1987/02. TASGRAV - The Tasmanian Gravity Data base

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Abstract

This report describes the history of the Tasmanian gravity data base and its contents as at January 1987. The original repository for the data base was with the Bureau of Mineral Resources (Canberra) but the Tasmania Department of Mines undertook the verification, correction and updating of the data base in 1981. Corrections have, to date, been completed only for the stations acquired on land.

HISTORY

The first gravity surveys undertaken in Tasmania were elements of mineral exploration programmes. Few details exist and the surveys are referenced by Leaman (1980). No data has been recovered from this period (1955-1960).

Regional surveys, or those with particular geological-structural targets, were introduced by Dr R. Green, then at the Geology Department of the University of Tasmania, with the support of Professor S. W. Carey. The initial surveys were at Red Hill (McDougall and Stott, 1961 - 6050) and Great Lake (Jones *et al.*, 1966 - 6250). The undoubted success of these surveys led to the purchase of a meter. Dr Green then travelled the mainline railway to Wynyard and, using railway survey levels at stations and crossings, produced a gravity profile. This revealed the Longford "anomaly" and strong gradients along the north-west coast. These features became topics for more extensive surveys (Hinch, 1965; Longman and Leaman, 1971; Sheehan, 1969). These follow-up projects were the first large-scale surveys - usually with a spacing of about 1.5 to 2 km. Meanwhile student exercises were used to provide profiles in many locations in southern Tasmania. These were unified by Cameron (1967) and Johnson (1972).

Cameron and Johnson provided a broad scale coverage of the entire island. Spacing was most irregular but sufficient stations were observed to crudely define the regional gravity field across continental Tasmania (Johnson, 1974). The statewide cover was upgraded by BMR helicopter surveys not long afterward (Zadoroznyj, 1975). This survey, with a regular 7 km spacing, provides the only data in some regions.

Until recently most gravity surveys have been directed at structural problems related to intrusion of Jurassic dolerite (6050, 6250, 6560, 6751b, 6851, 6950, 7051a, 7251a, 73-7951, 80-8151, 81-8351), Tertiary basin forms (6440, 6751a, 6751b, 7051b, 7151a, 7151b, 7151c, 7251b, Forester, 7351b, 7551b), or Devonian granite (7050, 7151c, 7351a).

Recent surveys have been more broadly based and directed at improved definition of the gravity field. These systematic surveys with a regular station spacing of about one kilometre will ultimately cover the entire island. Examples are in the Midlands (81-8351) and North-west (8551). The infusion of funding provided by the Mount Read Volcanics Project has enabled systematic coverage of large parts of western Tasmania, a process which had begun in the Zeehan region in late 1980.

From its early days the gravity data base had been viewed as an asset of considerable value, and every effort was made to maintain it. Reduction requirements were standardised, made compatible with the system codeveloped with the BMR, and computerised. Much of the credit for this rests with Dr R. Green. Until 1969 all data was transmitted to Canberra and compiled as part of the national data base.

The period 1966-1970, however, saw many changes in personnel, policy and acquisition. Dr Green transferred to the University of New England. Dr J. Shirley left the BMR to undertake a doctoral thesis and took over responsibility for the local data base. Up until this period most surveys were University projects. This began to change in late 1966 when one of us (D.E.L), with M. J. Longman, began systematic surveys in north and north-eastern Tasmania as part of basin-groundwater surveys for the Department of Mines and co-funded by the Water Resources Council. By 1971 most acquisition was generated by the Department of Mines which had recently acquired its own meter. Even the Scottsdale survey (7050 - Symonds, 1971) was proposed and supported by the Department of Mines.

