The role of substrate hydrogeology and surface hydrology in the construction of phreatomagmatic volcanoes on an active monogenetic field (Auckland, New Zealand)

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Abstract

Phreatomagmatic activity is pervasive in the Auckland Volcanic Field (AVF) with more than two thirds of the erupted volcanoes showing this type of activity at different degrees, dominantly at the onset of their eruptive histories. In general, the volcanoes built in the northern AVF rest on Late Miocene Waitemata Group rocks (turbiditic siltstone and sandstone succession), whereas in the southern AVF the Waitemata rocks are overlain by tens of metres of Plio-Pleistocene, water-saturated sediments (Tauranga Group and Kaawa Formation). Identifying the control exerted by the type of substrate in the eruption dynamics of the phreatomagmatic phases of three volcanoes in the AVF is the objective of this study. The stratigraphic, sedimentary, and pyroclast characteristics of the phreatomagmatic sequences of Maungataketake, Motukorea, and North Head volcanoes, together with supplementary information on the geology and hydrogeology of the area, were investigated to solve the problem. Three phreatomagmatic eruptive scenarios were outlined. Scenario 1 (Maungataketake eruption) and Scenario 2 (Motukorea eruption) depict the formation of maar-diatreme volcanoes in the southern and northern AVF, respectively. The dominant presence of lithics from the upper part of the substrate in their tephra rings suggests the construction of their tephra rings from shallow-seated explosions. Due to the water-saturated sediments filling the diatreme in Scenario 1, the eruption appears to have remained relatively wet throughout. Conversely, the drier Waitemata rocks involved in Scenario 2 promoted a progressive drying of the eruption. Scenario 3 (North Head eruption) represents a Surtseyan eruption scenario in which the rising magma erupted to the shallow sea floor (a few metres-water depth), promoting rapid chilling and explosive fragmentation. This study shows that the characterization of lithics within the tephra ring and the geological and hydrogeological information provide valuable clues to envisage the degree of influence of the substrate in the phreatomagmatic eruption dynamics. Other studies in the AVF appear to confirm this view. It is proposed that any future phreatomagmatic eruption in the AVF will be strongly influenced by the substrate hydrogeology and geology, as well as the surface hydrological conditions.

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Table of contents

Page

Abstract ... *i*
Acknowledgements ... *iii*
Table of contents ... *v*
List of figures ... *ix*
List of tables ... *xi*

Chapter 1. Introduction ... **1**
1.1 Introduction ... 1
1.2 Study site, motives, and objectives ... 3

Chapter 2. The principles of phreatomagmatism ... **5**
2.1 Introduction ... 5
2.1.1 Terminology ... 6
2.2 Monogenetic volcanism ... 7
2.3 Generalities on explosive water-magma interaction ... 8
2.3.1 Magma fragmentation and resulting juvenile pyroclasts ... 8
2.3.2 Host rock disruption and resulting lithics ... 10
2.3.3 Transport and deposition of pyroclasts ... 11
2.3.4 Resulting landforms and deposits ... 13
2.4 Controls on phreatomagmatic eruptions ... 14
2.4.1 Overview on kimberlite pipes in the substrate context ... 16
2.5 Conclusions ... 18

Chapter 3. Geological and hydrogeological setting ... **19**
3.1 Introduction ... 19
3.2 Geological and tectonic setting of the AVF ... 21
3.3 The AVF hydrogeology ... 26
3.3.1 The Waitemata Group ... 26
3.3.2 Basin filling Pliocene sediments: The Kaawa formation ... 26
3.3.3 Pliocene to Holocene basin filling sediments: The Tauranga Group ... 27
3.4 Understanding of the hydrogeological conditions at the time of the eruptions ... 27
3.5 Conclusions ... 28

Chapter 4. Methodology ... **29**
4.1 Introduction ... 29
4.2 Field work ... 29
4.3 Sample preparation and analysis ... 31

