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Petrophysical properties of core samples MRT001–MRT083

Prepared for Mineral Resources Tasmania

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Executive Summary

Mineral Resources Tasmania (MRT) approved a program of petrophysical property measurements in June 2013, with this batch of 83 samples to be measured for density, magnetic susceptibility, P-wave, and (where possible) S-wave velocities. These samples were delivered to Hot Dry Rocks Pty Ltd (HDR) in November 2010 for thermal conductivity measurement, which was undertaken in November 2010. Other properties were measured between 12–25 June 2013. The previously measured thermal conductivity results are included in this report for ease of data referencing.

Thermal conductivity was measured using a steady state divided bar apparatus. Density was measured using Archimedes' Principle. P-wave and S-wave velocity were determined by measuring ultrasonic pulse velocity, and magnetic susceptibility was measured using a commercial magnetic susceptibility meter calibrated for use with core specimens.

Thermal conductivity was measured at a mean temperature of 25°C (± 2°C). P-wave and S-wave velocities were measured at 22°C (± 2°C).

Principal Findings and Considerations

HDR considers the following points to be important:

- Thermal conductivity across all 248 specimens ranged from a low of 1.41 W/mK to a high of 10.19 W/mK.
- Harmonic mean thermal conductivity across all 83 samples ranged from a low of 1.43 ± 0.01 W/mK to a high of 9.35 ± 1.02 W/mK.
- Density across all 245 specimens ranged from a low of 1,964 kg/m^3 to a high of 3,016 kg/m^3.
- Arithmetic mean density across all 83 samples ranged from a low of 1,964 kg/m^3 to a high of 3,010 ± 6 kg/m^3.
- Magnetic susceptibility across all 83 samples ranged from a low of 0 to a high of 8,927 x 10^{-5}, expressed according to the unitless SI convention.

- Axial P-wave velocity across all 83 samples ranged from a low of 1,711 m/s to a high of 7,091 m/s.
- Axial 'first arrival' S-wave velocity across 58 measureable samples ranged from a low of 2,073 m/s to a high of 3,924 m/s.
- Thermal conductivity and seismic wave velocity of rocks are sensitive to temperature. This should be kept in mind when developing models of *in situ* properties.

Author

Anson Antriasian prepared this report. Specimen preparation and measurement was undertaken by Anson Antriasian. Graeme Beardsmore approved the release of the report in its final form.

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1. Introduction

1.1. Thermal Conductivity

Thermal conductivity (λ) is the physical property that controls the rate at which heat energy flows through a material in a given thermal gradient. In the S.I. system of units, it is measured in watts per metre-Kelvin (W/mK). In the Earth, thermal conductivity controls the rate at which temperature increases with depth for a given heat flow. The thermal conductivity distribution within a section of crust must be known in order to calculate crustal heat flow from temperature gradient data, or to predict temperature distribution from a given heat flow.

1.2. Density

Density (ρ) is the mass of a unit volume of material. In the S.I. system of units, it is measured in kilograms per cubic metre (kg/m^3).

1.3. Magnetic Susceptibility

Magnetic susceptibility (X) is a proportionality between the strength of magnetization that a material assumes in response to an applied magnetic field, versus the strength of the applied magnetic field. It is a unitless value according to the SI system.

1.4. P-wave and S-wave velocity

P-wave velocity (v_p) is the speed at which longitudinal pressure, or ‘primary’, waves propagate through a material. These are the first waves to be detected at any distance from the transmission point.

S-wave velocity (v_s) is the speed at which shear, or ‘secondary’, waves propagate through a solid material. S-waves propagate slower than P-waves, and become progressively attenuated as the material becomes fractured or fluid. In the S.I. system of units, v_p and v_s are both expressed in metres per second (m/s).

1.5. Rock Property Measurement Program

Mineral Resources Tasmania (MRT) approved a program of petrophysical property measurements in June 2013, on this batch of 83 samples[1] delivered to HDR in November 2010 from the wells listed in Table 1. Between 12–25 June 2013, HDR measured the density, magnetic susceptibility, P-wave and S-wave velocities of these samples.

1.6. Temperature and Thermal Properties

Thermal conductivity of rocks is sensitive to temperature (e.g. Vosteen and Schellschmidt, 2003[2]). The measurements presented in this report were all made in the range 25–30°C.

Table 1. Well name, age, formation, lithology, foliation angle, coordinates, depth, and sample ID's.

Well	Age	Formation	Lithological description	Foliation angle, with respect to radial axis of core	mE (MGA94)	mN (MGA94)	Depth (ft)	Depth (m)	Delivered sample name	Sample ID (HDR)
Duckbay-1	Proterozoic	Rocky Cape Group	Pale fine sandstone	No strong foliation	346157	5478213		199.1	TC-01	MRT001
Duckbay-1	Proterozoic	Rocky Cape Group	Dark siltstone	60°, cleavage along intermittent foliation	346157	5478213		319.5	TC-02	MRT002
Duckbay-1	Proterozoic	Rocky Cape Group	Dark siltstone	No strong foliation	346157	5478213		484.3	TC-03	MRT003
SMI-2 Smithton	Cambrian	Scopus Formation	Mudstone with 20% fine sandstone	10°, cleavage weakly follows foliation	333728	5480608		117.9	TC-04	MRT004
SMI-2 Smithton	Cambrian	Scopus Formation	Coarse sandstone	No strong foliation	333728	5480608		225.0	TC-05	MRT005
Forest-1	Neoproterozoic	Kanunnah Subgroup	Basalt	No strong foliation	352850	5480294		41.3	TC-06	MRT006
Forest-1	Neoproterozoic	Kanunnah Subgroup	Coarse sandstone	No strong foliation	352850	5480294		364.5	TC-07	MRT007
Forest-1	Neoproterozoic	Kanunnah Subgroup	Mudstone	No strong foliation	352850	5480294		467.1	TC-08	MRT008
Forest-1	Neoproterozoic	Black River Dolomite	Dolostone	No strong foliation	352850	5480294		1034.4	TC-09	MRT009

[1] In this report the word "sample" refers to a raw piece of rock delivered to HDR, while "specimen" refers to part of a sample prepared for rock property measurements. In general, three specimens are prepared from each sample.

