Acknowledgements

Michael Roach, my supervisor and chief guru for your assistance, expertise and support (even if you did reckon the funny bits in the seismic were basalt!). Thanks especially for scraping together the funds for the project after the grant application got rejected. I hope you enjoyed your holiday, you certainly deserved it.

James Reid - stand-in guru and all-around good guy - for your help and good humour, particularly in Michael’s absence. Thanks also for your lessons in the dark art – fortran 77.

Alan Jordan and Miles Lawler from the Tasmanian Aquaculture and Fisheries Institute, without whom this project could not have proceeded. Alan for providing ‘mates rates’ for the vessels and Miles for piloting them back and forth, back and forth, back and forth....thank you both.

David Mitchell from the University of Sydney, for his willingness to come to Hobart in the colder months (straight from the North West Shelf!) to conduct our seismic survey. His good humour and patience with my clumsiness (“Please don’t stand on the eel, Dave!”) certainly made the seismic survey a more pleasant experience than it might otherwise have been.

Pat Quilty for his willingness to help whenever required (particularly in terms of my literature review). Thanks also to Peter Harris, for looking at my seismic data early in the year and allowing me to use his carbonate distribution map in my thesis.

Mineral Resources Tasmania for their support both personally (through a State Government Mining Scholarship) and for their support of the project. Thanks particularly to the staff who attended and gave input at the mid-year thinktank, aka ‘Roachy’s presentation’ (“Hi Roachy, we’ve come for your presentation”). Thanks also to Dr. David Leaman for his attendance and input at ‘Roachy’s presentation’, and for other valuable discussions throughout the year.

The library staff at the SciTech and Morris Miller libraries here at Uni, the Mineral Resources Tasmania library at Rosny, and the CSIRO Marine library at Salamanca.

Cheers to my fellow honours students and any staff member or undergrad that said anything nice about me or helped me during the year. Special thanks to those who offered to review my chapters in the absence of Michael and James during the latter part of the year – Ben Jones, Luisa D’Andrea, Nolene Dorn, Geoff Peters and my brother Geoff Gibbons. Perhaps I should have taken up the offers! Special thanks also to Jodie Cutler and her friend George for their help with my fieldwork.

Thanks,
Dave.
# Table of Contents

ABSTRACT I

ACKNOWLEDGEMENTS II

LIST OF FIGURES V

LIST OF TABLES VIII

CHAPTER 1  INTRODUCTION 1
    THE DERWENT RIVER 1
    AIMS 4
    TECHNIQUES (FOR MARINE SURVEYS) 5
        POTENTIAL FIELD METHODS 5
        ELECTRICAL AND E/M 5
        SEISMIC 6
        SONAR 6

CHAPTER 2  GEOLOGY 8
    INTRODUCTION 8
    PREVIOUS WORK 8
    PREVIOUS GEOPHYSICAL SURVEYS 9
    GEOLOGY OF THE HOBART AREA 12
        STRATIGRAPHY 14
            LOWER PARMEEENER SUPER-GROUP 14
            UPPER PARMEEENER SUPER-GROUP 14
            TERTIARY 18
            QUATERNARY 20
        IGNEOUS ROCKS 22
            JURASSIC DOLERITE 22
            TERTIARY BASALT 24
        STRUCTURE AND STRUCTURAL HISTORY 26
        PETROPHYSICAL PROPERTIES 26
            MAGNETIC PROPERTIES 27
            ACOUSTIC PROPERTIES 28

