Geodetic Survey in Antarctica by the Fourth Japanese Antarctic Research Expedition, 1959–60

Shinichi OHASHI*, Eiichi INBE** and Seiichi KAKINUMA***

南極地域における測地観測について

大橋伸一*・印部英一**・柿沼清一***

要　　旨

第4次観測に於ては，天測点1点，基線5本を含む合計12点の基準点を設置した．その内訳は西オングル島内に4点，東オングル島に1点，ネスオイヤ島に1点，昭和基地西南方大陸上に3点，パッダ島内に3点（うち一点は天測点）で，基線は東オングル島より，西オングル島に向って1本，大陸に向って3本，合計4点を設置した．

Introduction

The geodetic survey team, organized to establish the control points for the aerophotogrammetry, participated in the first, second and fourth expeditions.

At the first expedition, the geodetic survey team set up one astronomical station and eight triangulation stations in East Ongul Island, whereby the 1/5000 map of East Ongul Island and 1/1000 map of Syowa Base and its vicinity were made up.

At the second expedition, the reobservation at the astronomical station in East Ongul Island by meridian transit telescope (the accuracy is $\pm 0.2''$) and the triangulation connecting East, West Ongul Islands and the Antarctic continent were scheduled, but not realized at all owing to the extremely bad ice field conditions.

At the third expedition, the coastal area between 39°30′ E to 42°15′ E, the length and the width of which were 130 km and 4.25 km respectively, was aerophotographed. Two 1/100,000 maps of Prince Olav Coast were compiled referring to two astronomical stations, 40°11.4′ E, 68°48.4′ S and 41°23.8′ E, 68°28.5′ S set up by the first wintering team 1956–57. At the same time, the other two 1/100,000 maps of Prince Harald Coast, which were mere enlargement of Norwegian 1/250,000 map made by H. E. HANSEN, in 1937, were revised by applying the astronomical station in East Ongul Island.

In the fourth expedition, we could set up twelve control points including one astronomical station and five base line with the aid of big size helicopter as shown in

* Geographical Survey Institute. Member of the Japanese Antarctic Research Expeditions, 1957–58 and 1959–60.

