Fluid Flow Processes at Mid-Ocean Ridge Hydrothermal Systems

by

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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.

30th September 2000 Timothy Edmund Jupp

“Correlation does not imply causality”

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

Summary

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The subseafloor 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 subseafloor convection cells. In particular, it is demonstrated that the properties of water limit seafloor vent temperatures to ~400°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 subseafloor 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 subseafloor convection cell incorporating the nonlinear properties of water.

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