
Volcanology and geochemistry of the Cambrian Mount Read Volcanics in the Basin Lake area, western Tasmania

by

Andrew T Jones

B.App.Sci. (RMIT) Hons. (Tas)



A thesis submitted in fulfilment of the requirements for the degree of
Master of Science

**Centre for Ore Deposit and Exploration Studies, School of Earth Sciences
University of Tasmania**

May 1999

Authority of Access

This thesis is not to be made available for loan or copying for one year from the date this statement was signed. Following that time the thesis may be made available for loan and limited copying in accordance with the *Copyright Act 1968*.

Signed:

Andrew Jones

A Jones

Date:

21/5/1999

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University, and to the best of my knowledge and belief, contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text of this thesis.

Signed:

Andrew Jones

A Jones

Date: 21/5/99

Abstract

The Basin Lake area is located in western Tasmania approximately 12 km north of Queenstown. A stratigraphic section through the late Middle Cambrian Mount Read Volcanics and overlying Late Cambrian to Early Ordovician Owen Conglomerate is exposed in outcrop and diamond drillcore. In this area, the Mount Read Volcanics consist of the Yolande River Sequence, Anthony Road Andesite and Tyndall Group.

The Great Lyell Fault and South Henty Fault were active normal faults during the Cambrian and bounded the extensional basin into which the lithologic associations of the study area were deposited. NW to NNW striking fault sets present in the area may represent Cambrian transfer faults. Silica-sericite-pyrite alteration has been focussed along these transfer faults and facies changes occur across them. Devonian orogenesis has reactivated faults across the area.

The Yolande River Sequence forms the basal unit within the area and comprises volcanoclastic turbidites and non-volcanic black mudstone deposited in a below-wave-base, probably deep water setting. Components in the volcanoclastic units suggest a dacitic provenance and include abundant pumice and volcanic crystals (feldspar, quartz) that were most likely supplied by explosive eruptions at subaerial or shallow marine, extrabasinal or basin-margin vents.

Intrusive into and overlying the Yolande River Sequence is the Anthony Road Andesite, an intrabasinal submarine dome, lava and intrusive complex largely comprising coherent and autoclastic facies of basaltic andesite, hornblende andesite and rhyolite. Interleaved with the coherent and autoclastic facies are black mudstone, limestone and ironstone. Limestone and ironstone occur towards the stratigraphic top of the Anthony Road Andesite and at the base of the overlying Tyndall Group.

The hornblende andesite and rhyolite associations of the Anthony Road Andesite have high-K calc-alkaline affinities whereas the stratigraphically higher basaltic andesite association is shoshonitic, with high P_2O_5 and light REE-enrichment. A similar transition from calc-alkaline to shoshonitic compositions has been noted in the Que-Hellyer Volcanics and the Lynch Creek basalts (Crawford et al., 1992). The rhyolite association of the Anthony Road Andesite has no recognised geochemical analogues in the Mount Read Volcanics.

Ironstone contains single strand filamentous textures similar to bacterial mats found at hydrothermal vent sites on the modern seafloor. Modern analogues favour deposition from low temperature (< 100°C) iron- and silica-rich, hydrothermal fluids on or within metres of the seafloor. Base and precious metal-rich barite veins in Tyndall Creek and hematite-carbonate-barite alteration with associated silver mineralisation at Howards Anomaly occur at a stratigraphically similar position to the ironstone facies. It is inferred that the limestone facies is laterally equivalent to this stratigraphic position.

The Tyndall Group is the youngest lithostratigraphic unit of the Mount Read Volcanics and records the final phases of volcanism and denudation of the source volcanic terrain. The group is dominated by thick, crystal-rich volcanoclastic sandstone, breccia and conglomerate with lesser limestone and rhyolite deposited in a marine below-wave-base setting by mass-flows. The volcanoclastic mass-flow units in the Mount Julia Member and Zig Zag Hill Formation are thick, coarse, and lacking finer interbeds which may suggest a shallower and more proximal depositional setting than for the Yolande River Sequence. The occurrence of welded ignimbrite and the dominantly dacitic to rhyolitic provenance of the Tyndall Group suggest the presence of felsic caldera volcanoes in the source area.