[2] **Vosteen, H.-D. and Schellschmidt, R.** (2003). Influence of temperature on thermal conductivity, thermal capacity and thermal diffusivity for different types of rock. *Physics and Chemistry of the Earth*, 28, 499–509.

Table 1. Continued...

Forest-1	Neoproterozoic	Black River Dolomite	Black shale	52°, cleavage along strong foliation	352850	5480294		1039.7	TC-10	MRT010
Forest-1	Neoproterozoic	Black River Dolomite	Dolostone	No strong foliation	352850	5480294		1054.3	TC-11	MRT011
BH2 Macquarie Hbr	Proterozoic	Rocky Cape Group correlate	Phyllite	50°, variable/wavy foliation	358920	5311691		121.6	TC-12	MRT012
BH2 Macquarie Hbr	Proterozoic	Rocky Cape Group correlate	Quartzite	70°, weakly visible foliation	358920	5311691		102.2	TC-13	MRT013
SBDP2	Tertiary	Tertiary basalt	Basalt	No strong foliation	391921	5406191		297.6	TC-14	MRT014
SBDP2	Ordivician	Gordon Group	limestone	No strong foliation	391921	5406191		340.9	TC-15	MRT015
SBDP2	Ordivician	Moina Sandstone	Red gritty sandstone	No strong foliation	391921	5406191		379.0	TC-16	MRT016
SBDP6	Tertiary	Tertiary basalt	Basalt	No strong foliation	392756	5402916		197.2	TC-17	MRT017
SBDP6	Devononian	Bell Shale	Fine quartz sandstone	No strong foliation	392752	5402916		304.4	TC-18	MRT018
SBDP6	Devononian	Bell Shale	Mudstone	45°, weakly visible foliation	392756	5402916		271.5	TC-19	MRT019
SBDP6	Devononian	Bell Shale	Mudstone	35°, cleavage weakly follows foliation	392756	5402916		278.1	TC-20	MRT020
SBDP9	Devononian	Florence Quartzite	Quartz sandstone	No strong foliation	388025	5402089		339.2	TC-21	MRT021
SBDP9	Devononian	Florence Quartzite	Quartz sandstone	No strong foliation	388025	5402089		313.6	TC-22	MRT022
DLR7	Ordivician	Gordon Group	Limestone	No strong foliation	488817	5187738		354.6	TC-23	MRT023
DLR7	Ordivician	Gordon Group	Limestone	No strong foliation	488817	5187738		376.3	TC-24	MRT024
Colesbay1	Devononian	Coles Bay Granite	Granite	No strong foliation	606312	5336783		137.6	TC-25	MRT025
Colesbay1	Devononian	Coles Bay Granite	Granite	No strong foliation	606312	5336783		563.0	TC-26	MRT026
Colesbay1	Devononian	Coles Bay Granite	Granite	No strong foliation	606312	5336783		923.0	TC-27	MRT027
FAL-1	Devononian	St Mary's Porphyry	Porphyry	No strong foliation	603332	5401545		46.4	TC-28	MRT028
King Island Salinity Sutto~	Neoproterozoic	King Island Granite	Coarse granite	No strong foliation	245002	5605341		30.0	TC-29	MRT029
King Island Salinity Payne	Neoproterozoic	King Island Granite	Fine granite	No strong foliation	245059	5598308		14.3	TC-30	MRT030
HEAZ-H1	Cambrian	Ultramafics	Pyroxenite	65°, may not be actual foliation	359312	5408983	598.5	182.4	TC-31	MRT031
HEAZ-H1	Cambrian	Ultramafics	Serpentenite	No strong foliation	359312	5408983	356.0	108.5	TC-32	MRT032

Table 1. Continued...

