BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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BMR RECORD 1982/40

GRAVITY AND MAGNETIC SURVEY OF NIUE ISLAND, 1979

by

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CONTENTS

ABSTRACT

A gravity and magnetic survey of Niue Island, a raised atoll in the Southwest Pacific Ocean, was conducted as part of a hydrogeological study of the island to assess its groundwater resources. 547 gravity stations and 305 magnetic stations were occupied; in addition, data from an earlier magnetic survey were included for analysis.

The results indicate that volcanic rocks underlie the coral limestone capping at a depth of 300-400 m below sea level. A dome-shaped dense volcanic core, believed to be of basaltic composition, is present beneath the southwest of the island. The core has a lateral density contrast of 0.20 tm^{-3} and a reverse magnetization of 3.0 Am^{-1}. A Lower-Middle Miocene age is inferred for the volcanic pedestal. The asymmetric location of the core within the island is evidence for large-scale landslide activity, particularly on the west and south flanks of the seamount.

The volcanic rocks are below the freshwater layer, and therefore have neglible influence on the island's groundwater resources.

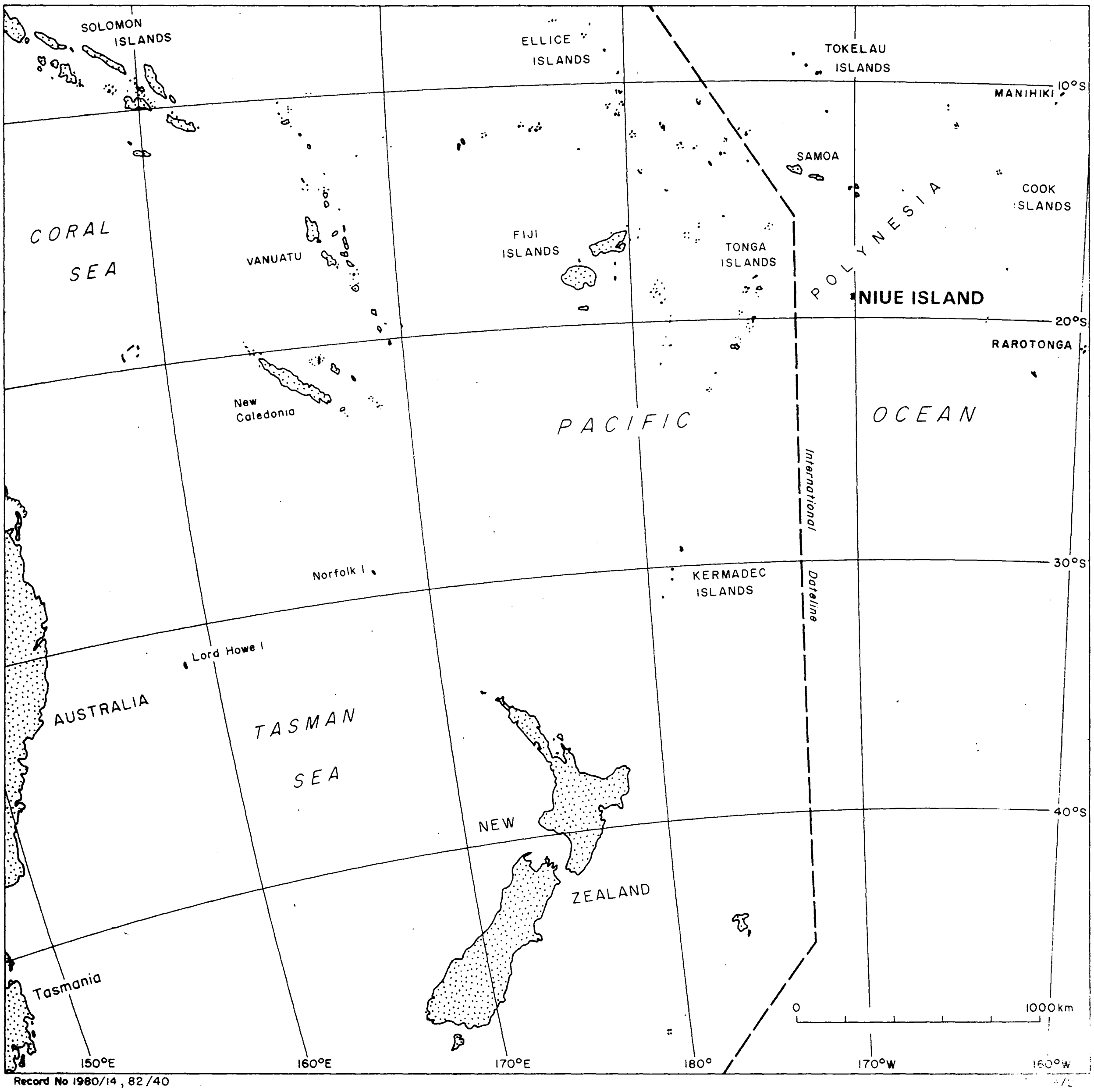


Fig. 1. Location map

INTRODUCTION

Niue Island is a raised coral atoll in the southwest Pacific Ocean (Figure 1). It is roughly circular in shape, about 18 km diameter, and is the only significant landmass for hundreds of kilometres. Samoa, 500 km to the north and Tonga, 400 km to the west are its nearest neighbours. The island rises steeply from an ocean depth of 5 km.

In March - May 1979, the author participated in an investigation of Niue's groundwater resources by the Bureau of Mineral Resources, Geology and Geophysics (BMR). The work was done on behalf of the Australian Development Assistance Bureau (ADAB) as an Australian foreign aid project. The other members of the three-man team were G. Jacobson (geologist) and A.W. Schuett (groundwater technician). The general results of the investigation are described in a separate BMR Record (Jacobson & Hill, 1980 a), and a summary has been published (Jacobson & Hill, 1980 b).

The geophysical input was in the form of 25 Wenner and Schlumberger resistivity depth probes (with current electrode spacings up to 3200m), and detailed gravity and magnetic surveys of the island.

Very little was known about the presumed volcanic substructure of Niue Island (Schofield, 1959). No exposures of basement rock exist on the island, and to date only coralline limestone and dolomite have been intersected during water-bore and mineral exploration drilling. Without adequate knowledge of the subsurface volcanic configuration some uncertainty would remain in any evaluation of groundwater resources. The gravity and magnetic surveys, which are the subject of this report, were done to shed more light on the structure of the igneous basement.

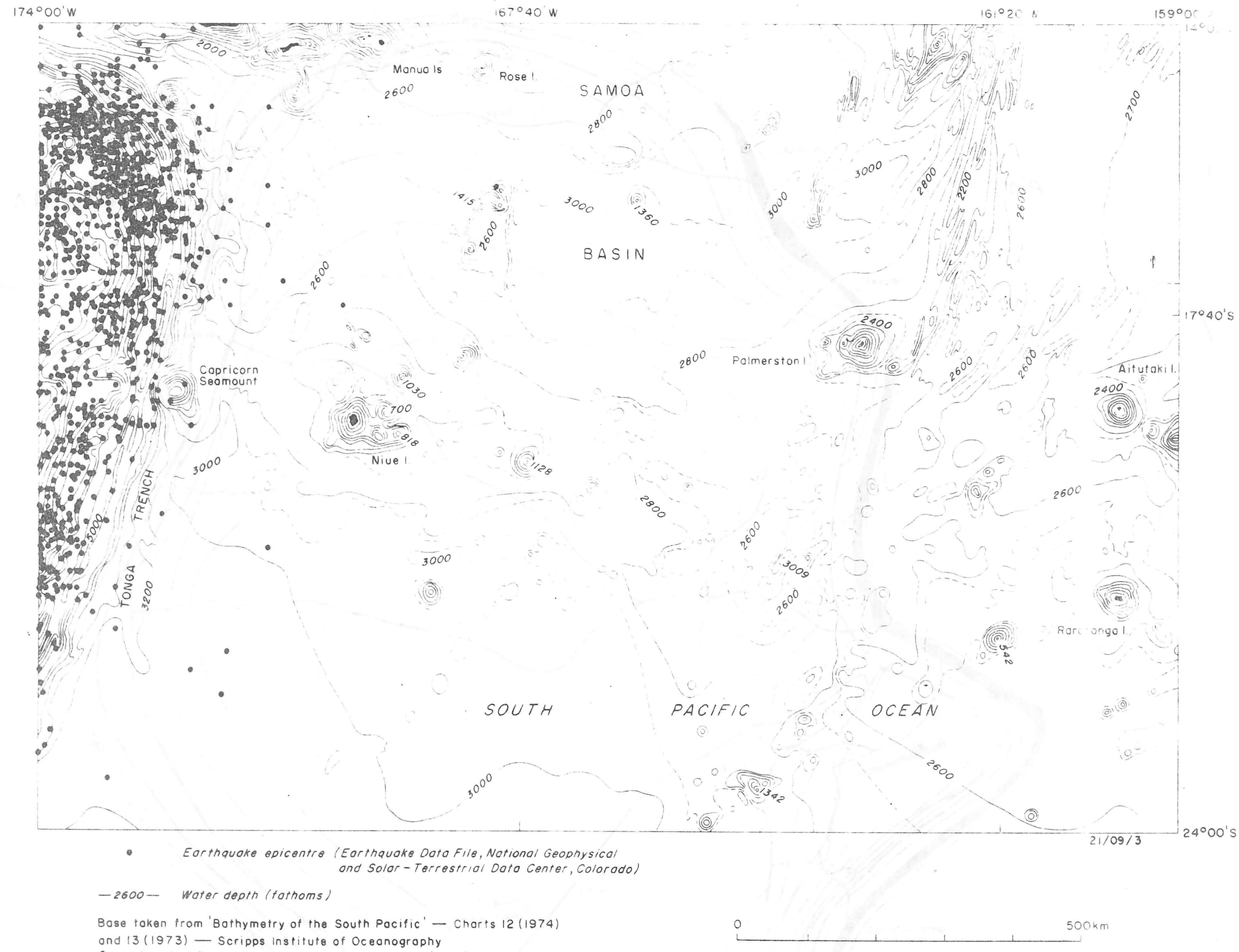
TECTONIC SETTING AND GEOLOGY

Niue is located at the edge of the Pacific plate. At the Tonga Trench about 270 km to the west, the Pacific plate is being consumed by subduction beneath the Australian plate at a rate of about 10 cm/year. The present-day tectonism of the area is well illustrated by the seismicity (Figure 2). Virtually all the seismic activity is associated with the under-thrusting of the descending plate. Relative stability of the Pacific crust is indicated by the low incidence of earthquakes away from the plate boundary. Tensional fracturing of the flexing lithosphere subparallel with the subduction zone may account for the minor activity present within the outer 300 km wide zone of the Pacific plate. Insufficient seismic data is available to allow any definite deductions to be made on recent tectonic activity at Niue.

