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GRAVITY MEASUREMENTS ON PAPUA NEW GUINEA CRUSTAL MOVEMENT SURVEY MARKERS, AND ALONG THE AUSTRALIAN CALIBRATION LINE, 1975

by

P. Wellman and H.M. McCracken

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SUMMARY

Sets of crustal movement markers have been established straddling two supposed active fault zones in Papua New Guinea. The relative horizontal and vertical positions of these survey markers were first measured in 1973, remeasured in 1975, and are periodically to be resurveyed by the Division of National Mapping. This report gives the gravity differences between the markers at the time of the 1975 National Mapping Survey. Remeasurement of the gravity intervals at the time of a later resurvey should enable the deep mass movements accompanying any surface movement to be estimated.

While in transit to and from the survey area the four LaCoste & Romberg gravity meters were calibrated along part of the Australian Calibration Line, and were used to make measurements extending and strengthening the National Gravity Network and more precisely determining the gravity intervals on calibration ranges.

1. INTRODUCTION

The Pacific and Australian Plates do not interact along a single boundary in the Papua New Guinea region. Instead there is a zone containing several smaller lithospheric plates (Fig. 1), each moving relative to the others (Johnson & Molnar, 1972). Most of the plate boundaries are at sea, and direct observations of the relative movement across the plate boundaries are difficult. Active plate boundaries are thought to pass through the 30-km-wide St Georges Channel between New Britain and New Ireland, to cross East Papua, and to cross New Guinea along the Ramu-Markham valley. Sites in St Georges Channel and in the upper Markham valley have been selected for accurate crustal movement measurements.

In the two survey areas groups of six or seven survey markers have been established straddling the fault zones; the relative horizontal positions of the stations were determined by laser geodimeter, and the relative vertical positions were determined either by first-order levelling (in the Markham valley) or by observation of simultaneous vertical angles (across St Georges Channel). Gravity differences between the stations were measured by calibrated LaCoste & Romberg gravity meters.

The upper Markham valley survey markers were first surveyed by the Division of National Mapping in August-September 1973 (Cooke & Murphy, 1974). Preliminary gravity measurements with one LaCoste & Romberg gravity meter were made in November 1973 (Dooley, 1975). Both the upper Markham valley and the St Georges Channel markers were surveyed in May-July 1975 with four LaCoste & Romberg gravity meters, and this report details the observed gravity differences between the markers at that time.

2. CALIBRATION OF LACOSTE & ROMBERG GRAVITY METERS

To measure the largest gravity interval between the markers (150 mGal) to an accuracy of 0.01 mGal the gravity meters have to be calibrated to an accuracy of better than $7x10^{-5}$(0.01 mGal/150.00 mGal). This calibration was carried out by observations at airport stations along the Australian Calibration Line (ACL), while in transit to and from the survey area; the calibration being based on eight widely spaced readings of the gravity meter micrometer screw on a 1700 mGal gravity interval. This interval is much larger than that obtainable on a calibration range. If a calibration range is used the calibration errors are greater than $7x10^{-5}$ because of the calibration range interval uncertainty, reading errors, and local systematic errors in the linearity of the micrometer screw.

Commercial air transport was used along the ACL. The gravity observations were taken in the order A-B-C- .... N .... -C-B-A, where A, B, C, ... N are the airports. The gravity intervals, determined from the manufacturers tables and corrected for earth-tide effects but not drift, are listed in Table 1. The Port Moresby-Lae intervals for G20A, G132, and G252 were not considered to be reliable because the pairs of intervals differ by over 0.05 mGal. For G20A, G101, and G132, the two measurements of the remaining gravity intervals were averaged. For G252 the intervals measured going north were treated separately from those measured going south because the meter appears to have had a scale change during the survey (on or about 1 June 1975). All reliable intervals were summed and fitted by least squares to Isogal-74 values of Wellman et al. (1974). The calibration constants obtained are listed below.

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Meter No	Ratio $\frac{\text{ACL GAG-2 Scale}}{\text{LaCoste table Scale}}$
G20A	1.000395 ± 0.000006
G101	1.002665 ± 0.000013
G132	1.000401 ± 0.000011
G252 north	1.000517 ± 0.000015
G252 south	1.000643 ± 0.000014

Gravity differences between the 1973 ACL survey and the 1975 ACL survey range from -.007 ± .003 mGal at Townsville to +.008 ± .007 mGal at Brisbane. These differences do not support the hypothesis of rapid secular variation of gravity along the east coast of Australia; Wellman et al. (1975) found that 1965-1973 mean differences range from +.051 ± .015 mGal at Townsville to -.049 ± 0.24 mGal at Brisbane.

3. THE UPPER MARKHAM VALLEY CRUSTAL MOVEMENT PROJECT

The Ramu-Markham Fault Zone underlies a wide continuous alluviated valley occupied by the Ramu and Markham Rivers. Rocks north of the fault zone are mainly sedimentary and basaltic, and are characteristic of oceanic rocks. Rocks south of the fault zone are mainly of continental origin, consisting of extensive granites and metamorphosed geosynclinal sediments. The crustal block north of the fault zone is being eroded more rapidly. The northern margin and centre of the Markham valley consist of alluvial fans of south-flowing Markham River tributaries; the southern margin of the Markham Valley contains the Markham River and the small sediment-drowned valleys of the north-flowing tributaries. The south-flowing tributaries are flanked by terraces (caused by slight downcutting); the edges of the terraces are young and do not appear to be displaced by faulting or creep.

The crustal movement is measured by determing the relative movement between crustal movement markers at the head of the Markham valley where the valley floor is narrowest (Figs 1 and 2; also Cooke & Murphy, 1974 airphotos).

