

R.V. Fisher · H.-U. Schmincke

Pyroclastic Rocks

With 339 Figures



Springer-Verlag
Berlin Heidelberg New York Tokyo 1984

Contents

Chapter 1 Introduction

The Sedimentary Record: Volcanic Contribution	3
Chemical Composition of Tephra	6
Types of Pyroclastic Accumulations	8

Chapter 2 Volcanoes, Volcanic Rocks and Magma Chambers

Tectonic Setting of Volcanoes	11
Divergent Margins	12
Convergent Margins	13
Intraplate Volcanoes	14
Form of Volcanoes	15
Origin of Magmas and Classification of Volcanic Rocks	16
Basaltic Magmas	17
Basalts	18
Andesite-Suite Magmas	20
Andesites	20
Differentiated Magmas	21
Magma Chambers	22
Volumes of Magma Chambers	22
Zonation in Magma Chambers	23
Large Calcalkalic Systems	27
Small Highly Alkalic Systems	30
Oceanic Rhyolite-Basalt Systems	33
Very Small Mafic-Intermediate Magma Systems	33

Chapter 3 Magmatic Volatiles and Rheology

Volatiles	35
Methods of Determining Volatiles	36
Composition and Amount of Volatiles	37
Water 38 – Carbon Dioxide 43 – Sulfur 47	
Volatile Distribution in Magma Columns	48
Rheology	51
Viscosity	52
Vesiculation	55

Chapter 4 Explosive Volcanic Eruptions

Types of Volcanic Activity	59
Types of Eruptions	60
Pyroclastic Eruptive Systems	61
Eruption Columns	61
Plinian Eruptions and Eruption Columns	63
Hawaiian and Strombolian Eruptions	69
Observations 69 – Eruptive Mechanisms 69	
Hydroclastic Eruptive Processes	74
Formation of Glassy Pyroclasts	75
Granulation	77
Inhibition of Vesiculation	77
Transfer of Heat	78
Steam Eruptions	78
Magma-Water Mixing and Fuel-Coolant Interaction	80
Phreatic and Phreatomagmatic (Vulcanian) Eruptions	82
Volcanic Energy	85

Chapter 5 Pyroclastic Fragments and Deposits

General Components	89
Vitric Particles and Pyrogenic Crystals	96
Glass Shards	96
Shards Formed by Vesiculation	96
Pumice	103
Pyrogenic Minerals	103
Surface Textures of Minerals and Shards	105
Structure	107
Pyroclastic Bed or Stratum	107
Graded Bedding	109
Cross Bedding	110
Massive Beds	114
Alignment and Orientation Bedding	114
Penecontemporaneous Deformation Structures	115
Texture	116
Grain Size and Size Distribution	116
Distribution Curves	118
Shape and Roundness	122
Fabric	123

Chapter 6 Subaerial Fallout Tephra

Components of Subaerial Fallout	128
Areal Distribution	132
Distribution and Thickness	132
Volume	139

Structures	141
Bedding	141
Mantle Bedding	144
Graded Bedding	148
Fabric	148
Size Parameters	150
Maximum Size of Components	150
Median Diameter	151
Grain-Size Distribution (Sorting)	153
Eolian Fractionation	156

Chapter 7 Submarine Fallout Tephra from Subaerial Eruptions

Chemical Composition	163
Structures of Submarine and Lacustrine Ash Layers	166
Areal Thickness Distribution and Volume	168
Grain Size and Sorting	173
Regional Distribution and Tephrochronology	176
Source	176
Correlation and Age	177
Pacific Region	179
Atlantic Region	182

Chapter 8 Pyroclastic Flow Deposits

Historic Development of Concepts	187
The Deposits	192
Volume	192
Relationship to Topography	193
Flow Units and Cooling Units	195
Components	197
Primary Structures in Unwelded Deposits	198
Internal Layering 198 – Gas-Escape Structures 200	
Emplacement Facies	203
Texture	206
Pyroclastic Flow Deposits 207 – Pyroclastic Surge	
Deposits 208 – Segregation of Crystals and Lithics 208	
Chemical Composition	209
Temperature Effects	210
Measured Temperatures 210 – Inferred Temperatures	
211 – Welding and Compaction 213 – Structures	
Related to Temperature and Viscosity 215	
Thermoremanent Magnetism	218
Classification and Nomenclature	218