** Geographical Survey Institute. Member of the Japanese Antarctic Research Expedition, 1956–57.

*** Geographical Survey Institute. Member of the Japanese Antarctic Research Expeditions, 1957–58 and 1958–59.

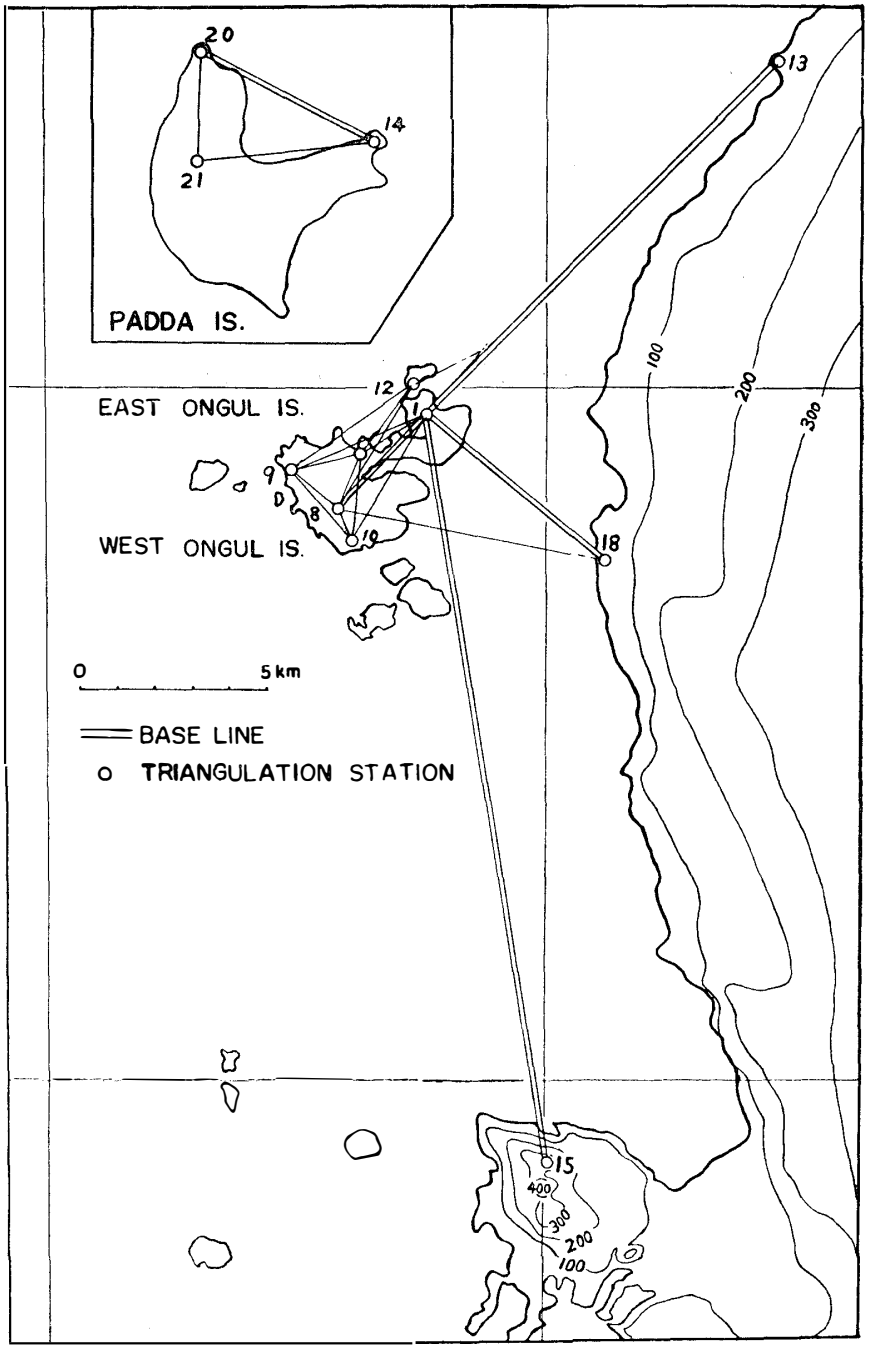

Fig. 1. Control points around Syowa Base.

Fig. 1; but we had unlucky obstacles two times which prevented farther developement of our project. The first was caused by the sudden growth of thick fog before leaving the helicopter off SOYA to Syowa Base where we were to stay with the helicopter for about ten days and proceed the survey project at the beginning of January 1960. The second was caused by the damage of the two helicopters at the same time before leaving off SOYA to Prince Olav Coast of 45° E to set up astronomical station.

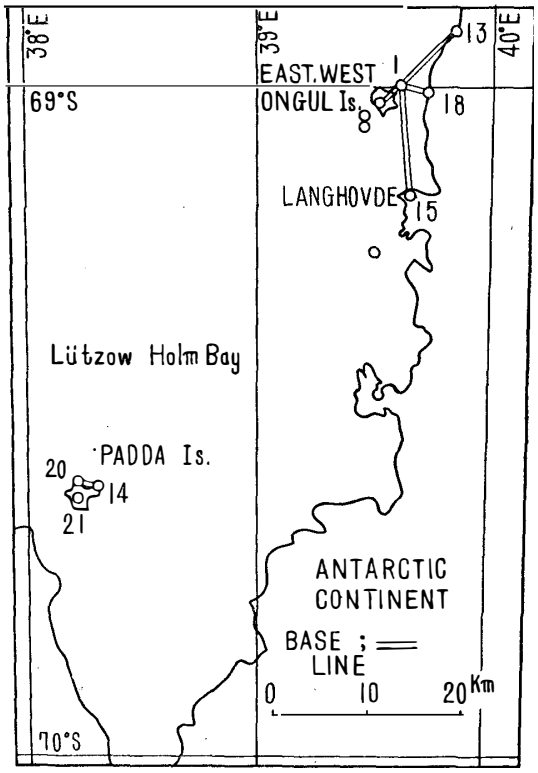

Fig. 2. Location of base line.

Development

Date; Jan. 16, 1960

Observation and observers;

E. INBE and S. KAKINUMA—triangulation at Nos. 1, 7, 8, 9 and 10.

S. OHASHI, S. KAKINUMA and T. KITAMURA—base line measurement between No. 18 and No. 1, and between No. 15 and No. 1, and triangulation at No. 1, No. 18 and No. 15.

Instrument;

Wild T-2 transits and tellurometers.