The geomorphology of Niue Island is shown in Figure 3. The raised former Mutalau Lagoon at the centre of the island is about 35 m above sea level, while the enclosing ancient atoll rim - the Mutalau Reef - is about 25 m higher. Coralline limestone/dolomite is the only rock exposed on the island (Schofield, 1959).

Dubois & others (1975) proposed that the Quaternary uplift of Niue is due to its movement along the upward bulge of the lithosphere before its subduction at the Tonga Trench (Figure 2).

Drilling to depths up to 300 m at a number of locations (Figure 3) has revealed only limestone and dolomite - no volcanics Fossil dating of cores from depths to 220 m in exploration drillhole DH4 indicate a Middle to Late Miocene age (G.C.H. Chaproniere, in Jacobson & Hill, 1980 a).



● Earthquake epicentre (Earthquake Data File, National Geophysical and Solar-Terrestrial Data Center, Colorado)

—2600— Water depth (fathoms)

Base taken from 'Bathymetry of the South Pacific' — Charts 12 (1974) and 13 (1973) — Scripps Institute of Oceanography

Computer plot of epicentres provided by A.S. Murray (BMR)

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Fig. 2. Earthquake plot and bathymetry

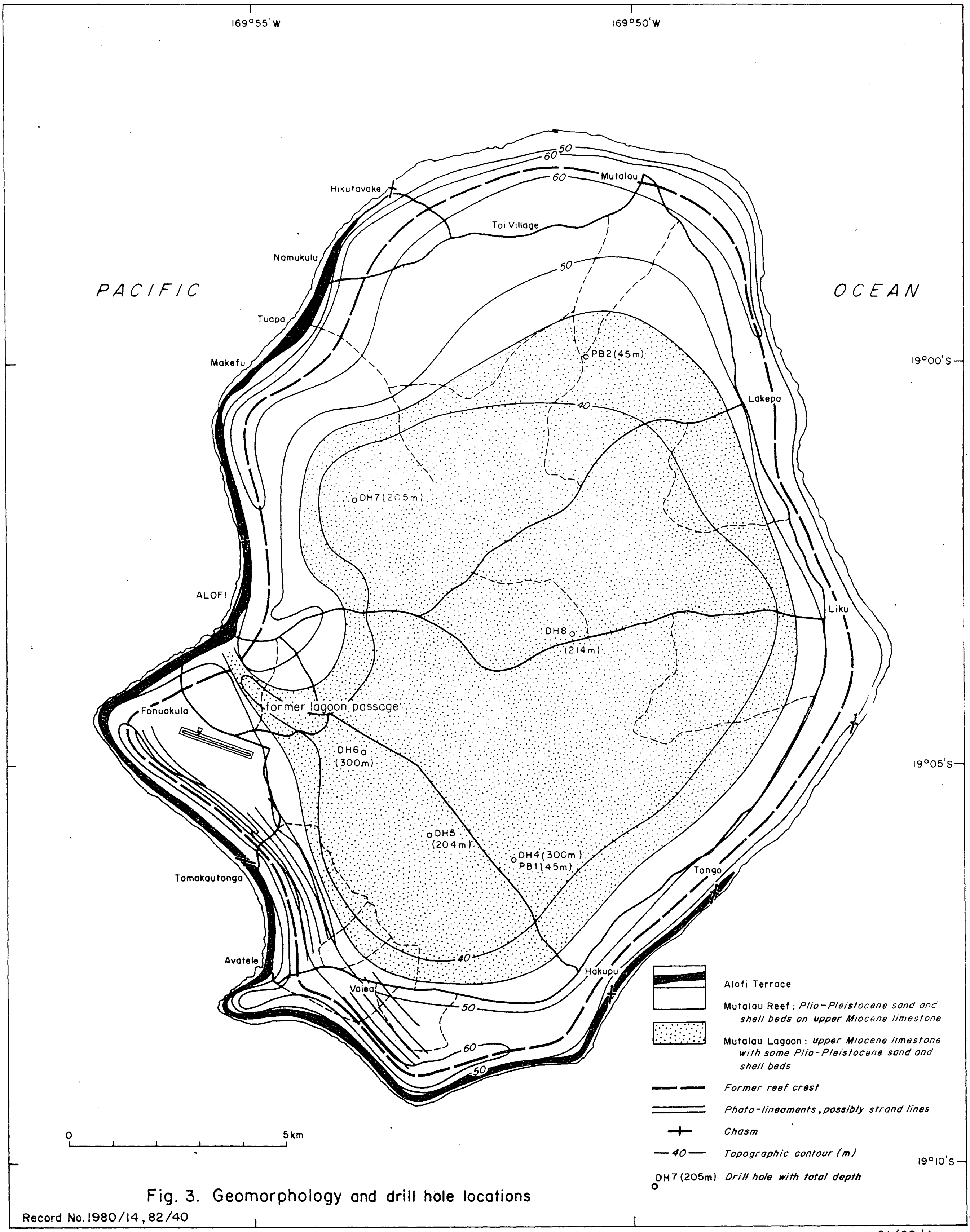

Fig. 3. Geomorphology and drill hole locations

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INSTRUMENTATION AND FIELD OPERATION

Instruments used for the surveys were a Canadian gravity meter (serial number s145) made by Sharpe Instruments of Canada, and a Geometrics G816 proton magnetometer. Gravity and magnetic observations were generally made along roads and tracks on the island, with stations being commonly spaced at about 300 m intervals. A 6.5 km magnetic traverse out to sea from Alofi was also undertaken. The magnetometer and observer were towed behind the government work launch in non-magnetic (aluminium) dingy.

HEIGHT CONTROL FOR GRAVITY STATIONS

(a) Stations along the main roads in the SW of the island were levelled by Public Works Department (PWD) and Justice Department surveyors. This applies to all stations along the Alofi-Hakupu, Alofi-Tamakautonga (via coast) - Avatele - Hakupu, Fonukula, Fuata-Vaiea Farm and power station (Paliati-airfield) roads. Misclosures were about 0.2 m or less.

(b) Heights (at about 50 m intervals) were available from PWD for the coast road in the north of the island, Namukulu-Liku.

(c) Established benchmark (A- and B- series) distributed throughout the island were utilized, where still intact. Many of the original benchmarks have been destroyed over the years, particularly by road graders.

(d) Some previously unsurveyed concrete markers (C- series) were levelled by the government surveysors - in particular, those along the Kapihi-Niufela track.

(e) Heights of bore-hole locations were measured by the government surveyors and by geologist Mr John Barrie of Avian Mining Pty. Ltd.

(f) The topographic contours of the Niue 1:50,000 map (published by the New Zealand Department of Lands and Survey, NZMS 250, 2nd edition - 1977) were found to contain some inconsistancies with survey data. Nevertheless, the map was useful as a guide in extrapolating height from known points for some of the stations on the minor vehicular tracks.

It is considered that gravity station elevations are generally correct to within 0.5 m - this accuracy applies to stations along all the major roads and tracks. However, elevations of some of the stations along minor tracks without surveyed control may be up to 2 m in error. Such elevation errors (i.e. 0.5 m and 2 m) correspond to errors in Bouguer anomaly of about 1 $\mu m.s^{-2}$ and 4 $\mu m.s^{-2}$, respectively.

NUMBER OF STATIONS OCCUPIED

Survey coverage consisted of 547 gravity stations and 305 magnetic stations.

In addition, results of 1978 magnetic work done by Mr Barrie using a BMR magnetometer were kindly provided. With this data, the number of magnetic stations selected for analysis was increased to 870.

REDUCTION AND PRESENTATION OF DATA

The gravity and magnetic readings were corrected for drift and diurnal variation, and reduced to common datums.

For the magnetic work the reference station adopted was benchmark B5 near Paliati High School. The total field here was taken as 41337 nT - with the magnetometer head held 2.5 m above the top of the concrete marker.

Between 1959 and 1963 the New Zealand Department of Scientific and Industrial Research established a gravity base on Niue, near the postoffice in Alofi (Robertson, 1965). The observed gravity at this station (37799A NIUE) was 9788315 ± 5 $\mu m.s^{-2}$. The location of the station is not far from the principal base station used during the survey - the top of benchmark A40, situated at the junction of the main street of Alofi and the Alofi-Hakupu Road. It is estimated that the gravity difference, station 37799A - station A40 = 3 $\mu m.s^{-2}$.

