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Theoretical and computer assisted studies in tectonics, structural geology and isotope dating

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THEORETICAL AND COMPUTER ASSISTED STUDIES IN TECTONICS, STRUCTURAL GEOLOGY AND ISOTOPE DATING

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Richard Leigh Thiessen

A Dissertation

Submitted to the State University of New York at Albany

in partial fulfillment of

the requirements for the degree of

Doctor of Philosophy

College of Science and Mathematics

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ABSTRACT

Several problems in the fields of tectonics, structural geology and isotopic dating were examined and simplified using computer programs. These problems include the theory of refolding, refold applications to three mining areas, hotspots and their relationship to mantle convection systems and ionium dating of volcanic rocks. In the first study, it was shown that current refold classification schemes are in adequate and so modifications were suggested. Various other aspects of multiple generations of interfering folds were also examined. The ideas of refold theory were then applied to three mining areas, the Chisel Lake Ore Body of Manitoba, the Galena-Roubaix District of South Dakota and Montauban-les-Mines of Quebec. These three studies represent three different techniques of identifying fold generations.

The third study of this dissertation involved the examination of hotspots/highspots at various localities of the earth. The distribution was then used to define a polygonal convection system, which is similar to laboratory mantle models. It was also attempted to integrate this model with recent whole mantle convection models to see if the combination was compatible with observed hotspot tracks.

The final study involves a review of the deficiencies of the various ionium dating techniques used on volcanic rocks. A new method was presented which is free of these deficiencies.

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Preface

In this day of high speed computers many geologic problems could be simplified or examined in more detail if a computer program were designed for the problem. This is a resource that has not been exploited to its fullest in the past and therefore, I have written and used Fortran programs for a variety of geologic problems in tectonics, structural and isotope geology during my four years of doctoral study at the State University of New York at Albany.

Most of the problems I examined were not related to each other. For this reason, the chapters of this dissertation are treated as independent units, each containing its own figures, tables, references and appendices.

The first chapter examines the theory of refolding. It details the kinds of interference patterns that occur in areas that have undergone several folding episodes. In order to facilitate this study, I wrote the program, REFOLD. One can input any number of generations of folds, specifying the fold orientations, amplitudes, wavelengths and wave form. The program then produces printer graphics of cross sections cut at any orientation and location in the resulting refold structure. Isovolumetric flattening and faulting can also be done. With the ensuing ability to examine a large number of refolds, my advisor, W.D. Means, and I were able to modify and extend current refold classification schemes. A portion of this study has been incorporated in a manuscript currently in press in the Journal of Structural Geology.

In the second chapter, I detail my attempts to apply refold theory to three different mining areas. These areas are the Chisel

Lake Ore Body of Manitoba, The Galena-Raubaix gold district of the Black Hills and the Montauban-les-Mines region of Quebec. I devised several methods for the examination of these regions. The program, REFOLD, was used again in this analysis, as was another program, TREND. The latter program examines strike and dip data with respect to a regional trend surface. TREND is included as an appendix to Chapter 2.

In the third chapter, I examine relationships between areas of anomalous volcanism (hotspots),uplift (highspots), and several mantle convection models. In the first part of the chapter, I detail a study of the hot spots/high spots of Africa and relate their distribution to a convection system of polygonal cells in the underlying mantle. This polygonal cell system has been produced in several laboratory models. This particular study resulted in a paper in Geology (1979, v. 7, p. 263-266) with K. Burke and W.S.F. Kidd. In the course of this study, the distance between hotspots over the curvature of the earth was required. To calculate this, I wrote the program, ARCSEP, which is included with Chapter 3.

The second half of Chapter 3 details an unsuccessful attempt to relate hotspot tracks to plumes riding passively in a whole mantle convection system. A program, MANTLE, was written to calculate the tracks based on a mantle convection model synthesized by Hager and O'Connell (1979). It also is included in Chapter 3. However, the predicted tracks did not fit the observed tracks very well. It was also hoped that a common depth of origin for all mantle plumes could be determined.

The last chapter of this dissertation examines the relatively limited field of ionium (Th-230) dating of igneous rocks. Several methods have been proposed to use this isotope for dating, but all these methods rest on assumptions that are not always valid. I therefore devised a new method that is free of these assumptions. The use of this method calls for a large number of computations and plotting the resultant data, so I wrote a program, IONIUM, specifically for this purpose. This program is an appendix to Chapter 4.

During the course of these studies, there were numerous people who provided invaluable assistance and comments, and deserve my thanks. These include my advisor, Win Means, and my other professors at the State University of New York at Albany, particularly Kevin Burke, John Dewey, Bill Kidd and Steve DeLong.

My colleagues, Dave Rowley, Sue Anderson, Celal Şengör, Eric Rosencrantz, Jack Casey and Don Videgar also provided useful discussions. I am particularly indebted to Severn Brown for his ideas and suggestions concerning the practical applications of refold theory. Chris Schoneveld drew Win Means and my attention to refolding, for which I am grateful. My wife, Daleah, willingly took on the task of proofreading this manuscript in its various stages, as well as provided invaluable assistance at every stage of my studies. Lastly, I wish to thank Mary Beth Frezon, Penchants calligraphy of Albany, for the unique title pages.

To Carolyn the cataloguer, who'll probably be the last person to lay eyes on this volume; have fun classifying it.

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