

**Fluid Flow Processes at Mid-Ocean Ridge  
Hydrothermal Systems**

**by**

**Timothy Edmund Jupp**

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## **Declaration**

This dissertation describes my original work except where acknowledgement is made in the text. It does not exceed the page limit and is not substantially the same as any other work that has been, or is being, submitted to any other university for any degree, diploma or other qualification.

30<sup>th</sup> September 2000

Timothy Edmund Jupp

**“Correlation does not imply causality”**

P.E. & S.L. Jupp,  
frequent *pers. comms.*,  
since 1974

# Summary

## Fluid flow processes at mid-ocean ridge hydrothermal systems

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The subsurface structure and temporal variability of mid-ocean ridge hydrothermal systems are examined from a largely theoretical standpoint.

The nature of tidal signals is considered in detail and there is a discussion of the mechanisms by which the tidal modulations observed at seafloor hydrothermal systems might be produced. A review of the known examples of tidal modulation at hydrothermal systems is presented, and a new procedure for the analysis of these tidally modulated time-series is proposed. Where possible, this new procedure is applied to datasets previously obtained at the seafloor and it is recommended for use in future analyses.

It is shown that the nonlinear thermodynamic properties of pure water are sufficient to impose a structure consistent with the known constraints on subsurface convection cells. In particular, it is demonstrated that the properties of water limit seafloor vent temperatures to  $\sim 400^\circ\text{C}$ , even when the energy source driving the convection cell is much hotter. A scaling analysis is presented to reveal how the lengthscales and timescales associated with a subsurface convection cell depend on the bulk crustal permeability.

The equations of poroelasticity are reviewed to demonstrate how the nonlinear thermodynamic properties of water influence the response of a hydrothermal system to tidal loading at the seafloor. A selection of simple analytical solutions reveals the phase relationship of the effluent temperature and effluent velocity at the seafloor to the ocean tide. A numerical simulation illustrates the effect of tidal loading on a two-dimensional subsurface convection cell incorporating the nonlinear properties of water.

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# Table of Contents

<b>Chapter 1: Introduction</b> .....	1
1.1 Mid-Ocean Ridge hydrothermal systems.....	2
1.2 Aims and dissertation outline.....	5
<b>Chapter 2: The nature of tidal signals</b> .....	8
2.1 Introduction.....	8
2.2 The Tidal Potential of a celestial body.....	9
2.3 Decomposition of the Tidal Potential.....	12
2.3.1 Decomposition by species.....	12
2.3.2 Frequency modulation by declinational changes.....	13
2.3.3 Amplitude modulation by lunar phase – spring and neap tides.....	14
2.3.4 Decomposition into harmonic series.....	16
2.4 The Solid Tide.....	22
2.4.1 Definition of the Solid Tide.....	22
2.4.2 The nature of the Solid Tide.....	22
2.5 The Ocean Tide.....	23
2.5.1 Definition of the Ocean Tide.....	23
2.5.2 The Equilibrium Tide.....	23
2.5.3 The Ocean Tide.....	24
2.5.4 The Load Tide.....	27
2.6 Tidal Streams.....	28
2.6.1 Rectilinear travelling waves in the open oceans.....	28
2.6.2 Rectilinear standing waves in small gulfs.....	30
2.6.3 The frequency spectrum of a rectilinear tidal stream.....	30
2.6.4 Rotating tidal streams.....	31
2.7 Conclusions.....	32
<b>Chapter 3: The analysis of tidal data</b> .....	34
3.1 Introduction.....	34
3.2 Non-parametric analysis.....	35
3.2.1 Simple Fourier transform methods.....	36
3.2.1.1 The periodogram.....	36
3.2.1.2 Local and broadband bias.....	37
3.2.1.3 The windowed periodogram.....	37
3.2.1.4 Discrete prolate spheroidal sequences.....	38
3.2.1.5 Band-averaging.....	39
3.2.1.6 Section-averaging.....	39
3.2.1.7 Conclusions.....	40
3.2.2 Multiple Window Power Spectra.....	40
3.2.2.1 Identification of line components.....	41
3.3 Parametric analysis.....	42
3.3.1 The Harmonic Method.....	43
3.3.2 The Admiralty Method.....	44
3.3.2.1 Derivation of the Admiralty Method basis functions $\{b_j(t)\}$ .....	46
3.3.2.2 The information content of a tidal signal.....	48
3.3.2.3 Astronomical and intrinsic non-stationarity.....	50
3.3.2.4 Robustification of the Admiralty Method.....	52
3.3.3 Drift removal by Bayesian methods.....	53
3.3.4 The HYBDRID code – a parametric method	