These events created special problems. Control of the data base, its local compilation and its data sources, rested with three separate organisations (BMR, University of Tasmania, Department of Mines respectively) all with differing facilities, expectations and needs. It was inevitable that inconsistencies and omissions would occur. Matters were not helped by the Apsley survey (6950) which was considered by Shirley to be of dubious reliability and consequently not sent to Canberra. Quality standards were set by the Department of Mines from this time (1968) and full corrections incorporated in the reduction process. Incompatible computing hardware meant that Department of Mines data could only be transmitted in printed form. Although the standard formats were used, this necessitated extra work and introduced some errors. But, by the time the gravity map of Australia was produced, the Canberra data base contained nearly all the Department of Mines data acquired up to 1975. Only minor surveys were omitted.

By 1980 problems were known to exist in the Canberra data base but for various technical and staff reasons these could not be resolved. No data were accreted to it after 1975. Then in 1981 Dr J. Shirley, who had retained the nominal responsibility for the data base, left the University for industry and Dr D. Leaman, who had built up the Department of Mines cover, resigned to become a consultant. The vacuum was shortlived.

One of us (R.G.R) requested transfer of the data base to Hobart now that computing facilities were appropriate, and took over responsibility of accretion, correction and organisation of the data - now called TASGRAV. This process began in late 1981.

Subsequent systematic surveys, incorporation of previously rejected surveys after review and correction, and normalisation of industry surveys has led to a massive increase in the data base.

PRECISION AND RELIABILITY OF SURVEYS INCLUDED

Table 1 lists the surveys which the authors consider to have been satisfactorily observed and now consistently corrected and verified. The station distribution is shown in Figure 1.

