PETROLOGY, GEOCHEMISTRY AND TECTONIC SETTING OF SOME FLYSCH DEPOSITS

by

MUKUL RAJ BHATIA

Thesis submitted for the degree of
DOCTOR OF PHILOSOPHY

at the

AUSTRALIAN NATIONAL UNIVERSITY
December, 1981

Unless otherwise acknowledged, all data and interpretations in this thesis are my own.

M R Bhatia

M. R. BHATIA

ACKNOWLEDGEMENTS

I wish to thank Dr. K.A.W. Crook for his supervision and guidance throughout this project and for many helpful discussions.

I am grateful to Dr. B.W. Chappell for his guidance in the geochemical analysis and for writing innumerable computer programs. Dr. S.R. Taylor provided the facilities to carry out the rare earth element determinations in his laboratory. His suggestions and advice on various aspects of this study are gratefully acknowledged. I am also thankful to Dr. J. Veizer for helpful discussions.

I thank Drs. R. Cas, F. Von Vanderberg and J. Fawckner for their help in organizing the field work in various basins.

Expert instruction and assistance were given by R. Freeman and J. Wasik (chemical analysis), J.H. Pennington (X-ray diffraction), P. Oswald-Sealey and M. Shelley (spark source). I am thankful to P. Winer and K. Handel for their help in computing.

I am grateful to my colleagues D. Hough, S. McLennan, D. Walker and M. Alam for their suggestions and help.

This study was carried out while I held an Australian National University Research Scholarship and I am grateful to Dr. K.S.W. Campbell and Dr. M.J. Rickard for providing the necessary facilities.

I wish to express appreciation to Mrs Denese McCann for typing the various drafts with great skill.

I take great pleasure in acknowledging the forebearance, encouragement, and enormous help in tabulation and proof reading given by Florence. Finally, I am indebted to my parents for their understanding and inspiration.

ABSTRACT

The Paleozoic flysch sequences of eastern Australia show large variations in their mineralogical and geochemical compositions. On the basis of detrital mineralogy, the following five graywacke suites are recognized : Tamworth, Hill End, Hodgkinson, Bendigo and Cookman. The graywackes exhibit increasing maturity from the Tamworth to Cookman suites, characterised by an increase in quartz content and a decrease in lithic and feldspar grains. The graywacke suites are derived from dominantly andesitic, dacitic, crystalline, meta-sedimentary and sedimentary source rocks, respectively. The associated mudrocks are also characterized by variations in abundances of phyllosilicates and tectosilicates (feldspar and quartz). Three broad groups of mudrocks are recognized : tectic type (Tamworth suite); phyllo-tectic type (Hill End and Hodgkinson suites); and phyllic type (Bendigo and Cookman suites).

With the increase in mineralogical maturity, increasing geochemical differentiation is observed in the sedimentary suites, in the form of enrichment of Si and Zr in graywackes, and enrichment of large cations (K, Rb, Ba), Al-group (Al, Ga) and ferromagnesian elements (Cr, Ni, Zn) in mudrocks, and loss of small cations (Ca, Na, Sr) in solution. A close similarity is observed between the Th, U, Nb, La/Y, Zr, Sc/Ni, Ni/Co, La/Yb and rare earth element characteristics of graywacke suites and orogenic andesites from various tectonic settings. On this basis, the Tamworth suite is assigned to an oceanic island arc; the Hill End suite to a continental island arc; and the Hodgkinson suite to an Andean type tectonic setting . The Bendigo and Cookman suite graywackes are characterised by their highly quartzose nature and highly fractionated chemistry, suggesting their recycled nature and possibly a passive margin type of tectonic setting.

The major element geochemistry of arenites can be used to infer the provenance type and tectonic setting of sedimentary basins. In general, there is a progressive decrease in total Fe as Fe_2O_3+MgO;TiO_2; Al_2O_3/SiO_2 and an increase in K_2O/Na_2O and $Al_2O_3/(CaO+Na_2O)$ in arenites as the tectonic setting changes from oceanic island arc to continental island arc to Andean type to passive margins.

The trace element characteristics of sedimentary rocks show excellent signatures of provenance types and tectonic settings. The most useful elements are those which are relatively immobile, fractionate only in the clastics and have low residence times in sea water, e.g., Th, U, Nb, Zr, REE, Y, Sc and Co. Optimum discrimination of oceanic island arc, continental island arc, Andean type and passive margin tectonic settings is achieved by La-Th; Ti/Zr-La/Sc; La/Y-Sc/Cr; La-Th-Sc; Th-Sc-Zr/10; Th-Co-Zr/10; and Rb-V-Zr plots, for arenites. The trace elements in mudrocks also show characteristics of the tectonic setting and the most discriminating parameters are Th, Nb, U, Nb/Y, Th/U, Zr/Th and La/Sc.

The bulk oceanic island arc sedimentary composition is similar to the composition of the total crust, whereas the average Andean type-passive margin sedimentary composition is comparable to the upper continental crustal composition. The continental island arc sedimentary composition is intermediate. The change from oceanic island arc to continental island arc to Andean type and passive margin sedimentary compositions is similar to the change in the average compositions of sedimentary rocks from Archean through Proterozoic to Phanerozoic. This suggests a gradual mafic to felsic transition in crustal composition through geological time.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 6

CHAPTER 7

CHAPTER 8

CHAPTER 9

APPENDIX A

APPENDIX D

APPENDIX E