The Owen Conglomerate conformably overlies the Tyndall Group in the Basin Lake area. Sedimentary facies include conglomerate, sandstone and mudstone mainly derived from Precambrian metamorphic basement. The conglomerates are well sorted and the clast population is commonly well rounded indicating significant reworking in a high energy environment. Facies variations indicate a change in conditions from below-wave-base to above-wave-base, with deposition interpreted to have occurred in subaerial to submarine alluvial fans and fan deltas.

Modern analogues for the palaeogeography of the Basin Lake area can be found in deep marine settings offshore from active subaerial volcanic terrains, such as the Bay of Plenty offshore from the Taupo Volcanic Zone, New Zealand. The high-K calc-alkaline hornblende andesite and rhyolite associations of the Anthony Road Andesite have geochemical analogues in modern arc settings. The closest modern analogues of the shoshonitic basaltic andesite association occur in post-collisional arc settings in Papua New Guinea, Turkey and the Himalayas.

Acknowledgements

I would like to acknowledge my supervisor Jocelyn McPhie for the assistance and advice which she has extended to me and for her proof reading of the text of this thesis. I thank my unofficial supervisors, Garry Davidson, Joe Stolz, Paul Kitto and Bruce Gemmell, for their expertise, advice and proof reading of parts of the text. An APRA (Industry) scholarship funded this research. Aberfoyle and Acacia are thanked for their financial support of the project.

The help, financial assistance and friendship extended to me by the former staff of Aberfoyle Resources Ltd has been greatly appreciated. Robina Sharpe and Rob Lewis are acknowledged for introducing me to the geology of the study area and for many helpful discussions. Garry Cooper and Scott Williams are thanked for their help shifting drillcore and all the other various things they have done while Richard de Bomford is thanked for his friendship throughout this study and for his assistance with all things logistical. Dave Wallace, Chris Young, Hugh Skey, Steve Richardson and John Hiscock are also thanked for their assistance.

Assistance with analytical work was extended to me from several quarters. In particular I would like to acknowledge Phil Robinson, Simon Stevens, Naomi Deards, Katie McGoldrick, Nilar Hlaing and Erin McGoldrick from the Geology Department, Mike Power, Christine Cook and Wis Jablonski from the Central Science Laboratory and Mike Jacobsen and Richie Wooley from Tasmania Development and Resources. Jeanette Harris, Peter Cornish, June Pongratz and Christine Higgins are thanked for their assistance with innumerable problems.

Many staff members and postgraduate students of both CODES and the Geology Department have assisted me with my studies. In particular, I would like to thank Matthew White, Alicia Verbeeten, Ron Berry, Tony Crawford, David Cooke, Andrew McNeill, Marcel Kamperman, Steve Hunns, Nathan Duhig, Uros Herlec, Singoyi Blackwell, Bill Wyman, Mark Doyle, Mohammad Adabi, Zohreh Amini, Cathryn Gifkins, Anthea Hill, David Rawlings, Peter McGoldrick, Andrew Tunks, Jamie Rodgers, Dave Selley, Bruce Anderson, Mark Duffett, Mike Roache, Steve Boden, Rohan Wolfe and Stuart Smith. Thanks to Bruce and Liz Anderson and Cathryn Gifkins for giving me somewhere to live right until the end.

A special acknowledgement for their consistent support and help with proof reading must go to my parents, Anthony and Faye Jones. Joe McKibben and Rohan Williams are thanked for moral support over the last three years. My final thankyou is to Bianca Manzi for her help with proof reading and for believing.

