2803	162.0					B	
978	2796	160.0					B	
979	2799	160.0					C	
980	2804	155.0					C	
981	2807	160.0					B	
South Pole	2800							

3.2. *Hardness of snow*

Hardness of snow was measured by Kinoshita's hardness-meter at the surface and at the depth of 10 cm at intervals of 8 km. In Fig. 4, moving average values of the surface hardness for 10 sites along the traverse route are shown.

As shown in Fig. 4, the hardness of surface snow measured on the return trip is lightly smaller than that measured on the trip to the South Pole. This would be due to changes in the conditions of snow surface during the summer season as will be mentioned later.

In the region between Syowa and 74.5°S, the average hardness of snow surface was about 10 kg/cm^2, a value larger than any of the values obtained from other regions in the traverse route. However the hardness in this region varied largely between 2 and 50 kg/cm^2 according to the condition of the surface; for example, hardness shows small value of 2.5–3.1 kg/cm^2 on drifts while it reaches the value as large as 20–50 kg/cm^2 on glazed surface.

Beyond 75°S, the hardness decreased rapidly and showed the minimum value of 1 kg/cm^2 at the Fuji Divide. To the south of 81°S, the average hardness was 3–4 kg/cm^2, but it decreased again towards the South Pole.

3.3. Density of snow cover

Density of snow was measured from the surface to the depth of 2 m at

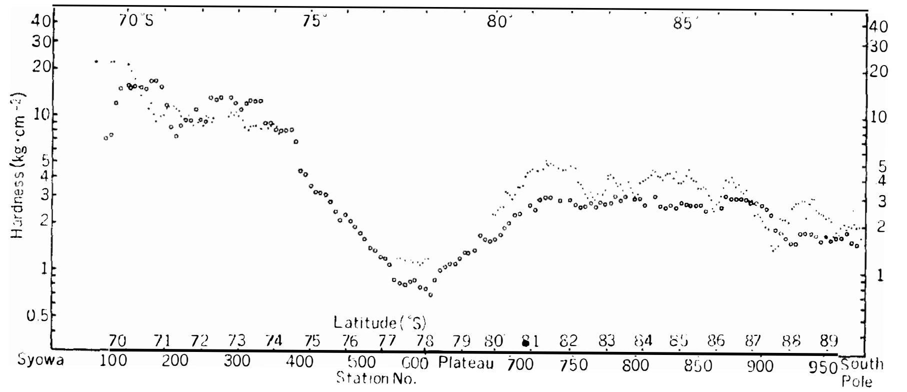

Fig. 4. Hardness of snow surface along the traverse route.
Solid circle: Values measured on the trip to the South Pole.
Open circle: Values measured in the return trip from the South Pole.

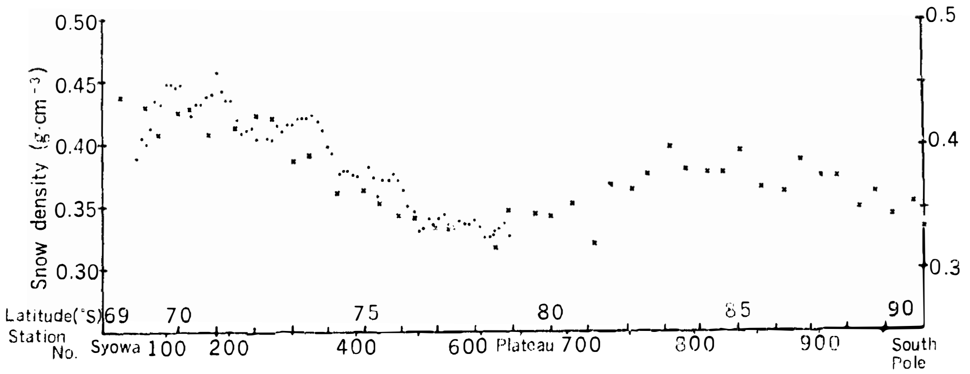

Fig. 5. Snow density profile along the traverse route.
Solid circle: Density of snow surface.
Cross mark: Average density from surface to 2 m depth.

Table 3. Hardness and density of near-surface snows.

Hardness in the table is the mean value of 3 or 4 data, except the maximum and the minimum values among the measured 5 or 6 data.

Station No.	Date		GMT	Hardness Surface (kg/cm²)	Hardness at 10cm deep (kg/cm²)	Snow temp. (−°C)	Air temp. (−°C)
	1968						
16	Sept.	28		19		28.5	
21		〃		2.5, 13			
37		29		2.8, 36		35.5	
58		30		2.8, 49		31.0	
70	Oct.	1		3.1, 53		32.5	
94		2		28	21	33.0	
98		〃		29			
122		9	12	31		32	30
126		〃	17	2.9		33	32
132		〃	18	31	8.0	36	36
138		10	14	16	3.8	30	28
142		10	17	9.2	4.4	32	32
154		11	14	10.7	5.1	31	30
158		〃	15	6.0		30	31
162		〃	16	6.0	10.7	35	33
166		〃	18	10.7		36	36
174		13	11	10.7	6.0	29	28
178		〃	14	9.2	8.0	27	25
182		〃	17	12.7	4.2	30	30
186		〃	19	10.7	6.5	34	33
194		14	13	5.5	7.2	33	30
198		〃	15	16	31	33	35
202		〃	18	12.5	4.4	36	37
206		〃	20	16		40	40
210		15		9.2		40	39
218		〃		10.7	12.5	38	
226		16	10	9.2		40	38
230		〃	12		5.1	38	37
234		〃		2.8		34	33
242		〃	19	5.5	10.7	40	40
246		18	08	6.5		40	34
250		〃	10	10.7	7.2	37	35

