Contents

Introduction 1
References 7

1 Sea-Floor Topography and Morphology of the Superswell Region 9
1.1 Introduction 9
1.2 Data Sources and Methods 12
1.3 Sea-floor Morphology in French Polynesia 15
1.3.1 Bathymetric Expression of the Superswell 15
1.3.2 Midplate Swells 17
1.3.3 Plate Boundary Features 18
1.3.4 Off-Ridge Features 20
1.4 Conclusions 25
Acknowledgements 26
References 26

2 Seismicity of the Society and Austral Hotspots in the South Pacific: Seismic Detection, Monitoring and Interpretation of Underwater Volcanism 29
2.1 Introduction 29
2.2 Seismic Waves Used 30
2.2.1 Seismic Tremors 32
2.2.2 *T* Waves 34
2.3 Volcano-Seismic Activities on the Society Hotspot 35
2.3.1 Generalities and Chronological Events 35
2.3.2 The Over-All Seismicity of the Society Hotspot 37
2.3.3 Seismic Detection, Magnitude and Seismic Moment 38
2.3.4 Overview of the Swarms 39
2.3.5 Evolution of the Swarms and Nature of the Recorded Events 45
2.3.6 Frequency-Magnitude Relationship 52
2.3.7 Seismic and Magmatic Activity in the Society Hotspot Volcanoes 55
2.4 Volcano-Seismic Activity of the Austral Hotspot: Macdonald Seamount 59
2.4.1 Seismic Swarms 60
2.4.2 Bathymetric Surveys of the Macdonald Seamount 63
2.5 Summary and Conclusions 65
2.5.1 Society Hotspot 67
2.5.2 Austral Hotspot 68
2.5.3 General Conclusions 69
Acknowledgements 70
References 70

3 A Global Isostatic Load Model and its Application to Determine the Lithospheric Density Structure of Hotspot Swells 73
3.1 Introduction 73
3.2 Isostasy of the Lithospheric Plate 74
3.2.1 Lithostatic Load 74
3.2.2 The Generalized Equation of Isostatic Load 76
3.3 Reference Model 80
3.3.1 Compensation Depth 80
3.3.2 Lithospheric Density 82
3.3.3 Location of the Reference Column 84
3.4 Lithospheric Density Structure of Hotspot Swells 95
3.4.1 Introduction 95
3.4.2 French Polynesia, South Pacific Super Swell 96
3.4.3 Hawaiian-Emperor Island Chain 102
3.4.4 Mascarene-Réunion Hotspot Track 109
3.4.5 Ascension Island 112
3.4.6 The Great Meteor and Josephine Seamounts 116
3.4.7 Iceland 120
3.5 Subsidence of Hotspot Structures 133
3.6 Conclusions 136
Acknowledgements 136
References 137

4 Origin of the 43 Ma Bend Along the Hawaiian-Emperor Seamount Chain . 143
4.1 Introduction 143
4.2 The Emperor Seamount Chain Paradox 145
4.2.1 Paleomagnetic Interpretations 145
4.2.2 A Simple Test 146
4.2.3 The E-SMC Paradox and Solution 148
4.3 The Origin of the 43 Ma Bend 148
4.3.1 Reasoning Towards a Preferred Model 148
4.3.2 "Trench Jam" at 43 Ma Caused by the Arrival of Hawaiian Plume Head/Oceanic Plateau 149
4.3.3 Evidence Versus Coincidence 151
4.4 Summary and Conclusion 152
Acknowledgements 153
References 153

5 South Pacific Intraplate Volcanism: Structure, Morphology and Style of Eruption 157
5.1 Introduction 157
5.2 Society Hotspot 158
5.2.1 Abyssal Hill Region and Limits of Hotspot Volcanism 161
5.2.2 The Sea Floor ("Bulge") Around the Hotspot Edifices 163
5.2.3 The Volcanic Edifices of the Society Hotspot 165
5.3 Austral Hotspot 175
5.3.1 The Submarine Edifices of the Austral Hotspot 175

