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TECHNICAL REPORT 23

CRUSTAL MOVEMENT SURVEY MARKHAM VALLEY- PAPUA NEW GUINEA 1975

by

B.J. Sloane and J.B. Steed

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CRUSTAL MOVEMENT SURVEY
MARKHAM VALLEY - PAPUA NEW GUINEA

ABSTRACT

This report describes the second survey of the Markham Valley crustal movement network, carried out in April/May 1975.

It deals principally with the results of the survey rather than instrumentation and techniques. These are fully described in Technical Report 18.

A detailed comparison of the results of the first and second surveys shows that some small differences were recorded in the measured distances between the six control stations. However, these differences can reasonably be explained by the estimated accuracy of the survey. No conclusive evidence of crustal movement could be found.

CRUSTAL MOVEMENT SURVEY
MARKHAM VALLEY - PAPUA NEW GUINEA

CONTENTS

CRUSTAL MOVEMENT SURVEY

MARKHAM VALLEY - PAPUA NEW GUINEA

1. INTRODUCTION

The initial survey of the Markham Valley Crustal Movement network was completed in September 1973. The equipment and techniques used and the results obtained were fully described in Technical Report 18 (TR18).

In April/May 1975, the second survey was completed. This survey differed from the first in only two ways. Firstly, the job was done solely by trilateration; and secondly, the vertical connections to the six control stations were carried out by first order differential levelling.

The decision not to observe horizontal angles was made after an analysis of the results of the 1973 survey which incorporated both trilateration and triangulation techniques. This analysis showed that the omission of horizontal angles would not cause any appreciable loss of accuracy in the final solution but it would have the beneficial effect of halving the time required for the survey.

First order differential levelling was carried to the six control stations, in preference to the 1973 method of slope distance and vertical angle, mainly to reduce the amount of equipment required for the survey but also to provide a check on the 1973 results.

2. GENERAL INFORMATION

2.1 Local departments

Once again PNG government departments provided valuable assistance. The Plant and Transport Authority in Lae hired five motor vehicles to the survey party and provided six 12-volt car batteries and the use of a 5-ton truck to transport the equipment from Lae to Mutsing and return.

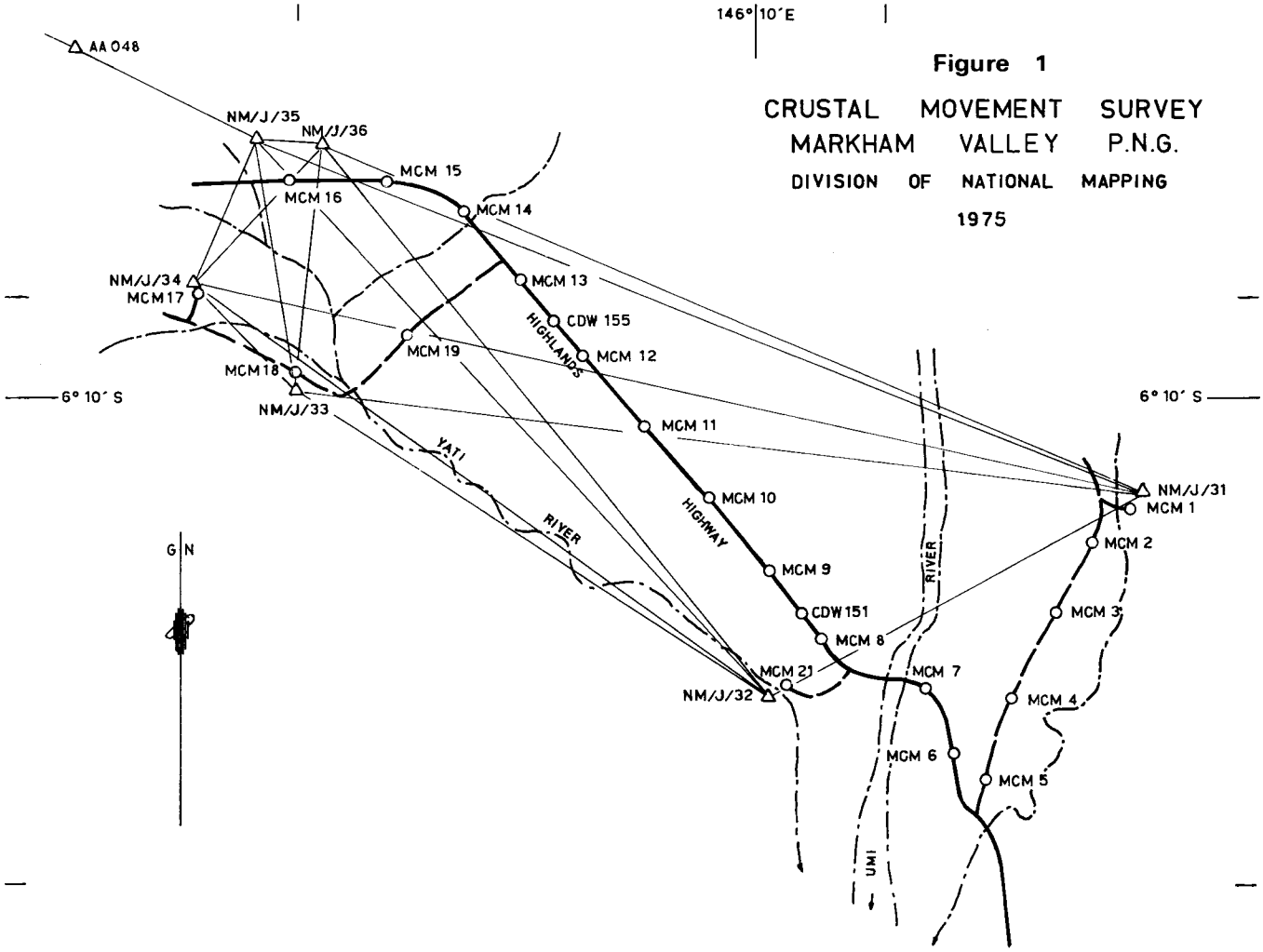
The Public Works Department provided two refrigerators plus construction material to place witness posts at all bench marks in the network; and the Department of Agriculture, Stock and Fisheries made two houses available at Mutsing Agricultural Station for accommodating the eight man survey team.

2.2 Weather

This survey began in mid April, about 14 weeks earlier than the start of the 1973 survey. Unlike the weather experienced in the first survey, the wet season had not ended and the field party encountered a lot of heavy rain and electrical storms. The majority of the lines were measured during breaks between storms and access to some of the stations was difficult due to flooded rivers and washed out tracks. Vehicles could not be driven off the main roads and labour lines had to be employed to transport the equipment to the stations.

Figure 1

CRUSTAL MOVEMENT SURVEY
MARKHAM VALLEY P.N.G.
DIVISION OF NATIONAL MAPPING
1975



2.3 Condition of survey marks

All control station pillars, reference marks and bench marks were found to be in excellent condition. A small amount of clearing of the kunai grass around the marks was all that was required before the survey began.

2.4 Land tenure

Only one complaint was received by the survey party about the rental paid for the land upon which the survey pillars and reference marks stood. Even this appeared to be unwarranted but nevertheless the complainant was advised to see the Assistant District Commissioner in Kaiapit for a hearing of his grievance.

3. DISTANCE MEASUREMENT

3.1 General

As far as possible, the equipment and techniques that were used in 1973 were maintained for this survey. Hence most of Section 4 in TR18 is still relevant and only those paragraphs which have changed or require clarification will be dealt with here.

3.2 Equipment

All distance measurements between the six control stations were made with AGA Geodimeter Model 8, serial number 80053. This instrument was used in the 1973 survey.

All other technical equipment was identical to that used in 1973. (See TR18, paragraphs 4.2 and 4.3)

3.3 EDM procedure

All fifteen possible lines connecting the six control stations were measured. Following the procedure adopted in 1973, all measurements were made in two sets on each of two separate days. A set consisted of two consecutive measurements. Sets were measured two hours apart, with the first set about one hour before sunset.

The detailed measuring procedure described in paragraph 4.6 of TR18 was rigorously followed. The only exceptions being that the time difference between sets sometimes varied slightly from two hours, depending on breaks in the weather, and quite often information was not relayed from the reflector stations to the geodimeter station due to malfunctions in the old NEC walkie-talkie radios.

3.4 Reduction of EDM observations

All Geodimeter lines were reduced during the morning following their measurement. Initially this work was done on a Hewlett Packard 9100B calculator using program GEODIMET4 but this machine broke down early in the survey and all further reductions were carried out with a HP45.

3.5 Heights used for EDM reductions

The 1973 heights of the six control stations were adopted for the purpose of the EDM reductions. These heights are:-

Station Number	Height in metres
NM/J/31	467.71
NM/J/32	445.28
NM/J/33	475.22
NM/J/34	438.07
NM/J/35	466.68
NM/J/36	491.03

3.6 Results

All measurements were recomputed in Canberra on the Cyber 76 using program GEODIMET.

A schedule of distance measurements showing comparisons between single measurements, sets and days is at Annex A.

A summary of the measurements of each line showing the adopted length, the standard deviation of a single measure and the standard error of the mean is at Annex B.