There are six primary markers, from 40 to 85 m above the valley floor, on high points near the end of ridges. These markers are concrete pillars, 1.2 m high and 0.6 m in diameter anchored on bedrock.

The gravity differences between the markers were measured on 7 and 8 June using a Jet Ranger helicopter for transport. Observations were made on a LaCoste tripod centred on the top of the pillar. Five complete circuits of the markers were observed. Table 2 gives the observed gravity differences between adjacent markers. Eight G20A intervals were rejected because the meter was below working temperature, and four other intervals were rejected because they differed by over 0.05 mGal from the mean interval for all meters. The rejected intervals are shown in brackets, or as dashes. The remaining gravity intervals have standard errors about the mean of 0.014 to 0.023 mGal. The loop misclosure (the arithmetic sum of the mean gravity interval for each tie) is 0.018 mGal; this is less than the 0.020 mGal expected error around the loop for the 95 percent confidence level (calculated from the standard errors of the means). The loop misclosure has been distributed around the loop giving equal weight to each interval and gravity values have been calculated using the tie to the Lae airport station 7390.0177(Table 2). Three of the six gravity intervals between station markers are determined to better than 0.01 mGal; the other three intervals are less well determined because of differences between the results of individual meters (G252 generally being anomalous). The gravity values obtained (Table 10) are 0.02 mGal higher than those obtained in 1973 (Dooley, 1975). This cannot be taken as evidence of a sudden change in gravity, because the gravity tie to Lae K in 1973 was weak. The gravity intervals between crustal movement markers have not changed significantly (Table 10).

Gravity observations were also made on bench marks both on the valley floor between the upper Markham crustal movement markers, and across the lower Markham valley 10 km west of Lae. Table 3 gives the gravity intervals from 7590.0036 (NM/J/36) and 7390.0177 (Lae K) to the bench marks used as control points, and Table 4 gives the gravity intervals from all measured bench marks to the control bench marks. All the gravity readings were taken with tripod legs resting on the concrete surrounding the bench mark; the reported gravity value is that observed at this level. The gravity values for the bench marks, together with the height (where measured) of the gravity station below the bench marks, are listed in Table 10.

4. THE ST GEORGES CHANNEL CRUSTAL MOVEMENT PROJECT

St Georges Channel, a trough 1900 m deep between New Britain and New Ireland links the Solomon Sea in the south with the Bismarck Sea in the north.

New Ireland is an elongate island trending northwest. At its south-eastern end, near St Georges Channel, the island is wider, and cut by two northwest-trending faults: the smaller Sapom Fault and the major active Weitin Fault. New Britain is arcuate (concave to the north) with a northeast trend at its eastern end, which is at right-angles to the trend of the nearby New Ireland. The eastern end of New Britain is cut by two fault systems: a northeast-trending set parallel to the trend of New Britain, and a northwest-trending set at right-angles to New Britain and parallel to New Ireland (BMR, 1972). On both sides of St Georges Channel the outcropping rocks are sediments, and basaltic and andesitic volcanics; these rocks are all of oceanic origin.

The South Bismarck Subplate, comprising New Britain and the southern part of the Bismarck sea, appears to adjoin the Pacific Plate in the region of St Georges Channel (Fig. 1). The exact position of the plate boundary is not well defined by shallow earthquakes, or any other observations. The two most likely positions for the plate boundary are: along the deep-water trough of St Georges Channel, i.e. north through St Georges Channel, then (with a right-angle bend) west into the Bismarck Sea and on a nearly straight northwest line along the Weitin Fault (north of St Georges Channel) and then along the southern margin of New Ireland.

The crustal movement markers are all on the margin of St Georges Channel (Fig. 3). Of the three stations on New Ireland, one is northeast of the Weitin Fault and thought to be on the Pacific Plate, and the two south of the Weitin Fault may be on the Pacific Plate. There are four stations on the western side of St Georges Channel: one on Duke of York Island and three on New Britain. All four stations are expected to be on the South Bismarck Subplate. A pillar on top of 'The Mother' volcano (659 m) was observed by the surveyors to tie the crustal movement network to the existing survey system. The gravity interval to this site was not measured since the site is expected to experience rapid movements due to adjacent volcanic activity, and access is difficult because of bad weather and a poor helicopter landing area.

The six crustal movement markers observed are on the tops of hills or on ridges, 100 to 300 m above sea-level, and less than 3 km from the St Georges Channel coastline. The pillars are slightly shorter than in the Markham Valley.

The gravity differences between the markers were measured on 10, 11, 12 and 24 June 1975 using a Bell-47 helicopter for transport. The differences were not measured in a single loop of all crustal movement markers, but in three loops each crossing St Georges Channel. One loop was of two stations, and two loops were of three stations. In addition two of the markers were tied to an Isogal station at Rabaul Airport. The loops were not observed in a simple pattern because of bad weather, mechanical problems with the helicopter, and the occupation of helicopter pads by surveyors. Table 5 gives the measurements obtained and Figure 3 shows the loops. Ten of the 124 measured gravity intervals were rejected because they differed by over 0.05 mGal from the mean interval. The remaining gravity intervals have standard errors about the mean of 0.008 to 0.022 mGal.

In the three loops with over two gravity stations the loop misclosures (the arithmetic sum of all the mean gravity intervals around the loop) are 0.003, 0.014, and 0.007 mGal; these are within the bounds of the expected errors around the loops at the 95 percent confidence level calculated from the standard errors of the means (0.016, 0.018, 0.020 mGal). The loop misclosures have been distributed around the loops (using inverse variances as weights), and the gravity values calculated (Table 10). The individual tie results for the four gravity meters were similar, so the errors are thought to be about the standard errors of the mean, i.e. at the 95 percent confidence level interval errors are 0.008 to 0.014 mGal.