PD85HF1	Proterozoic	Oonah Formation	Mudstone	28° cleavage along weakly visible foliation	359362	5367583		61.5	TC-33	MRT033
PD85HF1	Proterozoic	Oonah Formation	Mudstone	No strong foliation	359362	5367583		69.0	TC-34	MRT034
PD85HF1	Proterozoic	Oonah Formation	Black shale	65° cleavage along moderate foliation	359362	5367583		99.5	TC-35	MRT035
TYN006	Cambrian	Comstock Tuff	Coarse volcanic sandstone	No strong foliation	381449	5357129		163.8	TC-36	MRT036
TYN006	Cambrian	Mt Reed Volcanics	Andesite	30°, weak bedding planes?	381449	5357129		350.6	TC-37	MRT037
Shittim 1B	Proterozoic	Precambrian	Phyllite	70°, cleavage along strong foliation	534042	5216183		1700.8	TC-38	MRT038
Hunterston-1	Proterozoic	Precambrian	Dolostone	No strong foliation	495612	5326583		1227.8	TC-39	MRT039
Hunterston-1	Proterozoic	Precambrian	Sandstone	Approx. 35°, variable foliation	495612	5326583		1290.9	TC-40	MRT040
BLHY-1 (Black Harry)	Cambrian	Mt Reed Volcanics	Dacite	No strong foliation	390438	5399663		100.7	TC-41	MRT041
BLHY-1 (Black Harry)	Cambrian	Mt Reed Volcanics	Black shale	44°, strong foliation	390438	5399663		181.7	TC-42	MRT042
BLHY-1 (Black Harry)	Cambrian	Mt Reed Volcanics	Sandstone	18°, intermittent foliation	390438	5399663		127.2	TC-43	MRT043
Glenorchy-1	Permian	Woody Island Siltstone	Baked volcanics	No strong foliation	521012	5256383	360.0	109.7	TC-44	MRT044
Glenorchy-1	Cambrian	Mt Reed Volcanics	Andesitic volcanics	28°, variable foliation	521012	5256383	1965.0	598.9	TC-45	MRT045
Granton-1	Permian	Woody Island Siltstone	Mudstone	0°, weakly visible foliation	515726	5266675		298.4	TC-46	MRT046
Woodbridge-1	Permian	Truro Tillite	Phyllite	32°, cleavage along strong foliation	519400	5222751		1008.8	TC-47	MRT047
Woodbridge-1	Cretaceous	Cretaceous	Syenite	No strong foliation	519400	5222751		989.2	TC-48	MRT048
Woodbridge-1	Proterozoic	Precambrian	Tillite	No strong foliation	519400	5222751		20.8	TC-49	MRT049
Rowella-2	Tertiary	Tertiary basalt	Basalt	No strong foliation	492212	5440983		133.2	TC-50	MRT050
CSB1 South Bischoff	Devonian	Wombat Flat Granite	Granite	No strong foliation	371044	5402037		49.6	TC-51	MRT051
RED5 Redwater	Devonian	Dg: Housetop	Granite	No strong foliation	410732	5426283		196.7	TC-52	MRT052
EAF-13	Cambrian	Mount Read Volcanics (NCVC)	Tuff	No strong foliation	377613	5383765		173.7	TC-53	MRT053
EAF-13	Cambrian	Mt Read Volcanics (NCVC)	Breccia, volcanic	No strong foliation	377613	5383765		220.2	TC-54	MRT054

Table 1. Continued...

DR2	Cambrian	Dove Granite	Granite	No strong foliation	427912	5397933		330.0	TC-55	MRT055
DMS-1 Mt Stronach	Devonian	Mt Stonach Granite	Granite	No strong foliation	547197	5443278		28.2	TC-56	MRT056
SP-2 St Pauls	Devonian	Royal George Granite	Granite	No strong foliation	573912	5367683	397.0	121.0	TC-57	MRT057
BLD-1 Bald Hill	Devonian	Mt Paris Granite	Granite	No strong foliation	571912	5435183	393.5	119.9	TC-58	MRT058
BT166 Blue Tier	Devonian	Poimena Granite	Granite	No strong foliation	585125	5438015		194.8	TC-59	MRT059
BT51 Blue Tier	Devonian	Blue Tier Granite	Granite (coarse)	No strong foliation	585070	5435488		78.0	TC-60	MRT060
BT51 Blue Tier	Devonian	Blue Tier Granite	Granite (fine)	No strong foliation	585070	5435488		184.7	TC-61	MRT061
BOOB-3 Boobyalla	Tertiary	Tertiary sediments	Sandstone	No strong foliation	576025	5472382		192.5	TC-62	MRT062
BOOB-3 Boobyalla	Tertiary	Tertiary sediments	Conglomerate	No strong foliation	576025	5472382		249.9	TC-63	MRT063
BOOB-3 Boobyalla	Tertiary	Tertiary sediments	Sandstone, pebbly	No strong foliation	576025	5472382		305.2	TC-64	MRT064
S2 Salisbury Hill	Ordivician	Cabbage Tree Fm	Conglomerate, silicaceous	No strong foliation	486956	5433838	200.0	61.0	TC-65	MRT065
S2 Salisbury Hill	Ordivician	Cabbage Tree Fm	Sandstone, quartzose	No strong foliation	486956	5433838	259.0	78.9	TC-66	MRT066
BEA-A16 Beaconsfield	Cambrian	Cambrian ultramafics	Serpentenite	No strong foliation	471032	5439063	93.5	28.5	TC-67	MRT067
GV1 Golden Valley	Permian	Quamby Mudstone	Mudstone	No strong foliation	475023	5391515	585.2		TC-68	MRT068
RG145 Turnbridge	Permian	Wynyard Tillite	Diamictite	No strong foliation	524622	5335053		868.7	TC-69	MRT069
RG145 Turnbridge	Precambrian	Precambrian undiff	Phyllite	35°, cleavage along undulating foliation	524622	5335053		912.6	TC-70	MRT070
CM1	Precambrian	Precambrian undiff	Slate	55°	505517	5220803		549.1	TC-71	MRT071
Lisle-01 Lisle	Devonian	Lisle Granodiorite	Granodiorite	No strong foliation	528002	5434883		72.2	TC-72	MRT072
WA3	Cambrian	Luina Group	Komatite	No strong foliation	381212	5417883		254.3	TC-73	MRT073
WA3	Cambrian	Luina Group	Breccia, volcanic	No strong foliation	381212	5417883		274.5	TC-74	MRT074
WA5	Precambrian	Oonah Formation	Siltstone	35°, cleavage along foliation	380512	5409783		143.0	TC-75	MRT075
CK1 Copper King Cuprona	Precambrian	Oonah (Burnie) Formation	Phyllite	55°, cleavage along foliation	412602	5446153	270.0	82.3	TC-76	MRT076

Table 1. Continued...