Using this information, the observed gravity values for some of the major base stations used during the survey are as follows:-

Stations	Location	Latitude	Longitude	Elevation	Observed Gravity
		(deg S)	(deg W)	(m)	($\mu m.s^{-2}$)
A40 (top of benchmark)	Alofi	19.0552	169.9234	20.36	9788312.0
A5 (" " ")	Tamakautonga	19.1055	169.9167	25.42	9788377.8
A12 (" " ")	Hakupu	19.1266	169.8455	47.31	9788226.7
A20 (" " ")	Liku	19.0525	169.7906	45.56	9788002.4
A24 (" " ")	Lakepa	19.0083	169.8090	49.32	9788005.0
A28 (" " ")	Mutalau	18.9611	169.8301	67.82	9787829.6

(Note: Observed gravity values are given to 0.1 $\mu m.s^{-2}$ because relatively they were determined to this accuracy. Taken as absolute values, the possible error would be approximately ± 7 $\mu m.s^{-2}$.

Observed station values (see Appendix for all basic gravity station data) were converted to modified Bouguer anomalies by applying latitude (using the 1930 International Gravity Formula), elevation and terrain corrections (for above sea-level topography). A density of 2.1 tm^{-3} for the coralline limestone, indicated by laboratory measurements on core samples, was adopted for the reductions.

The data was further processed to remove the gravity effect of the island pedestal, so that my anomalous internal density distributions would be highlighted. To do this it was necessary to assume a density model for the pedestal below sea-level. Strange and others (1965) working in the Hawaiian Ridge region assumed increasing density with depth - a similar approach was taken in the case of Niue. The density increase is mainly attributed to compaction by the overlying material and the reduced vesicle space of volcanics deposited at depth. The model adopted was:-

Depth (m.)	Density contrast (relative to sea-water*, tm^{-3})
0 - 250	1.35
250 - 500	1.40
500 - 750	1.45
750 - 1000	1.50
1000 - 1500	1.50
1500 - 2000	1.60
2000 - 2500	1.60
2500 - 3000	1.65
3000 - 3500	1.70
3500 - 4000	1.75
4000 - 5000	1.75

* sea-water = 1.03 tm^{-3}

Bathymetric contours (Brodie, 1966) corresponding to the above depths were approximated by a set of polygons, and the island's submarine morphology represented by a vertical stack of horizontal laminae with boundaries corresponding to the polygonal contours and thicknesses equal to the contour intervals. A subroutine from the Fortran program of Spies (1975), based on the method of Talwani & Ewing (1960), was employed to calculate the total gravity effect of the island pedestrial at each of the gravity stations.

The final gravity and magnetic results were plotted as contour maps using a computer program developed by Murray (1977) - a grid spacing of 0.2 minutes (about 360 m) was chosen. The modified Bouguer anomalies plot is presented in Figure 4. Figure 5 shows the residual gravity after subtraction of the calculated island pedestal gravity contribution. The total magnetic intensity (F) contour map is shown in Figure 6.

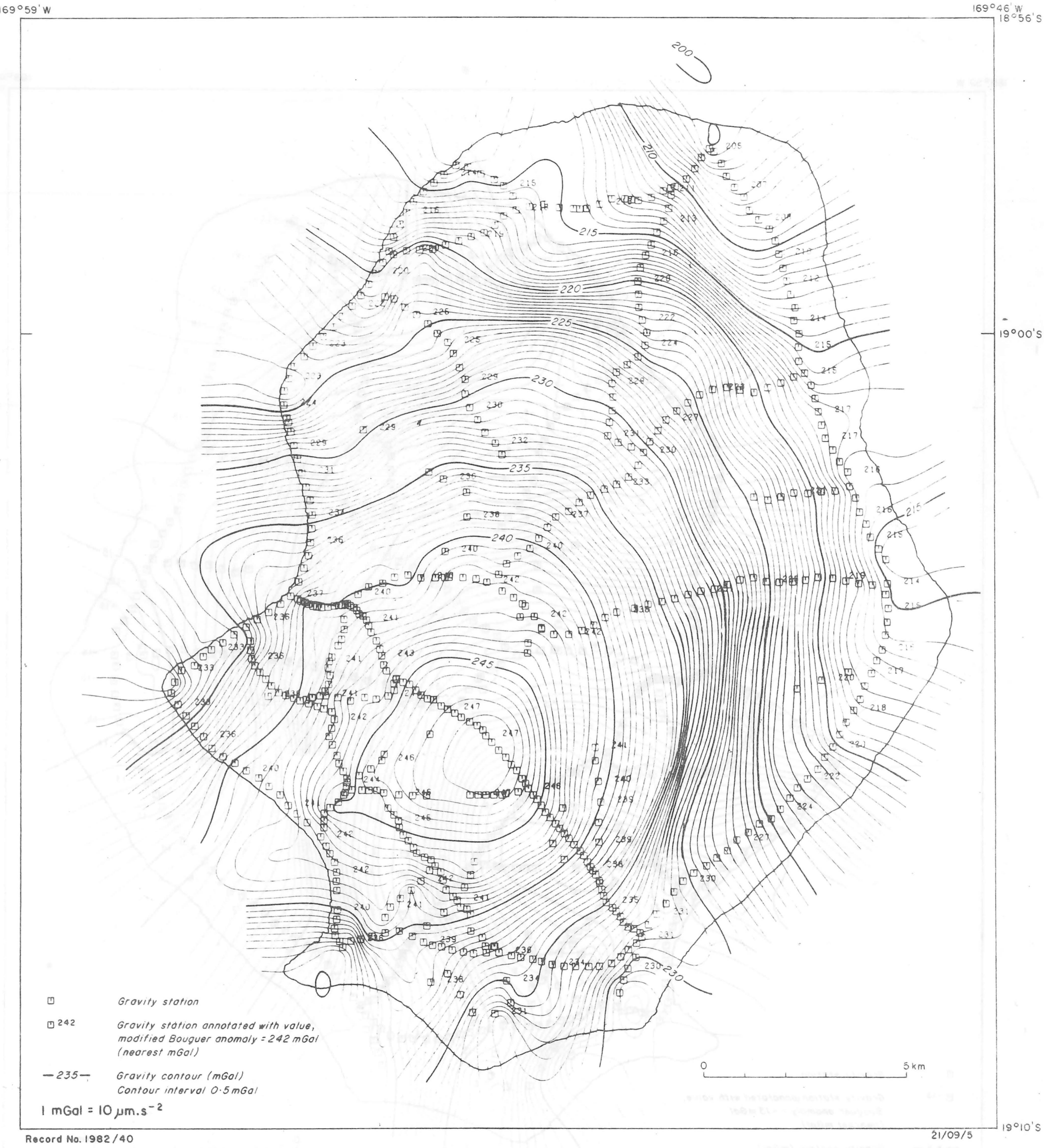

Fig.4. Niue gravity, modified Bouguer anomalies

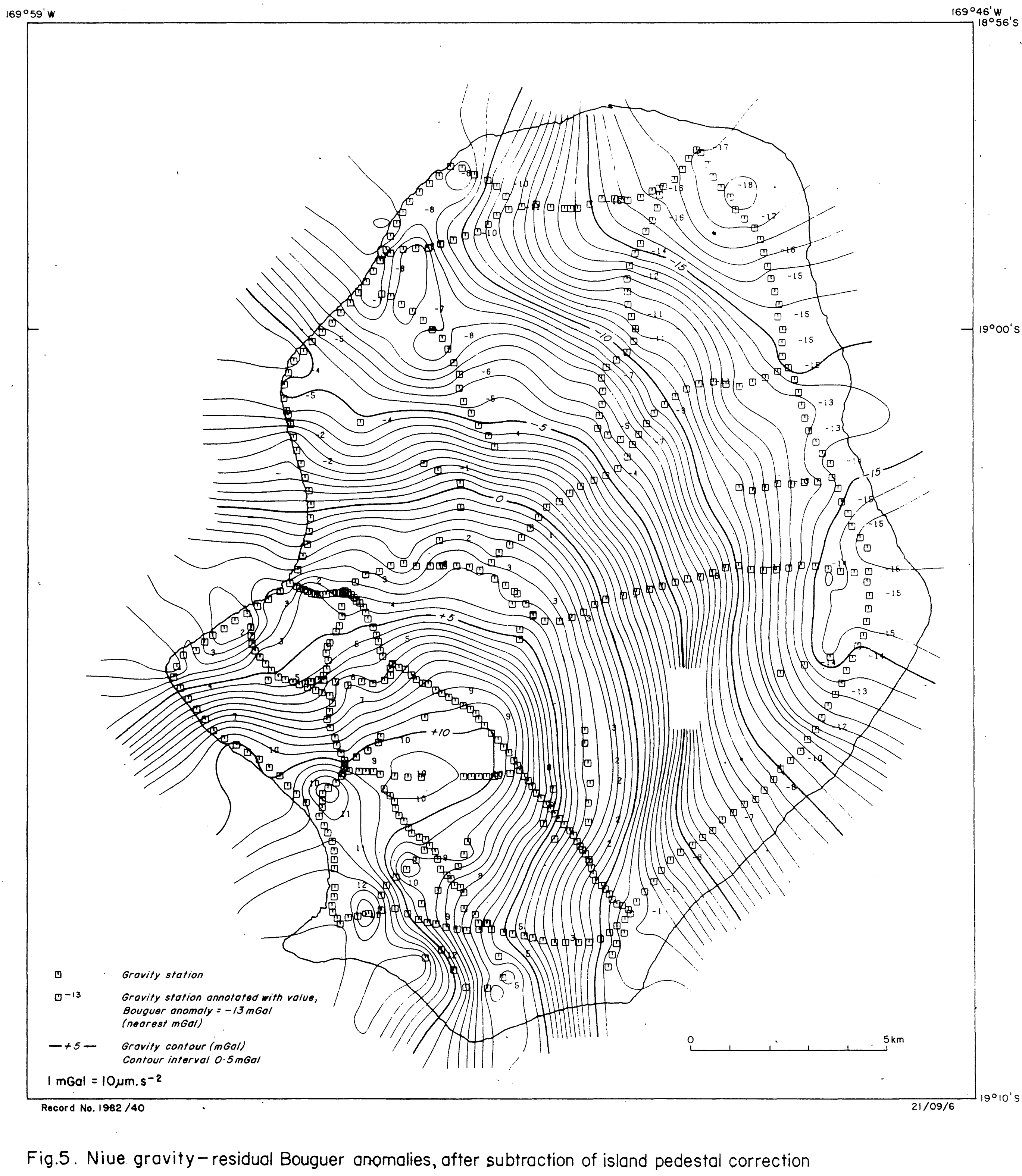

Fig.5. Niue gravity–residual Bouguer anomalies, after subtraction of island pedestal correction

