The Karikari Plutonics
of
Northland New Zealand

The petrology of an arc-type intrusion and its envelope

Richard Sean Ruddock

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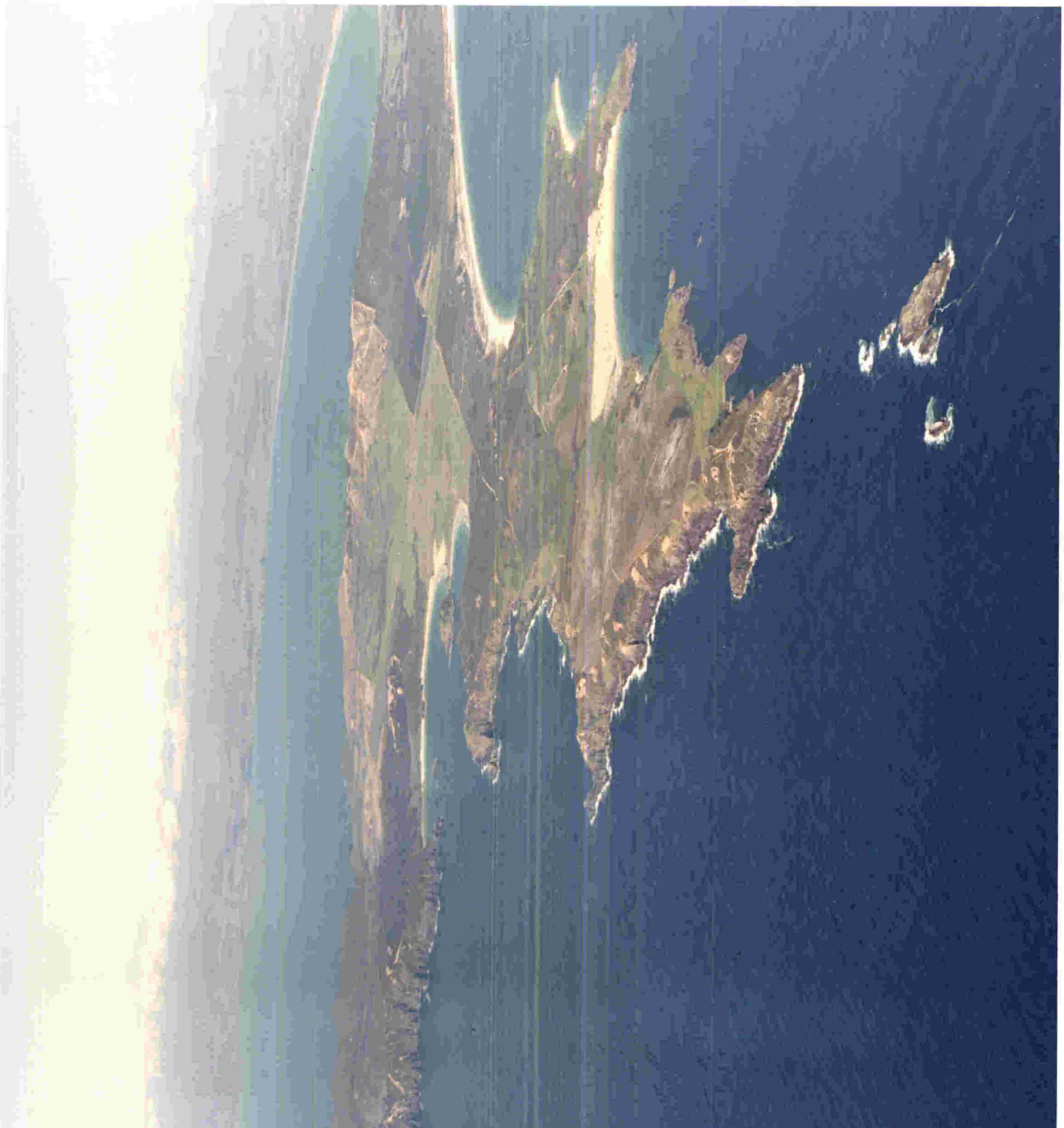
Frontispiece: Oblique aerial photograph looking south towards the Karikari Peninsula and Doubtless Bay (far distance). The rocky cliffs and island (Rocky Island) from the foreground into the right middle distance consist of plutonic and dyke lithologies of the Miocene Karikari Plutonics. The strong northwest-southeast structural control of igneous features can be seen in the overall elongation of the pluton and the numerous headlands and coves. Low areas and sand beaches consist of Late Tertiary to Holocene sediments. The high ground in the left middle distance consists of the Cretaceous country rock.