CK1 Copper King Cuprona	Precambrian	Oonah (Burnie) Formation	Sandstone	50°, weakly visible foliation	412602	5446153	294.0	89.6	TC-77	MRT077
Storeys-1 Storeys Creek	Devonian	Henbury Granite	Granite	No strong foliation	560362	538233	87.0	26.5	TC-78	MRT078
Shittim 1B	Precambrian	Precambrian undiff	Phyllite	70°, cleavage along foliation	534042	5216183		1706.3	TC-79	MRT079
Shittim 1B	Precambrian	Precambrian undiff	Phyllite	80°, cleavage along undulating foliation	534042	5216183		1739.6	TC-80	MRT080
LF4 Lefroy	Ordivician	Stony Head Sandstone	Sandstone	40°, cleavage along foliation	499865	5448257		163.0	TC-81	MRT081
LF4 Lefroy	Ordivician	Stony Head Sandstone	Phyllite	40°, cleavage along foliation	499865	5448257		172.5	TC-82	MRT082
FED-25 Federation	Devonian	Heemskirk Granite	Granite	No strong foliation	351983	5358938		144.0	TC-83	MRT083

2. Methodology

2.1. Specimen Preparation

HDR applied two different preparation methods to measure the petrophysical properties of the 83 samples, MRT001–MRT083, depending on sample quality and quantity. These methods are referred to in this report as ‘whole rock’ and ‘CME’ (Compensated Membrane Encapsulation).

2.1.1. ‘Whole Rock’ measurements

HDR prepared ‘Whole Rock’ specimens from most samples. In these cases, HDR prepared each specimen as a prism approximately ⅓ to ½ its diameter in thickness. Each prism was ground flat and polished on its ends to a standardized flatness and grit.

2.1.2. ‘CME’ measurements

‘Compensated Membrane Encapsulation’ specimens were prepared from samples MRT062 and MRT064. These samples were relatively unconsolidated, showing significant susceptibility to deterioration during water saturation. Specimens were encapsulated within a thin polymer membrane to confine the sample during vacuum saturation.

2.1.3. Vacuum Saturation

HDR evacuated all specimens under >95% vacuum for a minimum of three hours. Specimens were then submerged in water prior to returning to atmospheric pressure. Saturation continued at atmospheric pressure for a minimum of sixteen hours, and all specimens were left submerged in water until just prior to measurement.

2.2. Thermal Conductivity Measurement

Each of the 83 core specimens provided by MRT was measured for thermal conductivity (λ) using a divided bar apparatus (Figure 1). A divided bar apparatus is an instrument that places an unknown specimen in series with a standard of known thermal conductivity, then imposes a constant thermal gradient across the combination in order to derive the conductivity of the unknown specimen.

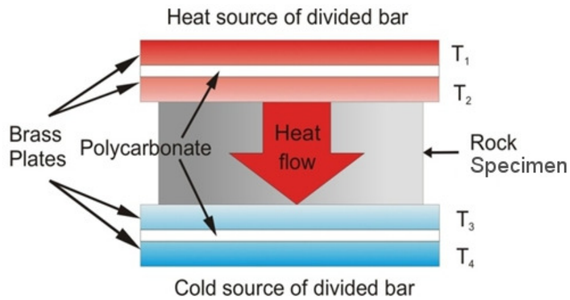


Figure 1. Schematic of a divided bar assembly showing rock specimen and brass plates with embedded temperature sensors.

Thermal conductivity was measured along the long axis of each core sample at a mean temperature of 25℃ (±2℃).

Uncertainty of thermal conductivity measurements of ‘whole rock’ specimens is approximately ±2% (based on instrument precision of the divided bar apparatus and calibration uncertainty). As thermal conductivity was measured at an earlier time than the rest of the measurements reported in this document, the thermal conductivity of specimens identified as ‘CME’ in this report was measured using a ‘hollow cell’ technique. Please refer to the reports on that earlier work (dated 22 Nov 2010 for MRT000–MRT050, and 17 Feb 2011 for MRT051–MRT083) for detailed explanation of the technique. Uncertainty of those measurements is approximately ±7%.

2.3. Density Measurement

Density (ρ) measurements were made in all cases at ambient atmospheric temperature and pressure, after vacuum-saturation as described in Section 2.1.3. Density was calculated for both ‘Whole Rock’ and ‘CME’ specimens. Density was determined according to the relationship:

$\rho = M_{ss}/V_b$

Where

V_b = bulk volume

M_{ss} = mass of saturated sample

For all specimens, V_b was determined by the application of Archimedes' Principle using a water bath corrected for change in fluid density due to temperature.

For density measurements of saturated consolidated samples ('whole rock'), the reported values have an estimated overall k=2 uncertainty of <±0.1%.

2.4. Magnetic Susceptibility Measurement

HDR measured magnetic susceptibility using a 'magROCK' magnetic susceptibility meter by Alpha Geoscience, calibrated for the measurement of core specimens with a resolution of $1x10^{-5}$ SI units and a range of $1x10^{-5}$ – 1 SI units. Measurements were made on whole core samples (not individual specimens) at an ambient temperature of 22℃ (±2℃). All samples were vacuum saturated before measurement.

2.5. P and S-Wave Velocity Measurement

P-wave velocity (v_p) and S-wave velocity (v_s) were determined by measuring the velocity of ultrasonic (250 kHz frequency) pulses through each specimen. Biaxial or triaxial measurements were made on core samples showing foliation, oriented with respect to the dominant foliation (if foliation exists) as shown in Table 3. Several non-foliated samples were measured radially due to limited sample quantity.

Anisotropic specimens are susceptible to 'S-wave splitting', in which the transmitted S-wave splits into two waves with orthogonal directions of vibration during travel through the core. Each S-wave has its own specific velocity. Only the velocities of the 'fastest' S-waves are given in this report.

3. Results

Table presents the measured thermal conductivity and density for each individual specimen, the harmonic mean and uncertainty of thermal conductivity for each sample (Figure 2), the arithmetic mean density and uncertainty for each sample, and the magnetic susceptibility for each sample.