CHAPTER 3  MAGNETIC SURVEY 30
    FIELD WORK 30
    SPACE WEATHER 33
    DATA PROCESSING 35
    HEADING TEST 43

CHAPTER 4  MAGNETIC MODELING 50
    INTRODUCTION 50
    SENSITIVITY TESTING 51
    MODELING 57

CHAPTER 5  SEISMIC SURVEY 71
    SEISMIC TERMS 72
    ACOUSTIC TURBIDITY 77
    THE BASALT THEORY 77
    DISPROVING THE BASALT THEORY 79
    THE EVIDENCE FOR SHALLOW GAS 79
        ACOUSTIC TURBIDITY 82
        ENHANCED REFLECTIONS 82
        ACOUSTIC BLANKING 83
        PHASE REVERSALS 83
        GAS SEEPS 85
        VELOCITY PULLDOWN 85
        INDIRECT EVIDENCE 85
### List of Figures

<table>
<thead>
<tr>
<th>Figure Number</th>
<th>Title/Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Overview map of study area (in the context of Tasmania)</td>
<td>2</td>
</tr>
<tr>
<td>1.2</td>
<td>Detailed map of study area</td>
<td>3</td>
</tr>
<tr>
<td>2.1</td>
<td>Traverse map and contours of the vertical component of magnetic intensity for the southern portion of a magnetic survey conducted in the Derwent Estuary in 1974/1975. Reproduced from Leaman (1975b).</td>
<td>10</td>
</tr>
<tr>
<td>2.2</td>
<td>Geological cross section from the Bowen Bridge alignment. Modified from Colhoun and Moon (1984)</td>
<td>12</td>
</tr>
<tr>
<td>2.3</td>
<td>Simplified geological map of the Hobart area</td>
<td>13</td>
</tr>
<tr>
<td>2.4</td>
<td>A photo of an exposure of Lower Parmeener Super-Group rocks at Opossum Bay (sparsely fossiliferous marine siltstone)</td>
<td>14</td>
</tr>
<tr>
<td>2.5</td>
<td>A map of the distribution of Lower Parmeener Super-Group rocks in the Hobart area</td>
<td>15</td>
</tr>
<tr>
<td>2.6</td>
<td>A photo of an exposure of Upper Parmeener Super-Group rocks at Second Bluff, Bellerive (current bedded sandstone)</td>
<td>16</td>
</tr>
<tr>
<td>2.7</td>
<td>A map of the distribution of Upper Parmeener Super-Group rocks in the Hobart area</td>
<td>17</td>
</tr>
<tr>
<td>2.8</td>
<td>A photo of Tertiary boulder beds exposed on the foreshore at Taroona</td>
<td>18</td>
</tr>
<tr>
<td>2.9</td>
<td>A map of the distribution of Tertiary sediments and sedimentary rocks in the Hobart area</td>
<td>19</td>
</tr>
<tr>
<td>2.10</td>
<td>A photo of Pleistocene marine sediments exposed at Arm End, South Arm</td>
<td>20</td>
</tr>
<tr>
<td>2.11</td>
<td>A map of the distribution of Quaternary sediments in the Hobart area</td>
<td>21</td>
</tr>
<tr>
<td>2.12</td>
<td>A photo of a thermal contact between a dolerite sill and Lower Parmeener Super-Group rocks near Blackmans Bay</td>
<td>22</td>
</tr>
<tr>
<td>2.13</td>