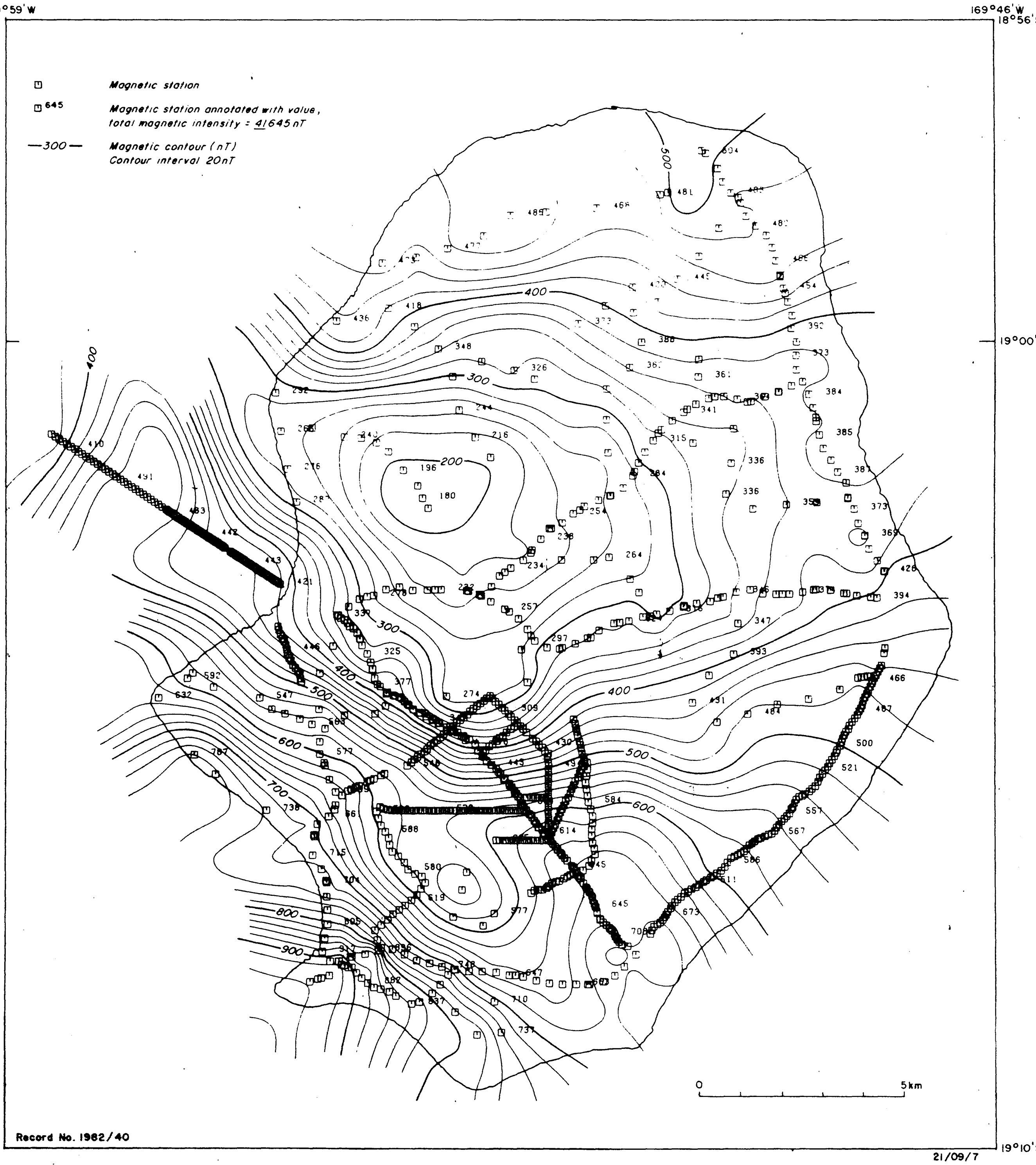

Fig.6. Niue magnetics, total magnetic intensity

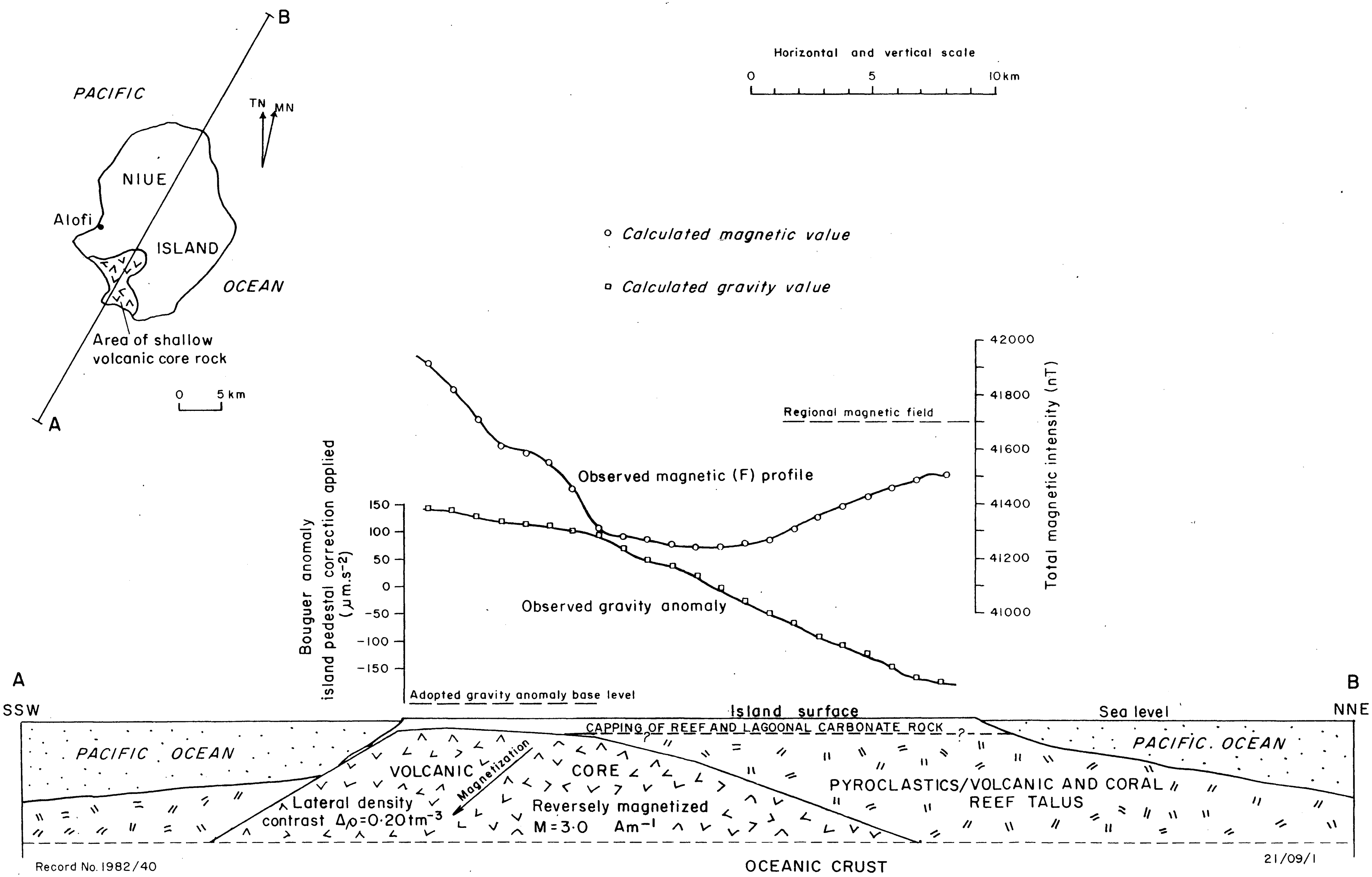

Fig.7 Interpreted volcanic substructure of Niue Island

MAIN FEATURES OF THE GRAVITY AND MAGNETIC FIELDS

A broad gravity high is located in the southern part of the island. The island pedestal corrected anomalies range from about - 180 $\mu m.s^{-2}$ in the north to +130 $\mu m.s^{-2}$ in the south.

An extensive depression in the magnetic field is present at the centre of the island. There is a relatively steep rise in the total field towards the south of the island, from about 41180 nT in the central west to about 41940 nT at the southern coast.

Both the gravity and magnetic fields exhibit steeper gradients in the south of the island around Avatele, thus indicating a shallower source depth in this part of the island.

ANALYSIS OF RESULTS

The geophysical results suggest the presence of a dense, reversely magnetized volcanic core centred in the southwest of the island.

To establish the configuration and geophysical parameters of the core, gravity and magnetic modelling was done. A SSW - NNE section through the centre of the island was selected for analysis - section AB shown in Figure 7. For both the magnetic and gravity case the core was modelled as a two-dimensional body of polygonal cross-section (Talwani & others, 1959; Heirtzler & others, 1962). Optimization of the match between observed and calculated profiles was assisted by a computer inversion routine applied to the geometric model parameters (i.e. co-ordinates of the polygon vertices) - trial & error forward modelling was used to evaluate the other parameters.

The regional geomagnetic field at Niue (1979) has components -

Total field (F)	41,700 nT
Declination (D)	13.4° E
Inclination (I)	- 37.5°

(Ref. 'Charts of the Earth's magnetic field. Epoch 1975.0' published by Defense Mapping Agency, Hydrographic Centre, Washington).