5.4 Pitcairn Hotspot ... 178
5.4.1 Volcanic Edifices of the Pitcairn Hotspot ... 180
5.4.2 The Distribution and Extent of Hotspot Volcanism ... 187
5.5 Hotspot Versus Non-Hotspot Volcanoes ... 190
5.5.1 Sea-Floor Lineation and Seamount Distribution ... 191
5.5.2 Morphological Classification of Intraplate Volcanoes ... 194
5.6 Style of Eruption and Formation of Hotspot Edifices ... 197
5.6.1 Types of Eruption ... 197
5.6.2 The Formation of a Volcanic Edifice ... 198
5.6.3 Relationship Between Hotspot Volcanic Edifices ... 200
5.7 Summary and Conclusions ... 201
Acknowledgements ... 203
References ... 203

6 Submarine Landslides in French Polynesia ... 209
6.1 Introduction ... 209
6.2 Geological Setting ... 210
6.2.1 Data ... 212
6.2.2 Landslide Characterization ... 213
6.3 Landslides of the Society Islands ... 214
6.3.1 Mehetia ... 214
6.3.2 Moua Pihaa Seamount ... 214
6.3.3 Tahiti ... 215
6.3.4 Moorea ... 217
6.3.5 Huahine ... 217
6.3.6 Raiatea-Tahaa ... 217
6.3.7 Bora Bora ... 219
6.3.8 Tupai ... 220
6.4 Austral Island Landslides ... 222
6.4.1 Macdonald ... 222
6.4.2 Rapa ... 222
6.4.3 Raivavae ... 224
6.4.4 Tubuai ... 224
6.4.5 Arago ... 227
6.4.6 Rurutu ... 229
6.4.7 Rimatara ... 231
6.5 Classification of the Society and Austral Landslides ... 233
6.5.1 Geometric Characteristics ... 233
6.5.2 Seismic Velocity ... 235
6.6 Evolution of the Mass Wasting with the Age of the Edifices ... 235
6.6.1 Landslide Related to Submarine Active Volcanoes ... 235
6.6.2 Landslide Related to Young Oceanic Islands (<4 Ma) ... 236
6.6.3 Landslide Related to Older Oceanic Islands (>4 Ma) ... 236
6.6.4 Landslide Related to Tectonic Events ... 236
6.7 Conclusion ... 236
Acknowledgements ... 237
References ... 237

7 Mantle Plumes are NOT From Ancient Oceanic Crust 239
7.1 Introduction 239
7.2 Petrological Arguments 240
7.2.1 Melting of Oceanic Crust Cannot Produce the High Magnesian Melts Parental to Many OIB Suites 240
7.3 Geochemical Arguments 240
7.3.1 Melting of Subduction-Zone Dehydrated Residual Oceanic Crusts Cannot Yield the Trace Element Systematics in OIB 240
7.3.2 OIB Sr-Nd-Hf Isotopes Record no Subduction-Zone Dehydration Signatures 242
7.4 Mineral Physics Arguments 246
7.4.1 Subducted Oceanic Crusts are too Dense to Rise to the Upper Mantle 247
7.4.2 Basaltic Melts in the Lower Mantle Conditions are Denser than Ambient Solid Peridotites 248
7.5 Summary 249
Acknowledgements 250
References 250

8 The Sources for Hotspot Volcanism in the South Pacific Ocean 253
8.1 Introduction 253
8.2 The Hotspot Chains of the South East Pacific 254
8.2.1 Cook-Australs 256
8.2.2 Society Islands 260
8.2.3 Pitcairn-Gambier Chain 264
8.2.4 Marquesas Islands 265
8.2.5 Juan Fernandez Chain 268
8.2.6 Foundation Seamounts 272
8.2.7 Easter/Sala y Gomez-Nazca Chain 273
8.3 Discussion: Petrogenesis of South East Pacific Hotspots 274
8.3.1 Location of Magma Sources: Plume, Asthenosphere or Lithosphere? 274
8.3.2 Superswell – How Geochemically Different is It? 275
Acknowledgements 280
References 280