This thesis is dedicated to the memory of Doreen June Vazey (1931-1988)

ABSTRACT

The Karikari Plutonics are Early Miocene in age and consist of two plutonic bodies, with age relations delineated by cross- cutting relationships, and associated later stage dykes. The older pluton is a complex body exhibiting textural variability, cumulate-style crystallisation, varied enclaves (indicating complex magma chamber processes including convection and crystallisation along steeply-dipping, northwest oriented fronts) and a multi-phase structural and dyke intrusion history. Modal analysis shows this body to be diorite to quartz monzodiorite, and geochemically calc-alkaline and medium-K in nature.

In contrast the younger pluton is extremely homogeneous and intruded by a single, volumetrically sparse, dyke phase. Modally quartz monzonite to granite (adamellite), and high-K, calc- alkaline, this body has higher Si, K-group + Na, REE group and HFSE group elements than the older pluton. Mineral differences are confined to An contents in plagioclase, En values in orthopyroxenes and a wider range of Al in younger pluton hornblendes. Igneous differentiation can be modelled within the older pluton and between the older and younger bodies, by fractional crystallisation dominated by plagioclase, with subordinate ortho- and clino- pyroxene and oxide phases.

The dykes show a compositional range from basaltic andesite to dacite, with andesite volumetrically dominant. A temporal trend can be seen with younger dykes becoming more felsic and of greater volume, and changing orientation from northeast to northwest. Two subdivisions can be made based on the presence or absence of hornblende. Pyroxene only dykes are mostly medium-K and dominantly andesitic, whereas hornblende-bearing lithologies are both medium-K and high-K, are andesite and dacite, and appear to be more evolved chemically.

The rock envelope into which the Karikari Plutonics was intruded consists of Cretaceous-age basalts, rhyolites and sedimentary lithologies. Although a regular contact aureole is not exposed, the lowest grade of contact metamorphism is delineated by the first occurrence of biotite. Rocks equivalent to the hornblende hornfels facies are widespread and rare pyroxene hornfels are found adjacent to contacts. Alteration and veining, particularly prevalent in fault/shear zones, and the presence of a magmatic-hydrothermal type breccia are evidence for a hydrothermal system associated with the waning stages of Lower Miocene-age igneous activity on the Karikari Peninsula. Fluid inclusion and stable isotope data indicates the presence of fluids of both magmatic and meteoric origin.

The Karikari Plutonics are correlated with the arc-type regional association of Northland and the Coromandel Peninsula. The source of these rocks is broadly M-type, hydrous and involving subduction zone, and modified mantle wedge components, but with some unspecified crustal involvement indicated by Sr isotopes. Specifically this source is modelled, for the Karikari Plutonics, as having LREE enriched 2x relative to HREE and partially melting ($<$ 15% of the source) at the base of the crust ($\geq$30 km). These melts gave rise to the arc-type association either erupting at the surface, or ponding in upper crustal ($\leq$10 km) magma chambers.

PREFACE

This thesis was initiated as part of a MSc. study in 1986. In line with this objective approximately three months field work were spent on the Karikari Peninsula during the period November, 1986 to February, 1987. Midway through 1987 the research project was transferred into a PhD., and the scope of the thesis consequently broadened. The original focus was to be the geochemistry of the Karikari Plutonics. However, the doctoral research involved a widening to a more comprehensive study of the petrology of the Miocene calc-alkaline rocks centred about Doubtless Bay.