Station No.	Date		GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)
				Surface (kg/cm²)	at 10cm deep (kg/cm²)		
256	Oct.	18	17	2.8	6.5	38	38
258		〃	19	16	4.8	39	40
282		21	09	12.5	4.2	43	41
286		〃		21	7.3	41	36
290		〃	13	9.2	10.7	42	35
294		〃		2.7	12.5	36	35
298		〃	18	8.0	12.5	38	37
306		22	08	9.2	9.2	44	39
310		〃	10	12	12	41	35
314		〃	12	7.1	4.9	36	35
318		〃	14	7.8	16.5	38	36
322		〃	16	9.4	12	36	35
326		〃	16	6.6	4.9	39	39
334		23	09	12	2.5	44	42
346		24	07	6.6	16.5	49	46
350		〃	09	7.1	8.4	46	42
358		〃	15	9.4	4.1	41	39
362		〃	17	8.4	4.4	40	37
366		〃	19	7.8	16.5	44	44
370		〃	21	10.5	26	49	43
378		25	09	12		49	45
418		28	09	3.5		50	47
422		〃	11	3.5		48	46
534	Nov.	6	10	1.2	1.3	52	49
538		〃	13	1.0	0.8	48	45
542		〃	17	1.1	1.0	50	46
550		〃	22	1.3		50	49
554		7	10	1.6	1.6	50	47
558		〃	14	1.6	2.1	47	44
566		〃	19	1.2		48	45
574		8	13	1.0	1.2	47	48
578		〃	16	0.9	1.7	49	43
586		〃		0.9	1.0	50	50
590		9	16	1.2		48	44
594		〃	18	0.9	1.1	49	49

Station No.	Date	GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)
			Surface (kg/cm²)	at 10cm deep (kg/cm²)		
598	Nov. 9	21	1. 2	1. 5	50	55
602	10	08	0. 9	0. 9	55	49
606	〃	10	1. 6	2. 3	50	43
610	〃	13	1. 2	2. 1	50	39
614	〃	15	1. 6	1. 9	50	39
622	〃	20	1. 6	2. 4	49	51
626	〃	22	1. 0		54	55
677	17	09	2. 2	1. 2	45	40
679	〃	12	1. 6	1. 7	43	36
681	〃	15	2. 0	2. 9	43	35
683	〃	17	1. 9	2. 2	39	38
685	〃	19	1. 9	0. 9	41	41
687	18	14	1. 9	2. 0	44	35
689	〃	16	2. 9	1. 3	40	36
691	〃	18	2. 7	7. 8	39	37
693	〃	19	2. 3, 4. 0	2. 6	42	40
695	19	18	1. 9	2. 0	41	38
697	〃	10	3. 7	1. 2	40	36
699	〃	12	2. 8	1. 3	41	35
701	〃	17	1. 9	2. 1	38	36
703	〃	18	2. 6	4. 3	39	38
705	〃	20	7. 8	2. 8	39	39
707	20	09	2. 2	3. 2	40	37
709	〃	11	2. 3	3. 5	40	35
711	〃	12	1. 6		38	33
713	〃	16	4. 9	0. 9	39	36
715	〃		5. 6	3. 7	39	37
717	〃	19	3. 2	7. 8	40	39
721	21	19	3. 7	4. 3	35	32
725	22	09	7. 2	1. 5	33	29
727	〃	10	5. 6	2. 5	34	26
729	〃	15	3. 0	5. 7	31	26
733	〃	17	3. 0		30	26
737	23	09	11	2. 5	29	26
741	〃	15	2. 9		26	23
743	〃	17	2. 6		30	24

Station No.	Date	GMT	Hardness Surface (kg/cm²)	Hardness at 10cm deep (kg/cm²)	Snow temp. (−°C)	Air temp. (−°C)
747	Nov. 23	20	4. 4		29	26
751	24	18	6. 6	1. 2	29	25
753	〃	20	3. 8	1. 9	33	26
755	25	09	7. 2	2. 0	35	33
757	〃	10	3. 2	9. 7	35	34
759	〃	12	3. 7	4. 6	35	31
761	〃	16	1. 6			
763	〃	17	1. 9	0. 9	33	33
765	〃	20	6. 5	7. 2	36	35
767	26	09	1. 3	5. 7	35	33
769	〃	10	1. 4	7. 2	35	30
773	〃	16	4. 8	3. 7	33	28
775	〃	18	6. 1	7. 5	33	28
777	〃	20	2. 1, 4. 8	1. 7	34	32
779	27	16	6. 6	5. 1	32	28
781	〃	18	1. 1	7. 2	30	29
783	〃	20	4. 0	2. 0	32	30
785	28	09	7. 7	2. 8	33	30
787	〃	10	4. 0	4. 0	33	33
789	〃	12	1. 7	1. 1	33	29
793	〃	17	3. 2	1. 5	33	31
795	〃		3. 0	2. 3	34	33
797	29	09	2. 8	1. 9	35	34
799	〃	10	3. 4	3. 1	34	30
801	〃	12	2. 8	1. 5	34	30
803	〃	15	5. 1	3. 4	32	30
805	〃	17	1. 6	2. 1	31	29
807	〃	19	5. 1	9. 7	32	30
809	30	16	2. 5	2. 7	32	29
811	〃	17	2. 9	2. 7	31	30
813	〃	20	8. 4	3. 0	32	30
815	Dec. 1	08	4. 8	1. 3	33	31
817	〃	10	3. 4	1. 5	32	31
819	〃	12	4. 6	2. 7	32	28
821	〃	15	4. 2	1. 2	29	29
823	〃	17	8. 4	2. 3	32	28
825	〃	19	1. 3	1. 7	33	31