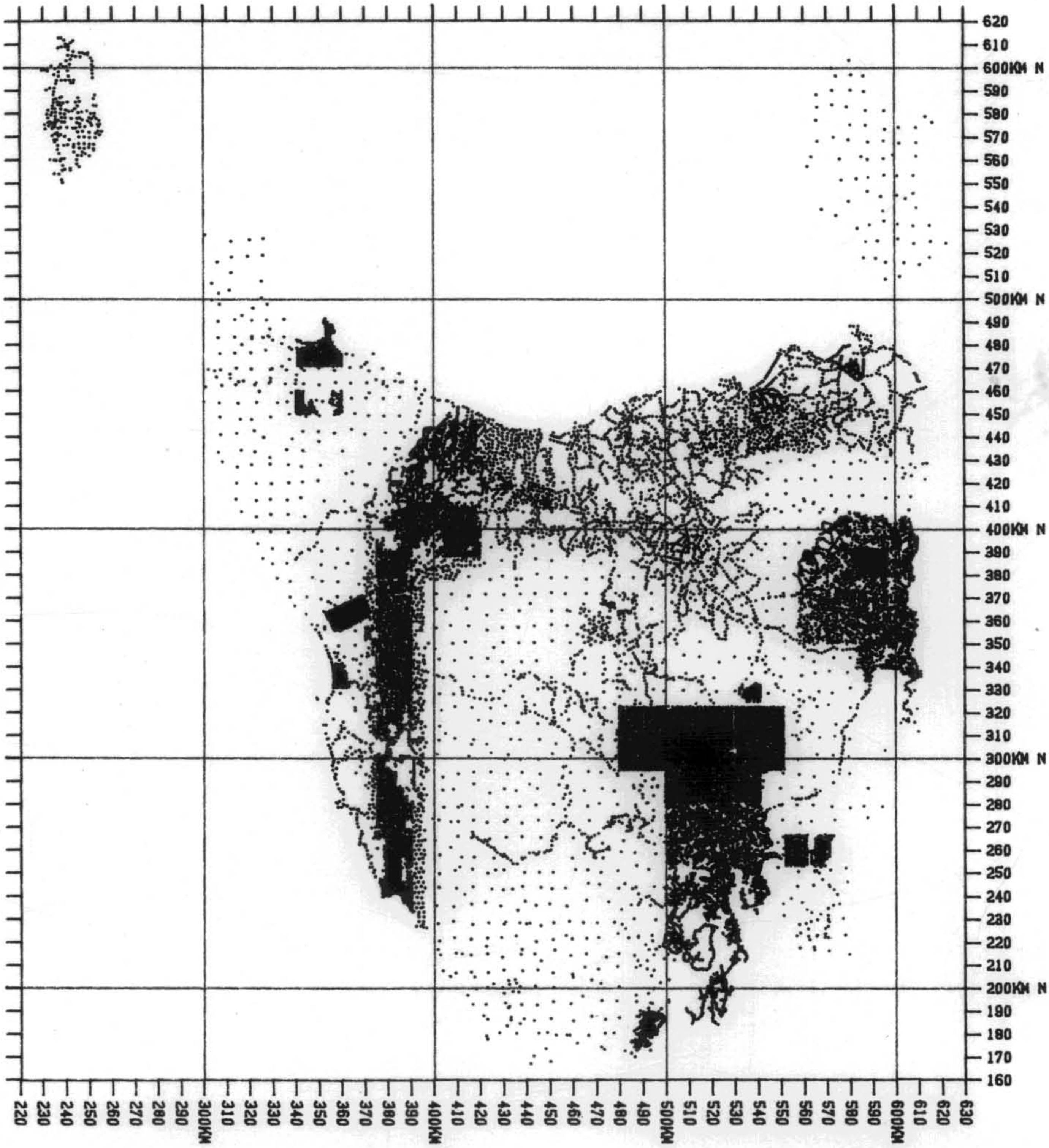

Figure 1. *Distribution of gravity stations.*

5 cm

Some surveys yet to be inserted include Oliver Hill (Leaman, 1974d) and Beulah (Leaman, 1975). These depend on completion of correction and ties to the State network.

The survey code is used to access discrete portions of the data base. It defines the year of survey and the orgnisation (e.g. 50 = University of Tasmania, 51 = Department of Mines).

The region of survey and observer provide description of the principals. The reference provides published sources where extant, theses otherwise unless the material was not documented. In the latter case the name of the observer is given.

Precision estimates are based on our view of the data sets, cross ties and assessment of techniques. These are not necessarily as reported by the original observers.

The ultimate reliability and accuracy of the reduced Bouguer anomalies depends on the care with which the original observations were made and the adequacy of essential corrections. We have found that the typical deviation or error in results is about 0.6 mgal (0.4 to 0.8 typically). This estimate is based on cross ties between surveys or comparison of values at or close to the same site. Many pairs agree within 0.3 mgal or better which, in view of the potential problems and survey vintages, is quite remarkable. Some data sets can be safely contoured with a 1 mgal interval and virtually all can be contoured with 2 mgal intervals.

OBSERVED GRAVITY

Most University and Department of Mines surveys have been directly tied to the Isogal network (Wellman *et al.*, 1985) or to a subsidiary primary network based on it (Richardson and Dix, 1986). Each survey then carried a second order tie network, usually with stations prefixed 9000 or 9900, for local adjustments and loop control. Drift and loop network adjustments were always applied to code 50 and 51 stations (Method: Gibson, 1941). Until 1975 most loop times were less than two or three hours.

Nearly all established errors were related to meter misreading of hundreds of divisions - usually 100 divisions. The problem arises as the hundred value changes and any distraction may cause the incorrect hundred value to be entered. This problem is identifiable and easily corrected where the local coverage is good. Some isolated BMR (7303) stations may retain this problem. Few other errors are likely and the precision quoted represents the loop distribution adjustment.

POSITION

Early surveys (6050, 6250, 6353 and parts of 6440, 6451, 6560, 6650 and 6751) relied on SPM and bench-mark locations. This greatly restricted coverage but minimised errors due to position or elevation uncertainties. It did not eradicate all errors as nominal positions were often occupied if the mark was buried, destroyed or misdescribed. In the absence of reliable topographic maps little else was possible.

In such surveys positions were quite accurately defined - being the result of triangulated survey or astronomical fix.