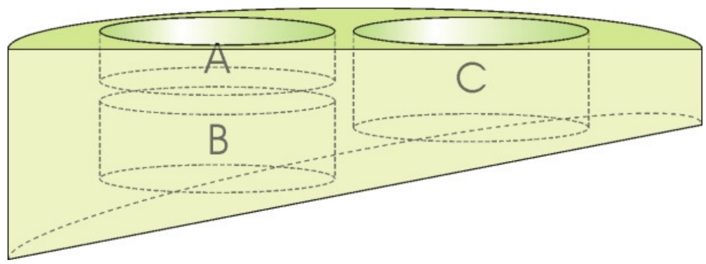


Figure 2. The average thermal conductivity or diffusivity of specimens in series (e.g. A and B) is found using the harmonic mean. The average conductivity or diffusivity of specimens in parallel (e.g. A and C) is found using the arithmetic mean.

Table 3 presents the P-wave and 'first arrival' S-wave velocities of each measured sample. Where a foliation was observed, biaxial or triaxial measurements were attempted. Diagrams at the top of Table 3 clarify the measurement direction with respect to the dominant foliation orientation, if any. S-wave velocity could not be resolved for samples too small, irregular or otherwise incapable of transmitting a detectible ultrasonic shear pulse.

Table 2. Well name, depth, sample name, HDR specimen ID, thermal conductivity, density and magnetic susceptibility for each specimen and sample, with mean and standard deviation values where applicable.

Well	Depth (ft)	Depth (m)	Delivered sample name	Specimen ID (HDR)		Thermal conductivity (W/mK), harmonic mean, standard deviation				Density (kg/m³), arithmetic mean, standard deviation				Magnetic susceptibility (unitless, x 10^{-5} SI)
Duckbay-1		199.10	TC-01	MRT001	A	3.99	3.86	±	0.11	2564	2545	±	19	15
					B	3.82				2525				
					C	3.77				2545				
Duckbay-1		319.50	TC-02	MRT002	A	3.44	3.42	±	0.06	2717	2714	±	7	14
					B	3.47				2719				
					C	3.36				2706				
Duckbay-1		484.30	TC-03	MRT003	A	4.27	4.17	±	0.09	2710	2708	±	4	9
					B	4.11				2710				
					C	4.13				2704				
SMI-2 Smithton		117.90	TC-04	MRT004	A	2.76	2.76	±	0.13	2750	2750	±	1	21
					B	2.63				2751				
					C	2.89				2749				
SMI-2 Smithton		225.00	TC-05	MRT005	A	5.75	5.63	±	0.11	2672	2675	±	2	0
					B	5.63				2676				
					C	5.52				2676				
Forest-1		41.30	TC-06	MRT006	A	2.35	2.35	±	0.01	3016	3010	±	6	8927
					B	2.35				3010				
					C	2.37				3004				
Forest-1		364.50	TC-07	MRT007	A	2.58	2.66	±	0.07	2948	2948	±	1	1290
					B	2.71				2949				
					C	2.69				2947				
Forest-1		467.10	TC-08	MRT008	A	2.67	2.55	±	0.10	2898	2868	±	28	3955
					B	2.49				2865				
					C	2.50				2842				
Forest-1		1034.40	TC-09	MRT009	A	4.64	4.73	±	0.12	2840	2843	±	3	0
					B	4.86				2845				
					C	4.70				2844				
Forest-1		1039.70	TC-10	MRT010	A	3.26	3.22	±	0.07	2762	2753	±	8	0
					B	3.26				2746				
					C	3.14				2751				
Forest-1		1054.30	TC-11	MRT011	A	5.12	5.08	±	0.04	2836	2838	±	3	0
					B	5.06				2842				
					C	5.05				2837				
BH2 Macquarie Hbr		121.60	TC-12	MRT012	A	8.27	9.35	±	1.02	2891	2934	±	37	0
					B	10.19				2955				
					C	9.83				2954				
BH2 Macquarie Hbr		102.20	TC-13	MRT013	A	6.45	6.54	±	0.13	2723	2736	±	11	0
					B	6.68				2743				
					C	6.48				2741				
SBDP2		297.60	TC-14	MRT014	A	1.55	1.55	±	0.00	2649	2650	±	2	1345
					B	1.55				2648				
					C	1.55				2651				
SBDP2		340.90	TC-15	MRT015	A	3.02	3.02	±	0.06	2713	2714	±	0	16
					B	2.96				2714				
					C	3.08				2714				
SBDP2		379.00	TC-16	MRT016	A	3.88	3.69	±	0.17	2721	2726	±	5	0
					B	3.63				2728				
					C	3.57				2730				
SBDP6		197.20	TC-17	MRT017	A	1.70	1.71	±	0.01	2830	2820	±	21	140
					B	1.72				2833				
					C	1.70				2796				
SBDP6		304.40	TC-18	MRT018	A	5.25	5.17	±	0.08	2519	2493	±	23	0
					B	5.09				2480				
					C	5.18				2479				
SBDP6		271.50	TC-19	MRT019	A	2.96	2.89	±	0.07	2543	2561	±	16	0
					B	2.84				2565				
					C	2.86				2575				
SBDP6		278.10	TC-20	MRT020	A	2.55	2.58	±	0.03	2614	2628	±	18	9
					B	2.61				2622				
					C	2.57				2648				

Table 2. Continued...