5. NATIONAL GRAVITY NETWORK - AIRPORT STATIONS AND CALIBRATION RANGES

During this survey the opportunity was taken to strengthen the Australian National Gravity Network. New airport excentres were established and ties to town stations were strengthened at Sydney, Townsville, Port Moresby, and Rabaul (Table 6). The gravity interval Rabual to Lae was flown four times, so the Rabaul gravity value is now known to nearly the same accuracy as stations along the ACL. Observations were made on calibration ranges at Canberra, Sydney, Brisbane, Townsville, Port Moresby, and a new calibration range was established near Rabaul (Table 7). Gravity values for these stations, based on Isogal-74 airport values (Wellman et al., 1974), are listed in Table 10.

Gravity meters must have an accurate calibration for secular variation and national gravity network surveys. To assess the stability of gravity meter calibration the more accurate calibrations of the BMR LaCoste & Romberg gravity meters and the Antarctic Division meter G104 (which is also used for accurate gravity measurements) are listed in Table 8. The ACL calibrations have been made using Isogal-74 values of Wellman et al. (1974) and the Western Pacific Calibration Line Calibrations using IGSN-71 values of Morelli et al. (1971). The 1967 result for G20 is from McCracken (in prep.),

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the 1969 result from Wellman et al. (1975), and the remaining pre-1975 results from Wellman et al. (1974). The meter G132 has shown a remarkably constant calibration factor for six years; other meters have changed by about 1×10^{-4} in a period of a year. LaCoste gravity meters must therefore be calibrated on the ACL for surveys of either secular variation or the National Gravity Network, unless the survey is much less than one year after a prior calibration.

A sufficient number of calibration range measurements was made on this survey to warrant a review of the results on all Australian calibration ranges. LaCoste & Romberg gravity meter measurements are summarized in Table 9. The Brindabella Range data are from observations by Mr J. van Son. In this table the results for a meter have been averaged when measurements have been repeated on the same range over a short period of time (up to one year). The mean intervals at Hobart, Canberra, Brisbane, Port Moresby, and Rabaul are sufficiently accurate for most purposes, but at Townsville, Alice Springs, Adelaide, Perth, and Brindabella further work is clearly desirable.

Two days were spent carrying out a semidetailed gravity survey of 51 stations on the roads surrounding the Rabaul caldera. This survey extended the semidetailed coverage of Laudon (1968) and Harrison (in Brooks, 1971) for the inside and rim of the Rabaul Caldera to $4^{\circ}30'$S latitude, $152^{\circ}00'$E longitude. The 1975 gravity values were determined using gravity meters G20A or G132; positions and heights were determined from 1:50 000 contour maps. A small car was used for transport. A report on the gravity results of the semi-detailed surveys in and around Rabaul Caldera is planned.

6. CONCLUSIONS

Gravity differences between crustal movement markers in the Markham valley and St Georges Channel areas have been established to an accuracy of better than 0.02 mGal. There appears to be no significant gravity change between Markham valley markers in the period 1973 to 1975.

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TABLE 1 - AIR TIE INTERVALS 1975

GRAVITY STATION	G20A North Bound	G20A South Bound	G101 North Bound	G101 South Bound	G132 North Bound	G132 South Bound	G252 North Bound	G252 South Bound
	Gravity Intervals (LaCoste scale mGal.)							
Canberra M 6893.0104								
	78.443	78.434	78.236	78.254	78.400	78.416	78.409	78.384
Sydney 7391.0105								
	539.503	539.456	538.211	538.196	539.471	539.462	539.423	539.308
Brisbane T 7390.0247								
	285.390		284.757		285.350		285.380	
Rockhampton K 6499.0149		535.596		534.391		535.612		535.460
	250.188		249.653		250.215		250.168	
Townsville O 7090.0151								
	123.427	123.439	123.136	123.117	123.429	123.420	123.394	125.431
Cairns A 5099.9952								
	288.078	288.093	287.483	287.433	288.070	288.087	288.017	288.991
Port Moresby L 6791.0476								
	201.811	201.898	201.364	201.394	201.847	201.798	201.748	201.870
Lae K 6791.0177								
	153.842	153.834	153.415	153.444	153.742	153.796	153.707	153.757
	153.785	153.793	153.312	153.432	153.756	153.779	153.714	153.802
Rabaul 6351.0170								

TABLE 2 - GRAVITY INTERVALS FOR MARKHAM VALLEY CRUSTAL MOVEMENT STATIONS

GRAVITY INTERVAL MEASURED		Gravity Interval (GAC-2 ACL mGal) G20A		G101		G132		G252		Mean Int. / No. of obs.	St. dev. / St. error mean
7590.0032	30.+	-	.114	.122	.109	.119	.100	.060	.091	30.099	.018
-7590.0031		.104	.121	.109	.101	.118	.104	.085	.081	18	.004
		.092		.073		(.146)		.079			
7590.0032	22.+	-	.137	.140	.113	.123	.120	.075	.078	22.110	.023
-7590.0033		.116	.140	.113	.109	-	.094	.088	.085	17	.006
		.136		(.170)		.125		.078			
7590.0034	9.+	-	.458	.451	.455	.453	.424	.451	.454	9.449	.018
-7590.0033		.472	.470	.456	(.378)	.424	.438	.426	.433	18	.004
		.482		.467		.421		.441			
7590.0034	16.+	-	-	.649	.668	.676	.693	.683	.690	16.673	.015
-7590.0035		.663	.655	.661	(.592)	.674	.665	.667	.678	17	.004
		.701		.662		.665		.698			
7590.0035	8.+	-	-	.144	.130	.126	.144	.130	.146	8.140	.014
-7590.0036		.164	.162	.131	.161	.145	.144	.148	.141	18	.003
		.115		.131		.142		.123			
7590.0031	7.+	.362	-	.360	.368	.350	.346	.358	.374	7.357	.016
-7590.0036		.367	.331	.357	.369	.368	.323	.370	.373	19	.004
		.324		.362		.347		.366			
(Lae)											
7390.0177	142.+	(.128)	.201	.163	.167	(.115)	.158	.196	.190	142.160*	.021
-7590.0031		.141	.152	(.254)	.141	(.088)	(.298)	.171	.178	7	.008

* excluding G252 data because of scale uncertainty.