<td>A map of the distribution of Jurassic Dolerite in the Hobart area</td>
<td>23</td>
</tr>
<tr>
<td>2.14</td>
<td>A photo of a Tertiary basalt lava flow overlying a tuffaceous deposit exposed at Sandy Bay</td>
<td>24</td>
</tr>
<tr>
<td>2.15</td>
<td>A map of the distribution of Cenozoic volcanic rocks (i.e. Tertiary basalts) in the Hobart area</td>
<td>25</td>
</tr>
<tr>
<td>3.1.1</td>
<td>Photo of the FMV Nubeena, a TAFI research vessel. Taken near Electrona in North West Bay</td>
<td>30</td>
</tr>
<tr>
<td>3.1.2</td>
<td>Photo of the FMV Poolta, a TAFI research vessel. Taken near Electrona in North West Bay</td>
<td>31</td>
</tr>
<tr>
<td>3.2</td>
<td>A map of magnetic survey lines for 2000 and 2001 used for gridding (i.e. not all of the survey lines – some were removed prior to gridding. See also figure 3.9)</td>
<td>32</td>
</tr>
<tr>
<td>3.3</td>
<td>Chart of variation in horizontal magnetic intensity measured by the Hobart IPS gradiometer for 4 days in March 2001, demonstrating the magnetic effects of a magnetic storm</td>
<td>34</td>
</tr>
<tr>
<td>3.5</td>
<td>Chart of the G856 base station record for day 2 of the magnetic survey, 2001 (i.e. 21st of March 2001)</td>
<td>35</td>
</tr>
<tr>
<td>3.6</td>
<td>Profile of magnetic intensity on line 5400 from the 2001 magnetic survey, showing drop outs</td>
<td>36</td>
</tr>
<tr>
<td>3.7</td>
<td>Profile of magnetic intensity on line 5400 after drop out editing</td>
<td>37</td>
</tr>
<tr>
<td>3.8</td>
<td>Profiles of magnetic intensity (after drop out editing) for all profiles used for gridding</td>
<td>38</td>
</tr>
<tr>
<td>3.9</td>
<td>All survey lines for the 2001 and 2000 magnetic surveys</td>
<td>39</td>
</tr>
<tr>
<td>3.10</td>
<td>False colour image of total magnetic intensity (TMI) grid</td>
<td>40</td>
</tr>
<tr>
<td>3.11</td>
<td>False colour image of total magnetic intensity grid from regional dataset for comparison to new data</td>
<td>41</td>
</tr>
<tr>
<td>3.12</td>
<td>Contour map of TMI, generated from gridded survey data</td>
<td>42</td>
</tr>
<tr>
<td>3.13</td>
<td>Schematic image of the magnetic response of a sphere of susceptible material, used to illustrate the effect of boat heading on magnetic measurements</td>
<td>43</td>
</tr>
<tr>
<td>3.14</td>
<td>Heading test data (raw) plotted as a function of time. Field and base station records shown</td>
<td>45</td>
</tr>
</tbody>
</table>
3.15 Diurnally corrected heading test data and northings from GPS log as a function of time, illustrating low resolution of non-differentially corrected GPS position data