Chapter 5. Reconstruction of the Maungataketake phreatomagmatic eruption and implications of the substrate **33**
5.0 Preface 33
5.1 Introduction 34
5.1.1 Maungataketake age 36
5.2 Geological and hydrogeological setting 37
5.3 General architecture of Maungataketake volcano 38
5.4 Methods and terminology 39
5.5 Results 44
5.5.1 Stratigraphy and sedimentary characteristics of the maar ejecta ring deposits 44
5.6 Eruption reconstruction 49
5.6.1 Phase 1. Vent opening and shallow explosions 49
5.6.2 Phase 2. Excavation into the Waitemata Group rocks 51
5.6.3 Phase 3. Shallow-seated explosions 51
5.6.4 Phase 4. Vent stabilization and waning of eruption 54
5.7 Maungataketake whole rock and glass chemistry 54
5.8 Discussion 56
5.8.1 Magma fragmentation and host rock disruption 56
5.8.2 Water availability within the host material 57
5.8.3 Unconsolidated water-saturated sediments and FCI 57
5.8.4 Duration and waning of the phreatomagmatic eruption 59
5.9 Conclusions 59
Statement of contribution to doctoral thesis containing publications 61

Chapter 6. Reconstruction of the Motukorea phreatomagmatic eruption and implication of the substrate **63**
6.0 Preface 63
6.1 Introduction 64
6.2 The Auckland Volcanic Field and the Waitemata Group rocks 65
6.3 General architecture of Motukorea volcano and local substrate setting 66
6.4 General terminology 67
6.5 Methodology 68
6.5.1 Field work and deposit characterization 68
6.5.2 Sample preparation and analysis 72
6.6 Results: Pyroclast characteristics 74
6.7 Sedimentary characteristics of maar ejcta ring formation 75
6.7.1 Lower Tuff Sequence (LTS) 76
6.7.2 Mid Scoria Unit (MSU) 78
6.7.3 Upper Tuff Sequence (UTS) 78
6.8 Discussion 79
6.8.1 Depth of explosions associated with the opening of vent and magma fragmentation 79
6.8.1.1 Magma fragmentation 80
6.8.2 Assumptions of substrate disruption based on volumes and nature of lithics: evidence for shallow-seated explosions 80
6.8.3 The reconstruction of Motukorea maar 83
6.8.3.1 The first phreatomagmatic stage (LTS 83
6.8.3.2 A change in eruptive style (MSU 83

6.8.3.3 The second phreatomagmatic phase (UTS) and termination of phreatomagmatism 83
6.9 Conclusions 84
Statement of contribution to doctoral thesis containing publications 86

Chapter 7. Reconstruction of the North Head (Maungauika) Surtseyan eruption and implications of the hydrological conditions **87**
7.0 Preface 87
7.1 Introduction 88
7.2 Surtseyan volcanism 89
7.3 The AVF and the North Head (Maungauika) tuff cone 90
7.3.1 The Auckland Volcanic Field 90
7.3.2 North Head (Maungauika) tuff cone 91
7.4 General terminology and methodology 91
7.4.1 Field work 91
7.4.2 Laboratory work 92
7.5 Results: North Head eruptive products 93
7.5.1 Pyroclast characteristics 97
7.5.2 Lithofacies 98
7.6 Tuff cone construction and eruption dynamics 101
7.6.1 Phreatomagmatic subunit 1 (PH1) 101
7.6.2 Phreatomagmatic subunit 2 (PH2) 102
7.6.3 Phreatomagmatic subunit 3 (PH3) 102
7.6.4 Phreatomagmatic subunit 4 (PH4) 102
7.7 Water influence on magma fragmentation 103
7.8 North Head volcano and Surtseyan activity in the AVF context and hazard implications 103
7.9 Conclusions 105
Statement of contribution to doctoral thesis containing publications 107

Chapter 8. Discussion and conclusions **109**
8.1 Introduction 109
8.2 Highlights of the studied cases (Chapters 5, 6, and 7) 111
8.2.1 Eruption scenarios 111
8.2.1.1 Scenario 1: the formation of Maungataketake maar-diatreme volcano 111
8.2.1.2 Scenario 2:.the formation of Motukorea maar-diatreme volcano 111
8.2.1.3 Scenario 3: the formation of North Head tuff cone volcano 112
8.2.2 Integration of results 112
8.2.2.1 Eruptive centres and types of deposits 112
8.2.2.2 Characteristics, percentage and distribution of pyroclasts 114
8.2.2.3 Local eruptive settings and environmental conditions 114
8.2.2.4 The inferences on eruptive styles and the waning of the phreatomagmatic phase 115
8.3 Discussion 116
8.3.1 What do pyroclasts reveal? 116
8.3.1.1 Juvenile fragments: witnesses of magma fragmentation? 116
8.3.1.2 Lithics: a window to the substrate 117
8.3.2 Deep versus. shallow excavation (Valentine and White model, and Lorenz model) 118
8.3.3 The relevance of the substrate and surface hydrological conditions 120
8.3.4 Hazard implications 122