* Helicopter "Sikorsky S-58" was used for the transportation of observers and instruments.

Date; Jan. 17, 1960

Observation and observers;

E. INBE—triangulation at Nos. 1, 7, 8, 9, 10 and 12.

S. OHASHI and S. Kakinuma—base line measurement and triangulation between No. 1 and No. 8.

Instrument;

Wild T-2 transits and tellurometers.

Date; Jan. 18, 1960

Observation and observer;

E. INBE—triangulation at Nos. 1, 7, 8, 9, 10 and 12.

S. OHASHI and S. KAKINUMA—base line measurement between No. 1 and No. 13.

Instrument;

Wild T-2 transits and tellurometers.

* Observer was supported by R. HAGA for booking of base line measurement at No. 13.

* Helicopter "Sikorsky S-58" was used for the transportation of observers and instruments.

Date; Feb. 2, 1960

Observation and observers;

E. INBE—astronomical survey and triangulation at No. 20.

S. OHASHI and S. KAKINUMA—base line measurement between No. 20 and No. 14 and triangulation at No. 20, No. 21 and No. 14.

Instrument;

Wild T-2 transits and tellurometers.

* Observers are supported by T. SUENAGA and Y. MATSUMOTO for booking and transportation of the instruments.

* Helicopter "Sikorsky S-58" was used for the transportation of observers and instruments.

Date; Feb. 3, 1960

Observation and observer;

E. INBE—triangulation at Nos. 1, 7, 8, 9, 10 and 12.

Instrument;

Wild T-2 transit.

Results of observation

Observation station (1)* (East Ongul Island)

Latitude:	$B=-69°\ 0'\ 35''.793$		Coordinates
Longitude:	$L=\ 39°35'\ 11''.219$		$X=-427.42$ m
			$Y=-141.99$
Height:			$H=\ 43.42$
True bearing:		$-0°\ 0'\ 12''$	Logarithmic distance
Astronomical station:		18 22 36	2.653 587
Iwajima:		36 27 0	3.422 351
	(13)	41 38 40	4.164 469*
	(18)	127 47 5	3.773 620*
	(15)	170 29 5	4.302 246*
	(10)	212 57 22	3.568 077
	(8)	230 40 50	3.491 336*
	(7)	248 23 15	3.272 308
	(12)	343 44 44	3.089 881
	(9)	253 48 59	3.568 361

Observation station (12) (Nesöya Island)

$B = -68°59'57''686$ $X = +753.35^{m}$

$L = 39°34'40''252$ $Y = -486.25$

$H = 35.74$

True bearing:	$-0°\ 0'41''$	Logarithmic distance
Iwajima:	63 42 20	3.329 705
(1)	163 44 44	3.089 881
(8)	213 8 49	3.574 748
(7)	216 44 27	3.368 084
(9)	235 25 41	3.590 944

Observation station (7) (West Ongul Island)

$B = -69°\ 0'58''021$ $X = -1\ 116.93^{m}$

$L = 39°32'34''513$ $Y = -1\ 882.39$

$H = 37.92$

True bearing:	$0°\ 2'38''$	Logarithmic distance
(12)	36 44 27	3.368 084
(1)	68 23 15	3.272 308
(10)	186 25 24	3.385 512
(8)	207 17 34	3.156 655
(9)	259 19 16	3.266 292

Observation station (9) (West Ongul Island)

$B = -69°\ 1'\ 8''995$ $X = -1\ 459.05^{m}$

$L = 39°29'51''112$ $Y = -3\ 696.67$

$H = 36.56$

True bearing:	$-0°\ 5'11''$	Logarithmic distance
(12)	55 25 41	3.590 944
(1)	73 48 59	3.568 361
(7)	79 19 16	3.266 292
(8)	128 52 45	3.171 934
(10)	143 20 9	3.412 156

Observation station (8)* (West Ongul Island)

$B = -69°\ 1'39''137$ $X = -2\ 391.60^{m}$

$L = 39°31'35''176$ $Y = -2\ 540.09$

$H = 47.69$

True bearing:	$-0°\ 3'34''$	Logarithmic distance
(7)	27 17 34	3.156 655
(12)	33 8 49	3.574 748
(1)	50 40 50	3.491 336*
(10)	161 17 30	3.080 308
(9)	308 52 45	3.171 934

Observation station (10) (West Ongul Island)