Station No.	Date	GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)
			Surface (kg/cm²)	at 10cm deep (kg/cm²)		
827	Dec. 2	09	2.0	2.5	33	30
829	〃	10	1.6	1.2	33	28
831	〃	12	1.2	1.2	29	27
833	〃	15	11	5.4	29	30
835	〃	17	6.6	2.9	32	31
837	4	13	3.1	3.7	33	31
839	〃	16	1.1	8.4	32	29
841	〃	18	8.4	2.6	32	28
843	〃	20	2.1	1.7	33	31
845	5	09	1.3	1.2	33	32
847	〃	10	2.3	1.7	32	30
849	〃	13	5.4	1.3	30	30
851	〃	15	4.6	3.5	32	29
853	〃	17	5.1	4.4	32	28
855	〃	19	2.4	2.3	34	31
857	6	09	1.7	1.2	32	31
859	〃	10	4.2	1.6	33	29
861	〃	13	2.3		31	27
863	〃	15	1.8	2.3	31	26
865	〃	17	2.6	7.2	30	27
867	〃	19	3.7	4.4	33	29
869	7	16	4.0	2.2	31	28
871	〃	18	5.1	4.4	29	29
873	〃	20	2.7	6.6	30	29
875	8	09	2.4	1.5	32	30
877	〃	10	5.7	4.4	31	29
879	〃	14	7.2	6.2	30	28
881	〃	15	1.3	1.2	28	28
883	〃	17	2.3	2.4	29	27
885	〃	19	5.4	4.4	31	28
887	9	09	1.2	3.5	30	30
889	〃	10	2.7	4.0	30	30
891	〃	12	3.2	1.5	29	28
893	〃	15	2.2	1.6	31	27
895	〃	17	2.3	3.2	29	28
897	〃	19	6.6	4.2	31	29
899	10	16	2.1	4.4	29	28

Station No.	Date		GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)
				Surface (kg/cm²)	at 10cm deep (kg/cm²)		
901	Dec.	10	17	1.2	1.1	30	28
903		〃	20	1.2	1.3	30	29
905		11	09	0.9	7.8	31	29
908		〃	11	1.7	1.6	27	28
909		〃	14	1.7		28	27
911		〃	16	1.9	7.2	28	26
913		〃	18	0.8	1.1	27	25
915		〃	20	1.5	2.3	29	27
917		12	09	2.1	1.4	30	29
919		〃	11	1.4		30	28
921		〃	14	1.5	3.2	29	27
923		〃	16	1.8	1.6	28	27
925		〃	17	8.4	0.7	29	26
927		〃	20	1.2	0.8	30	27
929		13	16	1.5	0.7	30	27
931		〃	18	1.4	1.4	32	27
933		〃	21	5.6	0.9	31	31
935		14	09	2.0	1.2	32	26
937		〃	10	3.5	2.6	31	25
939		〃	14	1.7	1.5	28	26
941		〃	15	2.2	1.2	31	24
943		〃	17	1.6	0.9	33	26
945		〃	20	2.0	1.9	33	28
947		15	09	6.6	1.4	31	23
949		〃	10	3.5	1.2	30	24
951		〃	14	1.4	1.9	32	28
953		〃	15	1.2	0.7	29	31
955		〃	17	1.6	0.7	30	32
957		〃	23	2.8	1.2	31	29
959		16	10	1.4	0.7	29	28
961		〃	11	1.2	0.8	28	28
962		〃	12	1.3	1.1	32	28
965		〃	16	1.4	1.4	29	32
967		〃	18	2.1	0.7	33	30
969		〃	19	4.3	1.5	29	32
971		〃	21	1.1	1.1	29	32
973		〃	23	3.1	2.1	31	30

Station No.	Date		GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)
				Surface (kg/cm²)	at 10cm deep (kg/cm²)		
975	Dec.	18	11	2.3	0.9	35	32
977		〃	13	1.5		30	29
979		〃	14	2.3	0.8	30	30
979		25	10	1.1		28	28
975		〃	15	1.9		32	31
971		26	14	0.7		26	29
967		〃	18	1.5		28	30
963		〃	22	1.1		28	27
959		27	10	1.5		27	30
955		〃	15	1.5		26	29
951		〃	17	2.7		26	29
947		〃	21	3.5		28	30
943		28	08	1.3		30	28
939		〃	11	1.2		31	26
935		〃	14	1.3		30	28
931		〃	16	1.3		30	28
927		〃	19	0.8		31	28
923		29	14	2.3		30	28
919		〃	17	1.7		30	28
915		〃	20	1.5		30	28
911		30	07	2.3		31	29
907		〃	09	1.2		26	24
903		〃	12	1.7		26	25
899		〃	14	2.3		26	25
895		〃	18	2.9		24	24
891		〃	20	2.1		26	24
887		31	07	5.4		28	26
883		〃	09	4.6		28	22
879		〃	12	3.0		26	25
875		〃	15	2.3		26	25
871	1969	〃	22	2.4		27	28
867	Jan.	1	02	2.2		29	28
855		〃	12	2.6		27	25
851		2	09	2.9		28	27
847		〃	11	2.7		25	23
842		〃	14	3.0		26	23
839		〃	17	0.8		27	24