4. CALIBRATIONS AND ADJUSTMENTS

4.1 Geodimeter constant

Shortly before the survey party left for PNG, both Geodimeters belonging to the Division of National Mapping were calibrated over the Telopea Park Baseline in Canberra. A description of the baseline and the calibration procedure can be found in paragraph 5.1 of TR18.

A value of +0.218m was obtained for the constant of Geodimeter 80053 and this was used for all work in the Markham Valley. The constant adopted in 1973 was +0.214m.

4.2 Frequency counter

A Takeda Riken model TR5578D univeral frequency counter, S/N 513, was used to continuously monitor Geodimeter modulation frequencies for the entire measuring program.

The Positional Astronomy Section of the Division of National Mapping calibrated this counter shortly before it was taken to Papua New Guinea by comparing it with caesium beam frequency standard Cs 205. It was found to be accurate to 1 part in 10^7.

4.3 Psychrometers

Bendix 566-3 electrically aspirated psychrometers were used for this survey. The thermometers were calibrated at the Research School of Physical Sciences at the Australian National University in Canberra.

The calibration was achieved by comparing each thermometer with finely graduated "master thermometers" in three constant temperature baths. The temperatures used were 10°C, 25°C and 33°C.

An average correction was then calculated for each thermometer. Most thermometers required no correction; the maximum correction was 0.2°C.

4.4 Barometers

Five mechanism precision aneroid barometers were calibrated by the National Measurement Laboratory in Sydney. These barometers were the ones used in the 1973 survey.

Each barometer was compared with a laboratory standard instrument at 800, 860, 920, 980, 1010 and 1050 millibars. An average correction was then adopted for each barometer.

A comparison of the 1973 and 1975 corrections shows a reasurring stability in this type of instrument.

Barometer serial no.	Correction (mb)		Difference (mb)
	1975	1973	
1399	-1.78	-1.58	-0.20
1400	-0.58	-0.43	-0.15
1402	-0.65	-0.63	-0.02
1405	-1.47	-1.24	-0.23
1408	-0.84	-0.73	-0.11

4.5 Zeiss Koni 007 levels

A field collimation check was carried out every morning before any levelling was commenced. The "two-peg" method was used and the collimation error was never allowed to excees 1mm in 50m.

4.6 Invar levelling staves

The two invar staves were not calibrated prior to the survey as the maximum difference in height between consecutive bench marks was about 18m and a calibration of four similar staves had resulted in calibration constants ranging from 1.000001 to 1.0000011. Under the worst conditions the maximum error in the difference in height between consecutive bench marks would have been 0.2mm.

4.7 Steel measuring bands

The 100m steel bands used in 1973 were again used on this survey. The 1973 calibrations were adopted as the bands had been carefully looked after and had received very little use during the intervening two years.

5. HORIZONTAL ANGLES

As explained in the introduction, no internal horizontal angles were observed. However, the angle at NM/J/35 between NM/J/31 and AA048 was observed to first order standards as a check on the rotational movement of the line NM/J/35 to NM/J/31. The observational procedure was similar to that described in paragraph 6 of TR18.

1975 value 185^{o} 23' 33.01" s.e. 0.22"
1973 value 185^{o} 23' 33.66" s.e. 0.34"

6. RECOVERY MARKS

6.1 General

Great care was taken in the connections of the RMs to the control stations as any localised pillar movements had to be detected and distinguished from any general movement in the valley floor.

No local movement of any pillar was detected. With two exceptions, all RM measurements agreed with the 1973 values. At station NM/J/35, RM 1 had moved 9mm upwards and 8mm horizontally; and at NM/J/34, RM 2 had moved 4mm downwards and 5mm horizontally.

6.2 Measuring procedure

The procedure described in paragraph 7.3 of TR18 was closely followed.

6.3 Computations

Computations were carried out in the field using a HP45 calculator. Final computations of all recovery mark measurements were carried out in Canberra using program RMCOORD.

7. LEVELLING

7.1 Standard

All levelling observed on this survey was to first order standard and was carried out in accordance with the Division of National Mapping specifications. A copy of these may be found in TR18, Annex C.

7.2 Bench marks

Because of the dense high kunai grass in the valley and the lack of witness posts, the BMs were at first difficult to find. However, those that could not be located by reference to the access diagrams were found by setting a theodolite on an appropriate control station and turning off the correct bearing to intersect the BM in question. The search party in the general locality of the BM then walked along parallel to the road, at the correct distance from the centreline until the man on the theodolite advised them by radio that they were "on line". At this point they were invariably standing on the BM, even though it may have been hidden by grass or muddy water.

In order to assist in the location of the BMs for future surveys and in order to avoid disturbance by road maintenance gangs, witness posts were placed at each BM. These were made of ½-inch water pipe with a flat metal disc on top, and were placed in 0.5m of concrete. See Figure 2.

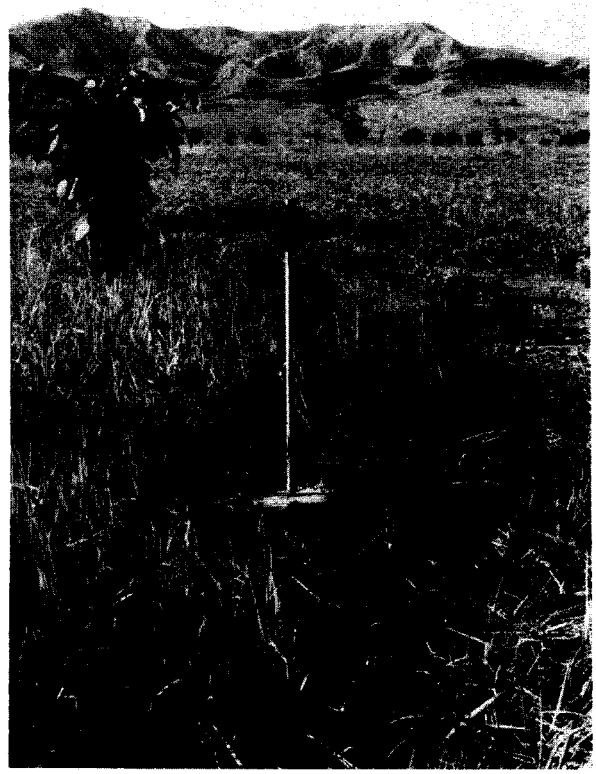


Figure 2

Witness Post at MCM 16

Figure 3

Reflector Party at NM/J/34

7.3 Equipment

The equipment used was:

Zeiss Koni 007 level S/N 157260, with metric micrometer.

Zeiss invar staves 305A and 305B, with aluminium poles for supports.

Change points - one three prong 6kg base plate for use on firm surfaces and a 0.3m long carrot shaped steel pin for use in soft ground.

7.4 Field procedure

The eight men in the survey party alternated on observing, booking and holding the staff. Three miles of levelling were completed each morning by a four-man party. This meant that three sections of two way levelling were completed every two days. Afternoons and evenings were devoted to Geodimeter work.

First order levelling connections were also carried up the hills to the control stations. These two-way connections usually took most of the day and were done towards the end of the survey when the Geodimeter work had been completed.

7.5 Results

In approximately 39km of two way levelling, including the connections to the control stations, only one misclose was obtained and this was due to a gross error.

MCM1 was adopted as the datum for the survey and the 1973 height of 401.6130m was held fixed. All other heights of BMs and control stations were then determined in relation to MCM1.

The adopted heights of the BMs and the levelling analysis are on the next two pages.

8. HORIZONTAL ADJUSTMENT

The net is unusual in that it is a survey of very high precision connected to a traverse of much lower order. The initial connection to two traverse stations served the purpose of orientating the net and giving the control stations reasonable coordinates on the AGD. However, without upgrading the connection of the net to first order stations outside the area affected by the crustal movement, it will be impossible to detect absolute movements of the six control pillars.

For this reason only relative movements of the pillars can be detected and so, for this adjustment, both the coordinates of NM/J/35 and the azimuth of the line from NM/J/35 to NM/J/31 were held fixed at their 1973 values.

Program VARYCORD, which is described in Technical Report 6, was used to adjust the network. The output is at Annex C.