For the modelling it was assumed that in the horizontal plane, the core's magnetization vector was co-aligned with, but opposite in direction to the earth's geomagnetic field. That this is a valid assumption, as an approximation at least, is evidenced in Figure 5 & 6 by the N-S (geomagnetic) trends in the disposition of local magnetic highs and lows and gravity highs corresponding to particular sub-surface features.

The cross-section of Figure 7 shows the interpreted sub-structure of Niue Island. This model provided the best fit to the observed data - the standard deviations of the calculated values from those observed were: magnetics - 14 nT, and gravity - 13 $\mu m.s^{-2}$.

Interpreted geophysical parameters of the volcanic core are as follows -

(i) lateral density contrast 0.20 tm^{-3}; density increases with depths from 2.6 tm^{-3} for the upper core to 3.0 tm^{-3} at a depth of 4 km.

(ii) reverse magnetization of magnitude 3.0 Am^{-1}.

(iii) inclination of magnetization vector is 137.5^{o} (cf. geomagnetic field inclination of - 37.5^{o}).

The volcanic core is centred in the southwest of the island around Avatele and lies at a depth of 300-400 m below sea-level. The top of the core is fairly flat, but irregular in outline with three lobes extending to the NE, SE and NW (see inset of figure 7). The size of the area underlain by relatively shallow core rock is about 20 km^2. The core lithology is thought to consist of basic (-? ultra-basic) intrusives and pillow lavas.

DISCUSSION

The upper part of the volcanic core is approximately flat-topped at about 350 m below sea-level. The original volcano may have been truncated to this level by wave-base and sub-aerial erosion. Subsequent subsidence would have lead to the growth of coral reefs and deposition of associated reefal sediments on, and adjacent to the volcanic platform. With continued subsidence, the coralline limestone capping would have extended upwards to eventually produce the Mutalau Reef & Lagoon, now exposed by Quarternary uplift.

The material laterally adjacent to the core is believed to consist of pyroclastic deposits, volcanic and coral reef talus. There is no significant expression of this material in the magnetic contours (Figure 6). Several explanations can be advanced to account for this. The material may contain/consist of -

(i) inherently non-or weakly magnetic lithologies (i.e. those of low magnetic susceptibility) e.g. carbonates, acid - ? intermediate tuffs.

(ii) weakly reverse-magnetized volcanics, the magnetic effect of which is counteracted by opposing induced magnetization.

(iii) clastic deposits of low - ? moderate susceptibility (e.g. volcanic talus, pyroclastics). Though the clasts may have been derived from parent rock posessing an appreciable remanent magnetization any residual effects of this magnetization at the surface would be nullified by the post-transport chaotic re-orientation of the individual clasts.

The interpreted 300-400 m depth (below sea-level) of the volcanic core is consistent with the drilling results, since no volcanics have been intersected so far. Furthermore, vertical electrical soundings completed at a number of locations over the island (Jacobson & Hill, 1980a) give no indication of dense volcanic core rock lying at average depths shallower than about 400 m. Relatively large electrode separations were used (out to a = 292-400 m for the Wenner arrays and AB/2 = 1100 - 1600 m for the Schlumberger arrays). However the effective depth of investigation is reduced on Niue due to the very low (about 2 ohm-m) salt-water saturated layer underlying the freshwater aquifer. The apparent resistivity plots show no increase in apparent resistivity at large current electrode spacings, as would be expected if dense volcanic rocks existed at shallow depth. No deep electrical sounding data is available for the area in the southwest of the island where gravity/magnetic results indicate relatively shallow core rock (Figure 7).

The fact that the volcanic core is not centrally located with respect to the island suggests that large sections of the volcano's flanks were removed by landslides, particularly in the southwest. This theory is reinforced by the embayed nature of the southern and western coastlines of the island. Schofield (1959) commented similarly, though he believed that the volcanic centre lay in the central west of the island.

AGE OF THE NIUE VOLCANO

The fact that the core's magnetization and the present geomagnetic field are closely aligned, though opposite in sense, suggests that the volcanic foundation of Niue is of Upper Tertiary age.

A number of atolls and guyots have been studied and estimates of their average sinking rates made (Wood, & Hay, 1970; Menard, 1964). It was established that a representative rate is 1000-1600 m per 50 million years. The geophysical data indicate that the coralline capping on Niue is about 400 m thick, and hence an age of 12.5 - 20 million years is inferred for the volcano. BMR palaeontological age determinations on drill-core samples gave a Middle-Upper Miocene age at a depth of about 200 m. Combining these results, it follows that the volcanic pedestal of Niue is probably of Lower-Middle Miocene age.

The best estimate of the inclination of the magnetization of the core gave a value 5^{o} steeper than that of the geomagnetic field alignment. This difference may, at least partly, be explain by the northerly drift of Niue on the Pacific Plate subsequent to the evolution of the volcano. In the region of Niue the absolute motion of the Pacific Plate is approximately 10 cm/year in direction 300^{o} (A.S.P.G., 1981). Assuming that the palaeomagnetic poles at the time of Niue's evolution were coincident with the present geomagnetic poles (except reversed) and that the plate motion has remained unaltered, an apparent 5^{o} steepening of the magnetization vector implies about 5^{o} (latitude) of northerly movement since evolution, corresponding to a time interval of 11 million years. Though this result is roughly of the expected order (see above), it is limited in its usefulness as an estimate of age due to the unconfirmed nature of the assumptions made, and also the limited accuracy of the magnetization direction determination.

COMPARISON WITH OTHER MAGNETIC AND GRAVITY STUDIES IN THE SW PACIFIC REGION

Gravity and magnetic surveys of a number of islands east of Nuie in the Southern and Northern Cook Groups have been made (Robertson 1967a, b; Woodward & others, 1970; Lumb & others, 1973).

The gravity work indicated that, for most of the islands studied, the observed data is compatible with a structural model consisting of an uncompensated island platform of density 2.35 t m^{-3} which contains a core of density 2.87 t m^{-3} and radius equal to the radius of the island at sea level. Though a model with a more complex density distribution and structural configuration is proposed for Niue, the parameters are basically similar to those of the Cook Group model.

Bipolar magnetic anomalies were recorded for islands of the Cook Group which are isolated and resting on a flat ocean floor (Rarotonga, Manihiki and Mangaia); complex patterns are associated with those islands located on ocean floor rises. Attempts to model the observed data by assuming homogeous internal magnetization of the islands proved to be unsatisfactory in general. Reasonable fits were obtained for the islands with bipolar anomalies. For these, values of 2.0 - 5.0 Am^{-1} were calculated for the internal magnetizations. The interpreted value for the volcanic core of Niue (3.0 Am^{-1}) falls within this range.

EFFECT OF VOLCANICS ON GROUNDWATER RESOURCES

The dense volcanic core rock is likely to be of low porosity and permeability and thus unsuitable as a production aquifer. Except for possible local upward projections of this rock in the Avatele area, it is thought to lie at a depth of about 300 - 400 m below sea-level or greater beneath the entire island. A comparable minimum depth is believed to apply to the flanking pyroclastic/volcanic & coral reef talus deposits as well.

The thickness of the freshwater layer is considerably less than 300 m, and is therefore probably confined entirely to the coralline capping. Thus the underlying volcanics are not considered to have any significant bearing on the freshwater hydrology.

Mineralization within the volcanics could be a potential source of contamination of the freshwater layer. But since the freshwater flow pattern is radially outward to the coast, there appears to be no serious risk - unless the lens is tapped near its base, or the natural flow is disturbed, say by overpumping. In these circumstances a marked increase in salinity of the pumped water would become evident as salt water containing possible contaminants was drawn up.

CONCLUSIONS

The coralline capping of Niue Island is underlain by Middle-Lower Miocene volcanics at a depth of 300-400 m below sea-level. These volcanics include a dense basaltic core located beneath the south-west of the island. The volcanic core has a lateral density contrast of 0.20 tm^{-3} and reverse magnetization of 3.0 Am^{-1}.

The volcanics are too deep to have any significant effect on groundwater resources.

REFERENCES

A.S.P.G., 1981 - Plate-tectonic map of the Circum-Pacific Region. South-West Quadrant. American Society of Petroleum Geologists, Tulsa, Oklahoma.

BRODIE, J.W., 1966 - Niue Island provisional bathymetry. New Zealand Oceanographic Institute, Wellington. Island Series, 1:200 000.

DUBOIS, J., LAUNAY, J. & RECY, J., 1975 - Some new evidence on lithospheric bulges close to island arcs. Tectonophysics, 26, 189-196.

HEIRTZLER, J.R., PETER, G., TALWANI, M. & ZURFLUEH, E.G., 1962 - Magnetic anomalies caused by two-dimensional structure: their computation by digital computers and their interpretation. Lamont Geological Observatory (Columbia University). Technical Report 6.

JACOBSON, G. & HILL, P.J., 1980 a - Groundwater resources of Niue Island. Bureau of Mineral Resources, Australia, Record 1980/14 (unpublished).

JACOBSON, G. & HILL, P.J., 1980 b - Hydrogeology of a raised coral atoll - Niue Island, South Pacific Ocean. BMR Journal of Australian Geology & Geophysics, 5, 271-8.

LUMB, J.T., HOCHSTEIN, M.P., & WOODWARD, D.J., 1973 - Interpretations of magnetic measurements in the Cook Islands, South-west Pacific Ocean. In COLEMAN, P.J. (Editor) - The Western Pacific - island arcs, marginal seas, geochemistry. University of Western Australia Press, Nedlands, W.A.

MENARD, H.W., 1964 - MARINE GEOLOGY OF THE PACIFIC. McGraw - Hill, New York.

MURRAY, A.S., 1977 - A guide to the use and operation of program CONTOR. Bureau of Mineral Resources, Australia, Record 1977/17 (unpublished).