TABLE 3 - GRAVITY INTERVALS, MARKHAM VALLEY BENCH MARKS - CONTROL STATIONS

GRAVITY INTERVAL MEASURED		Gravity Interval (GAG-2 ACL mGal)								Mean Interval	St. dev.
		G20A		G101		G132		G252		No. of Obs.	St. error mean
7590.1106	18.+	.763	.807	.847	.830	.788	.820	.802	.794	18.809	.022
-7590.1110		.812		.830		.808		.810		12	.006
7590.1110	5.+	.802	.794	.779	.780	.798	.793	.806	.795	5.793	.015
-7590.1116		.809		.797		.806		.755		12	.004
7590.1116	22.+	.930		.892		.914		.938		22.918	.020
-7590.0036 MN/J/36										4	.010
Lae 7390.0177	9.+	.896	.891	.879	.869	.884	.873	.920	.866	9.885	.018
-7590.2001										8	.006

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TABLE 4 - GRAVITY INTERVALS, MARKHAM VALLEY BENCH MARKS

GRAVITY STATION	Gravity interval to bench marks 7590.1110 and 7590.2001 (GAG-2 ACL mGal) G20A	G101	G132	G252	Mean Interval	No. of Obs.	st. dev.	st. error mean
7590.1106	18.809	18.809	18.809	18.809	18.809	4	-	-
7590.1107	16.227	16.269	16.265	16.252	16.253	4	.019	.010
7590.1108	17.420	17.491	17.440	17.429	17.445	4	.032	.016
7590.1109	6.987	7.031	7.009	6.994	7.005	4	.020	.010
7590.1110	0.	0.	0.	0.	0.	-	-	-
7590.1111	-6.980	-6.956	-6.957	-6.940	-6.958	4	.017	.008
7590.1112	-10.597	-10.606	-10.616	-10.595	-10.604	4	.010	.005
7590.1113	-13.064	-13.019	-13.058	-13.030	-13.043	4	.022	.011
7590.1114	-13.150	-13.131	-13.136	-13.118	-13.134	4	.013	.007
7590.1115	-11.240	-11.232	-11.255	-11.241	-11.242	4	.010	.005
7590.1116	-5.792	-5.792	-5.792	-5.792	-5.792	4	-	-
7590.2001	0.	0.	0.	0.	0.			
7590.2001	-2.763	-2.763	-2.759	-2.754	-2.760	4	.004	.002
7590.2003	-4.935	-4.916	-4.916	-4.929*	-4.924	4	.010	.005
7590.2004	-10.684	-10.666	-10.665	-10.679	-10.674	4	.010	.005
7590.2005	-13.880	-13.875	-13.895	-13.900	-13.988	4	.012	.006
7590.2006	-11.507	-11.497	-11.515	-11.518	-11.509	4	.009	.005
7590.2007	-17.224	-17.219	-17.240	-17.257	-17.235	4	.017	.009

* take of +.034 mGal assumed

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TABLE 5 - GRAVITY INTERVALS, ST GEORGES CHANNEL CRUSTAL MOVEMENT STATIONS

GRAVITY INTERVAL MEASURED		Gravity Interval (GAG-2 ACL mGal) G20A		G101		G132		G252		Mean / No. of Obs.	st. dev. / st. error mean
7590.0038	5.+	.464	.474	.510	.459	.471	.497	.504	.493	5.483	.017
-7590.0037		.499	.476	.468	.503	.469	.463	.481	.499	16	.004
7590.0037	116.+	.544	.541	.553	.577	.528	.502	.533	.505	116.535	.022
-7590.0039		.540		.540		.506		.546		12	.006
7590.0037	69.+	.157	.150	.158	.153	.160	.155	.156	.136	69.155	.012
-7590.0040		.148	.164	.161	.167	.136	.142	.142	.149	19	.003
		.171		.179		(.029)		.169			
7590.0040	47.+	.403	.387	.403	.395	.372	.368	.352	.376	47.383	.019
-7590.0039		.391	.392	.388	.416	.351	.366	.368	.403	16	.005
7590.0042	50.+	.726	.772	(.661)	.721	.714	.741	.742	.751	50.735	.021
-7590.0040		.746	.763	.708	.706	.741	(.834)	.724	(.792)	13	.006
7590.0041	31.+	.821	.792	.797	(.856)	.827	(.728)	.815	(.254)	31.810	.015
-7590.0042										5	.007
7590.0041	82.+	.547	.555	(4.57)	.561	.541	.562	.557	.546	82.553	.008
-7590.0040										7	.003
6351.0170	53.+	.779	.794	.769	.786	.767	(.666)	.777	(.698)	53.779	.010
-7590.0042										6	.004
6351.0170	35.+	.349	.357	.349	.313	.334	.309	.371	.353	35.344	.019
-7590.0037		.354	.373	.338	.324	.318	.326	.359	.361	20	.004
			.333		.359		.337		.363		