ADOPTED HEIGHTS

MARKHAM VALLEY CRUSTAL MOVEMENT SURVEY

1975

Pillars

NM/J/31	467.7156
NM/J/32	445.2909
NM/J/33	475.2289
NM/J/34	438.0929
NM/J/35	466.7011
NM/J/36	491.0366

Bench Marks

MCM 1	401.6130 (Datum)	MCM 11	403.8918
MCM 2	397.0765	MCM 12	403.2073
MCM 3	387.3216	MCM 13	409.9743
MCM 4	373.9356	MCM 14	417.3389
MCM 5	362.0498	MCM 15	412.3369
MCM 6	366.5247	MCM 16	407.5173
MCM 7	377.7947	MCM 17	397.7566
MCM 8	383.6124	MCM 18	390.2257
MCM 9	392.0609	MCM 19	396.1353
MCM 10	401.2111	MCM 21	365.7488

MARKHAM VALLEY FIRST ORDER LEVELLING 1975

	From	To	Diff. Height Forward	Diff. Height Backward	Distances km	Run Diff.	Field Books
	MCM 1	MCM 2	-4.5357	+4.5373	1.74	.0016	15136
	MCM 2	MCM 3	-9.7554	+9.7544	1.46	.0010	15136
	MCM 3	MCM 4	-13.3844	+13.3876	1.57	.0032	15136
	MCM 4	MCM 5	-11.8854	+11.8861	1.60	.0007	15136
	MCM 5	MCM 6	+4.4755	-4.4743	1.63	.0012	15136
*	MCM 6	MCM 7	+11.2707	-11.2692	1.32	.0015	15136
*	MCM 7	MCM 8	+5.8172	-5.8182	1.99	.0010	15136 15137
	MCM 8	MCM 9	+8.4483	-8.4487	1.63	.0004	15137
	MCM 9	MCM 10	+9.1504	-9.1500	1.60	.0004	15137
	MCM 10	MCM 11	+2.6801	-2.6813	1.57	.0012	15137
	MCM 11	MCM 12	-0.6831	+0.6860	1.64	.0029	15137
	MCM 12	MCM 13	+6.7663	-6.7677	1.68	.0014	15138
	MCM 13	MCM 14	+7.3657	-7.3635	1.51	.0022	15138
	MCM 14	MCM 15	-5.0016	+5.0023	1.61	.0007	15138
	MCM 15	MCM 16	-4.8182	+4.8209	1.56	.0027	15138 15145
	MCM 8	MCM 21	-17.8630	+17.8630	2.13	.0011	15137
*	MCM 13	MCM 19	-13.8395	+13.8385	2.69	.0010	15138
*	MCM 19	MCM 18	-5.9106	+5.9086	2.69	.0020	15138
	MCM 18	MCM 17	+7.5298	-7.5320	2.46	.0022	15138
	MCM 1	NM/J/31	+66.1030	-66.1022	0.40	.0008	15136
	MCM 21	NM/J/32	+79.5426	-79.5415	0.70	.0011	15137
	MCM 18	NM/J/33	+85.0031	-85.0033	0.37	.0002	15145
	MCM 17	NM/J/34	+40.3358	-40.3368	0.21	.0010	15145
	MCM 16	NM/J/35	+59.1837	-59.1838	1.18	.0001	15145
	MCM 15	NM/J/36	+78.7014	-78.6980	1.30	.0034	15145

Because the 1973 adjustment incorporated both angles and distances, it too was adjusted using distances only. This allowed a comparison of the 1973 and 1975 surveys to be made, based on similar data sets. The output from this adjustment is at Annex D.

9. COMPARISON OF RESULTS OF 1973 AND 1975 SURVEYS

9.1 Vertical

Two tables have been included at Annex E to compare the levelling results of the 1973 and 1975 surveys. The first table compares the adopted heights of the bench marks and the control stations and the second table, which is of much more significance, compares the individual section height differences between bench marks for the two surveys.

In the latter table it is shown that only two sections fall outside the limits of first order levelling ($D\sqrt{K}$ = .004). These sections are MCM 6 to MCM 7 and MCM 19 to MCM 18. However, at Annex H of TR18, it can be seen that section MCM 6 to MCM 7 was levelled three times in 1973 and, in fact, the result of the run that was rejected agreed very closely with the 1975 value. Also, even though the section MCM 19 to MCM 18 is outside first order limmts, the value obtained in 1975 agrees with the value of one of the runs made in 1973 to within first order limits.

9.2 Horizontal

The observed and adjusted distances from the 1973 and 1975 surveys are compared at Annex F. The data used in this comparison comes from the VARYCORD adjustments of the two surveys at Annexes C and D.

In order to gauge the quality of the observations listed in Annex F, the results of the two VARYCORD adjustments have been summarised below.

Adjustment to measured distances	1973	1975
Average adjustment without sign	1 mm	2 mm
Average adjustment with sign	0 mm	0 mm
Maximum adjustment	3 mm	7 mm

Finally, the coordinates of the six control stations, as given by the VARYCORD adjustments, were compared and the displacement vectors at each station were calculated. The results are listed in the table below and are shown diagrammatically in Figure 4.

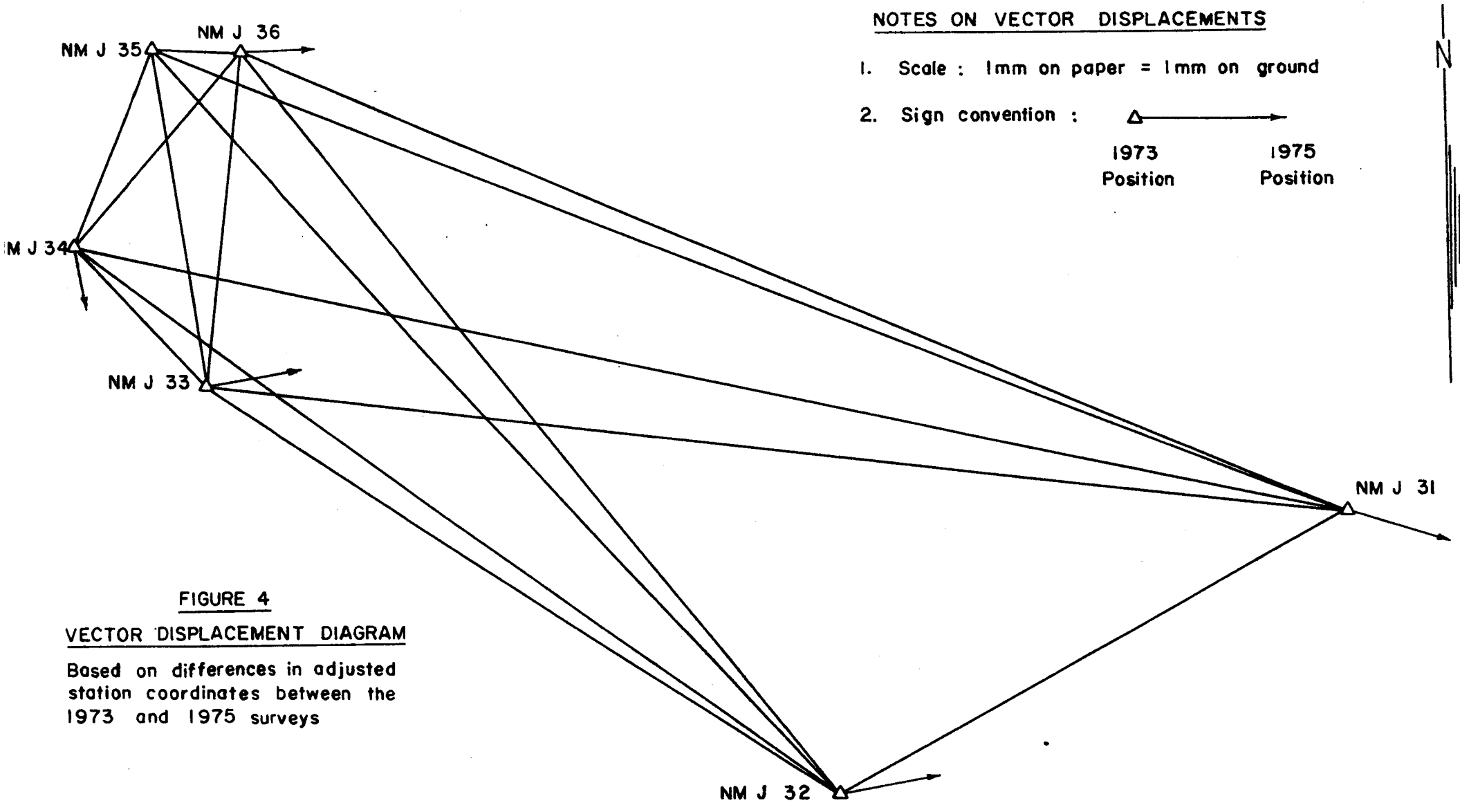


FIGURE 4

VECTOR DISPLACEMENT DIAGRAM

Based on differences in adjusted station coordinates between the 1973 and 1975 surveys

Station	Displacement Vector	
	Magnitude	Direction
NM/J/31	10 mm	108°
NM/J/32	19 mm	81°
NM/J/33	19 mm	81°
NM/J/34	13 mm	166°
NM/J/35	-	-
NM/J/36	15 mm	90°

10. CONCLUSION

10.1 Vertical movement

Following on from paragraph 9.1, it would seem that there have been no significant vertical movements in the valley floor between the 1973 and the 1975 surveys.

10.2 Horizontal movement

Even though the VARYCORD adjustment summary given in paragraph 9.2 shows that the quality of the measurements in both surveys was very high, the basic criterion for evaluating the two horizontal surveys is the estimated accuracy of the measuring procedure adopted.

AGA, the manufacturer of Geodimeters, claim that the Model 8 Geodimeter can measure a line with a mean square error (mse) of 6mm ± 1ppm. This estimate incorporates the following sources of error: setting, phase determination, Geodimeter constant, eccentricity of Geodimeter and reflector, frequency and meteorological data.

Based on the assumptions that the pillars have not moved, that the measurements obey the Normal Distribution law and that the manufacturer's estimated mse of a measurement is valid, it would be expected that the majority of the comparisons of the observed distances would lie within 1 mse (6mm ± 1ppm) of each other with one or two which could vary by up to 3 mse. In fact this is so. Of the 15 comparisons, 11 agree to within 1 mse, 2 to within 2 mse and 2 to within 3 mse. Hence the differences in the measured distances can reasonably be explained by the estimated accuracy of the survey.