					A	5.85				2573				
SBDP9		339.20	TC-21	MRT021	B	5.80	5.85	±	0.06	2581	2581	±	9	0
					C	5.91				2590				
					A	6.06				2558				
SBDP9		313.60	TC-22	MRT022	B	6.11	6.08	±	0.02	2568	2563	±	5	0
					C	6.08				2563				
					A	3.14				2711				
DLR7		354.60	TC-23	MRT023	B	3.09	3.12	±	0.03	2711	2711	±	0	9
					C	3.14				2711				
					A	3.23				2701				
DLR7		376.30	TC-24	MRT024	B	3.26	3.24	±	0.02	2678	2693	±	13	0
					C	3.23				2700				
					A	3.78				2613				
Colesbay1		137.60	TC-25	MRT025	B	3.81	3.72	±	0.12	2618	2612	±	7	0
					C	3.58				2605				
					A	3.70				2628				
Colesbay1		563.00	TC-26	MRT026	B	3.85	3.79	±	0.08	2628	2629	±	2	5
					C	3.82				2632				
					A	3.81				2639				
Colesbay1		923.00	TC-27	MRT027	B	3.74	3.72	±	0.09	2621	2631	±	9	9
					C	3.62				2635				
					A	2.96				2722				
FAL-1		46.40	TC-28	MRT028	B	2.93	2.94	±	0.02	2723	2720	±	3	36
					C	2.91				2717				
					A	3.72				2657				
King Island Salinity Sutto~		30.00	TC-29	MRT029	B	3.89	3.74	±	0.14	2660	2656	±	4	22
					C	3.61				2652				
					A	3.15				2634				
King Island Salinity Payne		14.30	TC-30	MRT030	B	3.24	3.19	±	0.05	2644	2641	±	6	26
					C	3.19				2645				
					A	3.65				3015				
HEAZ-H1	598.50	182.42	TC-31	MRT031	B	2.94	3.03	±	0.51	2854	2839	±	183	48
					C	2.65				2649				
					A	2.46				2764				
HEAZ-H1	356.00	108.51	TC-32	MRT032	B	2.44	2.48	±	0.05	2763	2782	±	33	2496
					C	2.54				2820				
					A	1.80				2750				
PD85HF1		61.50	TC-33	MRT033	B	2.18	2.17	±	0.46	2778	2757	±	18	0
					C	2.73				2744				
					A	2.11				2724				
PD85HF1		69.00	TC-34	MRT034	B	2.11	2.12	±	0.01	2719	2721	±	3	5
					C	2.13				2722				
					A	3.05				2674				
PD85HF1		99.50	TC-35	MRT035	B	3.04	3.07	±	0.03	2680	2675	±	5	5
					C	3.10				2671				
					A	2.88				2745				
TYN006		163.80	TC-36	MRT036	B	2.89	2.89	±	0.02	2758	2748	±	9	7872
					C	2.91				2740				
					A	2.91				2830				
TYN006		350.60	TC-37	MRT037	B	2.90	2.91	±	0.01	2840	2836	±	6	44
					C	2.93				2839				
					A	3.75				2759				
Shittim 1B		1700.80	TC-38	MRT038	B	4.01	4.01	±	0.28	2762	2759	±	3	17
					C	4.32				2756				
					A	4.90				2846				
Hunterston-1		1227.80	TC-39	MRT039	B	4.81	4.89	±	0.07	2846	2844	±	3	0
					C	4.96				2841				
					A	3.18				2749				
Hunterston-1		1290.90	TC-40	MRT040	B	3.37	3.24	±	0.12	2743	2747	±	4	23
					C	3.16				2751				
					A	4.16				2700				
BLHY-1 (Black Harry)		100.70	TC-41	MRT041	B	4.30	4.22	±	0.07	2703	2705	±	6	9
					C	4.21				2712				
					A	3.59				2737				
BLHY-1 (Black Harry)		181.70	TC-42	MRT042	B	2.80	3.28	±	0.46	2720	2726	±	10	5
					C	3.60				2720				

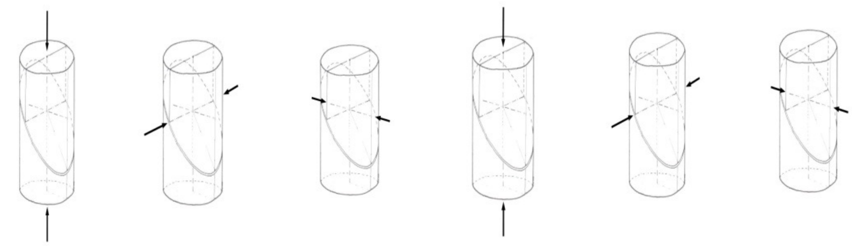
Table 2. Continued...