8.3.5 Conclusions....124

References....**127**

List of Appendices (information contained on CD)....**145**

List of Figures

Page

Fig. 2.1 Schematic cross-section of erupting maar-diatreme and tuff cone volcanoes, and of the volcanoes after eruption when the craters have been partially filled with sediments **8**

Fig. 2.2 Main morphological types of juvenile fragments found by experimental results of explosive interaction of magma with water **10**

Fig. 2.3 Generalized schematic cross-section of a dilute pyroclastic density current (base surge). **11**

Fig. 3.1 The AVF with the location of Maungataketake, Motukorea, and North Head volcanoes, along with other volcanoes **20**

Fig. 3.2 Generalized regional stratigraphic column of the lithologies found beneath the AVF **22**

Fig. 3.3 Simplified geology map from the area surrounding the Auckland region **23**

Fig. 5.1. Plan view of Maungataketake volcano showing five key sites (M1 to M5) **35**

Fig. 5.2. Schematic correlation of logs and identified units **41**

Fig. 5.3 Modal analysis and long axis of vesicles graphs **42**

Fig. 5.4. Stereo light microscope, plane-polarised, and scanning electron microscope images **46**

Fig. 5.5. Photographs and corresponding logs for key sites M1 to M5 .... **50**

Fig. 5.6. Photographs showing the lithofacies and boundaries between units in detail **52**

Fig. 5.7. Cartoons that represent a simplified model of the Maungataketake eruption history. **53**

Fig. 5.8. Major element (wt.%) variation diagrams **55**

Fig. 6.1. Aerial photograph of Motukorea volcano. **66**

Fig. 6.2. Stratigraphic sequence at *S1* **69**

Fig. 6.3 Stratigraphic sequence at *S2a/S2b* **71**

Fig. 6.4 Stratigraphic sequence at *S3* **72**

Fig. 6.5 Stratigrapic correlation between *S1*, *S2a/S2b*, and *S3* **73**

Fig. 6.6 Stereo light microscope, plane-polarised, and scanning electron microscope images **74**

Fig. 6.7 Close-upview of lithofacies. **76**

Fig. 6.8. Cartoons representing a simplified model of the Motukorea eruption history **82**

Fig. 7.1 Elevation and depth map and plan view of North Head volcano **89**

Fig. 7.2. Segment of the phreatomagmatic subunit PH1 and stratigraphic log **93**

Fig. 7.3. Stratigraphic sequence and log that contains the phreatomagmatic subunit PH2 .... **94**

Fig. 7.4. Stratigraphic sequence and log that contains the phreatomagmatic subunit PH3 .... **95**

Fig. 7.5. Segment of the phreatomagmatic subunit PH4 and stratigraphic log **96**

Fig. 7.6. Close-up view of the six lithofacies identified within the North Head sequence. **96**

Fig. 7.7 Stereo light microscope, plane-polarised, and scanning electron microscope images **98**

Fig. 7.8 Cartoons representing a simplified model of the North Head eruption history and construction.. **101**

Fig. 8.1 Schematic and simplified representation of the models of the three phreatomagmatic eruptive scenarios for similar settings in the Auckland Volcanic Field **110**

Fig. 8.2 Schematic and simplified representation of Lorenz model (1986) and its revised version proposed by Valentine and White (2012) 119

List of Tables

Page

Table 5.1 Nomenclature of Maungataketake deposit types and grain size **43**

Table 5.2 Lithofacies of Maungataketake deposits **47**

Table 5.3 Lithostratigraphic units of Maungataketake deposits.. **48**

Table 6.1 Nomenclature of Motukorea deposit types and grain size **70**

Table 6.2 Lithofacies of Motukorea deposits.. **77**

Table 7.1 Nomenclature of North Head deposit types and grain size **92**

Table 7.2. Lithofacies of North Head **99**

Table 8.1 Summary of the general morphometric, stratigraphic, sedimentary, and pyroclast characteristics of the studied volcanoes **113**