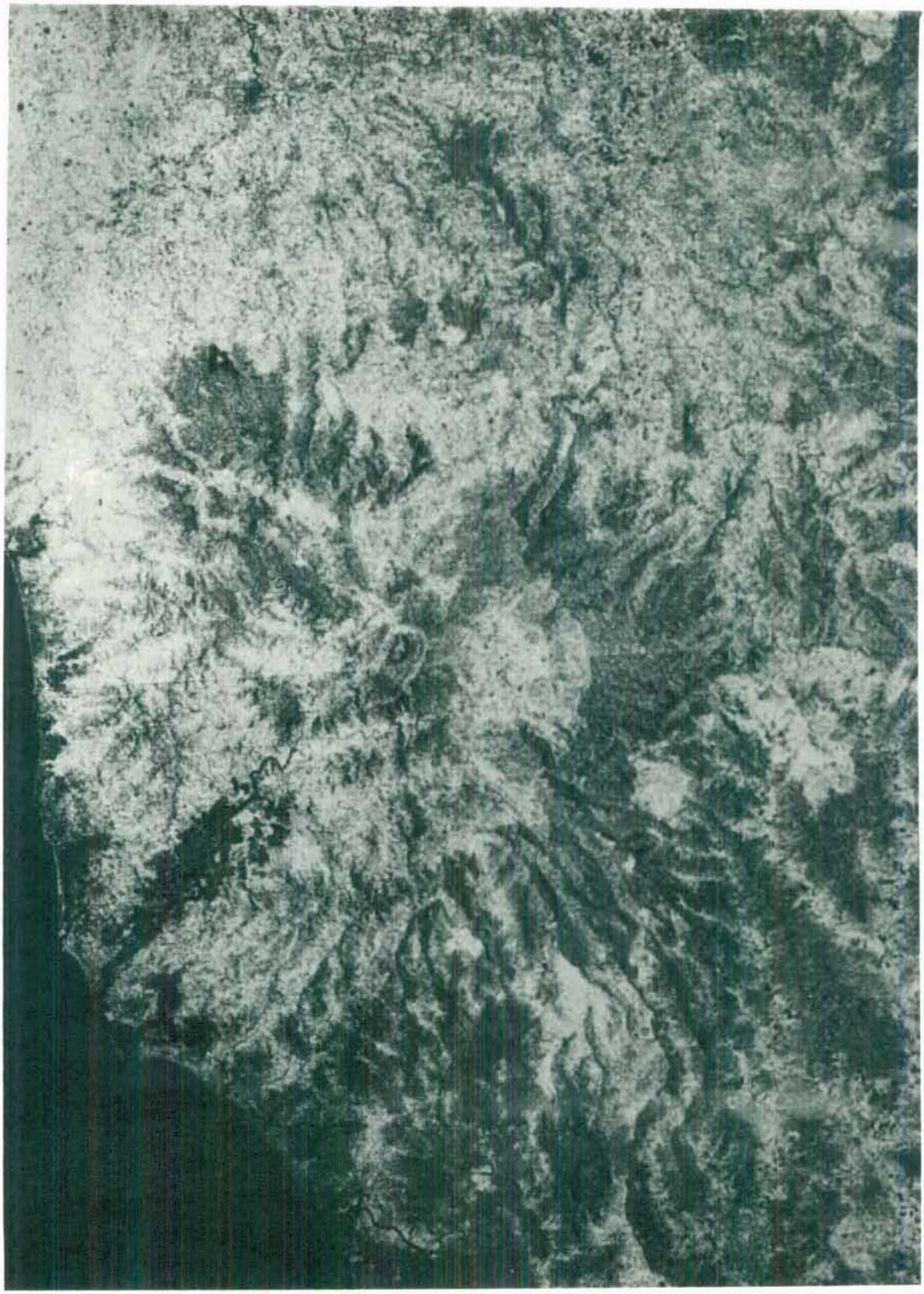
FRONTISPIECE

ERTS-A imagery of the Tweed Shield Volcano showing the radial drainage pattern, circular erosion caldera and central intrusive complex.



'It is possible that the story is <u>not</u> an invention'.

- Plato

THE MINERALOGY AND PETROLOGY OF THE SOUTHERN PORTION OF THE TWEED SHIELD VOLCANO, NCRTHEASTERN NEW SOUTH WALES

by

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I certify that this thesis has not been previously submitted in substance for any degree and that it is not being currently submitted for any other degree.

I further certify that any assistance in the preparation of this thesis, and all sources of information, have been formally acknowledged.

M.B. Duggan.

PREFACE

In 1968 Professor J.F.G. Wilkinson drew attention to the occurrence of tholeiitic rocks within the Tweed Shield Volcano and suggested that more than one lineage may be present. It was suggested to the author by Professor Wilkinson that a detailed mineralogical and chemical study of part of the Volcano would be of considerable interest.

An investigation was commenced in February, 1969 and this thesis presents the results of this project. With the exception of 7 major element analyses the author is responsible for all analytical results and conclusions. All technical assistance received during the study has been specifically cited in the Acknowledgements and Appendices. The results of all other workers are clearly acknowledged in the text.

A paper written in collaboration with Professor J.F.G. Wilkinson entitled "Tholeiitic andesite of high-pressure origin from the Tweed Shield Volcano, northeastern New South Wales" has been published in Contributions to Mineralogy and Petrology, Volume 39, pages 267-276, 1973.