BLHY-1 (Black Harry)		127.20	TC-43	MRT043	A	3.21	3.00	±	0.18	2756	2757	±	15	20
					B	2.93				2772				
					C	2.88				2742				
Glenorchy-1	360.00	109.73	TC-44	MRT044	A	2.82	2.85	±	0.04	2616	2618	±	5	10
					B	2.84				2624				
					C	2.89				2614				
Glenorchy-1	1965.00	598.93	TC-45	MRT045	A	2.07	2.21	±	0.16	2919	2908	±	10	35
					B	2.19				2899				
					C	2.40				2907				
Granton-1		298.40	TC-46	MRT046	A	2.80	2.77	±	0.17	2686	2687	±	3	90
					B	2.60				2690				
					C	2.93				2685				
Woodbridge-1		1008.80	TC-47	MRT047	A	2.02	1.98	±	0.09	2779	2786	±	6	10
					B	2.05				2791				
					C	1.89				2788				
Woodbridge-1		989.20	TC-48	MRT048	A	2.28	2.27	±	0.03	2657	2653	±	5	426
					B	2.24				2654				
					C	2.28				2648				
Woodbridge-1		20.80	TC-49	MRT049	A	2.52	2.52	±	0.01	2675	2674	±	1	24
					B	2.54				2675				
					C	2.51				2672				
Rowella-2		133.20	TC-50	MRT050	A	1.95	1.92	±	0.02	2898	2898	±	1	907
					B	1.90				2898				
					C	1.93				2897				
CSB1 South Bischoff		49.6	TC-51	MRT051	A	3.26	3.34	±	0.07	2664	2687	±	38	11
					B	3.35				2732				
					C	3.39				2666				
RED5 Redwater		196.7	TC-52	MRT052	A	3.27	3.32	±	0.05	2603	2599	±	3	0
					B	3.33				2598				
					C	3.37				2597				
EAF-13		173.7	TC-53	MRT053	A	3.49	3.48	±	0.03	2754	2748	±	5	20
					B	3.49				2744				
					C	3.45				2745				
EAF-13		220.2	TC-54	MRT054	A	3.86	3.64	±	0.23	2707	2706	±	1	14
					B	3.41				2707				
					C	3.66				2705				
DR2		330.0	TC-55	MRT055	A	3.79	3.85	±	0.05	2650	2663	±	15	5
					B	3.87				2659				
					C	3.88				2680				
DMS-1 Mt Stronach		28.2	TC-56	MRT056	A	3.50	3.50	±	0.01	2604	2602	±	1	0
					B	3.51				2603				
					C	3.49				2601				
SP-2 St Pauls	397.0	121.0	TC-57	MRT057	A	3.52	3.38	±	0.13	2578	2566	±	11	0
					B	3.33				2558				
					C	3.29				2563				
BLD-1 Bald Hill	393.5	119.9	TC-58	MRT058	A	3.32	3.39	±	0.07	2598	2606	±	8	0
					B	3.47				2614				
					C	3.38				2608				
BT166 Blue Tier		194.8	TC-59	MRT059	A	3.36	3.32	±	0.10	2661	2656	±	9	0
					B	3.39				2662				
					C	3.21				2646				
BT51 Blue Tier		78.0	TC-60	MRT060	A	3.23	3.28	±	0.12	2633	2631	±	2	0
					B	3.19								
					C	3.42				2630				
					D					2630				
BT51 Blue Tier		184.7	TC-61	MRT061	A	3.54	3.55	±	0.09	2636	2635	±	3	0
					B	3.65				2637				
					C	3.47				2632				
BOOB-3 Boobyalla		192.5	TC-62	MRT062	A	1.98	1.97	±	0.02		2052	±	0	5
					B	1.98								
					C	1.95								
					D					2052				
BOOB-3 Boobyalla		249.9	TC-63	MRT063	A	1.48	1.62	±	0.18	2270	2261	±	27	258
					B	1.59				2231				
					C	1.83				2282				

Table 2. Continued...

BOOB-3 Boobyalla		305.2	TC-64	MRT064	A	1.42	1.43	±	0.01		1964	±	0	2224
					B	1.44								
					C	1.41								
					D					1964				
S2 Salisbury Hill	200.0	61.0	TC-65	MRT065	A	6.18	6.17	±	0.07	2501	2519	±	17	0
					B	6.09				2521				
					C	6.23				2536				
S2 Salisbury Hill	259.0	78.9	TC-66	MRT066	A	6.99	7.02	±	0.04	2637	2637	±	1	0
					B	7.06				2636				
					C	7.02				2638				
BEA-A16 Beaconsfield	93.5	28.5	TC-67	MRT067	A	2.61	2.60	±	0.02	2564	2576	±	15	7512
					B	2.61				2570				
					C	2.58				2593				
GV1 Golden Valley	585.2		TC-68	MRT068	A	1.92	1.96	±	0.06	2613	2614	±	2	5
					B	1.95				2616				
					C	2.03				2613				
RG145 Turnbridge		868.7	TC-69	MRT069	A	3.61	3.43	±	0.15	2707	2709	±	2	23
					B	3.35				2707				
					C	3.34				2711				
RG145 Turnbridge		912.6	TC-70	MRT070	A	3.50	3.66	±	0.44	2662	2663	±	1	5
					B	4.20				2664				
					C	3.39				2664				
CM1		549.1	TC-71	MRT071	A	2.93	2.84	±	0.13	2774	2752	±	21	59
					B	2.70				2748				
					C	2.91				2732				
Lisle-01 Lisle		72.2	TC-72	MRT072	A	2.83	2.86	±	0.04	2721	2721	±	4	1947
					B	2.91				2718				
					D	2.85				2725				
WA3		254.3	TC-73	MRT073	A	1.76	1.79	±	0.03	2710	2703	±	11	48
					B	1.83				2690				
					C	1.79								
					D					2709				
WA3		274.5	TC-74	MRT074	A	1.91	1.94	±	0.05	2670	2677	±	9	37
					B	1.99				2676				
					C	1.92				2687				
WA5		143.0	TC-75	MRT075	A	3.59	3.53	±	0.08	2691	2687	±	5	5
					B	3.56				2681				
					C	3.43				2689				
CK1 Copper King Cuprona	270.0	82.3	TC-76	MRT076	A	2.65	2.67	±	0.04	2734	2731	±	7	0
					B	2.70				2723				
					D					2736				
CK1 Copper King Cuprona	294.0	89.6	TC-77	MRT077	A	5.55	5.55	±	0.04	2689	2692	±	4	0
					B	5.51				2690				
					C	5.58				2696				
Storeys-1 Storeys Creek	87.0	26.5	TC-78	MRT078	A	3.25	3.26	±	0.10	2610	2608	±	14	0
					B	3.18				2593				
					C	3.37				2621				
Shittim 1B		1706.3	TC-79	MRT079	A	4.16	4.18	±	0.08	2759	2757	±	2	21
					B	4.27				2757				
					C	4.12				2754				
Shittim 1B		1739.6	TC-80	MRT080	A	4.42	4.44	±	0.09	2757	2757	±	1	23
					B	4.36				2758				
					C	4.54				2756				
LF4 Lefroy		163.0	TC-81	MRT081	A	4.34	3.99	±	0.31	2687	2694	±	8	9
					B	3.74				2702				
					C	3.93				2692				
LF4 Lefroy		172.5	TC-82	MRT082	A	1.69	1.61	±	0.08	2868	2857	±	17	0
					B	1.61				2837				
					C	1.52				2868				
FED-25 Federation		144.0	TC-83	MRT083	A	3.43	3.13	±	0.26	2640	2636	±	9	11
					B	3.05				2642				
					C	2.95				2625				

Table 3. P-wave and 'first arrival' S-wave velocity for each sample. Direction of velocity measurements are indicated by arrows on the diagrams in the first row. Several non-foliated samples were measured radially due to limited sample quantity.