	for analysing tidal data.....	57
3.4	Conclusions.....	58
<b>Chapter 4:</b>	<b>Evidence of tidal modulation at seafloor hydrothermal systems.....</b>	<b>60</b>
4.1	Introduction.....	61
4.2	Juan de Fuca Ridge.....	63
4.2.1	Endeavour Segment (1).....	63
4.2.2	Endeavour Segment (2).....	66
4.2.3	Middle Valley.....	67
4.2.4	Cascadia Accretionary Prism.....	69
4.2.5	The Pipe Organ Site and the Kolmogorov hypothesis.....	69
4.3	Gulf of California.....	70
4.3.1	Introduction.....	70
4.3.2	Guaymas Basin.....	71
4.4	Equatorial East Pacific Rise.....	76
4.4.1	Rose Garden Site.....	76
4.4.2	Bio9 Vent Site.....	78
4.5	Southern East Pacific Rise.....	79
4.5.1	The RM24 Site.....	79
4.5.1.1	Overview of the Medusa instrument.....	79
4.5.1.2	Medusa measurements – time-domain.....	80
4.5.1.3	Medusa measurements – non-parametric analysis.....	82
4.5.1.4	Medusa measurements – parametric analysis.....	84
4.6	Western Pacific.....	89
4.7	Mid-Atlantic Ridge.....	89
4.7.1	The TAG mound.....	89
4.7.1.1	Water column measurements.....	90
4.7.1.2	Geothermal probe measurements.....	90
4.7.1.3	Medusa measurements – time-domain.....	93
4.7.1.4	Medusa measurements – non-parametric analysis.....	95
4.7.1.5	Medusa measurements – parametric analysis.....	97
4.7.1.6	Manatee and OBSH measurements.....	102
4.7.1.7	‘Shrimp density’ measurements.....	104
4.7.1.8	Summary of tidal modulation observed at TAG.....	106
4.7.2	The Menez Gwen Site.....	106
4.7.2.1	Medusa measurements – time-domain.....	106
4.7.2.2	Medusa measurements – non-parametric analysis.....	109
4.7.3	The Lucky Strike Site.....	111
4.7.3.1	Medusa measurements – time-domain.....	111
4.7.3.2	Medusa measurements – non-parametric analysis.....	113
4.7.3.3	Medusa measurements – parametric analysis.....	115
4.7.3.4	Water column measurements – time-domain.....	118
4.7.3.5	Water column measurements – non-parametric analysis... ..	120
4.7.3.6	Water column measurements – parametric analysis.....	124
4.8	Other hydrothermal sites.....	129
4.9	Conclusions.....	130
<b>Chapter 5:</b>	<b>Black smoker temperatures and the structure of subseafloor convection cells.....</b>	<b>135</b>
5.1	Introduction.....	135

5.1.1	Recharge zone.....	136
5.1.2	Reaction zone.....	136
5.1.3	Discharge zone.....	137
5.1.4	Hydrothermal vents.....	137
5.1.5	Recharge zone.....	138
5.2	Empirical constraints on convection cell structure.....	139
5.3	A simple model of hydrothermal convection.....	143
5.4	Scaling analysis.....	156
5.4.1	Cartesian geometry.....	156
5.4.2	Residence times in the discharge and reaction zones.....	159
5.4.3	Axisymmetric scaling laws.....	161
5.5	Conclusions.....	162
<b>Chapter 6:</b>	<b>Poroelasticity and tidal loading.....</b>	<b>163</b>
6.1	Introduction.....	163
6.2	Fundamental concepts of poroelasticity.....	165
6.2.1	The dependence of poroelastic parameters on fluid temperature....	165
6.2.1.1	Coefficient of effective stress: $\alpha$ .....	168
6.2.1.2	Storage compressibility: $S$ .....	169
6.2.1.3	Skempton ratio: $\beta$ .....	171
6.2.2	The governing equations of poroelasticity.....	173
6.3	Tidal loading of the seafloor.....	178
6.3.1	Tidal loading of a 1-d seafloor.....	178
6.3.1.1	Incremental pore pressure in an infinite halfspace.....	179
6.3.1.2	Incremental velocity in an infinite halfspace.....	181
6.3.1.3	Incremental temperature in an infinite halfspace.....	185
6.3.1.4	Incremental pore pressure in a finite permeable layer.....	188
6.3.1.5	Incremental velocity in a finite permeable layer.....	189
6.3.2	Tidal loading of a 2-d seafloor.....	191
6.3.2.1	Governing equations in 2-d.....	191
6.3.2.1	Numerical simulation.....	193
6.4	Conclusions.....	197
<b>Chapter 7:</b>	<b>Conclusions and suggested future work.....</b>	<b>200</b>
7.1	Directions for future research.....	200
7.1.1	Collection of further hydrothermal time-series.....	200
7.1.2	Less simplistic convection models.....	200
7.1.3	Direct imaging of subseafloor flow and temperature.....	204
7.2	Conclusions.....	205
<b>Appendix:</b>	<b>Nomenclature.....</b>	<b>209</b>
<b>References:</b> .....		<b>215</b>
	Books, papers and conference abstracts.....	215
	Computer codes by other authors.....	228
	Computer codes written for this dissertation.....	229