In the light of the above reasoning it must be concluded that if any horizontal movement did take place between 1973 and 1975, it was not of sufficient magnitude to be detected by the equipment and procedures used in the surveys.

One other point that should be mentioned now, for the guidance of those who undertake the next survey in the Markham Valley, is the use of reflectors on very short lines. The survey parties in both 1973 and 1975 used a standard AGA prism instead of a plastic reflector on the 1.1 km line from NM/J/35 to NM/J/36. Under the section titled Plastic Reflectors in the Operating Manual for the Model 8, it is stated that due to the arrangement of the optical systems, the use of a good quality retrodirective reflector, rather than a simple plastic reflector or reflecting tape, for distances less than 2 km can introduce an error of up to about 5 mm.

11. ACKNOWLEDGEMENTS

The Division of National Mapping is grateful to the Department of Transport in Lae for arranging for the supply of motor vehicles and to the Department of Public Works for the loan of two refrigerators.

The Agricultural Station at Mutsing, under Mr Bill Fullerton, once again provided accommodation and the use of refuelling facilities. This assistance was much appreciated.

Complete cooperation was obtained from all the village people, especially David at Zaklak, Luke at Tofmora, and Nanas at Atsunas. The children of the villages provided both help and humour and they will be warmly remembered.

Finally, we would like to acknowledge and thank the other members of the survey team for their contributions towards the successful completion of the survey. They are Messrs D. Gray, J. Edmonstone, P. Allen, R. Twilley, J. Guilfoyle and W. Stuchbery.

NM/J/31 to NM/J/32

Date	Time	Distance	Mean of Distances	Mean of Sets	Mean of Days	Range L1 L2K L3K mm	Range L1 L2K L3K ppm	Range Dist.	Range ppm Sets	Range ppm Days
24.4.75	1723-1730	7345.452				13	1.8			
24.4.75	1735-1743	.446	7345.449			16	2.2	0.8		
				7345.450					0.3	
24.4.75	1900-1907	7345.452	7345.451			14	1.9	0.3		
24.4.75	1910-1915	.450				10	1.4			
					7345.455					1.4
26.4.75	1712-1718	7345.457				9	1.2			
26.4.75	1721-1727	.463	7345.460			13	1.8	0.8		
				7345.460					0.0	
26.4.75	1950-1955	7345.461	7345.460			16	2.2	0.4		
26.4.75	1958-2004	.458				10	1.4			

NM/J/31 to NM/J/33

Date	Time	Distance	Mean of Distances	Mean of Sets	Mean of Days	Range L1 L2K L3K mm	Range L1 L2K L3K ppm	Range Dist.	Range ppm Sets	Range ppm Days
24.4.75	1755-1800	14526.435				16	1.1			
24.4.75	1804-1810	.434	14526.434			6	0.4	0.1		
				14526.437					0.4	
24.4.75	1925-1930	14526.441	14526.440			4	0.3	0.2		
24.4.75	1935-1940	.438				5	0.3			
					14526.437					0.1
26.4.75	1648-1655	14526.427				10	0.7			
26.4.75	1657-1704	.434	14526.430			7	0.5	0.5		
				14526.436					0.8	
26.4.75	1920-1928	14526.437	14526.442			16	1.1	0.7		
26.4.75	1931-1937	.447				8	0.6			

NM/J/31 to NM/J/34

Date	Time	Distance	Mean of Distances	Mean of Sets	Mean of Days	Range L1 L2K L3K mm	Range L1 L2K L3K ppm	Range Dist.	Range ppm Sets	Range ppm Days
19.4.75	1820-1830	16498.113				4	0.2			
19.4.75	1835-1841	.117	16498.115			2	0.1	0.2		
				16498.118					0.4	
19.4.75	2000-2011	16498.122	16498.112			6	0.4	0.1		
19.4.75	2013-2021	.121				19	1.2			
					16498.107					1.4
22.4.75	1700-1708	16498.085				44	2.7			
22.4.75	1710-1716	.093	16498.089			13	0.8	0.5		
				16498.095					0.7	
22.4.75	1859-1905	16498.102	16498.101			14	0.8	0.1		
22.4.75	1908-1914	. .100				26	1.6			

NM/J/31 to NM/J/35

Date	Time	Distance	Mean of Distances	Mean of Sets	Mean of Days	Range L1 L2K L3K mm	Range L1 L2K L3K ppm	Range Dist.	Range ppm Sets	Range ppm Days
5.5.75	1648-1655	16172.703				21	1.3			
5.5.75	1659-1706	.702	16172.702			10	0.6	0.1		
				16172.693					1.1	
5.5.75	1846-1852	16172.681	16172.684			5	0.3	0.3		
5.5.75	1855-1901	.686				10	0.6			
					16172.692					0.2
6.5.75	1650-1655	16172.693				14	0.9			
6.5.75	1700-1705	.693	16172.693			4	0.2	0.0		
				16172.690					0.4	
6.5.75	1845-1850	16172.689	16172.687			9	0.6	0.2		
	1855-1900	.685				8	0.5			

NM/J/31 to NM/J/36

Date	Time	Distance	Mean of Distances	Mean of Sets	Mean of Days	Range L1 mm	Range L2K L3K ppm	Range Dist. ppm	Range Sets ppm	Range Days
19.4.75	174701758	15113.385				5	0.3			
19.4.75	1801-1812	.379	15113.382			9	0.6	0.4		
				15113.389					0.9	
19.4.75	1945-1949	15113.395	15113.396			18	1.2	0.1		
19.4.75	1950-1957	.396				17	1.1			
					15113.381					1.0
22.4.75	1721-1726	15113.375				18	1.2			
22.4.75	1729-1735	.379	15113.377			11	0.7	0.3		
				15113.374					0.4	
22.4.75	1920-1925	15113.373	15113.371			28	1.8	0.3		
22.4.75	1927-1934	.369				18	1.2			
NM/J/32 to NM/J/33										
1.5.75	1700-1705	9626.467				10	1.0			
1.5.75	1707-1714	.475	9626.471			21	2.2	0.8		
				9626.470					0.1	
1.5.75	1900-1905	9626.468	9626.470			4	0.4	0.3		
1.5.75	1907-1915	.471				6	0.6			
					9626.466					0.9
2.5.75	1650-1656	9626.462				6	0.6			
2.5.75	1659-1703	.471	9626.466			4	0.4	0.9		
				9626.461					1.0	
2.5.75	1845-1849	9626.454	9626.456			18	1.9	0.3		
	1850-1856	.457				29	3.0			
NM/J/32 to NM/J/34										
29.4.75	1728-1735	12048.079				15	1.2			
29.4.75	1738-1745	.075	12048.077			12	1.0	0.3		
				12048.080					0.6	
29.4.75	1920-1928	12048.082	12048.084			15	1.2	0.4		
29.4.75	1930-1940	.087				10	0.8			
					12048.074					1.1
30.4.75	1738-1746	12048.073				8	0.7			
30.4.75	1749-1756	.063	12048.068			6	0.5	0.8		
				12048.067					0.2	
30.4.75	1940-1947	12048.067	12048.066			11	0.9	0.2		
30.4.75	1948-1958	.065				7	0.6			
NM/J/32 to NM/J/35										
5.5.75	1711-1718	12907.548				22	1.7			
5.5.75	1721-1727	.533	12907.540			33	2.6	1.2		
				12907.541					0.2	
5.5.75	1906-1913	12907.545	12907.542			7	0.5	0.5		
5.5.75	1915-1921	.538				7	0.5			
					12907.542					0.2
6.5.75	1710-1717	12907.546				18	1.4			
6.5.76	1720-1725	.538	12907.542			11	0.8	0.6		
				12907.544					0.3	
6.5.75	1905-1915	12907.549	12907.546			10	0.8	0.5		
6.5.75	1917-1925	.542				12	0.9			

NM/J/34 to NM/J/35

Date	Time	Distance	Mean of Distances	Mean of Sets	Mean of Days	Range L1 mm	Range L2K L3K ppm	Range Dist.	Range ppm Sets	Range ppm Days
30.4.75	1717-1725	2724.346				24	8.8			
30.4.75	1728-1735	.347	2724.346			7	2.6	0.4		
				2724.348					1.5	
30.4.75	1915-1925	2724.349	2724.350			11	4.0	0.4		
30.4.75	1926-1935	.350				8	2.9			
					2724.349					0.7
6.5.75	1730-1735	2724.350				12	4.4			
6.5.75	1737-1742	.352	2724.351			4	1.4	0.7		
				2724.350					0.4	
6.5.75	1930-1935	2724.346	2724.350			17	6.2	2.9		
6.5.75	1937-1945	.354				6	2.2			

NM/J/34 to NM/J/36

Date	Time	Distance	Mean of Distances	Mean of Sets	Mean of Days	Range L1 mm	Range L2K L3K ppm	Range Dist.	Range ppm Sets	Range ppm Days
8.5.75	1701-1707	3292.104				8	2.4			
8.5.75	1708-1714	.100	3292.102			27	8.2	1.2		
				3292.103					0.6	
8.5.75	1910-1917	3292.100	3292.104			3	0.9	2.7		
8.5.75	1918-1927	.109				17	5.2			
					3292.103					0.3
9.5.75	1645-1655	3292.104				5	1.5			
9.5.75	1657-1703	.096	3292.100			7	2.1	2.4		
				3292.102					1.2	
9.5.75	1845-1855	3292.109	3292.104			6	1.8	2.7		
9.5.75	1858-1903	.100				3	0.9			