3.16 Observed and calculated heading test data. Calculated data used to apply corrections

3.17 Comparison of magnetic data from 2000 and 2001 surveys – selected points from line intersections

4.1.1 Sensitivity testing example chart 1
4.1.2 Sensitivity testing example chart 2
4.1.3 Sensitivity testing results chart 1
4.1.4 Sensitivity testing results chart 2
4.1.5 Potent model for sensitivity testing number 1
4.1.6 Potent model for sensitivity testing number 2
4.1.7 Potent model for sensitivity testing number 3
4.1.8 Potent model for sensitivity testing number 4
4.2 Traverse 1 model results
4.3 Traverse 2 model results
4.4 Traverse 3 model results
4.5 Traverse 4 model results
4.6 Traverse 5 model results
4.7 Traverse 6 model results
4.8 Traverse 7 model results
4.9 Traverse 8 model results
4.10 Traverse 9 model results
4.11 Traverse 10 model results
4.12 Traverse 11 model results
4.13 Traverse 12 model results
4.14 Traverse 13 model results
4.15 Traverse 14 model results
4.16 Traverse 15 model results
4.17 Traverse 16 model results
4.18 Traverse 17 model results
4.19 Traverse 18 model results
4.20 Traverse 19 model results
4.21 Traverse 20 model results
4.22 Traverse 21 model results
4.23 Traverse 22 model results
4.24 Traverse 23 model results
4.25 Traverse 24 model results
4.26 Traverse 25 model results
4.27 Traverse 26 model results
4.28 Traverse 27 model results
4.29 Traverse 28 model results
4.30 Traverse 29 model results
4.31 Traverse 30 model results
4.32 Traverse 31 model results
4.33 Traverse 32 model results
4.34 Traverse 33 model results
4.35 Traverse 34 model results
4.36 Traverse 35 model results
4.37 Traverse 36 model results
4.38 Traverse 37 model results
4.39 Traverse 38 model results
4.40 Traverse 39 model results
4.41 Traverse 40 model results
4.42 Traverse 41 model results
4.43 Traverse 42 model results
4.44 Traverse 43 model results
4.45 Traverse 44 model results
4.46 Traverse 45 model results
4.47 Traverse 46 model results
4.48 Traverse 47 model results
4.49 Traverse 48 model results
4.50 Traverse 49 model results
4.51 Traverse 50 model results
4.52 Traverse 51 model results
4.53 Traverse 52 model results
4.54 Traverse 53 model results
4.55 Traverse 54 model results
4.56 Traverse 55 model results
4.57 Traverse 56 model results
4.58 Traverse 57 model results
4.59 Traverse 58 model results
4.60 Traverse 59 model results
4.61 Traverse 60 model results
4.62 Traverse 61 model results
4.63 Traverse 62 model results
4.64 Traverse 63 model results
4.65 Traverse 64 model results
4.66 Traverse 65 model results
4.67 Traverse 66 model results
4.68 Traverse 67 model results
4.69 Traverse 68 model results
4.70 Traverse 69 model results
4.71 Traverse 70 model results
4.72 Traverse 71 model results
4.73 Traverse 72 model results
4.74 Traverse 73 model results
4.75 Traverse 74 model results
4.76 Traverse 75 model results
4.77 Traverse 76 model results
4.78 Traverse 77 model results
4.79 Traverse 78 model results
4.80 Traverse 79 model results
4.81 Traverse 80 model results
4.82 Traverse 81 model results
4.83 Traverse 82 model results
4.84 Traverse 83 model results
4.85 Traverse 84 model results
4.86 Traverse 85 model results
4.87 Traverse 86 model results
4.88 Traverse 87 model results
4.89 Traverse 88 model results
4.90 Traverse 89 model results
4.91 Traverse 90 model results
4.92 Traverse 91 model results
4.93 Traverse 92 model results
4.94 Traverse 93 model results
4.95 Traverse 94 model results
4.96 Traverse 95 model results
4.97 Traverse 96 model results
4.98 Traverse 97 model results
4.99 Traverse 98 model results
5.1 Photo of the boomer seismic source catamaran (on land)
5.2 Photo of the seismic receiver array (eel) in the water
5.3 Photo of the electrostatic printer used to output the seismic profiles
5.4 Photo of the FMV Mal/anna (the vessel used for the seismic survey)
5.5 The two boats used for the seismic survey at Bridgewater. Two boats were used because of the shallow water depths.
5.6 Map of the seismic trackpaths, for 2000 and 2001
5.7 Calculated magnetic response of a thin sheet of basalt
5.8 Example of a 'blanket' of acoustic turbidity from Taylor (1992)
5.9 Map of the distribution of acoustic turbidity in the Derwent Estuary as defined from the seismic reflection profiles