$B = -69°\ 2'15''924$ $X = -3\ 531.15^{m}$

$L=$ 39°32′ 9″849		$Y=-2\ 154.19^{m}$
		$H=$ 43.14
True bearing:	−0° 3′ 1″	Logarithmic distance
(7)	6 25 24	3.385 512
(1)	32 57 22	3.568 077
(9)	323 20 9	3.412 156
(8)	341 17 30	3.080 308

Observation station (13)* (Prince Olav Coast)

$B=-68°54'43''012$		$X=+10\ 485.83^{m}$
$L=$ 39°49′ 40″935		$Y=+$ 9 562.39
		$H=$ 15.31
True bearing:	+0°13′19″	Logarithmic distance
(1)	221 38 40	4.164 469*

Observation station (18)* (Prince Olav Coast)

$B=-69°\ 2'33''060$		$X=-4\ 065.45^{m}$
$L=$ 39°42′ 14″230		$Y=+4$ 550.70
		$H=$ 36.29
True bearing:	+0° 6′23″	Logarithmic distance
(1)	307 47 5	3.773 620*

Observation station (15)* (Lang-Hovde)

$B=-69°11'14''056$		$X=-20\ 207.60^{m}$
$L=$ 39°40′ 11″978		$Y=+$ 3 173.49
		$H=$ 339.76
True bearing:	+0° 4′29″	Logarithmic distance
(1)	350 29 5	4.302 246*

Observation station (Iwajima)

$B=-68°59'27''132$		$X=+1\ 699.79^{m}$
$L=$ 39°37′ 32″534		$Y=+1$ 429.20
True bearing:	+0° 2′ 0″	$H=$ 37.14

Observation station (20)* (Padda Island)

$B=-69°36'43''000$		$X=-\ 0.00^{m}$
$L=$ 38°16′ 27″000		$Y=-$ 0.00
		$H=$ 109.63
True bearing:	+0° 0′ 0″	Logarithmic distance
(14)	104 58 4	3.669 078*
(21)	176 55 6	3.199 684

Observation station (14)* (Padda Island)

$B=-69°37'21''762$		$X=-1\ 205.49^{m}$
$L=$ 38°23′ 24″529		$Y=+4$ 509.07
		$H=$ 49.75
True bearing:	0° 6′31″	Logarithmic distance
(21)	265 8 33	3.647 370
(20)	284 58 4	3.699 078*

Observation station (21) (Padda Island)

$B=-69°37'34''032$		$X=-1\ 581.45$ m
$L=\ 38°16'34''885$		$Y=+\ 85.14$
		$H=\ 208.26$
True bearing:	$+0°\ 0'\ 7''$	Logarithmic distance
(14)	85 8 33	3.647 370
(20)	356 55 6	3.199 684

Note: * Base line station measured by Tellurometers.
Nos. 1~13, 15, 18 are referred to the astronomical station in East Ongul Island coordinately.
Nos. 14, 21 are referred to the astronomical station No. 20 coordinately.

Results of first expedition team (East Ongul Island)

Observation station, Astronomical station

$B=-69°\ 0'22''000$		$X=-\ 0.00$ m
$L=\ 39°35'24''000$		$Y=-\ 0.00$
		$H=\ 29.18$
True bearing:	$0°\ 0'\ 0''$	Logarithmic distance
(4)	174 30 18	3.108 473
(1)	198 22 36	2.653 587
(2)	221 42 51	3.123 432
(3)	250 31 46	2.410 877

Observation station (1)

$B=-69°\ 0'35''793$		$X=-427.42$ m
$L=\ 39°35'11''219$		$Y=-141.99$
		$H=\ 43.42$
True bearing:	$-0°\ 0'12''$	Logarithmic distance
Astronomical station:	18 22 36	2.653 587
(5)	73 21 65	3.062 032
(6)	99 52 18	2.956 887
(4)	162 41 50	2.949 740
(2)	232 44 46	2.969 606
(3)	343 33 8	2.551 626

Observation station (2)

$B=-69°\ 0'54''003$		$X=-991.85$ m
$L=\ 39°34'\ 4''397$		$Y=-884.15$
		$H=\ 33.34$
True bearing:	$-0°\ 1'14''$	Logarithmic distance
(3)	35 17 35	3.045 328
Astronomical station:	41 42 51	3.123 432
(1)	52 44 46	2.969 606
(4)	105 51 11	3.019 905