9 Plume-Ridge Interactions: New Perspectives 285
9.1 Introduction 285
9.2 Concepts 286
9.2.1 Mantle Plumes: Deep-Rooted Hot Materials or Wet Shallow Mantle Melting Anomalies? 286
9.2.2 Nature of Plume Materials 286
9.2.3 Ocean Ridges: Ridge Suction – The Active Driving Force for Plume-Ridge Interactions 288
9.2.4 Ridge Suction Increase with Increasing Spreading Rate 290
9.2.5 The Effect of Plume-Ridge Distance 292
9.3 Examples 292
9.3.1 "Proximal" Versus "Distal" Plume-Ridge Interactions 292
9.3.2 Spreading Rate Directs Plume Flows 294

9.4 Summary and Conclusion ... 301
Acknowledgements ... 304
References ... 304

10 Intraplate Gabbroic Rock Debris Ejected from the Magma Chamber of the Macdonald Seamount (Austral Hotspot): Comparison with Other Provinces ... 309
10.1 Introduction ... 309
10.2 The Macdonald Seamount ... 312
10.2.1 Eruptive Activity ... 312
10.2.2 Morphology and Structure ... 313
10.2.3 Sampling and Observations ... 314
10.2.4 Volcanic Terrains ... 314
10.3 Petrology ... 315
10.3.1 Analytical Techniques ... 315
10.3.2 Rock Descriptions ... 320
10.4 Geochemistry ... 331
10.5 Discussion ... 336
10.5.1 Comparison with Gabbros Recovered from Mid-Ocean Ridges ... 336
10.5.2 Comparison with Gabbroic Ejecta from Other Intraplate Regions ... 338
10.5.3 Origin of the Macdonald Seamount Gabbroic Clasts ... 341
10.6 Summary and Conclusions ... 343
Acknowledgements ... 344
References ... 344

11 The Foundation Chain: Inferring Hotspot-Plate Interaction from a Weak Seamount Trail ... 349
11.1 Introduction ... 349
11.2 Sample Preparation and Analytical Procedure ... 351
11.2.1 Sample Selection and Preparation ... 351
11.2.2 Dating Technique ... 351
11.2.3 Irradiation and Analysis ... 353
11.2.4 Data Reduction ... 355
11.3 Results ... 363
11.3.1 Migration of Volcanism Along the Foundation Chain ... 363
11.3.2 Hotspot-Spreading Center / Microplate Interaction ... 363
11.3.3 Volcanic Elongated Ridges (VERs) ... 364
11.4 Discussion ... 367
11.4.1 VERs and the Pacific-Antarctic Spreading Axis ... 367
11.4.2 Foundation VERs and the Selkirk Microplate ... 368
11.4.3 Pacific Plate Motion ... 369
11.4.4 Implications for Plume-Hotspot Theory ... 370
11.5 Conclusions ... 371
Acknowledgements ... 372
References ... 372

12 Hydrothermal Iron and Manganese Crusts from the Pitcairn Hotspot Region 375
12.1 Introduction 375
12.2 Geological Setting 376
12.3 Sample Description 378
12.3.1 Mineralogy 379
12.3.2 Age Dating 381
12.3.3 Biomineralization 382
12.4 Chemical Composition 385
12.4.1 Fe Crusts 388
12.4.2 Mn Crusts 390
12.4.3 Rare Earth Elements (REE) 393
12.5 Formation of Fe and Mn Crusts 395
12.6 Conclusions 398
Acknowledgements 399
References 399
Appendix 401

13 Methane Venting into the Water Column Above the Pitcairn and the Society-Austral Seamounts, South Pacific 407
13.1 Introduction 407
13.2 Geological Setting 409
13.3 Methods 410
13.4 Results and Discussion 411
13.4.1 Water Column Characteristics and Methane Distribution 411
13.4.2 Origin of Hydrothermal Methane 423
13.5 Conclusions 425
Acknowledgements 426
References 426

14 Petrology of Young Submarine Hotspot Lava: Composition and Classification 431
14.1 Introduction 431
14.2 Composition and Description of Oceanic Rocks 432
14.2.1 Common Mineral Constituents 432
14.2.2 Rock Types 436
14.3 Relationship Between Intraplate-Hotspot and Spreading-Ridge Magmatism . 449
14.4 Compositional Differences Among Hotspots 450
14.4.1 Relationship between Large and Small Hotspot Edifices 451
14.4.2 Volcanic Stratigraphy 454
14.5 Summary and Conclusions 455
Acknowledgements 457
References 457

Index 461