However, most surveys between 1965 and 1970 depended on the first generation of topographical basemaps. These occasionally lacked detail and were often at scales in excess of 1:31 680. Positions could rarely be defined better than 50 or 75 m. This problem was exacerbated when surveys left established roads. The first survey of this type was Hobart (6851) although the first machine plots (1:15 840) made available by the Lands Department eased the problems. This facility was not generally available for several years. Fortunately few surveys relied on broad coverage until later stages of the East Coast Survey (especially 78-7951 of 73-7951, 80-8151). The positional uncertainty may be a resultant or confined to either easting or northing. There is no means of establishing which.

TERRAIN CORRECTIONS

The entire TASGRAV data base as presented includes a terrain correction for every station. Although some of these are restricted to Hammer zone K (approximately 10 km), most have been calculated to zone M (~22 km). All corrections have been manually calculated using the method of Hammer (1939) and most are the responsibility of one author (D.E.L). It is not claimed that these calculations are perfect, nor necessarily completely accurate (below) but they are consistent and free of unnecessarily subjective influences.

In older versions of this data base only Department of Mines stations were terrain corrected - especially those observed from 1970. Only surveys 6751b and 6850 were fully corrected at initial presentation before this date.

This means that older surveys should be carefully appraised in their published forms (especially 6050, 6250, parts of 6560). Many other surveys have never been released and the severe risk of misinterpretation has been avoided. The need for correction was first established by Longman and Leaman (1971 - 6751a) when extending the Longford Survey (Hinch, 1965 - 6440). Subsequent determinations have shown that the typical Tasmanian terrain correction exceeds 0.5 mgal and in many regions exceeds 1.0 mgal. Most surveys display ranges in this correction between 0.1 and 6 mgal. (Corrections up to 30 mgal have been required). The effect of ignoring this correction is to destroy any semblance of survey reliability and introduce uncertainties well in excess of the RMS error from all other sources.

Manual procedures continue to be used since consistency is desirable and it is not possible to provide corrections of the desired precision digitally. No digital topographic data base yet exists which could be used and it is unreasonable to expect that any such data base would provide sufficient detail for general calculation of the correction within zones A to E or F. As much of the variation between stations occurs in this range, some manual correction would still be essential. Beyond zone H manual correction is relatively straightforward and the gain from computerisation is uncertain.

Apart from arithmetic errors or density conversion errors (from 2.00 to 2.67 t/m^3 for the reduction) most uncertainties relate to the immediate vicinity of the station. Imperfect descriptions are often provided for this area and invalid assumptions may be made for the critical zones A to C. Every effort should be made to ensure a near nil correction within zones A to B by careful siting of the station. Most observers have not considered this (except D.E.L) and problems must persist with many older surveys, although no effort has been spared to validly locate the station and provide a reliable correction.

While there can be no doubt that the present corrections are much better than no corrections at all it is likely that many values are underestimates as near-zone effects may have been minimised. It will also be evident that no two correctors or programmes could provide identical answers in reasonable calculation times as various practical assumptions or judgements are made which are related to the limits of reliance required of the calculation.

Recent calculations (for the MRV project) have revealed other, rather depressing, problems. While most corrections have been derived from map scales of the order of 1:15 840, transfer of templates between detailed maps and 1:50 000 maps often exposes discrepancies in excess of two contour intervals (up to 80 m). Some hills and valleys have been completely omitted. This reflects drafting(?) problems and the extent of the problem is unknown.

ELEVATION

Only those surveys dependent on barometric elevation determinations carry significant errors. These are clearly indicated in Table 1. Unfortunately many of the issues were not recognised by early workers and the error band often quoted was too narrow (see also Leaman, 1984 and Green, 1961). It is also probable that occasional stations lie outside the range quoted. All stations which appeared obviously doubtful have been deleted but future surveys in north-western Tasmania may locate others (especially within Sheffield 6850).

It should be noted that barometric elevations on a regional or semi-regional basis cannot be determined to an accuracy better than 1.25 to 2.5 m without extensive and careful cross ties and procedures, and that even this reliability requires demanding techniques.