STATION DATE	TOFMORA TIME	NM J 31 TO DISTANCES	STATION FREQ	ZAKLAK CORRECTIONS	NM J 32 CORRECTED DISTANCES
24-04-75	1723-1730	7345.452		-.001	7345.452
24-04-75	1735-1743	7345.447		-.000	7345.446
24-04-75	1900-1907	7345.452		-.000	7345.452
24-04-75	1910-1915	7345.450		-.000	7345.450
26-04-75	1712-1718	7345.459		-.002	7345.457
26-04-75	1721-1727	7345.464		-.001	7345.463
26-04-75	1950-1955	7345.462		-.001	7345.461
26-04-75	1958-2004	7345.460		-.002	7345.458

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.006	.800	.002	.283

MEAN OF ACCEPTABLE MEASUREMENTS 7345.455

STATION DATE	TOFMORA TIME	NM J 31 TO DISTANCES	STATION FREQ	RAGINAM CORRECTIONS	NM J 33 CORRECTED DISTANCES
24-04-75	1755-1800	14526.435		.000	14526.435
24-04-75	1804-1810	14526.434		-.001	14526.434
24-04-75	1925-1930	14526.440		.001	14526.441
24-04-75	1935-1940	14526.439		-.001	14526.438
26-04-75	1648-1655	14526.430		-.003	14526.427
26-04-75	1657-1704	14526.438		-.004	14526.434
26-04-75	1920-1928	14526.437		.000	14526.437
26-04-75	1931-1937	14526.449		-.002	14526.447

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.006	.401	.002	.142

MEAN OF ACCEPTABLE MEASUREMENTS 14526.437

STATION DATE	TOFMORA TIME	NM J 31 TO DISTANCES	STATION FREQ	WANKUN CORRECTIONS	NM J 34 CORRECTED DISTANCES
19-04-75	1820-1830	16498.115		-.002	16498.113
19-04-75	1835-1841	16498.120		-.003	16498.117
19-04-75	2000-2011	16498.124		-.002	16498.122
19-04-75	2013-2021	16498.123		-.002	16498.121
22-04-75	1700-1708	16498.087		-.002	16498.085
22-04-75	1710-1716	16498.095		-.002	16498.093
22-04-75	1859-1905	16498.105		-.003	16498.102
22-04-75	1908-1914	16498.102		-.002	16498.100

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.014	.827	.005	.292

MEAN OF ACCEPTABLE MEASUREMENTS 16498.107

STATION DATE	TOFMORA TIME	NM J 31 TO DISTANCES	STATION FREQ	OMMAN CORRECTIONS	NM J 36 CORRECTED DISTANCES
19-04-75	1747-1758	15113.387		-.002	15113.385
19-04-75	1801-1812	15113.382		-.002	15113.379
19-04-75	1945-1949	15113.397		-.002	15113.395
19-04-75	1950-1957	15113.399		-.003	15113.396
22-04-75	1721-1726	15113.377		-.002	15113.375
22-04-75	1729-1735	15113.381		-.001	15113.379
22-04-75	1920-1925	15113.376		-.003	15113.373
22-04-75	1927-1934	15113.372		-.003	15113.369

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.010	.659	.004	.233

MEAN OF ACCEPTABLE MEASUREMENTS 15113.381

STATION DATE	RAGINAM TIME	NM J 33 TO DISTANCES	STATION FREQ	ZAKLAK CORRECTIONS	NM J 32 CORRECTED DISTANCES
01-05-75	1700-1705	9626.468		-.000	9626.467
01-05-75	1707-1714	9626.477		-.002	9626.475
01-05-75	1900-1905	9626.466		.002	9626.468
01-05-75	1907-1915	9626.469		.002	9626.471
02-05-75	1650-1656	9626.461		.001	9626.462
02-05-75	1659-1703	9626.470		.002	9626.471
02-05-75	1845-1849	9626.452		.002	9626.454
02-05-75	1850-1856	9626.455		.002	9626.457

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.008	.785	.003	.278

MEAN OF ACCEPTABLE MEASUREMENTS 9626.466

STATION DATE	RAGINAM TIME	NM J 33 TO DISTANCES	STATION FREQ	ATSUNAS CORRECTIONS	NM J 35 CORRECTED DISTANCES
01-05-75	1720-1732	4334.768		-.000	4334.768
01-05-75	1733-1740	4334.760		-.000	4334.759
01-05-75	1919-1928	4334.768		.001	4334.769
01-05-75	1930-1935	4334.764		.001	4334.764
02-05-75	1708-1714	4334.762		.001	4334.763
02-05-75	1717-1722	4334.768		.001	4334.768
02-05-75	1900-1905	4334.768		.001	4334.769
02-05-75	1907-1916	4334.769		.001	4334.770

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.004	.842	.001	.298

MEAN OF ACCEPTABLE MEASUREMENTS 4334.766

STATION DATE	RAGINAM TIME	NM J 33 TO DISTANCES	STATION FREQ	OMMAN CORRECTIONS	NM J 36 CORRECTED DISTANCES
01-05-75	1745-1750	4264.133		-.000	4264.132
01-05-75	1752-1759	4264.138		-.000	4264.137
01-05-75	1940-1945	4264.142		.001	4264.143
01-05-75	1947-1953	4264.142		.001	4264.143
02-05-75	1725-1730	4264.134		.001	4264.135
02-05-75	1733-1736	4264.136		.000	4264.136
02-05-75	1920-1927	4264.146		.001	4264.146
02-05-75	1928-1943	4264.138		.001	4264.138

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.005	1.208	.002	.392

MEAN OF ACCEPTABLE MEASUREMENTS 4264.139

STATION DATE	WANKAN TIME	NM J 34 TO DISTANCES	STATION FREQ	ZAKLAK CORRECTIONS	NM J 32 CORRECTED DISTANCES
29-04-75	1728-1735	12048.078		.000	12048.079
29-04-75	1738-1745	12048.075		.000	12048.075
29-04-75	1920-1928	12048.082		.000	12048.082
29-04-75	1930-1940	12048.087		-.000	12048.087
30-04-75	1738-1746	12048.073		-.000	12048.073
30-04-75	1749-1756	12048.064		-.001	12048.063
30-04-75	1940-1947	12048.068		-.001	12048.067
30-04-75	1948-1958	12048.065		-.000	12048.065

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.009	.706	.003	.250

MEAN OF ACCEPTABLE MEASUREMENTS 12048.074

STATION DATE	WANKAN TIME	NM J 34 TO DISTANCES	STATION FREQ	RAGINAM CORRECTIONS	NM J 33 CORRECTED DISTANCES
29-04-75	1752-1800	2474.249		.000	2474.250
29-04-75	1802-1810	2474.250		.000	2474.250
29-04-75	1945-1955	2474.251		-.000	2474.251
29-04-75	1957-2005	2474.249		.000	2474.249
30-04-75	1655-1704	2474.241		.000	2474.241
30-04-75	1706-1713	2474.244		.000	2474.244
30-04-75	1855-1903	2474.239		-.000	2474.239
30-04-75	1905-1911	2474.243		-.000	2474.242

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.005	1.930	.002	.682

MEAN OF ACCEPTABLE MEASUREMENTS 2474.246

STATION DATE	ATSUNAS TIME	NM J 35 TO DISTANCES	STATION FREQ	TOFMORA CORRECTIONS	NM J 31 CORRECTED DISTANCES
05-05-75	1648-1659	16172.702		.001	16172.703
05-05-75	1659-1706	16172.700		.002	16172.702
05-05-75	1846-1852	16172.682		-.001	16172.681
05-05-75	1855-1901	16172.686		.000	16172.686
06-05-75	1650-1655	16172.693		0.000	16172.693
06-05-75	1700-1705	16172.693		.001	16172.693
06-05-75	1845-1850	16172.688		.000	16172.689
06-05-75	1855-1900	16172.684		.001	16172.685

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.008	.484	.003	.171

MEAN OF ACCEPTABLE MEASUREMENTS 16172.692

STATION DATE	ATSUNAS TIME	NM J 35 TO DISTANCES	STATION FREQ	ZAKLAK CORRECTIONS	NM J 32 CORRECTED DISTANCES
05-05-75	1711-1718	12907.548		.000	12907.548
05-05-75	1721-1727	12907.532		.001	12907.533
05-05-75	1906-1913	12907.544		.001	12907.545
05-05-75	1915-1921	12907.538		.001	12907.538
06-05-75	1710-1717	12907.545		.001	12907.546
06-05-75	1720-1725	12907.537		.001	12907.538
06-05-75	1905-1915	12907.548		.001	12907.549
06-05-75	1917-1925	12907.542		.001	12907.542