Station No.	Date	GMT	Hardness Surface (kg/cm²)	Hardness at 10cm deep (kg/cm²)	Snow temp. (−°C)	Air temp. (−°C)
835	Jan. 4	13	3.0		26	24
831	〃	16	5.1		26	24
827	〃	19	2.4		26	24
823	〃	22	2.1		27	25
819	5	08	2.6		28	27
815	〃	11	3.2		27	25
807	〃	17	1.2		26	26
803	6	07	3.7		30	29
799	〃	09	2.2		28	27
791	〃	18	1.1		26	26
787	7	07	7.2		27	26
783	〃	10	1.7		26	24
779	〃	13	5.4		25	22
775	〃	16	1.6		26	22
771	〃	18	3.5		27	24
767	8	15	1.3		25	24
763	〃	18	2.8		26	25
759	〃	21	1.5		29	29
755	9	16	1.5		27	25
751	〃	18	1.6		27	26
747	10	07	5.4		29	29
739	〃	12	3.0		28	25
731	〃	18	4.4		27	27
727	〃	20	1.3		30	31
723	11	07	4.4		33	34
719	〃	10	3.5		29	27
715	〃	13	2.2		29	28
707	12	07	2.7		33	34
703	〃	12	1.6		29	28
699	〃	15	0.8		28	29
695	〃	19	1.4		30	31
691	〃	21	4.4		31	33
687	13	08	1.5		35	34
683	〃	11	0.6		30	29
679	〃	15	1.9		29	29
675	〃	19	1.9		30	30
671	14	07	0.6		33	29
666	〃	11	1.3		28	26

Station No.	Date		GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)	Density	
				Surface (kg/cm²)	at 10 cm deep (kg/cm²)			Surface (g/cm³)	at 10 cm deep (g/cm³)
662	Jan.	20	10	1. 2	2. 8	34	31		
654		〃	17	1. 6	1. 4	32	32	0. 24	0. 33
650		〃	20			35	35	0. 35	0. 33
646		21	08	2. 3	2. 6	35	35	0. 34	0. 28
638		〃	12	0. 8	0. 7	34	32	0. 37	0. 34
630		〃	16	0. 8	0. 7	32	32	0. 37	0. 31
622		〃	20	1. 0	0. 7	33	35	0. 32	0. 34
620		〃	22			36	38	0. 32	0. 33
614		22	09	0. 7	1. 2	38	36	0. 30	0. 30
606		〃	14	0. 9	0. 8	34	32	0. 31	0. 36
598		〃	18	0. 7	0. 7	35	34	0. 32	0. 34
590		〃	23	0. 7	0. 4	38	41	0. 32	0. 35
582		23	10	0. 5	0. 5	35	32	0. 30	0. 43
574		〃	15	0. 5	0. 9	33	32	0. 32	0. 33
566		〃	19	0. 5	0. 4	35	36	0. 30	0. 33
558		24	10	1. 4	0. 4	39	38	0. 36	0. 32
550		25	17	1. 0	0. 9	35	35	0. 34	0. 35
542		〃	22	1. 9	0. 9	38	40	0. 34	0. 35
534		26	09	0. 5	0. 9	40	37	0. 34	0. 33
526		〃	13	0. 6	0. 7	35	33	0. 35	0. 35
518		〃	17	0. 9	0. 7	34	33	0. 33	0. 31
510		〃	21	1. 2	2. 3	38	40	0. 31	0. 34
502		27	10	2. 7	1. 2	37	34	0. 36	0. 37
494		〃	15	1. 6	1. 1	33	31	0. 28	0. 33
486		〃	19	0. 7	0. 8	33	33	0. 34	0. 32
478		28	09	2. 6	1. 4	39	36	0. 42	0. 38
470		〃	13	1. 6	1. 3	34	30	0. 36	0. 35
462		29	11	3. 8	3. 1	35	33	0. 45	0. 40
454		〃	15	2. 0	1. 3	30	29	0. 33	0. 35
446		〃	19	2. 3	2. 1	33	35	0. 34	0. 37
438		30	08	2. 5	0. 9	40	37	0. 38	0. 36
430		〃	11	3. 0	5. 7	35	34	0. 41	0. 32
422		〃	15	1. 1	1. 1	32	32	0. 35	0. 36
414		〃	20	4. 8	1. 3	35	38		
406	Feb.	2	09	4. 6	2. 4	43	40	0. 41	0. 42
398		〃	12	5. 7	4. 8	37	37	0. 42	0. 38
390		〃	14	2. 6	3. 2	36	33	0. 31	0. 34

Station No.	Date		GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)	Density	
				Surface (kg/cm²)	at 10 cm deep (kg/cm²)			Surface (g/cm³)	at 10 cm deep (g/cm³)
382	Feb.	2	17	3. 7	2. 8	33	34	0. 35	0. 41
374		〃	20	4. 6	2. 3	38	44	0. 39	0. 34
366		3	09	9. 7	9. 7	40	39	0. 40	0. 44
358		〃	12	3. 8	7. 2	38	35	0. 38	0. 38
350		〃	15	27	4. 8	34	32	0. 45	0. 38
342		〃	18	14. 5	5. 4	33	33	0. 38	0. 43
334		3	21	4. 0	1. 3	36	39	0. 39	0. 48
326		4	10	4. 0	21. 5	33	33	0. 46	0. 44
318		〃	14	8. 4	4. 0	30	29	0. 38	0. 43
310		〃	18	9. 7	6. 6	32	31	0. 42	0. 39
302		〃	20	3. 5	7. 8	32	33	0. 42	0. 39
294		5	09	41	3. 5	33	34	0. 41	0. 46
286		〃	11	7. 7	4. 8	31	30	0. 43	0. 41
278		〃	15					0. 42	0. 40
270		〃	18	6. 6	5. 7	37	38	0. 36	0. 39
262		6	07	4. 4	11	31	30	0. 42	0. 45
254		〃	10	3. 8	2. 8	28	26	0. 39	0. 36
246		〃	14	14. 5	14. 5	23	21	0. 45	0. 40
238		〃	17	14. 5	2. 1	20	20	0. 42	
230		〃	20	3. 5	4. 4	21	20	0. 38	0. 37
222		7	07	8. 4	3. 4	25	26	0. 44	0. 46
214		〃	12	5. 4	5. 7	20	20	0. 41	0. 42
206		〃	15	4. 0	12. 5	23	24	0. 36	0. 42
198		〃	16	11	3. 3	30	30	0. 45	0. 48
190		8	08	21	6. 2	24	23	0. 47	0. 44
182		〃	13	4. 8	7. 8	15	15	0. 46	0. 45
174		〃	16	5. 4	5. 7	15	15	0. 41	0. 48
166		9	09	7. 2	5. 4	23	23	0. 47	0. 46
158		〃	13	2. 7	4. 4	17	16	0. 37	0. 39
150		〃	16	14. 5	2. 7	17	16	0. 52	0. 37
142		〃	18	41	2. 3	19	19	0. 46	0. 39
134		10	09	41	8. 4	23	21	0. 46	0. 44
126		〃	11	16. 5	2. 7	18	16	0. 46	0. 37
122		〃	16	21	12. 5	14	13		
118		〃							0. 50
110		11	11	3. 5	5. 4	16	16	0. 46	0. 41
102		〃	15	6. 6	3. 2	13	11	0. 43	0. 46