TIDE CORRECTION

No individual tide corrections have ever been applied to any data set to the authors' knowledge. Normal practice, since 1960, has been to observe short period loops or cross tie loops and remove tidal effects as part of the drift correction.

REDUCTION

The reduction programme, as devised by R. Green and the BMR, has been described in its evolved form by Richardson (1983).

THE DATA BASE

The compilation (TASGRAV) provides an eight column entry for each station.

Column 1. Station number composed of year plus source code and station number within the survey. e.g. 8651.8080, year = 86, source = 51, station = 8080.

Columns 2 and 3. Geographic co-ordinates, latitude and longitude.

Column 4. Height above mean sea level (Australian height datum) in metres.

Column 5. Observed gravity (cm s^{-2})

Column 6. Theoretical gravity (cm s^{-2})
1930 ellipsoid.

Column 7. Terrain correction for Bouguer density of 2.67 t/m^3.

Column 8. Bouguer anomaly. Reduction at 2.67 t/m^3.

DATA AVAILABILITY

At the time of writing this report (December, 1986) copies of the data base, or updates of existing copies, may be purchased from the Tasmania Department of Mines. Copies of the Tyndall survey data and the Mt Read Volcanics Project data are not currently included in the data base but may be purchased separately from the same source. Details of current costs should be obtained from the Department of Mines before ordering the data.

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[6 February 1987]

Table 1. SURVEYS INCLUDED IN TASGRAV

Code	Area	Observer/reference	Meter	Calibration constant	Survey accuracy (+-) Observed gravity (mgal)	Position (m)	Terrain correction (mgal)	Elevation (m)
6050	Red Hill	McDougall & Stott (1961)			0.03	25	0.05	0.1
6250	Great Lake	Jones et al. (1966)			0.03	30	0.1 max	0.2
6353	NW railway	R. Green			0.02	20	0.03	0.05
6440	Longford	Hinch (1965)	W201	0.0900	0.03	100	0.02	0.1-2.0
6451	South Hobart	D. Leaman	W273	0.0899	0.02	25	0.1	0.1-2.0
6560	Cygnet	Leaman & Naqvi, (1967)	W273	0.0896	0.03	75	0.05	1.0-2.0
6650	East Tasmania	Cameron (1967)			0.05	10	0.05	0.1
6750	West Tasmania	Johnson (1972)			0.05	10-100	0.05	0.1-3.0
6751a	North Tertiary	Longman and Leaman (1971)	W169	0.1010	0.04	50	0.10	1.0-2.0
6751b	Richmond	Leaman (1972b)	W273	0.1008	0.03	50	0.05	1.25
6751c	Kingston	Leaman (1972b)	W169	0.1010	0.02	5	0.05	0.01
6752	North Tertiary	Longman and Leaman (1971)	W723	0.1008	0.04	50	0.10	1.0-2.0
6850	Sheffield	Sheehan (1969)	W273	0.1008	0.04	10-100	0.02-0.4	0.1-5.0
6851	Hobart	Leaman (1972b)	W273	0.1008	0.03	50	0.1	1.5
6950	Apsley	Butters (1970)	W273	0.1008	0.06	100	0.1	3
6951	Gladstone	Leaman (1973a)	W273	0.1008	0.02	15	0.02	0.1
7050	Scottsdale	Symonds (1971)	W273	0.1008	0.05	100	0.05	0.1-3.0
7051a	Kingborough	D. Leaman	W273	0.1008	0.04	50	0.05	1.5
7051b	Tamar	Leaman et al. (1973)	W273	0.1008	0.03	75	0.05	1.5-2.0
7151a	Dunalley	Leaman (1973c)	W273	0.1008	0.02	25	0.01	0.1
7151b	Mt William	D. Leaman	W273	0.1008	0.02	25	0.01	0.1
7151c	N.E. Tasmania	Leaman & Symonds (1975)	W273	0.1008	0.04	75	0.03	2
	Bruny	Clark (1972)	W273	0.1008	0.05	75	0.05-0.02	2.0-3.0
	Port Sorell	Leaman (1973b)	W273	0.1008	0.03	50	0.02	1.5-2.0
	King Island							
	Adventure Bay	Leaman (1975a)	W913	0.094	0.03	25	0.02	0.5
	Port Sorell	Cromer (1977)	W913	0.094	0.04	50	0.02	2.0-2.5
7251	Strahan profile	Leaman (1974c)	W913	0.094				
7251a	Kingston-Taroona	Leaman (1974a)			0.02	25	0.05	0.1
7251b	Pipeclay	Leaman (1974b)	W913	0.094	0.02	25	0.01	0.1
51	Forester	Leaman & Jordan (1973)	W913	0.094	0.04	50	0.02	2
7351a	Rossarden	Leaman (1975b)	W913	0.094	0.02	5	0.1-0.4	0.05
7351b	Moonah	Collins et al. (1977)	W913	0.094	0.04	50	0.05	1
7303	Tasmania BMR	Zadoroznyj (1975)			0.08	150	0.05-1	5-10
75-7650	Oatlands	Ruswandi (1977)	W273	0.1008	0.06	100	0.15	1.5-3.0
7551a	Betsey	D. Leaman	W913	0.094	0.40	50	0.05	1.5
73-7951	East Coast Coal Project	Leaman & Richardson (1981a)	W913	0.094	0.05	75	0.05-0.4	1.5-2.5
80-8151	East Coast Coal Project	Leaman & Richardson (1981a)	W913	0.094	0.03	50	0.05-0.4	1