TABLE 6 - GRAVITY INTERVALS OF ISOGAL NETWORK INTRA-TOWN TIES

GRAVITY INTERVAL MEASURED	Gravity Interval (GAG-2 ACL mGal)									Mean Int. / No. of Obs.	st. dev. / st. error mean
		G20A		G101		G132		G252			
Rabaul											
6351.0170	29.+	.401	.393	.357	.382	.384	.371	.391	.409	29.387	.014
-6791.9980		.397		.383		.397		.376		12	.004
Rabaul											
7590.0180	0.+	.588	.593	.608	.616	.600	.595	.610	.610	0.601	.010
-6351.0170		.591		.607		.589		.608		12	.003
Rabaul											
6351.0170	0.+	.043	.055	.044	.047	.047	.032	.043	.055	0.046	.007
-6791.0180										8	.003
Rabaul											
6791.9980	55.+	.683	.679	.677	.701	.683	.679	.678	.666	55.681	.010
-7590.0280										8	.003
Rabaul											
6351.0170	153.+	(.903)	(.895)	.824	.853	.804	.858	(.786)	.856	153.837	.019
Lae											
-6791.0177		.846	.854	(.721)	.841	.818	.841	.813	(.901)	11	.006
Port Moresby											
7090.0176		9.011		8.995		8.970		9.002		8.995	.018
-6791.0476		8.993		8.972		8.998		9.021		8*	.006
Townsville											
5099.9951	0.+	-	.029	.026	.020	.013	.022	.020	.018	0.021	.005
-7090.0151										7	.002
Townsville											
7590.0151	0.+	.011	.005	.017	.023	.013	.009	.014	.008	0.012	.006
-7090.0151		.006		.021		.012		.008		12	.002

TABLE 6 (CONTINUED)

GRAVITY INTERVAL MEASURED		Gravity Interval (GAG-2 ACL mGal) G20A		G101		G132		G252		Mean Int. / No. of Obs.	st. dev. / st. error mean
Sydney											
6891.0305	0.+	.563	.557	.555	.534	.558	.550	.556	.563	0.553	.011
-7391.0105		.537		.557		.540		.568		12	.003
Sydney											
6891.0305	1.+	.099	.082	.071	.074	.084	.074	.100	.073	1.082	.012
-7590.0105		.065		.074		.088		.097		12	.003
Sydney											
7391.0105	0.+	.502	.542	.517	.520	.539	.536	.529	.521	0.524	.011
-7590.0105		.526		.514		.526		.516		12	.003
Sydney											
7590.0105	31.+	.537	.517	(.567)	.532	.517	.502	.517	.502	31.518	.013
-6091.0105										7	.005

* includes results from the 1973 survey 7390

TABLE 7 - GRAVITY INTERVALS ON CALIBRATION RANGES

GRAVITY INTERVAL MEASURED		Gravity Interval (GAG-2 ACL mGal)								Mean Interv. / No obs.	st. dev. / st. error mean
		G20A		G101		G132		G252			
7590.0380	80.+	.580	.581	.567	.568	.581	.552	.570	.568	80.562	.016
-7590.0280		.561	.568	.581	.576	.560	.522	.551	.559	36	.003
Rabaul		.559	.575	.569	.584	.536	.550	.554	.547		
		.595	.565	.561	.555	.548	.545	.562	.554		
		.554		.588		.533		.543			
7090.0176	52.+	.368	.351	.360	.341	.366	.361	.358	.349	52.360	.010
-7390.0376		.356		.358		.375		.375		12	.003
Port Moresby											
6091.0151	60.+	.519	.503	.520	.511	.542	.538	.539	.543	60.527	.017
-6091.0251		.509		.507		.550		.547		12	.005
Townsville											
6091.0147	58.+	.262	.246	-	.267	.227	-	.250	.263	58.255	.016
-6091.0247		.236		.249		.262		.283		10	.005
Brisbane											
6091.0105	58.+	.986	.997	.959	.978					58.998	.022
	59.+					.012	.004	.026	.018		
-6091.0205										8	.008
Sydney											
6491.0304	54.+	.764	.774	.764	.762	.765	.774	(.594)	.764	54.770	.009
-6491.0204		.756	.760	.768	.768	.778	.773	.760	.771	23	.002
Canberra		.789	.797	.769	.777	.771	.769	.765	.771		

TABLE 8 - CALIBRATION CONSTANTS OF LACOSTE & ROMBERG GRAVITY METERS, 1965-1975

Year	Survey No. / Calibration Line	$\left(\frac{\text{GAG-2 ACL mGal}}{\text{manufacturers mGal}} - 1\right) \times 10^6$ & ERM** in μGal on lower line				
		G20/G20A	G101	G104	G132	G252
1965.2	6591	571 ± 36				
	ACL	14				
1967.4	6791	409 ± 52				
	-	97				
1969.8	6990	548 ± 14	355 ± 9	255 ± 7	373 ± 3	
	WPCL	60	48	34	13	
1970.5	7090	385 ± 15	107 ± 100		420 ± 8	
	ACL	44	115		28	
1971.3	7190	650 ± 16	136 ± 96		409 ± 7	359 ± 20
	ACL	47	264		20	35
1972.9	7213	*	*	314 ± 11		*
	ACL			30		
1973.4	7390	377 ± 4	2689 ± 6		461 ± 10	533 ± 5
	ACL	12	20		25	16
1975.5	7590	395 ± 6	2665 ± 13		401 ± 11	517 ± 15
	ACL	8	22		15	12
						643 ± 14
						19

ACL = Australian Calibration Line, Isogal 74 values of Wellman et al. (1974)

WPCL = Western Pacific Calibration Line, IGSN-71 values of Morelli et al. (1971)

**ERMS = error root-mean-square

* = major overhaul-new screw for G20, major adjustment for G101, and minor adjustment for G252 with new calibration table.

