
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 <i>T</i> 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-Australis	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