5.10 Example 1 of a possible phase reversal on one of the seismic reflection profiles
5.11 Example 2 of a possible phase reversal on a seismic reflection profile
5.12 Example of probable gas seepage and velocity pulldown
5.13 Example of a pockmark from the Derwent Estuary
5.14 Example of a pockmark from the literature (Taylor, 1992)
5.15 Map of water column disturbances defined from the seismic reflection profiles
5.16 Schematic of possible chemical and biological boundaries and conditions necessary for the bacterial production of methane
5.17 Map of the distribution of calcium carbonate in the shallow sediments of the Derwent Estuary (provided by Dr. Peter Harris)
5.18 Photo of the 'Craie' corer owned by TAFI and used for shallow sediment sampling
5.19 Photo of borosilicate glass sample bottles used for the collection of wet sediment samples
5.20 Map of the location of sediment samples, coded according to measured methane concentration (normalised by sample mass)
5.21 Schematic of some seismic energy travelpaths – primary reflections
5.22 Schematic of some seismic energy travelpaths – simple multiples
5.23 Example of seafloor multiples
5.24 Schematic of some seismic energy travelpaths – complex multiples 102
5.25 Example 1 of multiple reflections from the Derwent Estuary seismic profiles 103
5.26 Example 2 of multiple reflections from the Derwent Estuary seismic profiles 104
5.27 Example of how a multiple reflection can interfere with the interpretation of primary reflections 105
6.1 The seismic profile taken alongside the southern side of the Tasman Bridge 106
6.2 The input velocity model used for acoustic finite difference (AFD) modeling 108
6.3 High frequency model output (i.e. a 'pseudo-boomer' record) from the AFD modeling 109
6.4 Moderate frequency model output from the AFD modeling 110
6.5 Low frequency model output from the AFD modeling 111
6.6 Low frequency 'pseudo-boomer' record calculated by acoustic finite differencing 112
7.1 Trackpaths map for 'long' seismic lines (i.e. lines 3, 5, 7, 21, 22, 23, 16 and 17) 115
7.2 Trackpaths map for 'short' seismic lines (i.e. lines 24 to 34 inclusive) 116
7.3.1 Line 3 raw seismic profile 119
7.3.2 Line 3, interpretation 120
7.4.1 Line 23, raw seismic profile 121
7.4.2 Line 23, interpretation 122
7.5.1 Line 22, raw seismic profile 123
7.5.2 Line 22, interpretation 124
7.6.1 Line 5, raw seismic profile 125
7.6.2 Line 5, interpretation 126
7.7.1 Line 16, raw seismic profile 127
7.7.2 Line 16, interpretation 128
7.8.1 Line 17, raw seismic profile 129
7.8.2 Line 17, interpretation 130
7.9.1 Line 21, raw seismic profile 131
7.9.2 Line 21, interpretation 132
7.10.1 Line 7, raw seismic profile 133
7.10.2 Line 7, interpretation 134
7.11.1 Line 24, raw seismic profile 135
7.11.2 Line 24, interpretation 136
7.12.1 Line 25, raw seismic profile 137
7.12.2 Line 25, interpretation 138
7.13.1 Line 26, raw seismic profile 139
7.13.2 Line 26, interpretation 140
7.14.1 Line 27, raw seismic profile 141
7.14.2 Line 27, interpretation 142
7.15.1 Line 28, raw seismic profile 143
7.15.2 Line 28, interpretation 144
7.16.1 Line 29, raw seismic profile 145
7.16.2 Line 29, interpretation 146
7.17.1 Line 30, raw seismic profile 147
7.17.2 Line 30, interpretation 148
7.18.1 Line 31, raw seismic profile 149
7.18.2 Line 31, interpretation 150
7.19.1 Line 32, raw seismic profile 151
7.19.2 Line 32, interpretation 152
7.20.1 Line 33, raw seismic profile 153
7.20.2 Line 33, interpretation 154
7.21.1 Line 34, raw seismic profile 155
7.21.2 Line 34, interpretation 156
8.1 False-colour image of bathymetry, generated from gridded data 160
8.2 Contours of bathymetry, generated from gridded data 161
9.1 Combined geological interpretation map 163
9.2 Image of gridded magnetic data, reduced to the pole. Used for qualitative interpretation 166
9.3 Image of first vertical derivative of reduced to pole magnetic data. Used for qualitative interpretation 167
# List of Tables

<table>
<thead>
<tr>
<th>Table Number</th>
<th>Title/Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>List of sonic velocity ranges for common geological materials found in the Hobart area</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>Results of headspace gas analysis</td>
<td>98</td>
</tr>
</tbody>
</table>