TABLE 9 - AUSTRALIAN CALIBRATION RANGE RESULTS 1965-1975

Name of Range & IGC letter	BMR Station Numbers	Interval of Barlow (1967)	Status of range 1975	Gravity Interval (GAG-2 ACL mGal) LaCoste & Romberg meters only			
				Mean	No. det.	St. dev.	St. error mean
HOBART L-M	6091.0160-6091.0260	54.71	present	54.648	5	.013	.006
MELBOURNE P-Q	6091.0101-6091.0201	53.04	present	53.026	7	.026	.010
CANBERRA L-K	6491.0304-6491.0204	54.76	present	54.772	11	.008	.002
SYDNEY N-O	6091.0105-6091.0205	58.99	present	59.003	9	.023	.008
BRISBANE D-N	6091.0147-6091.0247	58.26	present	58.251	14	.013	.003
TOWNSVILLE L-M	6091.0151-6091.0251	60.51	present	60.554	10	.037	.012
PORT MORESBY Q-V	7090.0176-7390.0376	-	present	52.363	9	.008	.003
RABAUL	7590.0380-7590.0280	-	present	80.562	4	.012	.006
ALICE SPRINGS M-L	6091.0235-6091.0135	52.10	present	52.196	4	.024	.012
ADELAIDE	6091.0108-6091.0208	62.61	present	62.627	1	-	-
PERTH M-L	6091.0217-6091.0117	53.98	destroyed	54.018	5	.04	.02
PERTH	7391.0117-7391.0217	-	present	54.242	2	-	-
BRINDABELLA	7490.0001-7490.0020	-	present	229.573	4	.027	.013

TABLE 10 - GRAVITY VALUES

PLACE & IGC LETTER*		BMR No.	GRAVITY VALUE (Sydney A = 979 671.86 mGal: GAG-2 ACL mGal)	
SYDNEY	T	6891.0305	979 685.658	Airport - Flight Facilities
		7391.0105	979 685.104	Airport - Ansett terminal
		7590.0105	979 684.579	Airport - TAA Terminal
	N	6091.0105	979 653.062	Calibration range bottom
	O	6091.0205	979 594.059	Calibration range top
TOWNSVILLE	O	7090.0151	978 609.606	Airport - in security area
		7590.0151	978 609.618	Airport - street side
	A	5099.9951	978 609.627	Pendulum station - RAAF area
PORT MORESBY	L	6791.0476	978 197.946	Airport - at control tower
	Q	7090.0176	978 206.941	Calibration range bottom
	V	7390.0376	978 154.578	Calibration range top
LAE	K	6791.0177	977 996.043	Airport-Crowley terminal
	M	7390.0177	977 996.691	Airport - on tarmac
		7590.0031	977 854.531	NM/J/31 1973 value 977 854.521
		7590.0032	977 884.633	NM/J/32 " 977 884.614
		7590.0033	977 862.526	NM/J/33 " 977 862.503
		7590.0034	977 871.978	NM/J/34 " 977 871.959
		7590.0035	977 855.308	NM/J/35 " 977 855.293
		7590.0036	977 847.171	NM/J/36 " 977 847.142
		7590.1106	977 894.690	MCM06
		7590.1107	977 892.134	MCM07
		7590.1108	977 893.326	MCM08 2.5 cm below BM
		7590.1109	977 882.886	MCM09
		7590.1110	977 875.881	on BM
		7590.1111	977 868.923	4 cm below BM
		7590.1112	977 865.277	MCM12 1 cm below BM
		7590.1113	977 862.838	MCM13 3 cm below BM

PLACE & IGC LETTER*	BMR No.	GRAVITY VALUE	
LAE	7590.1114	977 862.747	MCM14 3 cm below BM
	7590.1115	977 864.639	MCM15
	7590.1116	977 870.089	MCM16
	7590.2001	977 986.806	Markham-Wau road monument
	7590.2002	977 984.046	Markham River Bridge monument
	7590.2003	977 981.882	BM/CDW/W10 7.6 cm below BM
	7590.2004	977 976.132	BM/CDW/W9 level with BM
	7590.2005	977 972.818	PWD/BM/H7 1 cm below BM
	7590.2006	977 975.297	PWD/BM/H6 1 cm below BM
	7590.2007	977 969.571	PWD/BM/H8 0.6 cm below BM
RABAUL	6351.0170	978 149.880	Airport - Flight Services
	6791.0180	978 149.835	Airport - Terminal
	6791.9980	978 120 494	Geophysical Observatory
	7590.0180	978 150.481	Tavurvur Seismic Vault
	7590.0280	978 064.813	Calibration Range top
	7590.0380	978 145.375	Calibration Range base
	7590.0037	978 114.533	NM/J/37
	7590.0038	978 120.016	NM/J/38
	7590.0039	977 997.995	NM/J/39
	7590.0040	978 045.375	NM/J/40
	7590.0041	978 127.922	NM/J/43
	7590.0042	978 096.106	NM/J/42