Station No.	Date		GMT	Hardness		Snow temp. (−°C)	Air temp. (−°C)	Density	
				Surface (kg/cm²)	at 10 cm deep (kg/cm²)			Surface (g/cm³)	at 10 cm deep (g/cm³)
94	Feb.	11	18	8.4	2.3	13	13	0.48	0.45
86		12	08	4.2	6.2	16	15	0.41	0.41
78		〃	11	8.4	4.4	13	12	0.40	0.41
70		〃	14		2.7	14	13	0.44	0.46
62		13	09	5.4	11	20	21	0.25	0.42
54		〃	11	14.5	3.4	16	16	0.42	0.39
46		〃	14	4.6	3.4	12	11	0.44	0.43
38		〃	18	2.6	5.4	14	15	0.21	0.42

intervals of 50–70 km along the whole traverse route (Table 4). Besides the above measurements, density of snow surface was measured at intervals of 16 km between Syowa Station and the Plateau Station (see Table 3). In Fig. 5, values of average density from the surface to the depth of 2 m are shown by cross marks and moving average of the surface densities for 5 sites are plotted by solid circles.

The density of snow seems to change from one region to another with the relief and the hardness. On the marginal slope, snow density exceeds 0.40 g/cm³, but near the Fuji Divide and the South Pole, it is less than 0.35 g/cm³.

3.4. *Some observations on the surface of snow*

3.4.1. Glazed surface and crack

The distribution of glazed surfaces along the traverse route is shown by letter A in Table 2 and Fig. 3. Glazed surface was found to have been developed on the upper part of the mound formed on the ice sheet, where accumulated snow was scarcely found (see Table 2 and Photos 3 and 18). When such a place was passed one month later during the return trip, some of the glazed surfaces were decorated with hoarfrost while the others were covered by a thin cover of snow.

Most of the cracks observed were located on these glazed surfaces. They were patterned in the form of polygons and of parallel strips (Photos 3 and 17). Cracks were often observed also on the smooth surface without sastrugi. In this case, cracks were almost in the pattern of parallel strips. Although the cracks were mostly narrow with the width less than several centimetres, cracks wider than the width of caterpillar of snow vehicle were found at times. Sketches of vertical sections of two kinds of cracks are shown in Fig. 6.

3.4.2. Tracks of snow vehicle

On the snow surface, we found the tracks left by the snow vehicles that carried the traverse party from Syowa Station to the Plateau Station and back one year before by JARE 1967–68. Table 2 shows the survival rate of the track

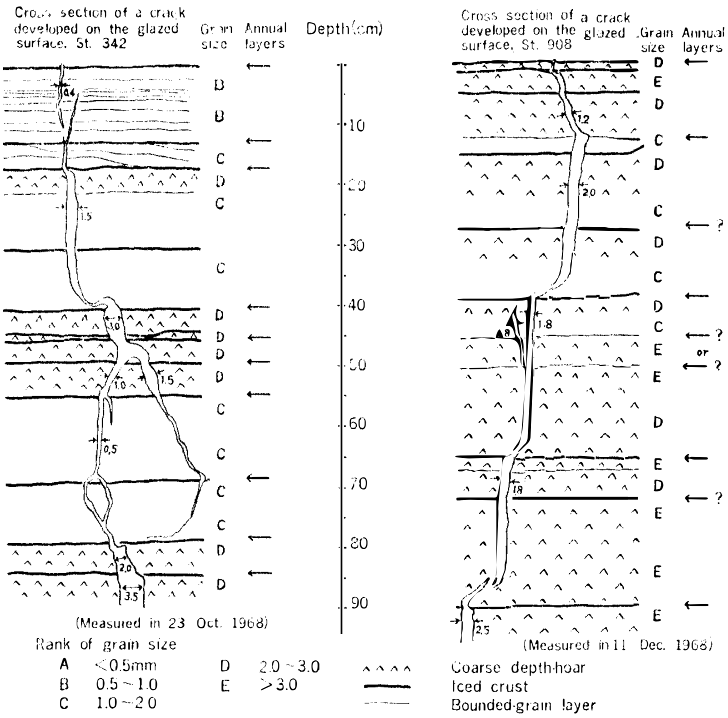

Fig. 6. Cross sections of cracks developed on the glazed and smooth surfaces.

of snow vehicle. "The survival rate of track" is defined as the ratio of the length of survived track of the snow vehicle to a certain distance run by the vehicle; for example, if the vehicle covers 500 m and the track mark remains 200 m, then the survival rate is 40%.