ABSTRACT

In the southern portion of the Tweed Shield Volcano, north-eastern New South Wales, a sequence of alkaline rocks (the Kyogle Basalt) thins eastward where it is overlain by a subalkaline succession composed predominantly of tholeiitic andesite and rhyolite, with minor icelandite and rhyodacite (in stratigraphic sequence, the Lismore Basalt, Nimbin Rhyolite and Blue Knob Basalt).

On the basis of detailed mineralogical and chemical data, two distinct tholeiitic series have been recognised, respectively designated the low-Si series and the high-Si series. Members of the low-Si series (almost exclusively tholeiitic andesites) contain groundmass olivines but lack groundmass Ca-poor pyroxenes. In members of the high-Si series (tholeiitic andesite → rhyodacite), groundmass olivines are absent but Ca-poor pyroxenes occur as phenocryst and groundmass phases and commonly in reaction coronas around olivine phenocrysts. These differences reflect differing levels of silica saturation in the two series.

Rhyolites, including vitric and microcrystalline variants (the latter often resulting from devitrification), commonly contain phenocrysts of quartz, sanidine and minor oligoclase. Microphenocrysts of ferrohypersthene and ilmenite may also occur in these rocks.

Some rocks contain relatively high pressure pyroxenes and plagioclases. In the low-Si series the pyroxenes (bronzite and subcalcic augite), which are enriched in Al^{VI} relative to groundmass pyroxenes, crystallized at moderately high pressures (about 9 kb). In the high-Si

series, early-formed ferroaugites are not enriched in Al and these probably crystallized at substantially lower pressures (about 5 kb). The moderately high pressure plagioclases of both volcanic series are enriched in Na relative to groundmass plagioclases. They typically consist of a relatively sodic core surrounded by a zone of sieving and resorption which is in turn mantled by a thin rim of glassy, more calcic plagioclase.

Low silica activities inhibited the crystallization of Ca-poor pyroxenes in members of the low-Si series. The groundmass augites of this series exhibit increasing Ca contents with increasing Fe/Mg ratios of the pyroxenes and of their respective host rocks. This trend is interpreted as a response to a decrease in the activity of Fe^{2+} caused by a progressive increase in f_{O_2} through the series. Phenocrysts of ferroaugite commonly preceded more magnesian microphenocryst and groundmass pyroxenes in rocks of the high-Si series. This is attributed to a combined effect of Fe depletion in the host liquids through precipitation of ilmenite phenocrysts and increasing f_{O_2} in the liquids during ascent to near-surface conditions.

In the low-Si series, with increase in the degree of evolution of the host rocks there is a progressive change in the nature of the Fe-Ti oxide assemblage from ilmenite alone through ilmenite plus magnetite to magnetite alone. An R_2O_3-poor ilmenite is the dominant Fe-Ti oxide throughout the high-Si series and in the rhyolites. For most of the tholeiitic rocks, relatively low oxygen fugacities, estimated to be intermediate between the fayalite-magnetite-quartz and the wüstite-magnetite buffer assemblages, are inferred from the Fe-Ti oxide data.

The Fe and Or contents of plagioclases are discussed in relation to their environment of crystallization. Entry of Fe into plagioclase is favoured by rapid rates of crystallization. The Or contents of plagioclases are a function of host rock chemistries insofar as these control the location of the solidus-solvus intersection in the system Ab-An-Or.

The absence of primary hydrous phases, the abundance and sodic character of plagioclase phenocrysts and the predominance of ilmenite over magnetite in most of the rocks collectively indicate that the tholeiitic magmas were in general relatively water-deficient during intratelluric crystallization and subsequent eruption.

As a group the tholeiitic rocks comprise a relatively alkali rich suite (especially with respect to K_2O) exhibiting only moderate iron enrichment. The relatively high K contents of the mafic rocks possibly result from the breakdown of small amounts of phlogopite during partial melting in an inhomogeneous source region. With increasing degree of evolution there is a significantly stronger trend toward normative quartz enrichment in the high-Si series than in the low-Si series.

It is proposed that the low-Si series resulted from fractionation of a mafic tholeiitic parent at moderately high pressures (~9 kb) near the crust mantle boundary involving the removal of plagioclase and aluminian clinopyroxene together with, or followed by olivine. Fractionation of aluminian augite at elevated pressures prevented clinopyroxene from becoming a near liquidus phase at low pressures, thereby inhibiting its appearance as a low pressure phenocryst phase in most of the evolved members of the series.

The high-Si series probably developed through fractionation at intermediate depths in the crust (~5 kb) where the fractionating phases were olivine, ferroaugite, ilmenite and plagioclase. The two tholeiitic series may conceivably be related via a common parent magma, the contrasting chemical trends possibly reflecting fractionation under significantly different pressure regimes.

The origin of the rhyolitic magma is critically assessed. The available field and chemical data are more consistent with an origin involving extreme fractionation than with a crustal anatexis model. It is likely that the acid magma evolved through extreme fractionation of a more mafic parent at moderate crustal depths under relatively anhydrous conditions.

The origin of the Tweed Shield Volcano is briefly discussed in terms of a tectonic model involving plate movement over an upper mantle melting source.

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Mrs. R. Cuskelly patiently typed the final copy of the thesis.

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