* International Gravity Commission

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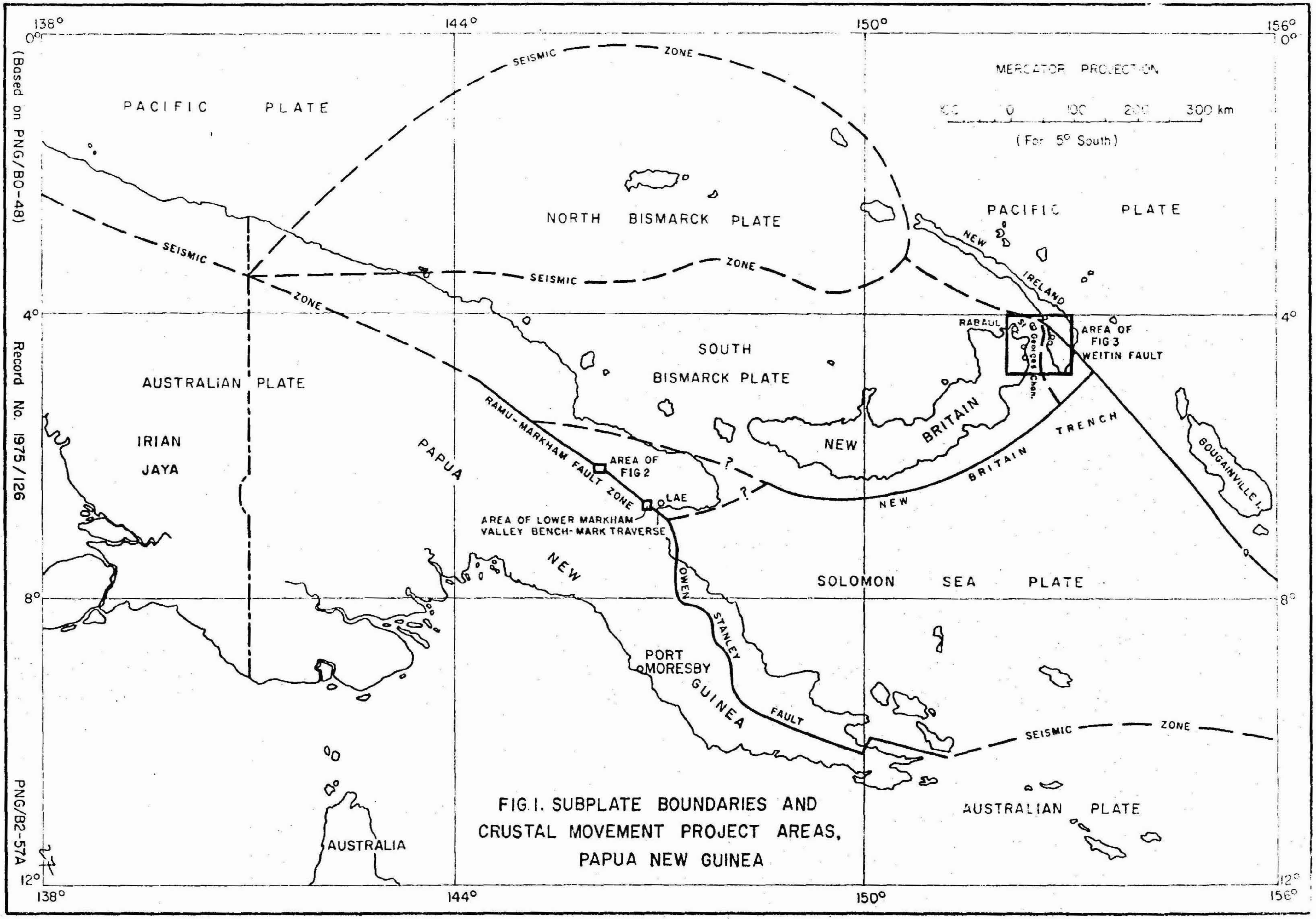

FIG.1. SUBPLATE BOUNDARIES AND CRUSTAL MOVEMENT PROJECT AREAS, PAPUA NEW GUINEA

(Based on PNG/BO-48)