Observation station (3)

$B=-69°\ 0'24''770$	$X=-\ 85.85$ m

$L=$ 39°35′ 2″145		$Y=-242.83$
		$H=$ 33.31
True bearing:	−0° 0′20″	Logarithmic distance
Astronomical station:	70 31 46	2.410 877
(5)	90 32 30	3.081 409
(6)	116 34 51	3.045 434
(4)	162 56 29	3.095 809
(1)	163 33 8	2.551 626
(2)	215 17 35	3.045 328

Observation station (4)

$B=-69°$ 1′ 3″237		$X=-1277.83$ m
$L=$ 39°35′35″069		$Y=+$ 122.93
		$H=$ 35.38
True bearing:	+0° 0′10″	Logarithmic distance
(6)	42 3 22	2.971 401
(2)	285 51 11	3.019 905
(1)	342 41 50	2.949 740
(3)	342 56 29	3.095 809
Astronomical station:	354 30 18	3.108 473

Observation station (5)

$B=-69°$ 0′25″132		$X=-$ 97.25 m
$L=$ 39°36′50″697		$Y=+963.29$
		$H=$ 41.20
True bearing:	+0° 1′21″	Logarithmic distance
(6)	203 42 39	2.724 410
(1)	253 22 5	3.062 032
(3)	270 32 30	3.081 409

Observation station (6)

$B=-69°$ 0′40″800		$X=-582.66$ m
$L=$ 39°36′31″523		$Y=+750.10$
		$H=$ 40.70
True bearing:	+0° 1′ 3″	Logarithmic distance
(5)	23 42 39	2.724 410
(4)	222 3 22	2.971 401
(1)	279 52 18	2.956 887
(3)	296 34 51	3.045 434

Investigation of the results

The position of our astronomical station in Padda I. on the revised 1/100,000 map is read as

$$\varphi=69°33'5\,\mathrm{S}, \qquad \lambda=38°11'0\,\mathrm{E},$$

whereas our result is

$$\varphi'=69°36'7\,\mathrm{S}, \qquad \lambda'=38°16'4\,\mathrm{E}.$$

So that

$$\varphi' - \varphi = 3'2 \ldots\ldots \text{approx. } 6 \text{ km}$$
$$\lambda' - \lambda = 5'4 \ldots\ldots \text{approx. } 4 \text{ km}.$$

The discrapancy shows that the position of Padda Island is displaced from it's true position about 6 km northward and 4 km westward on the map.

In Padda Island, as the level is referred to the surface of the shelf ice, it should be corrected by the thickness of the shelf ice above mean sea level in the future, but there may remain an ambiguity of about 0.5 m.

The height in the vicinity of Syowa Base are triangulated referring to approximate mean sea level.

We painted yellow crosses of 2 m on the rocky places as the signals for the aero-photogrammetry, but some of them were hardly recognized on the photograph taken from the helicopter flying about 50—100 m high. Incidently we found the cotton sheets put on the rocky places by the first wintering team for the same purpose but not used. They are, however, presumed to be more distinctive than paints.

For the triangulation, as the atomospheric transparency was extremely good, we could recognize the station mark (a half redish and half white flag) separated about 20 km. It is considered that the stations separated more than 30 km can be sighted without heliotrope.

Tellurometer is an electronic microwave distance meter. The nominal accuracy is $3\times10^{-6}\pm2$ inches and the weight is about 60 kg including battery and accessaries.

Judging from the good uniformity of the atomospheric conditions, the accuracy of 10^{-5} seemed to be attained though there was no way to prove it, except the base line between No. 1 (astronomical station in East Ongul I.) and No. 18 (the nearest rocky place in the continent from Syowa Base) owing to the ambiguity of the reduction of the centre on the part of No. 18. The ambiguity is about 0.5 m.

It takes about nine hours to accomplish the observations at one group of control points. Two teams consisted of three persons each are necessary to do the work.

The items are:

The time;

Transportation of the instruments from helicopter to the station .....2 hours (average)
Distant measuremet .....2.5 hours
Levelling .....4 hours
Total 8.5 hours.

* The astronomical observation is done concurrently.

The number of workers;

One person is for astronomical observation or levelling.
One person is for distant measurement.
One person is for booking and supplementary work.
Total Three persons.