Survival rates greater than 80% were found mostly in the zones of small snow accumulation and of glazed snow surface (Photo 18). This fact shows that snow accumulates in the zone of glazed surfaces only in a negligibly small amount, if any, throughout the whole period of a year. In the zones of large snow accumulation and of rough surface, the rate was less than 10%.

In the region between 70°S and 74.5°S, the survival rate varied in accordance with the repetitive change in snow accumulation, and nearly constant values of 20-30% were obtained in the region between 74.5°S and 76°S (Photo 19). In the region of the Fuji Divide, the tracks were covered with a thin snow layer but could easily be recognized (Photo 20). These regional changes in the survival rate coincide with changes in the annual snow accumulation measured by snow stakes, and this will be discussed later.

3.4.3. Changes in the snow surfaces during the summer season

Since the party returned from the South Pole in the late summer, hoarfrost on the snow surface was frequently observed (Photo 21). The crystals of hoarfrost can be divided into two types; the spike-like type and the scale-like type. Spike-like crystals formed only in such cases when the weather was calm and fine for a particularly long period. The hoarfrosts of this type were easily broken by the winds of about 7-8 m/s, and deposited around snow drifts of sastrugi (Photo 22). The layers of scale-like crystals began to form towards the end of November when the weather was calm and the air temperature become higher than −30°C, and grew to the thickness of 2-3 cm within 3-4 days in the midsummer.

The hoarfrosts grew faster on the sloped flanks of drifts than on the horizontal flat surface on snow; for example, the layers of spike-like crystals on the drifts grew up to the thickness of 1.5-2.0 cm in 2 days, whereas those on the flat surfaces remained less than 1.0 cm in thickness. Repetition of such a process of formation and deposition of hoarfrost crystals might cause a gradual wearing down of the rough surface of snow and at the same time redistributed the snow more uniformly over the surface.

4. Snow Accumulation

4.1. Measurements of snow accumulation by snow stakes

In December 1967, and January 1968, the traverse party of JARE 1967-68 installed snow stakes at intervals of 2 km from the Plateau Station to Syowa Station. Measurements of snow accumulation using these stakes were carried out in April 1968, in September-November 1968, in January-February 1969. Table 2 shows the values of annual and seasonal accumulation obtained on the above three trips. In Figs. 7 and 8, moving averages of annual and seasnonal accumulations obtained at 10 sites are plotted.

As shown in Fig. 7, the annual snow accumulation showed a general tendency of decrease from Syowa to the Plateau. On the steep marginal slope between St. 16 and St. 70, the accumulation was about 20 $g \cdot cm^{-2} \cdot year^{-1}$, the greatest of the values obtained in the whole route. Between the marginal slope and 74.5°S, the accumulation varied in places within the range of 0 to 15 $g \cdot cm^{-2} \cdot year^{-1}$. In the plateau area between 74.5°S and the Plateau Station, the accumulation was nearly constant at 4 $g \cdot cm^{-2} \cdot year^{-1}$.

This difference in the values of accumulation observed to the north and to the south of 74.5°S will be due to the different topography and weather conditions in the two regions. In the southern region, the slope is more gentle, snow surfaces are more flat and smooth, and winds are lower than in the northern region. The recurrent changes in accumulation to the north of 74.5°S are probably due to the large scale undulation of ice sheet.

In the region between St. 16 and St. 144 near Syowa Station, measurements of accumulation were conducted in January, April, October, 1968 and in following February. Results thus obtained are shown in Fig. 8. The snow accumulation was large in the winter season (from April to October, during about 160 days). In the summer season (October to February, during about 130 days), the accumulation was negative, that is, ablation occurs instead of accumulation.

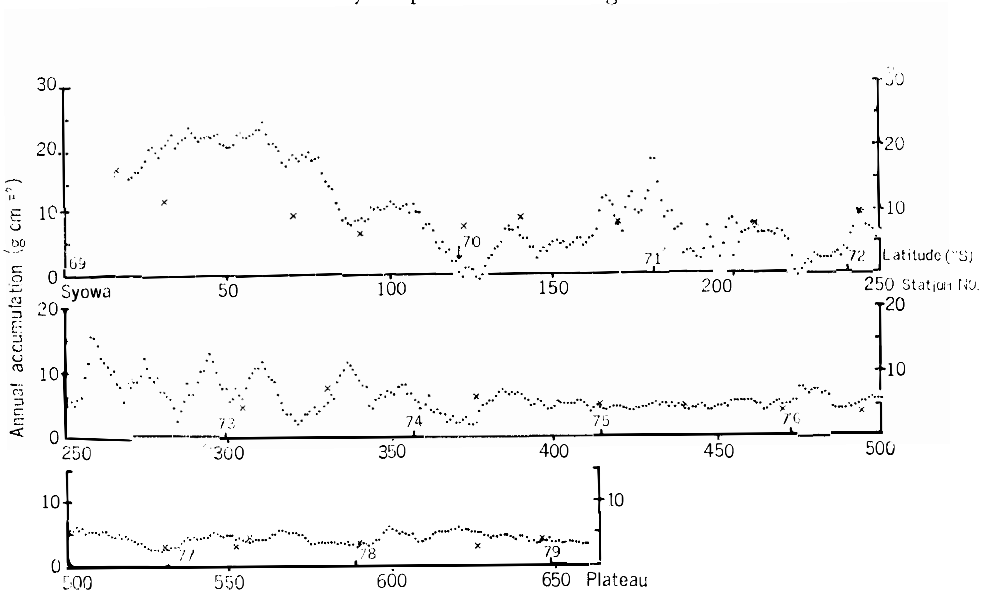

Fig. 7. Annual accumulation of snow along the traverse route from Syowa Station to the Plateau Station. Solid circle: Accumulation measured by snow stakes. Cross mark: Accumulation determined by snow stratigraphy.