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.006	.428	.002	.151

MEAN OF ACCEPTABLE MEASUREMENTS 12907.542

STATION DATE	ATSUNAS TIME	NM J 35 TO DISTANCES	STATION FREQ	WANKUN CORRECTIONS	NM J 34 CORRECTED DISTANCES
30-04-75	1717-1725	2724.346		0.000	2724.346
30-04-75	1728-1735	2724.347		-.000	2724.347
30-04-75	1915-1925	2724.349		-.000	2724.349
30-04-75	1926-1935	2724.350		-.000	2724.350
06-05-75	1730-1735	2724.350		-.000	2724.350
06-05-75	1737-1742	2724.352		.000	2724.352
06-05-75	1930-1935	2724.346		.000	2724.346
06-05-75	1937-1945	2724.354		.000	2724.354

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.003	1.060	.001	.375

MEAN OF ACCEPTABLE MEASUREMENTS 2724.349

STATION DATE	OHMAN TIME	NM J 36 TO DISTANCES	STATION FREQ	ZAKLAK CORRECTIONS	NM J 32 CORRECTED DISTANCES
08-05-75	1732-1739	12138.629		.000	12138.629
08-05-75	1740-1747	12138.644		-.001	12138.643
08-05-75	1944-1954	12138.639		-.000	12138.638
08-05-75	1955-2001	12138.642		0.000	12138.642
09-05-75	1705-1711	12138.635		.001	12138.636
09-05-75	1713-1720	12138.639		.000	12138.640
09-05-75	1905-1915	12138.646		-.001	12138.644
09-05-75	1917-1925	12138.636		-.001	12138.635

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.005	.426	.002	.150

MEAN OF ACCEPTABLE MEASUREMENTS 12138.638

STATION DATE	OHMAN TIME	NM J 36 TO DISTANCES	STATION FREQ	WANKUN CORRECTIONS	NM J 34 CORRECTED DISTANCES
08-05-75	1701-1707	3292.104		.000	3292.104
08-05-75	1708-1714	3292.100		.000	3292.100
08-05-75	1910-1917	3292.100		-.000	3292.100
08-05-75	1916-1927	3292.109		-.000	3292.109
09-05-75	1645-1655	3292.104		-.000	3292.104
09-05-75	1657-1703	3292.096		.000	3292.096
09-05-75	1845-1855	3292.109		.000	3292.109
09-05-75	1858-1903	3292.101		-.000	3292.100

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.005	1.438	.002	.508

MEAN OF ACCEPTABLE MEASUREMENTS 3292.103

STATION DATE	OHMAN TIME	NM J 36 TO DISTANCES	STATION FREQ	ATSUNAS CORRECTIONS	NM J 35 CORRECTED DISTANCES
07-05-75	1726-1731	1121.976		.000	1121.976
07-05-75	1734-1741	1121.976		.000	1121.976
07-05-75	1914-1923	1121.980		-.000	1121.980
07-05-75	1923-1933	1121.981		.000	1121.981
08-05-75	1716-1722	1121.980		.000	1121.980
08-05-75	1724-1731	1121.979		-.000	1121.979
08-05-75	1928-1935	1121.984		.000	1121.984
08-05-75	1937-1942	1121.983		.000	1121.983

REJECTS	GOOD MEAS.	STANDARD DEVIATION METRES	PPM	S.E. OF MEAN METRES	PPM
0	8	.003	2.394	.001	.846

MEAN OF ACCEPTABLE MEASUREMENTS 1121.980

PROGRAM AMENDED MAY 1971 GEODETIC SURVEY OF AUSTRALIA COMPUTED 17/09/75

SURVEY ADJUSTMENT - LEAST SQUARES VARIATION OF COORDINATES ON THE SPHEROID

MARKHAM VALLEY CRUSTAL MOVEMENT SURVEY SECTION MARKH75

AUSTRALIAN GEODETIC DATUM
A= 6378160.00 MS 1/F= 298.250

UNIT WEIGHTS ACCORD WITH THE FOLLOWING STANDARD ERRORS =
DIRECTIONS (SECONDS) AZIMUTHS DISTANCES MS
0.5 1.0 0.03 +3.0 PPM
NORMAL SECTION AZIMUTHS

OBSERVED VALUES OF ANGLES AND AZIMUTHS REJECTED IF MORE THAN*****0 SECONDS FROM VALUES COMPUTED FROM COORDINATES
OBSERVED VALUES OF DISTANCES REJECTED IF MORE THAN*****0 MS FROM VALUES COMPUTED FROM COORDINATES
NO REJECTIONS

ORDER OF MATRIX = 10 BANDWIDTH = 9 BANDMAT = 55 INVERSION TIME IN SECONDS .005
NUMBER OF ACCEPTABLE OBSERVATIONS 16 OF WHICH ANGLES = 0 AZIMUTHS = 1 DISTANCES = 15

STATION	SERIAL	SOUTH LATITUDE	ADJ-INIT	EAST LONGITUDE	ADJ-INIT	RHO	NU	HEIGHT MS
FIXED POINTS								
ATSUNAS	NM J 35 2	6. 7. 35.9148	0.0000	146. 5. 23.8470	0.0000	6336185,87	6378403.20	466.68
ADJUSTED POINTS								
OHMAN	NM J 36 3	6. 7. 37.7355	0.0000	146. 4. .2926	.0004	6336185,99	6378403,24	491.03
WANKUN	NM J 34 4	6. 8. 57.2340	.0004	146. 4. 48.4869	.0001	6336191,20	6378404,99	438.07
TOFMORA	NM J 31 5	6. 10. 48.2223	.0002	146. 13. 33.5222	.0004	6336198,52	6378407.44	467.71
RAGINUM	NM J 33 6	6. 9. 55.5825	-.0001	146. 5. 43.9638	.0006	6336195,04	6378406,27	475.22
ZAKLAK	NM J 32 7	6. 12. 46.9505	-.0004	146. 18. 6.1226	.0007	6336206,38	6378410,08	445.28
		AVERAGE .0002		AVERAGE .0004				
		MAXIMUM .0004 AT 7		MAXIMUM .0007 AT 7				

OBSERVATIONS AT	SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
ATSUNAS	NM J 35 2	6. 7. 35.9148	146. 5. 23.8470	466,68	MS		MARKH75

OBSERVATIONS TO		ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
TOFMORA	NM J 31 5	111. 25. 53.89		53.89	0.00	16172.693	16172.692	-.001
ZAKLAK	NM J 32 7	137. 45. 20.52				12907.545	12907.542	-.003
RAGINUM	NM J 33 6	171. 47. 49.45				4334.766	4334.766	0.000
WANKUN	NM J 34 4	203. 31. 8.60				2724.348	2724.349	.001
OHMAN	NM J 36 3	92. 51. 28.29				1121.979	1121.980	.001
ORIENTATION CONSTANT		0. 0. 0.00	AVERAGE	AVERAGE			AVERAGE	.001
			MAXIMUM	MAXIMUM			MAXIMUM	.003

OBSERVATIONS AT		SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT		SECTION
OHMAN	NM J 36	3	6. 7. 37.7355	146. 6. 12926	491.03	MS	MARKH75

OBSERVATIONS TO			ADJ AZIMUTH	OBS DIRN	OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
ZAKLAK	NM J 32	7	141. 29. 43.21					12138.634	12138.638	.004
RAGINUM	NM J 33	6	186. 45. 40.16					4264.141	4264.139	-.002
WANKUN	NM J 34	4	222. 6. 49.49					3292.103	3292.103	0.000
ATSUNAS	NM J 35	2	272. 51. 24.40					1121.979	1121.980	.001
TOFMORA	NM J 31	5	112. 47. 7.89					15113.380	15113.381	.001
ORIENTATION CONSTANT			0. 0. 0.00	AVERAGE		AVERAGE			AVERAGE	.002
				MAXIMUM		MAXIMUM			MAXIMUM	.004

OBSERVATIONS AT		SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT		SECTION
WANKUN	NM J 34	4	6. 8. 57.2340	146. 4. 48.4869	438.07	MS	MARKH75

OBSERVATIONS TO			ADJ AZIMUTH	OBS DIRN	OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
ZAKLAK	NM J 32	7	125. 51. 26.92					12048.077	12048.074	-.003
RAGINUM	NM J 33	6	136. 25. 17.62					2474.243	2474.246	.003
ATSUNAS	NM J 35	2	23. 31. 12.38					2724.348	2724.349	.001
OHMAN	NM J 36	3	42. 6. 57.17					3292.103	3292.103	0.000
TOFMORA	NM J 31	5	101. 56. 3.25					16498.114	16498.107	-.007
ORIENTATION CONSTANT			0. 0. 0.00	AVERAGE		AVERAGE			AVERAGE	.003
				MAXIMUM		MAXIMUM			MAXIMUM	.007

OBSERVATIONS AT		SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT		SECTION
TOFMORA	NM J 31	5	6. 10. 48.2223	146. 13. 33.5222	467.71	MS	MARKH75

OBSERVATIONS TO			ADJ AZIMUTH	OBS DIRN	OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
ZAKLAK	NM J 32	7	240. 13. 36.09					7345.455	7345.455	0.000
RAGINUM	NM J 33	6	276. 23. 3.05					14526.431	14526.437	.006
WANKUN	NM J 34	4	281. 55. 6.87					16498.114	16498.107	-.007
ATSUNAS	NM J 35	2	291. 25. 1.40					16172.693	16172.692	-.001
OHMAN	NM J 36	3	292. 46. 19.31					15113.380	15113.381	.001
ORIENTATION CONSTANT			0. 0. 0.00	AVERAGE		AVERAGE			AVERAGE	.003
				MAXIMUM		MAXIMUM			MAXIMUM	.007