The Flows	222
Origin	222
Transport and Mobility	225
Tufolavas, Froth Flows, Foam Lavas and Globule Flows	227
Ignimbrite Vents: Speculation	230

Chapter 9 Deposits of Hydroclastic Eruptions

Definition of Terms	231
Components of Hydroclastic Deposits	234
Grain Size Distribution	234
Characteristics of Essential Components	235
Accretionary Lapilli	238
Accidental Clasts	239
Maximum Size of Fragments Related to Energetics	239
Ultramafic Xenoliths	241
Structures	242
Penecontemporaneous Soft Sediment Deformation	242
Vesicles (Gas Bubbles)	242
Bedding Sags	245
Mudcracks	246
Base Surge Deposits	247
Bed Forms from Base Surges	249
Sandwave Beds 250 – Plane-Parallel Beds 254 –	
Massive Beds 254	
Bed Form Facies	254
U-Shaped Channels	256
Maar Volcanoes	257
Classification	257
Origin	258
Dimensions	260
Areal Extent and Geometry 260 – Volume 261	
Chemical Composition	262
Littoral Cones	263
Deposits	263
Origin	264
Peperites	264

Chapter 10 Submarine Volcaniclastic Rocks

Deep Water Stage	265
Pillow Breccias	267
Fine-grained Hyaloclastites	270
Shoaling Submarine Volcano	274
Transition Submarine – Subaerial	275
Volcaniclastic Aprons	276

Silicic Submarine Eruptions	279
Subaqueous Pyroclastic Flows	281
Terminology	285
Nonwelded Deposits	285
Environment of Deposition	285
Components	285
Grain Size, Sorting and Fabric	287
Bedding and Grading	287
The Massive Lower Division 289 – Upper Division 290	
Relationship to Eruptions and Eruptive Centers	292
Welded Deposits	293
Discussion	294

Chapter 11 Lahars

Debris Flows as Fluids	298
Distribution and Thickness	299
Surface of Lahars	301
Basal Contact of Lahars	302
Components of Lahars	303
Grain-Size Distribution	303
Vesicles	306
Grading	307
Fabric	308
Comparison of Lahars with Other Kinds of Coarse-Grained	
Deposits	309
Origin	309

Chapter 12 Alteration of Volcanic Glass

Diagenesis	312
Alteration of Basaltic Glass	314
Palagonite	314
Physical Properties 315 – Textural Changes 315 –	
Mineralogical Changes 317 – Zeolites 318 –	
Chemical Changes 320	
Process of Palagonite Formation	323
Rate of Palagonitization	326
Alteration of Silicic Glass	327
Hydration and Ion Exchange	327
Advanced Stages of Alteration	329
Saline Alkaline Lake Environment	330
Marine Environment	333
Bentonites and Tonsteins	336
Burial Diagenesis and Metamorphism	340

Chapter 13 Stratigraphic Problems of Pyroclastic Rocks

Relation of Volcanic Activity to Rock Stratigraphy	347
Volcanic Activity Units	347
Eruption Unit	349
Stratigraphic Problems in Young Volcanic Terranes	350
Stratigraphic Nomenclature in Older Volcanic Terranes	350
Tephrochronology	352
Volcanic Facies	356
Facies Based upon Position Relative to Source	356
Near-Source Facies 358 – Intermediate-Source Facies 359 – Distant-Source Facies 359 – Caldera Facies 359	
Facies Based upon Environment of Deposition	361
Facies Based upon Primary Composition	361
Compositional Facies 362 – Petrofacies 365	
Diagenetic Rock Facies 365	
Stratigraphic Examples	367
Oshima Volcano, Japan	368
San Juan Volcanic Field, USA	371
Archean Greenstone-Belt Volcanoes, Canada	378

Chapter 14 Pyroclastic Rocks and Tectonic Environment

Convergent Margins, Magmatic Arcs, and Sedimentation	383
The Trench	386
Fore-Arc and Back-Arc Basins	391
The Cordilleran System	392
Western North America: Paleozoic Rocks 392 –	
Southern South America: Upper Mesozoic Flysch 396 –	
Cenozoic Tectonism and Volcanism: Western North America 398	
Oceanic Island Arc Settings	400
Volcaniclastic Rocks and Facies; Cenozoic 400 –	
Lau Basin and Tonga Arc 405 – Lesser Antilles Arc 405	
The Pre-Cambrian	408
<i>References</i>	410
<i>Subject Index</i>	449
<i>Locality Index</i>	465