Record No. 1975/126

PNG/B2-57A

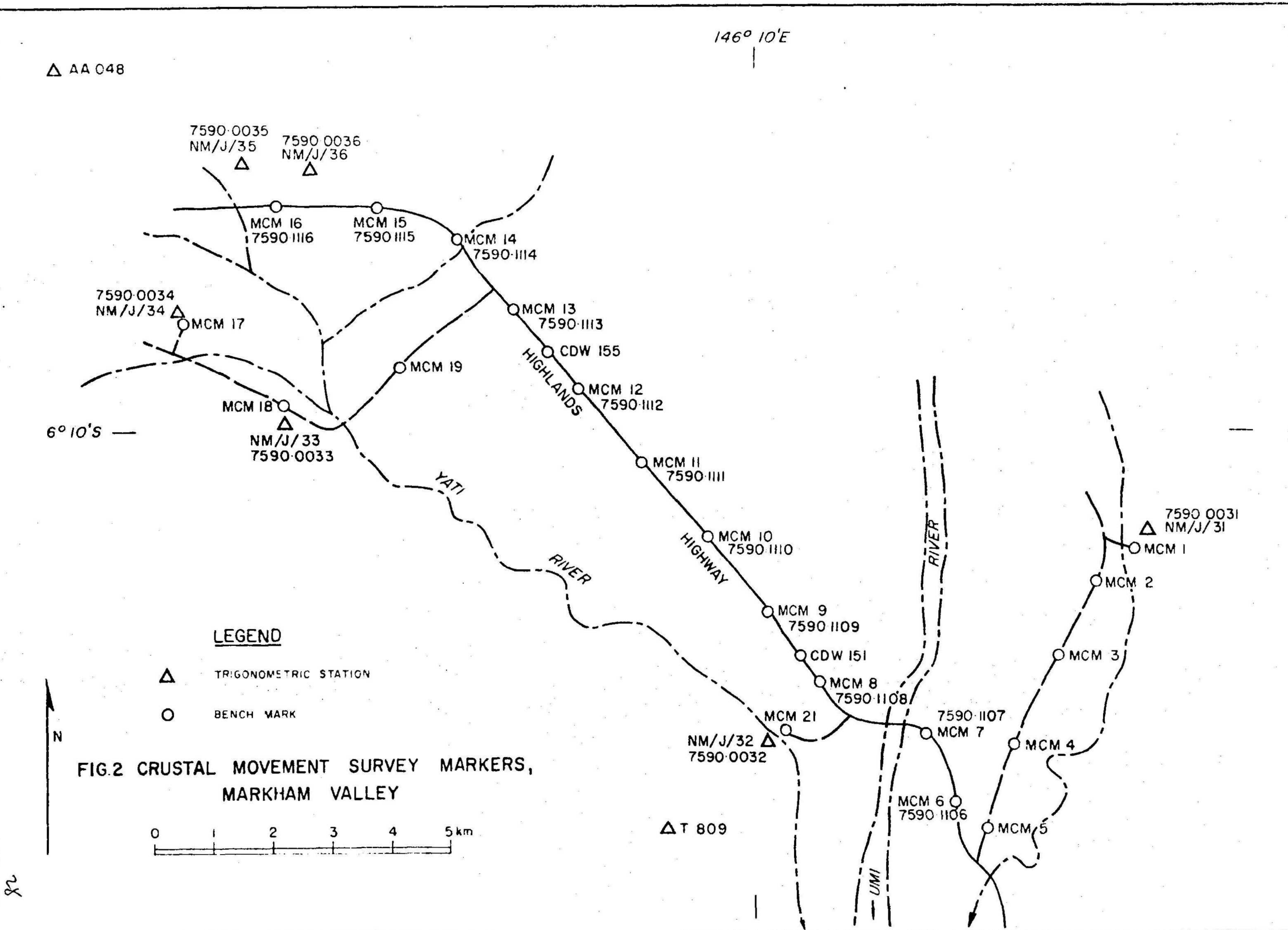

FIG.2 CRUSTAL MOVEMENT SURVEY MARKERS, MARKHAM VALLEY

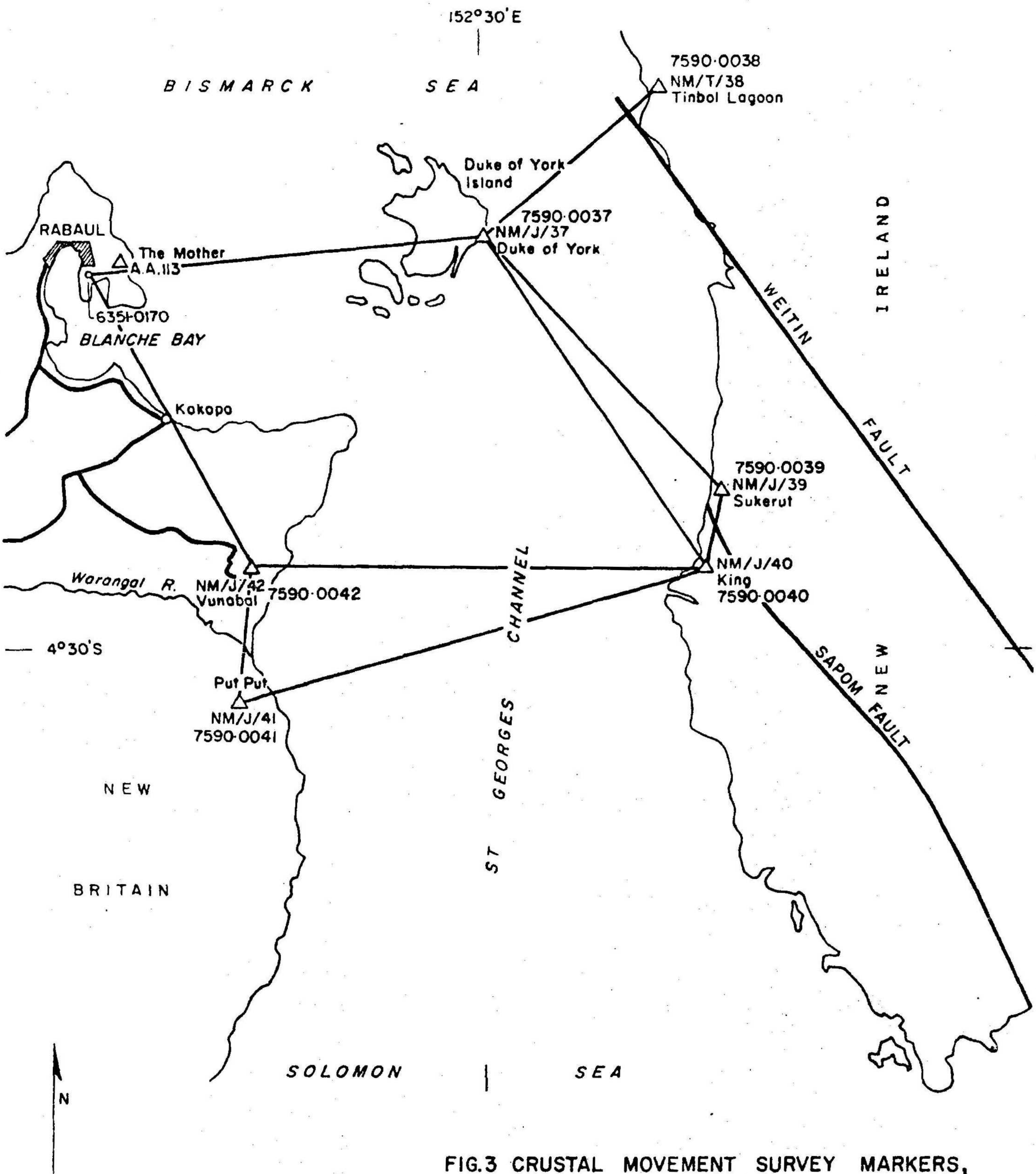

FIG.3 CRUSTAL MOVEMENT SURVEY MARKERS, ST GEORGES CHANNEL

Record No. 1975/126

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