OBSERVATIONS AT		SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
RAGINUM	NM J 33	6	6. 9. 55.5825	146. 5. 43.9638	475.22	MS		MARKH75
OBSERVATIONS TO			ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
ZAKLAK	NM J 32	7	123. 9. 17.82				9626.465	9626.466	.001
WANKUN	NM J 34	4	316. 25. 11.67				2474.243	2474.246	.003
ATSUNAS	NM J 35	2	351. 47. 47.29				4334.766	4334.766	0.000
OHMAN	NM J 36	3	6. 45. 41.91				4264.141	4264.139	-.002
TOFMORA	NM J 31	5	96. 23. 53.54				14526.431	14526.437	.006
ORIENTATION CONSTANT			0. 0. 0.00	AVERAGE	AVERAGE			AVERAGE	.003
				MAXIMUM	MAXIMUM			MAXIMUM	.006

OBSERVATIONS AT		SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
ZAKLAK	NM J 32	7	6. 12. 46.9505	146. 10. 6.1226	445.28	MS		MARKH75
OBSERVATIONS TO			ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
RAGINUM	NM J 33	6	303. 8. 49.56				9626.465	9626.466	.001
WANKUN	NM J 34	4	305. 50. 52.71				12048.077	12048.074	-.003
ATSUNAS	NM J 35	2	317. 44. 50.18				12907.545	12907.542	-.003
OHMAN	NM J 36	3	321. 29. 16.78				12138.634	12138.638	.004
TOFMORA	NM J 31	5	60. 13. 58.48				7345.455	7345.455	0.000
ORIENTATION CONSTANT			0. 0. 0.00	AVERAGE	AVERAGE			AVERAGE	.002
				MAXIMUM	MAXIMUM			MAXIMUM	.004

WHOLE ADJUSTMENT	AVERAGE	0.00	AVERAGE	0.00		AVERAGE	.002
	MAXIMUM	0.00	MAXIMUM	0.00 AT 0 AND 0,		MAXIMUM	.007 AT 5
ABSOLUTE	AVERAGE	0.00	AVERAGE	0.00		AVERAGE	0.000

TIME FOR THIS SECTION .104 SECONDS

END OF RUN

NMD/76/159

PROGRAM AMENDED MAY 1971 GEODETIC SURVEY OF AUSTRALIA COMPUTED 23/02/76

SURVEY ADJUSTMENT - LEAST SQUARES VARIATION OF COORDINATES ON THE SPHEROID

NG - MARKHAM VALLEY CRUSTAL MOVEMENT SURVEY SECTION MARKHAM

AUSTRALIAN GEODETIC DATUM
A= 6378160.00 MS 1/F= 298.250

UNIT WEIGHTS ACCORD WITH THE FOLLOWING STANDARD ERRORS -
DIRECTIONS (SECONDS) AZIMUTHS DISTANCES MS
0.5 1.0 0.03 +3.0 PPM
NORMAL SECTION AZIMUTHS

OBSERVED VALUES OF ANGLES AND AZIMUTHS REJECTED IF MORE THAN 999, SECONDS FROM VALUES COMPUTED FROM COORDINATES
OBSERVED VALUES OF DISTANCES REJECTED IF MORE THAN 999, MS FROM VALUES COMPUTED FROM COORDINATES
NO REJECTIONS

ORDER OF MATRIX = 10 BANDWIDTH = 9 BANDMAT = 55 INVERSION TIME IN SECONDS .005
NUMBER OF ACCEPTABLE OBSERVATIONS 16 OF WHICH ANGLES = 0 AZIMUTHS = 1 DISTANCES = 15

STATION	SERIAL	SOUTH LATITUDE	ADJ-INIT	EAST LONGITUDE	ADJ-INIT	RHO	NU	HEIGHT MS
FIXED POINTS								
NM J 35	2	6. 7. 35.9148	0.0000	146. 5. 23.8470	0.0000	6336185.87	6378403.20	466.681
ADJUSTED POINTS								
NM J 36	3	6. 7. 37.7355	-.0045	146. 6. .2921	.0021	6336185.99	6378403.24	491.029
NM J 34	4	6. 8. 57.2336	-.0064	146. 4. 48.4868	.0068	6336191.20	6378404.99	438.073
NM J 31	5	6. 10. 48.2222	.0022	146. 13. 33.5219	.0019	6336198.52	6378407.44	467.708
NM J 33	6	6. 9. 55.5826	-.0074	146. 5. 43.9632	.0032	6336195.04	6378406.27	475.218
NM J 32	7	6. 12. 46.9506	-.0094	146. 10. 6.1220	.0020	6336206.38	6378410.08	445.283
		AVERAGE .0060		AVERAGE .0032				
		MAXIMUM .0094 AT 7		MAXIMUM .0068 AT 4				

OBSERVATIONS AT	SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
NM J 35	2	6. 7. 35.9148	146. 5. 23.8470	466.681	MS		MARKHAM

OBSERVATIONS TO	SERIAL	ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
NM J 32	7	137. 45. 20.79				12907.537	12907.537	0.000
NM J 33	6	171. 47. 50.41				4334.765	4334.764	-.001
NM J 34	4	203. 31. 9.10				2724.341	2724.342	.001
NM J 36	3	92. 51. 28.43				1121.964	1121.965	.001
NM J 31	5	111. 25. 53.89		53.89	0.00	16172.683	16172.681	-.002
ORIENTATION CONSTANT		0. 0. 0.00	AVERAGE	AVERAGE			AVERAGE	.001
			MAXIMUM	MAXIMUM			MAXIMUM	.002

OBSERVATIONS AT	SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
NM J	36 3	6. 7. 37.7355	146. 6. .2921	491.029	MS		MARKHAM
OBSERVATIONS TO		ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
NM J	32 7	141. 29. 43.30			12138.636	12138.637	.001
NM J	33 6	186. 45. 40.41			4264.144	4264.145	.001
NM J	34 4	222. 6. 49.34			3292.088	3292.086	-.002
NM J	35 2	272. 51. 24.54			1121.964	1121.965	.001
NM J	31 5	112. 47. 7.81			15113.383	15113.383	0.000
ORIENTATION CONSTANT		0. 0. 0.00	AVERAGE	AVERAGE		AVERAGE	.001
			MAXIMUM	MAXIMUM		MAXIMUM	.002

OBSERVATIONS AT	SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
NM J	34 4	6. 8. 57.2336	146. 4. 48.4868	438.073	MS		MARKHAM
OBSERVATIONS TO		ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
NM J	32 7	125. 51. 27.27			12048.074	12048.071	-.003
NM J	33 6	136. 25. 19.33			2474.239	2474.240	.001
NM J	35 2	23. 31. 12.88			2724.341	2724.342	.001
NM J	36 3	42. 6. 57.02			3292.088	3292.086	-.002
NM J	31 5	101. 56. 3.33			16498.109	16498.112	.003
ORIENTATION CONSTANT		0. 0. 0.00	AVERAGE	AVERAGE		AVERAGE	.002
			MAXIMUM	MAXIMUM		MAXIMUM	.003

OBSERVATIONS AT	SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
NM J	31 5	6. 10. 48.2222	146. 13. 33.5219	467.708	MS		MARKHAM
OBSERVATIONS TO		ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
NM J	32 7	240. 13. 35.99			7345.467	7345.467	0.000
NM J	33 6	276. 23. 2.95			14526.441	14526.440	-.001
NM J	34 4	281. 55. 6.95			16498.109	16498.112	.003
NM J	35 2	291. 25. 1.40			16172.683	16172.681	-.002
NM J	36 3	292. 46. 19.23			15113.383	15113.383	0.000
ORIENTATION CONSTANT		0. 0. 0.00	AVERAGE	AVERAGE		AVERAGE	.001
			MAXIMUM	MAXIMUM		MAXIMUM	.003

OBSERVATIONS AT	SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
NM J 33 6		6. 9. 55.5826	146. 5. 43.9632	475.218	MS		MARKHAM
OBSERVATIONS TO		ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
NM J 32 7		123. 9. 17.85				9626.469	9626.470	.001
NM J 34 4		316. 25. 13.38				2474.239	2474.240	.001
NM J 35 2		351. 47. 48.26				4334.765	4334.764	-.001
NM J 36 3		6. 45. 42.16				4264.144	4264.145	.001
NM J 31 5		96. 23. 53.44				14526.441	14526.440	-.001
ORIENTATION CONSTANT		0. 0. 0.00	AVERAGE	AVERAGE			AVERAGE	.001
			MAXIMUM	MAXIMUM			MAXIMUM	.001