81-8351	Midlands	R. Richardson	W273	0.1008 }				
			W913	0.094 }				
			S183	0.0998 }	0.05	25	0.01-0.05	1.5
			S308	0.1006 }				
			S308	0.1985 }				
84-8551	Smithton	R. Richardson	S183	0.0998 }				
			W913	0.094 }	0.05	25	0.01-0.05	1.5
7151	Stanley	Cromer (1972)	W913	0.094	0.05	20	0.01-0.15	1.5
7351	Stanley	Baillie and Leaman (1978)	W913	0.094	0.05	5	0.01-0.15	0.05
8150	Zeehan	Amoco	LCR35	1.0465	0.02-0.08	10-50	0.05-0.2	0.05-0.5
			LCR561	1.00926				
			W ?	0.09153				
81-8551	Zeehan	R. Richardson	W169	0.1009 }				
			W273	0.1008 }				
			W913	0.094 }				
			S183	0.0998 }	0.05	25	0.01-0.15	2.5
			S308	0.1006 }				
			S308	0.1006 }				
8251	Priory	CSR	G473	1.00909	0.02	5	0.01-0.05	0.05
	Sorell	R. Richardson	S183	0.0998	0.05	25	0.01-0.05	1.5
			W913	0.094	0.05	25	0.01-0.05	1.5
8351	Strahan	Richardson (1985)	S183	0.0998	0.05	20	0.01-0.05	0.05-1.5
82-8350	Housetop	Shell		0.09977	0.08	100	0.15	1.5-2.5
8150	Elliott bay	Geopeko	W592	0.10206	0.05	20	0.05	0.5-1.5
8151	Jones and Co.	Richardson (1981)	G132	1.0599				
51	Port Sorell	Leaman (1973b)	W913	0.094	0.03	50	0.02	1.5-2.5
8551	Tyndall		S183	0.0998	0.05	20	0.05-0.15	2.0
85-8651	Mt Read Volcanics Project		{ S183	0.0998	0.05	20	0.05-0.15	2.0
			{ W592	0.10392	0.05	35	0.05-0.15	2.5
			{ W913	0.094	0.05	35	0.05-0.15	2.5
8551	Que River	Leaman and	W273	0.1008 }				
		Richardson (1981b)	W913	0.094 }	0.05	5	0.02	0.1
85-8651	Hellyer	Hudspeth and	W913	0.094 }				
		Richardson (1985)	S183	0.0998 }	0.05	5	0.02	0.1
			W592	0.10392 }				