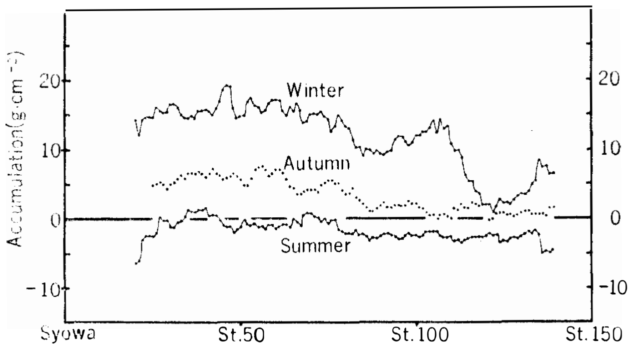

Fig. 8. Seasonal accumulation of snow profile from St. 16 to St. 144 near Syowa Station. Measurements of accumulation by snow stakes were carried out on January 7-13, April 22-27, September 28-October 10, 1968 and February 9-15, 1969.

4.2. *Measurement of snow accumulation from snow stratigraphy*

For the purpose of estimating the average snow accumulation, stratigraphy, density, hardness, and grain size of snow cover were examined in 2-m pits dug at 44 sites on the traverse route.

The summer layers are coarse-grained and have depthhoar, are of low density and hardness. The winter layers are fine grained, rather homogeneous, and of high density and hardness. These seasonal variations in the snow layers composing the snow cover were used as the criteria for distinguishing the annual snow layers.

Table 4. Snow and water accumulation.

Station No.	Depth of pit (cm)	Snow accumulation		Density		Water accumulation		Stratification in a pit wall	Snow surface condition	Surface topography of ice sheet
		Min. (cm/year)	Max. (cm/year)	Average (g/cm³)	Number of measurement	Min. (cm/year)	Max. (cm/year)			
16	450	90.0	90.0						Gullied	Slope down to the W
31	110	22.0	27.5	0.438	21	8.8	12.0	Uniform	Smooth	Gentle slope down to the W
70	175	19.5	21.8	0.429	35	8.4	9.4	〃	〃	〃
90	196	15.1	17.8	0.407	28	6.2	7.2	〃	Gullied	Top of dominant saddle
122	173	17.3	21.6	0.426	15	7.4	9.2	Very irregular	〃	Bottom of trough
140	230	20.9	23.0	0.428	24	9.0	9.8	〃	〃	Gentle slope down to the N
170	138	19.7	27.6	0.407	25	8.0	11.2	Irregular	〃	Shallow besin
212	114	19.0	22.8	0.412	17	7.8	9.4	Uniform	〃	Northside of saddle
244	195	21.7	24.3	0.422	10	9.2	10.3	Irregular	〃	Southside of trough
270	190	21.1	23.7	0.421	11	8.9	10.0	〃	〃	Top of broad saddle
304	190	11.9	12.6	0.386	8	4.6	4.9	Uniform	Glazed	Top of dominant mound
330	194	19.4	19.4	0.389	39	7.6	7.6	Irregular	Gullied	Bottom of trough
376	185	16.8	16.8	0.360	11	6.1	6.1	〃	〃	Even feature
414	194	12.9	16.1	0.363	40	4.7	5.8	Uniform	Smooth	Top of broad mound
440	115	12.8	14.3	0.353	8	4.5	5.0	〃	〃	Even feature
470	156	11.1	13.0	0.342	12	3.8	4.4	Irregular	Gullied	Gentle slope down to the N
494	202	11.2	13.4	0.340	20	3.8	4.6	Uniform	Smooth	Even feature
530	196	8.5	10.3	0.332	18	2.8	3.4	〃	〃	〃
552	165	8.7	10.3	0.333	14	2.9	3.4	〃	〃	〃
556	202	11.8	12.6	0.333	21	3.9	4.2	Irregular	〃	〃
590	176	8.8	10.3	0.337	16	3.0	3.5	Uniform	〃	〃
626	169	8.9	10.5	0.317	15	2.8	3.3	〃	〃	Faint step on a gentle slope
646	153	10.9	10.9	0.348	18	3.8	3.8	〃	〃	Bottom of shallow basin
Plateau		10.5*		0.335**	6	3.5			〃	Top of faint mound

Station No.	Depth of pit (cm)	Snow accumulation		Density		Water accumulation		Stratification in a pit wall	Snow surface condition	Surface topography of ice sheet
		Min. (cm/year)	Max. (cm/year)	Average (g/cm³)	Number of measurement	Min. (cm/year)	Max. (cm/year)			
675	180	10.6	11.2	0.345	15	3.7	3.9	Irregular	Gullied	Even feature
687	178	10.5	11.1	0.343	20	3.6	3.8	Uniform	〃	〃
705	170	11.3	13.0	0.352	17	4.0	4.6	Irregular	〃	〃
723	198	11.6	12.3	0.321	20	3.7	3.9	Uniform	Smooth	Faint saddle
735	193	13.8	16.0	0.368	39	5.1	5.9	Irregular	Gullied	Even feature
753	194	13.8	14.9	0.364	24	5.0	5.4	Very irregular	〃	Bottom of narrow trough
765	201	15.5	15.5	0.376	30	5.8	5.8	Irregular	Glazed	Northside of trough
783	192	17.5	17.5	0.397	37	7.0	7.0	〃	Gullied	〃
795	206	17.2	18.7	0.380	39	6.5	7.1	〃	〃	Even feature
813	196	14.1	14.1	0.377	38	5.3	5.3	〃	Glazed	Gentle slope down to the SW
825	200	18.1	20.0	0.378	38	6.8	7.6	〃	Gullied	〃
837	318	19.9	22.7	0.394	49	7.6	8.9	〃	〃	〃
855	205	14.6	17.0	0.365	40	5.3	6.2	〃	〃	Even feature
873	198	16.5	18.0	0.362	26	6.0	6.5	Very irregular	〃	Southside of saddle
885	201	20.1	20.1	0.388	38	7.8	7.8	〃	〃	Gentle slope down to the SW
903	194	17.6	17.6	0.376	34	6.6	6.6	Uniform	Smooth	Bottom of shallow basin
915	192	17.5	19.2	0.374	31	6.6	7.2	Irregular	Gullied	Southside of dominant mound
933	193	17.5	19.3	0.349	37	6.1	6.7	〃	Smooth	Top of dominant mound
945	199	18.1	19.9	0.363	38	6.6	7.2	〃	〃	〃
957	200	16.7	22.2	0.344	38	5.7	7.6	Uniform	〃	Northside of mound
975	203	20.3	22.5	0.356	40	7.2	8.0	〃	〃	Bottom of shallow basin
South Pole		22.8*		0.334***	4	7.6				