Table of Contents

	<u>Page No.</u>
Title Page	i
Declaration	ii
Authority of Access	iii
Abstract	iv
Acknowledgements	vi
Table of Contents	vii
List of Figures	xi
List of Tables	xiii
List of Plates	xiv
Chapter 1 Introduction	1
1.1 Aims	1
1.2 Location and access	2
1.3 Exploration and mining history	4
1.4 Previous work	7
1.5 Thesis organisation	9
Chapter 2 Regional Geology	10
2.1 Introduction	10
2.2 The Mount Read Volcanics	10
2.2.1 Central Volcanic Complex	11
2.2.2 Eastern quartz-phyric sequence	14
2.2.3 Basaltic-andesitic units	14
2.2.4 Western volcano-sedimentary sequences	15
2.2.5 Tyndall Group	16
2.3 Owen Conglomerate (Denison Group)	18
2.4 Cambrian economic mineralisation	18
2.5 Location of the study area in the Mount Read Volcanics	19
Chapter 3 Structural Geology	20
3.1 Introduction	20
3.2 Structural analysis of the Basin Lake area	21
3.2.1 Domain 1	21
Bedding, columnar jointing and flow banding	24
Folds and cleavage	24
3.2.2 Domain 2	26
Bedding	26
Folds and cleavage	26
3.2.3 Comparison of Domains 1 and 2	30
3.3 Faults	30
3.3.1 South Henty Fault	30
3.3.2 Great Lyell Fault	33
3.3.3 NW to NNW faults	34
3.3.4 NE faults	34
3.3.5 Discussion of faults	36
3.4 Summary and conclusions	36

Chapter 4	Facies characteristics of lithostratigraphic units in the Basin Lake area	38
4.1	Introduction	38
4.2	Yolande River Sequence	38
	4.2.1 Black mudstone facies	41
	4.2.2 Volcanic mudstone facies	41
	4.2.3 Coarse feldspar-pumice sandstone	41
	4.2.4 Pumiceous lithic-rich breccia	41
	4.2.5 Sedimentation processes, depositional setting and provenance of the Yolande River Sequence	42
4.3	Tyndall Group	43
	4.3.1 Comstock Formation	43
	Limestone facies	44
	Volcaniclastic sandstone facies	44
	Black mudstone facies	45
	Crystal-rich volcaniclastic sandstone facies	45
	Polymictic volcanic breccia facies	47
	4.3.2 Zig Zag Hill Formation	47
	Graded volcaniclastic sandstone/siltstone facies	47
	Polymictic conglomerate facies	48
	Coherent rhyolite and monomictic rhyolite breccia facies	48
	4.3.3 Sedimentation processes, depositional setting and provenance of the Tyndall Group	50
4.4	Owen Conglomerate (Denison Group)	54
	4.4.1 Jukes Conglomerate	54
	4.4.2 Lower Conglomerate Unit	56
	4.4.3 Newton Creek Sandstone	56
	4.4.4 Middle Owen Conglomerate	57
	4.4.5 Sedimentation processes, depositional setting and provenance of the Owen Conglomerate	57
4.5	Post-volcanic dykes in the Mount Julia Member and Newton Creek Sandstone	58
	4.5.1 Basalt dykes	58
	4.5.2 Rhyolite dyke	59
4.6	Stratigraphic relationships	60
	4.6.1 Stratigraphic relationships in the Basin Lake area	60
	4.6.2 Comparison of stratigraphic relationships in the Basin Lake area with the southern Mount Read Volcanics	60
4.7	Summary of depositional setting and provenance of the study area	61
Chapter 5	Lithofacies, facies associations and facies architecture of the Anthony Road Andesite	63
5.1	Introduction	63
5.2	Basaltic andesite association	64
	5.2.1 Pyroxene-feldspar-phyric basaltic andesite	64
	5.2.2 Facies architecture of the basaltic andesite association	66
5.3	Hornblende andesite association	69
	5.3.1 Massive facies	69
	5.3.2 Andesitic breccia facies	70
	5.3.3 Matrix-supported andesitic breccia	73
	5.3.4 Andesitic-dacitic volcaniclastic sandstone	73
	5.3.5 Facies architecture of the hornblende andesite association	73
5.4	Rhyolite association	74
	5.4.1 Quartz-feldspar-phyric rhyolite facies	74
	5.4.2 Monomictic breccia facies	75
	5.4.3 Rhyolitic volcaniclastic breccia/sandstone	75
	5.4.4 Facies architecture of the rhyolite association	77