OBSERVATIONS AT	SERIAL	SOUTH LATITUDE	EAST LONGITUDE	HEIGHT			SECTION
NM J 32 7		6. 12. 46.9506	146. 10. 6.1220	445.283	MS		MARKHAM
OBSERVATIONS TO		ADJ AZIMUTH	OBS DIRN OBS-ADJ	LPL AZ	LPL-ADJ	ADJ LENGTH	OBS LENGTH	OBS-ADJ
NM J 33 6		303. 8. 49.59				9626.469	9626.470	.001
NM J 34 4		305. 50. 53.07				12048.074	12048.071	-.003
NM J 35 2		317. 44. 50.45				12907.537	12907.537	0.000
NM J 36 3		321. 29. 16.88				12138.636	12138.637	.001
NM J 31 5		60. 13. 58.37				7345.467	7345.467	0.000
ORIENTATION CONSTANT		0. 0. 0.00	AVERAGE	AVERAGE			AVERAGE	.001
			MAXIMUM	MAXIMUM			MAXIMUM	.003

WHOLE ADJUSTMENT	AVERAGE	0.00	AVERAGE	0.00			AVERAGE	.001
	MAXIMUM	0.00	MAXIMUM	0.00 AT	0 AND	0,	MAXIMUM	.003 AT 4
ABSOLUTE	AVERAGE	0.00	AVERAGE	0.00			AVERAGE	0.000

TIME FOR THIS SECTION .105 SECONDS

END OF RUN

ADOPTED HEIGHTS

MARKHAM VALLEY CRUSTAL MOVEMENT SURVEY
COMPARISON BETWEEN 1975 AND 1973 VALUES

Pillars

	1973	1975	1975-1973
NM/J/31	467.7080	467.7156	+ 0.0076
NM/J/32	445.2826	445.2909	+ 0.0083
NM/J/33	475.2176	475.2289	+ 0.0113
NM/J/34	438.0728	438.0929	+ 0.0201
NM/J/35	466.6810	466.7011	+ 0.0201
NM/J/36	491.0290	491.0366	+ 0.0076

Bench Marks

MCM 1	401.6130	401.6130	(Datum)
MCM 2	397.0776	397.0765	- 0.0011
MCM 3	387.3226	387.3216	- 0.0010
MCM 4	373.9364	373.9356	- 0.0008
MCM 5	362.0462	362.0498	+ 0.0036
MCM 6	366.5212	366.5247	+ 0.0035
MCM 7	377.7831	377.7947	+ 0.0116
MCM 8	383.6065	383.6124	+ 0.0059
MCM 9	392.0564	392.0609	+ 0.0045
MCM 10	401.2072	401.2111	+ 0.0039
MCM 11	403.8916	403.8918	+ 0.0002
MCM 12	403.2056	403.2073	+ 0.0017
MCM 13	409.9697	409.9743	+ 0.0046
MCM 14	417.3326	417.3389	+ 0.0063
MCM 15	412.3303	412.3369	+ 0.0066
MCM 16	407.5080	407.5173	+ 0.0093
MCM 17	397.7378	397.7566	+ 0.0188
MCM 18	390.2086	390.2257	+ 0.0171
MCM 19	396.1267	396.1353	+ 0.0086
MCM 21	365.7416	365.7488	+ 0.0072

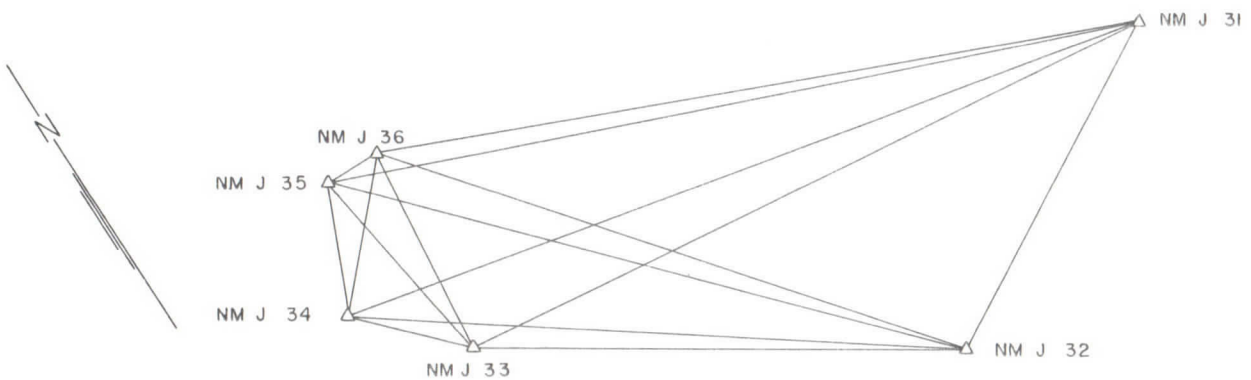
COMPARISON OF HEIGHT DIFFERENCES BETWEEN SECTIONS FOR 1973 AND 1975 SURVEYS

Section		Distance (kilometres)	Difference in Height		(2)-(1)=D (metres)	D/ K
From	To		1973 (1)	1975 (2)		
MCM 1	MCM 2	1.74	- 4.5354	- 4.5365	- 0.0011	.001
MCM 2	MCM 3	1.46	- 9.7550	- 9.7549	+ 0.0001	.000
MCM 3	MCM 4	1.57	-13.3862	-13.3860	+ 0.0002	.000
MCM 4	MCM 5	1.60	-11.8902	-11.8858	+ 0.0044	.004
MCM 5	MCM 6	1.63	+ 4.4750	+ 4.4749	- 0.0001	.000
MCM 6	MCM 7	1.32	+11.2619	+11.2700	+ 0.0081	.007
MCM 7	MCM 8	1.99	+ 5.8234	+ 5.8177	- 0.0057	.004
MCM 8	MCM 9	1.63	+ 8.4499	+ 8.4485	- 0.0014	.001
MCM 9	MCM 10	1.60	+ 9.1508	+ 9.1502	- 0.0006	.000
MCM 10	MCM 11	1.57	+ 2.6844	+ 2.6807	- 0.0037	.003
MCM 11	MCM 12	1.64	- 0.6860	- 0.6846	+ 0.0014	.001
MCM 12	MCM 13	1.68	+ 6.7641	+ 6.7670	+ 0.0029	.002
MCM 13	MCM 14	1.51	+ 7.3629	+ 7.3646	+ 0.0017	.001
MCM 14	MCM 15	1.61	- 5.0023	- 5.0020	+ 0.0003	.000
MCM 15	MCM 16	1.56	- 4.8223	- 4.8196	+ 0.0027	.002
MCM 8	MCM 21	2.13	-17.8649	-17.8636	+ 0.0013	.001
MCM 13	MCM 19	2.69	-13.8430	-13.8390	+ 0.0040	.002
MCM 19	MCM 18	2.69	- 5.9181	- 5.9096	+ 0.0085	.005
MCM 18	MCM 17	2.46	+ 7.5292	+ 7.5309	+ 0.0017	.001

COMPARISON OF OBSERVED AND ADJUSTED DISTANCES

BETWEEN THE 1973 AND THE 1975 SURVEYS

Distances Between		1	Standard Deviation		2	Standard Deviation		3	4	1-2		3-4	
		1975 Observations			1973 Observations			1975 Adjusted values	1973 Adjusted values				
A	B		mm	ppm		mm	ppm			mm	ppm	mm	ppm
NM/J/31	NM/J/32	7 345.455	6	0.8	7 345.467	4	0.5	7 345.455	7 345.469	-12	1.6	-14	1.9
	33	14 526.437	6	0.4	14 526.440	3	0.2	14 526.431	14 526.437	- 3	0.2	- 6	0.4
	34	16 498.107	14	0.8	16 498.112	7	0.4	16 498.114	16 498.104	- 5	0.3	+10	0.6
	35	16 172.692	8	0.5	16 172.681	11	0.7	16 172.693	16 172.679	+11	0.7	+14	0.9
	36	15 113.381	10	0.7	15 113.383	8	0.5	15 113.380	15 113.378	- 2	0.1	+ 2	0.1
NM/J/32	NM/J/33	9 626.466	8	0.8	9 626.470	5	0.5	9 626.465	9 626.471	- 4	0.4	- 6	0.6
	34	12 048.074	9	0.7	12 048.071	3	0.3	12 048.077	12 048.076	+ 3	0.2	+ 1	0.1
	35	12 907.542	6	0.4	12 907.537	6	0.5	12 907.545	12 907.541	+ 5	0.4	+ 4	0.3
	36	12 138.638	5	0.4	12 138.637	8	0.7	12 138.634	12 138.640	+ 1	0.1	- 6	0.5
NM/J/33	NM/J/34	2 474.246	5	1.9	2 474.240	4	1.8	2 474.243	2 474.239	+ 6	2.4	+ 4	1.6
	35	4 334.766	4	0.8	4 334.764	4	1.0	4 334.766	4 334.767	+ 2	0.5	- 1	0.2
	36	4 264.139	5	1.1	4 264.145	3	0.8	4 264.141	4 264.145	- 6	1.4	- 4	0.9
NM/J/34	NM/J/35	2 724.349	3	1.1	2 724.342	5	2.0	2 724.348	2 724.340	+ 7	2.6	+ 8	2.9
	36	3 292.103	5	1.4	3 292.086	4	1.3	3 292.103	3 292.087	+17	5.2	+16	4.9
NM/J/35	NM/J/36	1 121.980	3	2.4	1 121.965	4	3.7	1 121.979	1 121.964	+15	13.4	+15	13.4



ANNEX F