

Melt Generation and Magma Chamber Processes in the Purico Complex and Implications for Ignimbrite Formation in the Central Andes

Inaugural-Dissertation

zur

Erlangung des Doktorgrades der Naturwissenschaften
durch den Fachbereich Geowissenschaften und Geographie
der Justus-Liebig-Universität Gießen

vorgelegt von

Diplom-Mineraloge

Axel Karl Schmitt

aus Ilbenstadt

Scientific Technical Report STR99/18

Table of contents

| | |
|---|----|
| EINFÜHRUNG UND ZUSAMMENFASSUNG IN DEUTSCHER SPRACHE | 1 |
| ABSTRACT | 8 |
| TABLE OF CONTENTS | 10 |
| LIST OF FIGURES | 11 |
| LIST OF TABLES | 13 |
| GEOLOGICAL INTRODUCTION, PREVIOUS WORK AND SCOPE OF THE STUDY | 14 |
| CHAPTER 1 MAGMATIC PROCESSES IN THE PURICO MAGMA CHAMBER AND IMPLICATIONS FOR THE SOURCE OF MONOTONOUS IGNIMBRITES | 19 |
| INTRODUCTION | 19 |
| FIELD RELATIONS IN THE PURICO COMPLEX | 20 |
| STRATIGRAPHY AND PUMICE TYPES | 21 |
| <i>The Lower Purico Ignimbrite I</i> | 21 |
| <i>The Lower Purico Ignimbrite II</i> | 22 |
| <i>The Upper Purico Ignimbrite</i> | 22 |
| <i>Dacitic pumice</i> | 22 |
| <i>Crystal-rich inclusions</i> | 23 |
| <i>Rhyolitic pumice</i> | 23 |
| <i>Andesitic and banded pumice</i> | 23 |
| <i>Lavas</i> | 23 |
| VOLUMES AND PHYSICAL VOLCANOLOGY | 23 |
| MINERALOGY, MINERAL AND GLASS COMPOSITIONS..... | 25 |
| <i>Andesitic and banded pumice</i> | 25 |
| <i>Dacitic pumice</i> | 25 |
| <i>Rhyolitic pumice</i> | 26 |
| <i>Upper Purico tuffs</i> | 26 |
| <i>Dome D lavas</i> | 26 |
| <i>Mineral-melt partition coefficients</i> | 26 |
| PRESSURE, TEMPERATURE AND VOLATILE CONDITIONS IN THE PURICO MAGMA CHAMBER | 30 |
| GEOCHEMISTRY | 32 |
| COMPOSITIONAL VARIATION IN THE PURICO MAGMA CHAMBER: A PETROGENETIC MODEL | 36 |
| <i>Generation of compositional layering by fractional crystallization</i> | 36 |
| <i>Open system processes - recharge of andesitic magma</i> | 39 |
| <i>Fractionation processes: gradual versus instantaneous</i> | 40 |
| <i>Mixing and mingling in magma chambers</i> | 41 |
| <i>Styles of compositional zonation in the central Andes</i> | 42 |
| CONCLUSIONS | 43 |
| CHAPTER 2 PRE-ERUPTIVE VOLATILE CONTENTS OF IGNIMBRITE-FORMING MAGMAS IN THE CENTRAL ANDES - THE PURICO COMPLEX, N-CHILE | 44 |
| INTRODUCTION | 45 |
| METHODOLOGY AND EXAMPLES OF PREVIOUS MELT INCLUSION STUDIES | 45 |
| GEOLOGICAL BACKGROUND..... | 46 |

| | |
|---|------------|
| METHODS..... | 47 |
| RESULTS | 48 |
| <i>Petrography of melt inclusions</i> | 48 |
| <i>Major and trace element composition of inclusion and matrix glasses</i> | 52 |
| <i>Water and CO₂ contents</i> | 53 |
| <i>Fluorine, Chlorine and Sulfur</i> | 56 |
| DISCUSSION | 57 |
| <i>Magmatic volatiles inferred from melt inclusion studies</i> | 57 |
| <i>Volatiles and eruptive style</i> | 58 |
| <i>General implications for APVC ignimbrite magmatism - a synthesis</i> | 59 |
| SUMMARY AND CONCLUSIONS | 61 |
| CHAPTER 3 PETROGENESIS OF APVC IGNIMBRITES | 62 |
| INTRODUCTION AND AIMS OF THIS SECTION | 62 |
| STRATIGRAPHY, PETROGRAPHY, MINERALOGY, PRE-ERUPTIVE T, P AND VOLATILE CONDITIONS..... | 62 |
| <i>San Bartolo Group</i> | 63 |
| <i>Silapeti Group</i> | 67 |
| <i>Pressure, Temperature and Volatile contents</i> | 68 |
| GEOCHEMISTRY | 72 |
| GEOCHEMICAL MODELS FOR IGNIMBRITE PETROGENESIS | 76 |
| <i>Previous models</i> | 76 |
| <i>Crustal and mantle components</i> | 77 |
| <i>Evidence for crustal melting in the central Andes</i> | 78 |
| <i>Crustal contribution to APVC ignimbrite magmas</i> | 79 |
| DISCUSSION | 82 |
| <i>New insights into magma generation</i> | 82 |
| <i>Comparison with other areas of large scale ignimbrite magmatism</i> | 83 |
| SUMMARY AND CONCLUSIONS | 83 |
| CHAPTER 4 MICROANALYTICAL TECHNIQUES APPLIED IN MELT INCLUSION STUDIES | 85 |
| GENERAL | 85 |
| SAMPLE PREPARATION | 86 |
| ELECTRON MICROPROBE ANALYSIS..... | 86 |
| ION MICROPROBE ANALYSIS..... | 88 |
| FOURIER-TRANSFORM INFRARED SPECTROSCOPY | 90 |
| PRECISION AND ACCURACY FOR VOLATILE DETERMINATIONS..... | 91 |
| MELT INCLUSION VOLATILES COMPARED TO PHASE EQUILIBRIA ESTIMATES | 96 |
| <i>Natural rock phase diagrams</i> | 96 |
| <i>The plagioclase-melt equilibrium geohygrometer (HOUSH&LUHR 1991)</i> | 96 |
| <i>The MERZBACHER & EGGLEER (1984) geohygrometer</i> | 97 |
| CONCLUSIONS..... | 98 |
| LIST OF EQUATIONS | 99 |
| REFERENCES | 100 |
| APPENDIX A METHODOLOGY | |
| APPENDIX B DATA TABLES | |