ROBERTSON, E.I., 1965 - Gravity base stations in the south-west Pacific Ocean. New Zealand Journal of Geology and Geophysics, 8, 424-39.

ROBERTSON, E.I., 1967a - Gravity effects of volcanic islands. New Zealand Journal of Geology and Geophysics, 10, 1466-83.

ROBERTSON, E.I., 1967b - Gravity survey in the Cook Islands. New Zealand Journal of Geology and Geophysics, 10, 1484-98.

SCHOFIELD, J.C., 1959 - The geology and hydrology of Niue Island, South Pacific. New Zealand Geological Survey Bulletin 62.

SPIES, B.R., 1975 - A Fortran program for calculating the gravity effect of a three-dimensional body of arbitrary shape. Bureau of Mineral Resources, Australia, Record 1975/4 (unpublished).

STRANGE, W.E., WOOLLARD, G.P. & ROSE, J.C., 1965 - An analysis of the gravity field over the Hawaiian Islands in terms of crustal structure. Pacific Science 19, 381-89.

TALWANI, M., WORZEL, J.L.& LANDISMAN, M., 1959 - Rapid gravity computation for two-dimensional bodies with application to the Mendocino submarine fracture zone. Journal of Geophysical Research, 64, 49-59.

WOOD, B.L. & HAY, R.F., 1970 - Geology of the Cook Islands. New Zealand Geological Survey Bulletin 82.

WOODWARD, D.J. & HOCHSTEIN, M.P. 1970 - Magnetic measurements in the Cook Islands, South-West Pacific Ocean. New Zealand Journal of Geology and Geophysics, 13, 207-24.

Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Observed Gravity (μms^{-2})
1	22.36	19.05515	169.92343	1000.0
2	25.42	19.10546	169.91674	1065.8
3	56.20	19.07604	169.92845	944.9
4	23.86	18.98737	169.90427	778.0
5	59.22	18.97406	169.87312	658.7
6	67.82	18.96108	169.83006	517.6
7	49.32	19.00834	169.80904	693.0
8	54.56	19.05252	169.79060	690.4
9	47.31	19.12657	169.84550	914.7
10	60.62	19.12739	169.91010	939.3
11	42.32	19.05229	169.87981	993.7
12	52.70	19.05670	169.91082	954.4
13	35.00	19.02505	169.84488	879.4
14	54.63	19.07699	169.92133	963.6
15	33.65	19.05851	169.85090	980.6
16	48.59	19.12989	169.87723	972.7
17	32.23	19.09543	169.87063	1082.1
18	48.40	19.00585	169.81038	690.5
19	48.60	19.00289	169.81047	685.6
20	50.90	19.00008	169.81033	671.0
21	50.30	18.99731	169.81148	667.6
22	51.90	18.99463	169.81124	654.2
23	51.60	18.99182	169.81219	648.0
24	51.50	18.98900	169.81310	642.2
25	52.00	18.98632	169.81387	632.4
26	51.18	18.98333	169.81477	622.6
27	51.75	18.98056	169.81554	610.2
28	51.57	18.97806	169.81683	601.5
29	52.20	18.97611	169.81917	598.6
30	52.50	18.97411	169.82123	591.3
31	59.00	18.97134	169.82242	568.2
32	62.30	18.96925	169.82452	555.8
33	60.30	18.96694	169.82629	556.4
34	62.43	18.96421	169.82739	541.5
35	64.20	18.96167	169.82906	522.9
36	63.10	18.96294	169.83183	544.4
37	59.60	18.96530	169.83331	569.0
38	58.00	18.96748	169.83518	587.8
39	56.20	18.96907	169.83771	601.0
40	56.00	18.96998	169.84034	608.4
41	54.10	18.97138	169.84297	623.1
42	55.00	18.97202	169.84588	626.1
43	55.64	18.97188	169.84741	627.1
44	56.00	18.97170	169.84894	626.7
45	56.60	18.97170	169.85181	631.1
46	56.60	18.97284	169.85453	637.6
47	57.20	18.97375	169.85735	643.5
48	58.61	18.97384	169.85897	641.9
49	57.60	18.97379	169.86036	644.8
50	58.70	18.97356	169.86351	644.9
51	58.10	18.97288	169.86681	647.6
52	57.85	18.97338	169.87015	658.1
53	60.20	18.97533	169.87589	663.8
54	58.60	16.97729	169.87785	674.2
55	59.60	18.97888	169.88024	680.6
56	60.30	18.97969	169.88310	684.5
57	61.00	18.98060	169.88588	686.1
58	62.00	18.98146	169.88879	689.9
59	64.00	18.98237	169.89161	690.7

Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Obs. Grav (μms^{-2})
60	65.00	18.98246	169.89452	700.4
61	59.00	18.98264	169.89744	699.7
62	34.00	18.98346	169.90031	757.3
63	23.00	18.98510	169.90274	773.3
64	58.45	18.97116	169.87379	651.7
65	60.95	18.96898	169.87589	636.7
66	65.59	18.96766	169.87794	618.2
67	68.30	18.96648	169.88091	612.5
68	53.80	18.96503	169.88382	643.9
69	23.00	18.96467	169.88645	698.9
70	25.00	18.96671	169.88908	703.1
71	25.20	18.96839	169.89132	708.5
72	23.90	18.97020	169.89362	717.9
73	23.80	18.97229	169.89586	727.5
74	24.50	18.97461	169.89744	736.0
75	22.60	18.97706	169.89887	742.5
76	23.05	18.97978	169.90031	753.1
77	23.70	18.98274	169.90136	764.3
78	22.80	18.98968	169.90590	788.7
79	23.00	18.99204	169.90762	792.2
80	23.30	18.99427	169.90958	802.6
81	23.50	18.99640	169.91173	806.7
82	23.80	18.99863	169.91373	813.8
83	24.00	19.00062	169.91598	815.8
84	24.20	19.00267	169.91832	822.1
85	24.50	19.00485	169.92028	826.8
86	24.70	19.00694	169.92252	828.5
87	24.40	19.00948	169.92377	823.2
88	24.20	19.01207	169.92472	823.8
89	23.90	19.01502	169.92482	835.4
90	23.60	19.01774	169.92420	858.3
91	23.40	19.02069	169.92329	871.6
92	23.10	19.02355	169.92262	892.9
93	22.80	19.02641	169.92186	904.6
94	22.50	19.02927	169.92085	913.6
95	22.30	19.03227	169.91994	928.1
96	22.10	19.03513	169.91904	941.8
97	21.90	19.03817	169.91861	954.7
98	21.70	19.04103	169.91870	965.1
99	21.50	19.04394	169.91899	974.0
100	21.30	19.04671	169.91942	984.4
101	21.00	19.04930	169.92047	969.6
102	20.80	19.05220	169.92162	996.8
103	50.20	19.01093	169.80761	693.7
104	50.05	19.01370	169.80670	704.9
105	50.00	19.01647	169.80598	712.4
106	49.90	19.01928	169.80527	715.1
107	48.90	19.02205	169.80441	721.3
108	50.25	19.02451	169.80273	712.4
109	58.20	19.02696	169.80125	692.8
110	59.10	19.02914	169.79939	684.5
111	58.30	19.03218	169.79896	698.9
112	57.10	19.03459	169.79762	694.6
113	56.60	19.03754	169.79676	69.68
114	56.70	19.04003	169.79528	693.4
115	55.60	19.04280	169.79437	693.5
116	57.20	19.04526	169.79256	683.6
117	56.60	19.04748	169.79093	680.0
118	20.77	19.05683	169.92563	1005.0

Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Observed Gravity (μms^{-2})
119	22.41	19.05856	169.42831	996.9
120	23.57	19.06006	169.93089	987.4
121	24.00	19.06165	169.93332	974.5
122	24.20	19.06319	169.93605	963.7
123	24.15	19.06491	169.93853	961.8
124	24.16	19.06632	169.94106	956.2
125	27.15	19.06778	169.94288	954.6
126	30.10	14.06964	169.94484	941.0
127	31.05	19.07064	169.94771	937.9
128	30.00	19.07313	169.94924	921.8
129	25.47	19.07540	169.94106	945.2
130	25.32	19.07781	169.94847	956.9
131	26.80	19.08017	169.64666	966.2
132	25.49	19.08235	169.94474	981.3
133	25.75	19.08453	169.94278	994.6
134	23.88	19.08698	169.94092	1011.7
135	24.16	19.08871	169.93844	1024.4
136	24.10	19.09007	169.93576	1035.4
137	23.62	19.09166	169.93323	1040.7
138	23.23	19.09316	169.93050	1046.1
139	23.04	19.09493	169.92816	1049.1
140	23.22	19.09670	169.92573	1052.5
141	22.46	19.09892	169.92391	1056.0
142	23.36	19.10069	169.92195	1060.0
143	23.83	19.10251	169.91971	1065.4
144	51.60	19.05484	169.90843	956.7
145	50.90	19.05325	169.90609	954.7
146	50.20	19.05252	169.90298	957.5
147	48.60	19.05125	169.90031	956.0
148	46.90	19.05079	169.89734	959.3
149	45.20	19.05143	169.89443	972.5
150	43.50	19.05138	169.89123	983.3
151	42.40	19.05129	169.88817	991.4
152	42.35	19.05134	169.88511	991.4
153	42.35	19.05157	169.88220	994.3
154	41.00	19.05066	169.87718	987.8
155	40.00	19.04843	169.87541	986.6
156	39.20	19.04680	169.87293	986.2
157	38.50	19.04521	169.87020	982.3
158	38.00	19.04312	169.86824	976.1
159	37.20	19.04081	169.86633	966.4
160	36.60	19.03863	169.86447	958.0
161	36.00	19.03745	169.86160	949.8
162	35.60	19.03558	169.85921	941.3
163	35.00	19.03404	169.85673	933.9
164	34.70	19.03277	169.85362	921.5
165	34.50	19.03177	169.85090	911.2
166	34.50	19.03023	169.84822	899.4
167	34.70	19.02773	169.84607	889.6
168	35.30	19.02278	169.84344	869.8
169	35.80	19.02047	169.84163	854.8
170	36.20	19.01820	169.83986	840.7
171	36.60	19.01633	169.83747	831.2
172	37.00	19.01461	169.83499	821.5
173	37.40	19.01293	169.83236	808.5
174	37.90	19.01179	169.82954	795.7
175	38.30	19.01138	169.82624	782.0
176	38.70	19.01193	169.82333	770.5
177	39.70	19.01243	169.82032	761.1
178	41.30	19.01143	169.81726	749.3
179	44.00	19.01043	169.81434	733.8
180	47.00	19.00916	169.81148	713.5
181	46.50	19.12398	169.84397	924.2
182	46.00	19.12176	169.84215	923.0
183	45.50	19.11958	169.84005	918.2
184	45.00	19.11713	169.83833	911.6
185	44.50	19.11490	169.83623	907.2
186	44.70	19.11318	169.83389	901.0
187	44.90	19.11168	169.83102	890.5
188	45.10	19.11000	169.82873	880.7
189	45.30	19.10850	169.82639	872.7
190	45.50	19.10623	169.82428	866.6
191	46.80	19.10464	169.82175	857.3
192	47.40	19.10283	169.81927	847.7
193	48.70	19.10178	169.81659	834.8
194	49.30	19.09974	169.81463	828.8
195	49.30	19.09742	169.81243	820.7
196	49.40	19.09524	169.81081	812.1
197	51.70	19.09336	169.80856	803.4
198	54.70	19.09134	169.80627	793.7
199	53.20	19.08884	169.80474	786.1
200	49.20	19.08666	169.80288	780.6
201	46.20	19.08407	169.80140	776.5
202	46.40	19.08149	169.79996	771.6
203	46.50	19.07899	169.79829	764.8
204	46.60	19.07667	169.79681	756.0
205	47.70	19.07390	169.79576	748.3
206	49.00	19.07127	169.79428	743.0
207	50.30	19.06859	169.79308	731.6
208	51.70	19.06637	169.79184	721.6
209	52.20	19.06328	169.79112	713.6
210	52.70	19.06056	169.79069	710.1
211	53.20	19.05770	169.79041	704.1
212	53.70	19.05479	169.79098	711.4
213	50.00	19.05279	169.79394	718.0
214	43.90	19.05252	169.79705	747.2
215	39.60	19.05198	169.79991	759.2
216	38.80	19.05138	169.80283	775.1
217	38.15	19.05120	169.80608	790.6
218	37.50	19.05179	169.80894	802.6
219	37.00	19.05216	169.81181	813.6
220	36.60	19.05225	169.81477	829.8
221	36.30	19.05211	169.81769	839.3
222	35.90	19.05129	169.82051	853.9
223	35.55	19.05175	169.82352	869.1
224	35.20	19.05275	169.82639	884.0
225	35.00	19.05370	169.82920	897.4
226	34.84	19.05411	169.83217	906.3
227	34.66	19.05484	169.83503	918.4
228	34.48	19.05570	169.83804	930.3
229	34.30	19.05633	169.84091	942.2
230	34.13	19.05688	169.84392	954.3
231	33.95	19.05774	169.84693	967.1
232	33.70	19.05969	169.85348	992.2
233	34.00	19.06128	169.85606	1001.2
234	34.40	19.06242	169.85873	1009.1
235	34.80	19.06323	169.86160	1020.0
236	35.20	19.06323	169.86495	1022.8

Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Observed Gravity (μms^{-2})	Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Observed Gravity (μms^{-2})
237	35.60	19.06183	169.86767	1019.9	296	40.20	19.03436	169.81430	794.2
238	35.90	19.05947	169.86925	1016.8	297	39.20	19.03504	169.81726	808.1
239	26.20	19.05729	169.87125	1013.1	298	38.70	19.03440	169.82037	819.9
240	38.20	19.05552	169.87388	1003.0	299	54.20	19.13574	169.87555	943.2
241	40.20	19.05415	169.87641	1004.5	300	58.30	19.14033	169.87465	934.7
242	56.03	19.07636	169.91870	964.7	301	59.50	19.14260	169.87818	901.7
243	54.00	19.07595	169.91564	980.0	302	59.20	19.14237	169.88310	928.1
244	52.00	19.07636	169.91297	994.1	303	57.50	19.13865	169.88583	951.4
245	50.00	19.07708	169.91015	1008.0	304	54.80	19.13429	169.88865	969.9
246	47.00	19.07636	169.90700	1015.3	305	60.00	19.13606	169.89237	968.4
247	45.00	19.07672	169.90442	1018.1	306	42.00	19.07100	169.79944	762.7
248	43.00	19.07604	169.90174	1027.8	307	39.20	19.07268	169.80536	796.5
249	39.00	19.07341	169.90045	1033.8	308	38.20	19.07449	169.81095	824.5
250	44.61	19.07259	169.89992	1025.5	309	40.90	19.09674	169.89935	1064.2
251	34.50	19.07490	169.90040	1051.7	310	39.70	19.09692	169.89629	1071.6
252	47.90	19.09406	169.91082	1027.0	311	38.50	19.09697	169.89319	1078.4
253	46.00	19.09266	169.90824	1046.4	312	51.00	19.12430	169.89319	994.6
254	44.10	19.09129	169.90556	1059.1	313	46.70	19.12144	169.88941	1012.8
255	42.20	19.08952	169.90313	1056.2	314	41.70	19.11622	169.88482	1035.5
256	41.90	19.08825	169.90260	1054.2	315	40.15	19.11359	169.88349	1052.8
257	36.30	19.05683	169.87188	1013.7	316	38.60	19.11082	169.88263	1055.0
258	36.50	19.05956	169.87240	1015.2	317	51.60	19.13079	169.84684	896.8
259	36.20	19.06210	169.86762	1022.5	318	52.80	19.13311	169.84860	898.9
260	36.10	19.06510	169.87068	1032.5	319	54.40	19.13552	169.84956	886.8
261	36.10	19.06709	169.87078	1035.5	320	55.70	19.13815	169.85047	878.1
262	35.60	19.02392	169.84760	880.7	321	36.70	19.10669	169.85496	1007.5
263	26.20	19.02296	169.85052	881.6	322	35.50	19.10251	169.85501	1013.4
264	37.17	19.02156	169.85281	883.6	323	34.50	19.09824	169.85453	1013.3
265	37.54	19.01874	169.85243	874.8	324	33.40	19.09388	169.85506	1021.7
266	38.28	19.01629	169.85181	863.3	325	32.50	19.08957	169.85577	1026.8
267	39.02	19.01343	169.85162	854.2	326	32.50	19.08680	169.85577	1029.6
268	39.76	19.01057	169.85185	846.2	327	36.10	19.11036	169.86265	1023.7
269	40.50	19.00821	169.85085	828.6	328	35.00	19.10690	169.86523	1046.9
270	39.83	19.00662	169.84846	817.4	329	56.00	18.99232	169.90231	718.7
271	39.15	19.00494	169.84607	809.4	330	63.00	18.99281	169.90026	720.9
272	38.48	19.00253	169.84450	794.9	331	65.00	18.99454	169.89782	732.5
273	37.80	18.99985	169.84411	786.6	332	59.60	18.99608	169.89524	754.0
274	39.10	18.99722	169.84507	777.9	333	57.40	18.99804	169.89280	757.8
275	40.40	18.99459	169.84588	765.1	334	55.30	19.00008	169.89070	771.4
276	41.33	18.99182	169.84593	751.5	335	53.30	19.00194	169.88841	776.1
277	42.27	18.98905	169.84607	742.0	336	51.40	19.00426	169.88712	792.2
278	43.20	18.98619	169.84550	721.3	337	49.60	19.00725	169.88578	808.2
279	45.59	18.98360	169.84430	698.1	338	47.90	19.00975	169.88449	829.1
280	47.98	18.98142	169.84306	680.7	339	46.30	19.01279	169.88454	842.4
281	49.89	18.97874	169.84177	664.9	340	44.60	19.01565	169.88353	853.8
282	51.59	18.97638	169.84024	647.8	341	43.00	19.01824	169.88177	867.4
283	53.28	18.97370	169.83914	633.0	342	41.30	19.02087	169.88014	879.8
284	54.98	18.97089	169.83857	609.6	343	39.60	19.02314	169.87785	892.7
285	56.00	18.96939	169.83867	604.8	344	38.00	19.02560	169.87641	907.9
286	58.50	19.12249	169.90246	992.6	345	42.41	19.05134	169.88912	989.5
287	54.60	19.12035	169.90126	997.1	346	43.27	19.04589	169.88903	972.6
288	50.10	19.11854	169.89906	1006.6	347	43.35	19.03867	169.88420	953.5
289	46.30	19.11681	169.89665	1005.7	348	44.94	19.03345	169.88430	933.4
290	42.80	19.11490	169.89448	1033.7	349	45.03	19.03068	169.88941	916.0
291	39.70	19.11268	169.89257	1043.6	350	47.15	19.02918	169.89266	900.2
292	50.90	19.03313	169.80226	729.4	351	55.00	19.02028	169.90723	823.9
293	45.00	19.03327	169.80531	752.8	352	23.55	19.01869	169.92382	858.3
294	42.70	19.03363	169.80832	766.2	353	32.70	19.09611	169.87288	1087.1
295	41.20	19.03354	169.81143	782.6	354	33.50	19.09652	169.87560	1089.7

Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Observed Gravity (μms^{-2})	Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Observed Gravity (μms^{-2})
355	53.63	19.09679	169.87646	1089.2	414	35.25	19.10283	169.86461	1049.2
356	34.10	19.09679	169.87828	1091.9	415	34.45	19.10383	169.86366	1045.6
357	34.55	19.09679	169.88005	1090.8	416	34.47	19.10487	169.86265	1040.7
358	35.00	19.09679	169.88177	1090.2	417	36.00	19.10591	169.86165	1031.0
359	35.50	19.09679	169.88358	1087.1	418	36.12	19.10723	169.86050	1024.7
360	38.38	19.08407	169.89242	1070.9	419	36.03	19.10859	169.85916	1018.3
361	24.40	19.05579	169.92186	1002.2	420	37.00	19.10955	169.85835	1012.2
362	29.83	19.05620	169.92119	995.1	421	37.41	19.11086	169.85754	1004.5
363	39.98	19.05647	169.92018	984.2	422	38.19	19.11191	169.89687	998.8
364	43.07	19.05683	169.91942	972.9	423	38.34	19.11272	169.85630	994.5
365	49.25	19.05729	169.91846	962.3	424	38.14	19.11359	169.85568	989.1
366	54.80	19.05742	169.91760	951.5	425	38.90	19.11486	169.85491	985.1
367	54.34	19.05756	169.91655	950.8	426	39.39	19.11531	169.85477	981.0
368	53.06	19.05747	169.91512	952.1	427	39.11	19.11667	169.85434	979.4
369	54.16	19.05724	169.91369	949.5	428	40.04	19.11799	169.85391	971.7
370	56.37	19.05711	169.91273	945.4	429	39.35	19.11940	169.85334	967.9
371	58.58	19.05715	169.91192	940.0	430	39.80	19.12049	169.85195	961.0
372	58.67	19.05692	169.91130	947.2	431	41.39	19.12126	169.85114	953.3
373	52.84	19.05720	169.91015	956.8	432	43.73	19.12235	169.85018	942.8
374	52.98	19.05760	169.90934	957.9	433	44.01	19.12348	169.84956	939.3
375	51.49	19.05820	169.90872	963.5	434	44.56	19.12448	169.84846	933.7
376	51.01	19.05892	169.90824	967.5	435	44.63	19.12485	169.84727	929.7
377	50.16	19.05933	169.90738	972.0	436	45.01	19.12571	169.84586	923.6
378	49.88	19.06024	169.90657	976.0	437	23.23	19.10746	169.91555	1071.6
379	48.81	19.06137	169.90609	981.2	438	22.89	19.10905	169.91469	1073.5
380	46.65	19.06278	169.90556	990.0	439	22.21	19.11086	169.91369	1073.1
381	45.01	19.06455	169.90437	996.6	440	21.72	19.11295	169.91325	1071.9
382	45.08	19.06628	169.90360	1001.9	441	21.46	19.11486	169.91330	1069.4
383	47.53	19.06768	169.90317	1001.1	442	21.80	19.11681	169.91321	1064.5
384	47.58	19.06959	169.90274	1007.0	443	21.13	19.12090	169.91306	1056.8
385	45.85	19.07082	169.90212	1012.5	444	21.26	19.12289	169.91325	1048.5
386	44.61	19.07245	169.89997	1024.2	445	19.82	19.12480	169.91373	1041.8
387	42.39	19.07322	169.89839	1033.2	446	19.52	19.12625	169.91359	1037.4
388	40.91	19.07363	169.89696	1040.8	447	32.97	19.12753	169.91259	1002.3
389	36.62	19.07490	169.89558	1055.2	448	52.83	19.12875	169.91192	943.7
390	37.09	19.07590	169.89443	1058.4	449	67.55	19.12707	169.90790	953.6
391	38.62	19.07667	169.89300	1057.9	450	66.43	19.12648	169.90542	962.5
392	38.73	19.07686	169.89166	1060.3	451	61.89	19.12575	169.90246	975.2
393	37.57	19.07817	169.88994	1066.9	452	55.51	19.12539	169.89930	986.3
394	37.22	19.07885	169.88855	1070.4	453	52.72	19.12648	169.89639	986.6
395	36.83	19.07967	169.88693	1073.4	454	48,80	19.12771	169.89395	992.9
396	36.71	19.08053	169.88549	1075.1	455	49.57	19.12839	169.89194	989.1
397	37.08	19.08149	169.88363	1077.1	456	49.88	19.12871	169.88994	985.6
398	37.04	19.08226	169.88196	1079.2	457	49.60	19.12939	169.88760	983.9
399	37.36	19.08317	169.88071	1079.5	458	50.68	19.12984	169.88511	975.7
400	37.33	19.08439	169.88005	1082.1	459	51.63	19.13011	169.88287	968.5
401	36.25	19.08575	169.87876	1085.5	460	49.32	19.12993	169.88005	971.5
402	35.90	19.08743	169.87723	1087.5	461	48.59	19.12989	169.87723	972.7
403	35.15	19.08889	169.87565	1087.6	462	46.75	19.13052	169.87446	972.8
404	35.82	19.09043	169.87441	1086.0	463	47.76	19.13089	169.87240	966.3
405	34.07	19.09166	169.87321	1085.0	464	47.96	19.13129	169.86972	961.3
406	32.27	19.09338	169.87202	1086.1	465	47.55	19.13175	169.86777	958.2
407	32.14	19.09438	169.87125	1084.6	466	47.22	19.13238	169.86542	952.8
408	32.23	19.09543	169.87063	1082.1	467	48.78	19.13275	169.86280	944.0
409	33.72	19.09679	169.86953	1075.2	468	47.47	19.13275	169.86026	941.5
410	34.33	19.09770	169.86872	1070.0	469	48.03	19.13275	169.85730	935.6
411	34.87	19.09897	169.86781	1063.7	470	48.24	19.13270	169.85491	927.0
412	33.19	19.10042	169.86686	1064.4	471	48.63	19.13207	169.85228	919.6
413	34.86	19.10151	169.86581	1056.1	472	49.21	19.13070	169.85018	915.9

Stn. No.	Elev. (m)	Latitude S (deg.)	Longitude W (deg.)	Observed Gravity (μms^{-2})
473	47.92	19.12921	169.84851	915.4
474	46.40	19.12784	169.84669	917.4
475	43.39	19.09565	169.90986	1039.7
476	41.24	19.09574	169.90757	1051.8
477	40.86	19.09579	169.90599	1055.3
478	40.95	19.09579	169.90422	1055.5
479	42.13	19.09633	169.90269	1055.0
480	42.25	19.09951	169.90179	1055.2
481	40.06	19.10096	169.90045	1062.2
482	42.54	19.10215	169.89945	1054.1
483	39.33	19.10364	169.89925	1059.6
484	42.10	19.10523	169.89839	1051.9
485	42.39	19.10641	169.89725	1050.1
486	42.54	19.10782	169.89610	1047.9
487	42.61	19.10905	169.89543	1045.6
488	40.53	19.10991	169.89366	1049.4
489	39.07	19.11045	169.69223	1054.2
490	38.78	19.11173	169.89132	1051.6
491	40.99	19.11300	169.89008	1043.4
492	41.23	19.11468	169.88955	1038.9
493	40.23	19.11681	169.88889	1036.8
494	42.12	19.11813	169.88740	1029.3
495	43.26	19.11894	169.88645	1020.7
496	44.31	19.12040	169.88568	1015.0
497	44.46	19.12081	169.88430	1013.7
498	44.24	19.12194	169.88349	1011.5
499	45.16	19.12539	169.88344	998.6
500	45.62	19.12675	169.88091	990.8
501	49.17	19.12857	169.88024	976.9
502	49.06	19.12862	169.87837	975.1
503	49.59	19.12857	169.87813	970.1
504	56.35	19.07677	169.91994	960.9
505	56.03	19.07631	169.91861	964.6
506	55.52	19.07595	169.91689	969.3
507	53.37	19.07499	169.91579	975.6
508	52.69	19.07359	169.91498	975.1
509	52.51	19.07173	169.91464	973.8
510	54.04	19.07014	169.91512	968.0
511	40.29	19.06877	169.91483	1000.0
512	51.15	19.06791	169.91426	974.2
513	50.12	19.06551	169.91287	976.9
514	50.29	19.06419	169.91211	975.8
515	48.97	19.06215	169.91153	973.3
516	51.44	19.06006	169.91158	964.4
517	53.13	19.06455	169.93242	904.0
518	60.05	19.06646	169.93232	893.7
519	65.83	19.06818	169.93213	896.1
520	64.86	19.06968	169.93141	910.5
521	60.51	19.07104	169.93027	924.7
522	58.16	19.07250	169.92898	934.0
523	56.42	19.07390	169.92769	941.3
524	55.41	19.07531	169.92611	948.4
525	55.50	19.07590	169.92453	953.0
526	54.70	19.07649	169.92276	958.5
527	55.81	19.07763	169.91942	965.3
528	54.14	19.07822	169.91751	974.5
529	53.73	19.07872	169.91607	981.1
530	53.09	19.07935	169.91426	986.3
531	50.11	19.08094	169.91369	997.3
532	48.76	19.08280	169.91431	1001.9
533	52.10	19.08448	169.91488	995.6
534	50.16	19.08625	169.91416	1006.5
535	49.49	19.08848	169.91311	1013.8
536	49.42	19.09016	169.91268	1018.8
537	47.89	19.09179	169.91173	1025.5
538	47.31	19.09334	169.91091	1031.7
539	48.58	19.09506	169.91101	1031.2
540	41.96	19.09624	169.91130	1025.1
541	54.73	19.09674	169.91163	1022.3
542	58.26	19.09824	169.91282	1014.3
543	60.41	19.09938	169.91464	1010.6
544	64.36	19.10056	169.91593	996.0
545	59.39	19.10210	169.91598	995.7
546	56.67	19.10360	169.91603	998.5
547	34.19	19.09951	169.86299	1050.5