5.5	Sedimentary facies association (non-volcanic)	77
	5.5.1 Black mudstone facies	77
	5.5.2 Limestone facies	78
	5.5.3 Ironstone facies	78
5.6	Facies architecture of the Anthony Road Andesite	80
	5.6.1 Depositional environment	80
	5.6.2 Eruption and emplacement processes	80
	5.6.3 Proximity to source vents	81
	5.6.4 Character and evolution of the volcanic centre	81
Chapter 6 Volcanic Geochemistry of the Basin Lake area		83
6.1	Introduction	83
6.2	Mineral chemistry	83
	6.2.1 Analytical methods	83
	6.2.2 Clinopyroxene	85
	6.2.3 Amphibole	87
	6.2.4 FeTi oxide (magnetite)	88
	6.2.5 Apatite	91
	6.2.6 Cr-spinel	91
	6.2.7 Discussion	92
6.3	Wholerock geochemical classification	95
	6.3.1 Analytical methods	95
	6.3.2 Element mobility	95
	6.3.3 Geochemical characteristics of the Anthony Road Andesite	96
	Basaltic andesite association	96
	Hornblende andesite association	100
	Rhyolite association	101
	6.3.4 Geochemical characteristics of rhyolite in the Tyndall Group	103
	6.3.5 Geochemical characteristics of post-volcanic dykes: Mount Julia	
	Member and Newton Creek Sandstone	105
	Basalt dykes	105
	Rhyolite dyke	105
6.4	Discussion	106
	6.4.1 Geochemical characteristics of the Basin Lake area	106
	6.4.2 Comparison of the Basin Lake area with volcanic units elsewhere	
	in the Mount Read Volcanics	108
	Anthony Road Andesite	108
	Tyndall Group	113
	Tholeiitic basaltic dykes	113
	6.4.3 Modern volcanic successions comparable to the associations of the	
	Anthony Road Andesite	115
	The hornblende andesite association	115
	The basaltic andesite association	116
6.5	Conclusions	117
Chapter 7 Alteration in the Anthony Road Andesite		119
7.1	Introduction	119
7.2	Alteration styles: distribution, mineralogy and textures	119
	7.2.1 Groundmass and phenocryst alteration	120
	7.2.2 Veins	121
7.3	Alteration geochemistry	123
	7.3.1 Chlorite chemistry	123
	7.3.2 Wholerock geochemistry	126
	Element mobilities	126
	Mass change/ mass balance using immobile elements	126
	7.3.3 Magnetite destructive alteration	131

7.4	Discussion	133
	7.4.1 Timing of alteration	134
	7.4.2 Comparison with alteration elsewhere in the Mount Read Volcanics	135
7.5	Conclusions	136
Chapter 8 The Lake Newton Ironstone		137
8.1	Introduction	137
	8.1.1 Terminology	139
8.2	Field relationships and associated alteration	139
8.3	Ironstone mineralogy and texture	140
	8.3.1 Microbial fossils	142
8.4	Ironstone Geochemistry	142
	8.4.1 Analytical methods	142
	8.4.2 Major and selected trace element geochemistry	145
	8.4.3 Rare earth element geochemistry	145
	8.4.4 Geochemical characteristics of the Lake Newton Ironstone	145
8.5	Discussion	151
	8.5.1 Origin of the Lake Newton Ironstone	151
	8.5.2 Model for ironstone formation	151
	8.5.3 Geochemical comparison with modern seafloor and ancient VHMS-related ironstones	153
	Modern seafloor ironstones	153
	Ancient VHMS-related ironstones	153
8.6	Conclusions	154
Chapter 9 Synthesis		157
9.1	Facies architecture of the Basin Lake area	157
9.2	Geological history and facies architecture of the study area	159
9.3	Mafic-intermediate successions in the Mount Read Volcanics	164
9.4	Importance of the Lake Newton Ironstone	168
9.5	Analogous modern volcanic settings	168
	9.5.1 Palaeogeographic analogues	168
	9.5.2 Geochemically similar volcanic settings	169
Bibliography		172
Appendices		191
	Appendix A - Sample Catalogue	
	Appendix B - Structural Data	
	Appendix C - Carbon-Oxygen Isotopes	
	Appendix D - Electron Microprobe Data	
	Appendix E - Wholerock Geochemical Data	
	Appendix F - X-Ray Diffraction Results	
	Appendix G - Diamond Drillhole Locations and Graphic Logs of Drillholes	
	Appendix H - Maps of the Study Area	