Sample ID	P-wave velocity, axial (m/s)	P-wave velocity, radial, along foliation strike (m/s)	P-wave velocity, radial, perpendicular to foliation strike (m/s)	'first arrival' S-wave velocity, axial (m/s)	'first arrival' S-wave velocity, radial, along foliation strike (m/s)	'first arrival' S-wave velocity, radial, perpendicular to foliation strike (m/s)
MRT001	5214			2886		
MRT002	4913			2804		
MRT003	5763			3301		
MRT004	4935			3280		
MRT005	5705			3511		
MRT006	6147			3206		
MRT007	5911			3517		
MRT008	5983	6011	6011	3033	3417	
MRT009	6914			3920		
MRT010	4044					
MRT011	6938			3924		
MRT012	6823			3659		
MRT013	6063	5719	5631	3880	3894	3853
MRT014	4861			2548		
MRT015	6349			3541		
MRT016	5199			2990		
MRT017	5884			3655		
MRT018	4799			2835		
MRT019		3557				
MRT020	4275	4367	4367	2506		
MRT021	5461			3203		
MRT022	5134			2950		
MRT023	6413			3022		
MRT024	6260			3000		
MRT025	5628			3370		
MRT026	5788			3843		
MRT027	5226			3308		
MRT028	6058			3887		
MRT029	5751			3185		
MRT030	5487			2790		
MRT031	6762			3763		
MRT032	6192			3134		
MRT033		5306			3279	
MRT034		4789			2444	
MRT035		4317				
MRT036	5752					
MRT037	6355			3834		
MRT038	5663					
MRT039	7091			3300		
MRT040	5523			3180		

Table 3. Continued...

MRT041	5141			2955		
MRT042	4770	4968	4490	3162		
MRT043	5220	5640	5324	2854		
MRT044	4436	4905		2945		
MRT045	6175			3675		
MRT046	4757			2732		
MRT047		6048	5430			
MRT048	5832			3250		
MRT049	3965			2108		
MRT050	6181			3286		
MRT051	5950			3532		
MRT052	6016			3674		
MRT053	4986			2517		
MRT054	5766			3369		
MRT055	6013			3735		
MRT056	5744			3554		
MRT057	5185			3153		
MRT058	5094			2946		
MRT059	5703			3533		
MRT060	5516					
MRT061	5648					
MRT062	1764					
MRT063	2735					
MRT064	1711					
MRT065	4930					
MRT066	5672					
MRT067	5049					
MRT068	3579					
MRT069	5121					
MRT070	4209					
MRT071	5040					
MRT072	5994					
MRT073	3833					
MRT074	3810					
MRT075		5027				
MRT076		6147	3182			
MRT077	5378			2808		
MRT078	5631			3397		
MRT079	5970	6129	4886	3135	3477	2289
MRT080	6283	6114	4874	3623	3435	2073
MRT081		5346	5121			
MRT082		6485	5332			
MRT083	6121			3391		

4. Considerations

The following points must be considered if extrapolating the results in this report to *in situ* formations:

- The samples upon which the measurements were made are only several square centimetres in surface area. While the samples were presumably chosen to represent the geological sections from which they came, there is no guarantee that the sections themselves are typical of the overall geological formations. This is especially true for heterogeneous or anisotropic formations. This introduces an unquantifiable random error into the results.
- Porosity exerts a primary influence on the petrophysical properties of a rock. For example, water is substantially less thermally conductive than typical mineral grains[3], and water saturated pores act to reduce the bulk thermal conductivity of the rock. Gas-filled pores reduce the bulk conductivity even more dramatically. Results reported in this document are whole-rock measurements. No adjustments were made for porosity. It is to be expected that the properties of a given formation may vary from place to place if the porosity of the formation varies (for example, thermal conductivity typically decreases with increasing porosity).
- Thermal conductivity and sonic velocity of rocks are sensitive to temperature. This should be kept in mind when developing models of *in situ* properties.

[3] **Beardsmore, G.R. and Cull, J.P.** (2001). *Crustal heat flow: A guide to measurement and modelling.* Cambridge University Press, Cambridge. 324pp.

Addendum

(from A. Antriasian e-mail 11/9/13)

Regarding the density apparatus, the technique implements Archimedes' principle; the weight of a rock sample in air is recorded, then the weight of the rock sample submerged in water (being suspended from the analytical scale under-hook) is recorded. The temperature of that water bath is noted and the actual density of water is calculated to determine the volume displaced by the rock sample, which together with the weight in air, is used to calculate density.

Regarding sound velocity measurement practices, the apparatus used was a a "Pundit Lab+" unit, manufactured by Proceq. The apparatus consisted of a sound pulse emitting transducer, a sound sensing transducer, and a control unit that allowed the delay time between pulse emitting and sensing to be measured. The associated uncertainties are presented with an uncertainty factor of k=1. These values are based on the propagation of uncertainties in measurements associated with calculating velocity.