In addition the rock envelope surrounding the Karikari plutonic body was examined. This includes the study of late stage deuteric, contact metamorphic and hydrothermal aspects connected with the intrusion at Karikari Peninsula. A further month was spent in the field, in December, 1987, with these wider objectives in mind.

Other research relevant to this thesis, with which the author has been involved, include the Miocene rocks at North Cape, and those of the Cone Rock through Whangaroa Harbour coastline. Finally the MSc. study of Martin (1988, which included some of the area studied by Cooper, 1968) of the Miocene dykes and plutonics on the southern side of Doubtless Bay, completes the areal cover of research of the two northern centres of Miocene-age, arc-type activity. Two related papers, pertinent to this study are: Smith et al. (1989), which is a regional introduction to this activity; and, Ruddock and Spörli (1989), which outlines the structural aspects of the Karikari plutonic complex. Both these papers are bound into the back of this thesis, and serve as appendices to the following text.

This thesis, then, is the summary of all previous research, and presents a new body of data for the plutonic and hypabbysal rocks of the Karikari Peninsula and the country rocks into which they are intruded.

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I wish to thank my supervisors: the late Professor R.N. Brothers for his enthusiasm for this topic and in particular for the PhD. transfer, also for his help with "doing the boat-work"; to Professor P.M. Black, in particular for identifying all those "sheet silicates" and for dealing with all the red tape and paper work; and, to Dr. I.E.M. Smith, without whose help and ideas this project would have been only half finished.

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I am indebted to the Auckland University Research Committee which provided grants to enable my trip to Canberra to undertake INAA analysis, and to finance the stable isotope analyses undertaken at I.N.S., Wellington. Thanks to Professor Bruce Chappell (A.N.U.) and Dr. Doone Wyborn (B.M.R., Canberra) for thoughtful and fruitful discussions whilst I was in Canberra. A Northland thesis would not be complete without the 'laconic' comments of Dr. Fred Brook and Dr. Mike Isaac of the Geologic Survey of Auckland - thanks for the rides and no, all igneous rocks do not look the same ..!

In my last five years in the Graduate School at A.U. I have been fortunate enough to be associated with a fine group of fellow students - thanks for making life that much more enjoyable. In particular Hamish Martin is thanked for interesting discussions in the office and for help (?) in the field.

To the locals of the Far North, and Karikari Peninsula in particular, thank you for the permission to cross land, cups of tea, friendly advice (and not so friendly!), lifts and free beer.

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Finally, to my wife Sandra - thanks for all your love, understanding, patience and help, without which this thesis would not have been possible and the last four years not half as enjoyable . . .

Cheers

TABLE OF CONTENTS

Chapter 5

DYKES

Chapter 6

PHYSICAL ASPECTS OF THE KARIKARI PLUTONICS

Chapter 7

EMPLACEMENT AND MAGMA CHAMBER PROCESSES

Chapter 8

PETROGENESIS

ABBREVIATIONS

AFM - triangular diagram of total alkalis (Na+K=A), total iron (F) and magnesium (M)
Al_T - Total aluminium atoms per formula unit
An - anorthite
a.f.u. - atoms per formula unit
A.U.# - Auckland University rock number
Di - distribution coefficent for element i between crystal and liquid.
D.I. - differentiation index
En - enstatite
fO_2 - oxygen fugacity
Fs - ferrosilite
GR - grid reference
HFSE - high field strength element
HREE - heavy rare earth elements (Gd-Lu)
IAT - island arc tholeiites
INAA - instrumental neutron activation analysis
K_D - bulk distribution coefficent
LILE - large ion lithophile elements
LREE - light rare earth elements (La-Eu)
Ma - millions of years
Mg# - magnesium number
MORB - mid ocean ridge basalt
Or - orthoclase
P - pressure
P-MORB - plume-type MORB
ppm - parts per million
REE - rare earth element(s)
T - temperature
Usp - ülvospinel
Wo - wollastonite
wt% - weight percent
XRD - X-ray diffraction
XRF - X-ray fluorescence

Other abbreviations are standard for the SI metric units.