* Meteorological data of each station.

** Average density of near surface snow (0-20 cm deep) at Sts. 646 and 675.

*** Average density of near surface snow (0-20 cm deep) at St. 975.

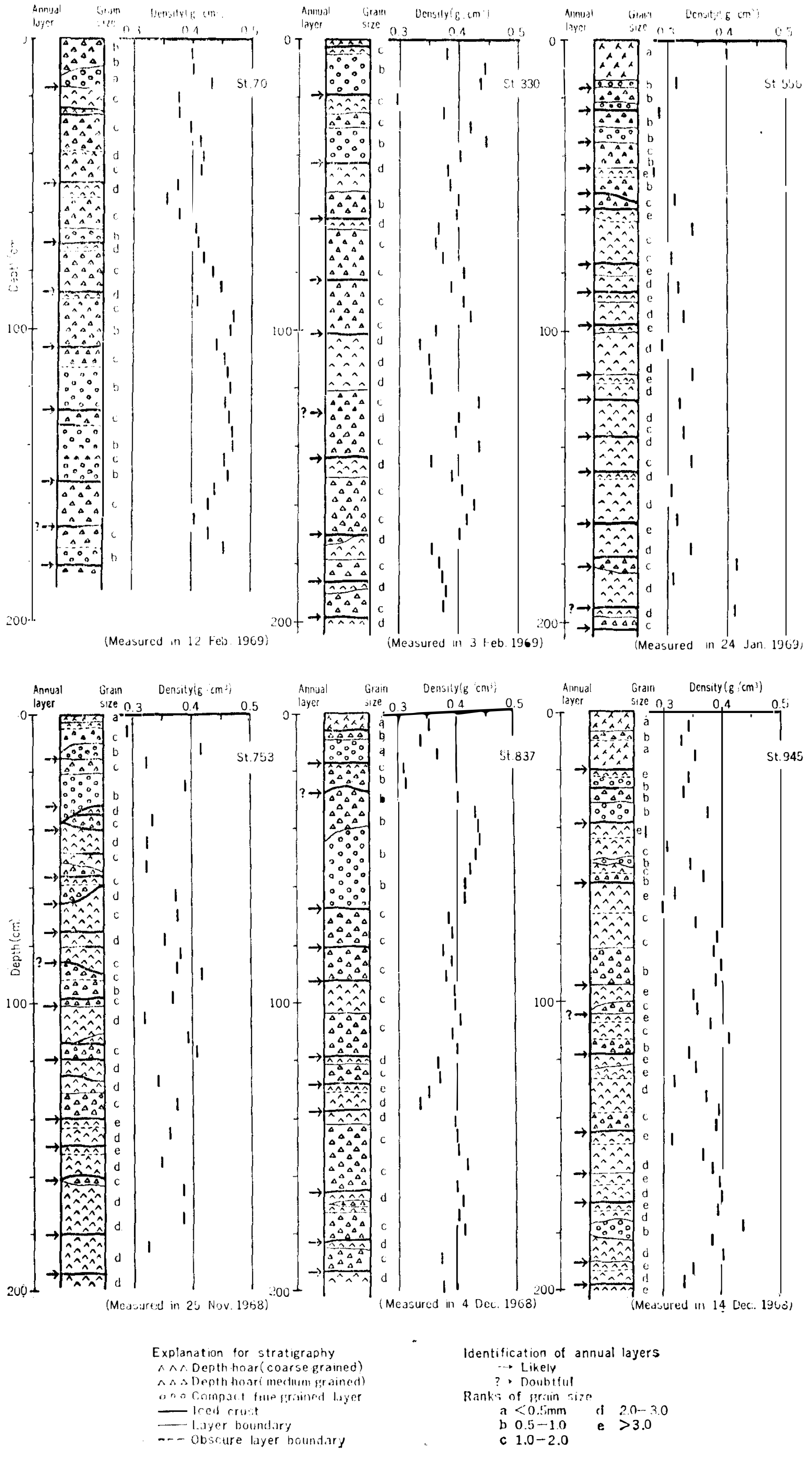

Fig. 9. Pit diagrams at Sts. 70, 330, 556, 753, 837, and 945.

Table 4, and Fig. 2 in p. 46 (FUJIWARA *et al.*, 1971) give the annual snow accumulation determined by the snow stratigraphy. In Fig. 7, in which the accumulations obtained from the snow stakes are plotted, the accumulations from the stratigraphy are shown by cross marks. The values of accumulation from the stakes and stratigraphy agree fairly well, except at St. 30, St. 70, and St. 122.

Reference

FUJIWARA, K., S. KAKINUMA, and Y. YOSHIDA (1971): Survey and some considerations on the antarctic ice sheet. JARE Scient. Rep., Special Issue, No. 2, 30-48.