

CONTENTS

LIST OF CONTRIBUTORS	v
FOREWORD	vii

The Focal Mechanism of Earthquakes

BY WILLIAM STAUDER, S.J.

1. Introduction	1
2. The Direction of Faulting Inferred from the First Motion of P	3
3. Representation of Foci by Mathematical Models	20
4. The Use of S Waves in Focal Mechanism Studies	25
5. Other Recent Developments	39
6. Significance of Results	54
7. Concluding Remarks	70
Acknowledgments	70
List of Symbols	70
References	71

Properties and Processes at the Earth's Surface in Relation to the General Circulation of the Atmosphere

BY P. A. SHEPPARD

1. Introduction	77
2. The General Circulation as a Budgetary Exercise	78
3. Momentum Budget and Exchange	80
4. Vertical Eddy Transfer of Energy	83
5. Patterns of Surface Transfer	87
6. Utilization of Patterns of Flux	90
List of Symbols	94
References	94

Identification of Aerosols

BY JAMES P. LODGE, JR.

1. Introduction	97
2. Detection of Aerosols	99
3. Sampling Techniques	100

4. Particle Size Determination	109
5. Analysis and Determination of Identity	113
6. Determination of Concentrations	122
7. Conclusion	124
References	125

Effects of Trapped Particles on the Geomagnetic Field

BY JOHN R. APEL, S. FRED SINGER, AND ROBERT C. WENTWORTH

1. Introduction	132
2. Trapped Particle Motion in a Dipole Field	135
3. Calculation of Magnetic Field Perturbations	142
4. Comparison with Experimental Results	166
5. Decay of a Ring Current	169
Appendix I. Diamagnetic Toroid	173
Appendix II. Self-consistent Field	178
Appendix III. Mathematical Appendix	179
Appendix IV. Liouville's Theorem and the Geomagnetic Field	183
Acknowledgments	186
List of Symbols	186
References	188

Celestial Geodesy

BY W. M. KAULA

1. Introduction	192
2. Orbit Analysis	193
3. Geometrical Considerations and Error Analysis	241
4. Rocket and Artificial Satellite Techniques	252
5. Lunar Techniques	269
6. Combination of Celestial and Terrestrial Geodesy	271
7. Geophysical Implications	275
Acknowledgments	277
List of Symbols	277
References	281

**The Problem of the Mantle-Crust Mix: Lateral
Inhomogeneity in the Uppermost Part of the Earth's Mantle**

BY KENNETH L. COOK

1. Introduction.....	296
2. Definitions.....	297
3. Velocity Considerations.....	299
4. Statement of the Problem.....	303
5. Summary of Data.....	306
6. Mid-oceanic Ridge System.....	308
7. Island Arcs.....	315
8. Continents.....	320
9. A Suggested Model for the Active Tectonic Belts.....	332
10. Evidence for Convection Currents.....	334
11. Example of Model.....	335
12. Other Implications of the Model.....	337
13. Problems Concerning the Mohorovičić Discontinuity.....	345
14. Abrupt or Gradational Boundary.....	346
15. Depth of Isostatic Compensation.....	347
16. Area of Mantle-Crust Mix.....	347
17. Summary.....	348
Acknowledgments.....	350
References.....	350
 AUTHOR INDEX.....	361
SUBJECT INDEX.....	371

THE FOCAL MECHANISM OF EARTHQUAKES

William Stauder, S. J.

Institute of Technology, St. Louis University, St. Louis, Missouri

1. Introduction	1
2. The Direction of Faulting Inferred from the First Motion of P	3
2.1. The Byerly Method of Fault Plane Determination	4
2.2 Other Methods	12
3. Representation of Foci by Mathematical Models	20
3.1. Position of the Problem	20
3.2. The Theory of Point Sources	20
3.3. Applications	23
4. The Use of S Waves in Focal Mechanism Studies	25
4.1. Nodal Lines of S	25
4.2. The Amplitude of S	26
4.3. The Polarization of S	27
4.4. Model Studies	38
5. Other Recent Developments	39
5.1. Advances in the Theory of Earthquake Foci	39
5.2. The Use of Surface Waves	48
5.3. The Introduction of Numerical Methods	51
5.4. Other Parameters	54
6. Significance of Results	54
6.1. General Conclusions	54
6.2. The Circum-Pacific Region	57
6.3. Other Regions	64
6.4. Limitations	67
7. Concluding Remarks	70
Acknowledgments	70
List of Symbols	70
References	71

PROPERTIES AND PROCESSES AT THE EARTH'S SURFACE IN RELATION TO THE GENERAL CIRCULATION OF THE ATMOSPHERE

P. A. Sheppard

Imperial College, London, England

	<i>Page</i>
1. Introduction.....	77
2. The General Circulation as a Budgetary Exercise.....	78
3. Momentum Budget and Exchange.....	80
4. Vertical Eddy Transfer of Energy.....	83
5. Patterns of Surface Transfer.....	87
6. Utilization of Patterns of Flux.....	90
List of Symbols.....	94
References.....	94

IDENTIFICATION OF AEROSOLS

James P. Lodge, Jr.*

Laboratory of Engineering and Physical Sciences, Division of Air Pollution, Robert A. Taft Sanitary Engineering Center, Public Health Service, U. S. Department of Health, Education, and Welfare,
Cincinnati, Ohio

	<i>Page</i>
1. Introduction.....	97
2. Detection of Aerosols.....	99
3. Sampling Techniques.....	100
3.1. General.....	100
3.2. Gravitational-Inertial Methods.....	101
3.3. Diffusional Methods.....	106
3.4. Gradient Methods.....	106
3.5. Sieving Methods.....	109
4. Particle Size Determination.....	109
4.1. General.....	109
4.2. Size Determination without Collection.....	110
4.3. Classification Techniques.....	111
4.4. Size Determination in Collected Samples.....	112
5. Analysis and Determination of Identity.....	113
5.1. General.....	113
5.2. Bulk Analysis.....	114
5.3. Single Particle Techniques.....	117
6. Determination of Concentrations.....	122
6.1. General.....	122
6.2. Number Concentration.....	122
6.3. Mass Concentration.....	123
6.4. Limitations.....	124
7. Conclusion.....	124
References.....	125

EFFECTS OF TRAPPED PARTICLES ON THE GEOMAGNETIC FIELD

John R. Apel*

Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Maryland

S. Fred Singer

University of Maryland, College Park, Maryland

and

Robert C. Wentworth

Lockheed Missiles and Space Company, Palo Alto, California

	<i>Page</i>
1. Introduction.....	132
1.1. Historical Summary.....	132
1.2. The Trapped Particle Hypothesis.....	133
1.3. Discussion of the Ring Current.....	133
1.4. Synopsis of the Paper.....	135
2. Trapped Particle Motion in a Dipole Field.....	135
2.1. Description of Trapped Particle Motion.....	135
2.2. Magnetic Moment and Drift Velocity.....	137
2.3. Application to the Dipole Field.....	138
2.4. Approximate Magnetic Effects.....	141
3. Calculation of Magnetic Field Perturbations.....	142
3.1. A Model of the Outer Radiation Belt.....	142
3.2. Number Density and Energy Spectrum.....	142
3.3. Latitudinal Density Distribution.....	144
3.4. Modifications to the Equatorial Distribution.....	145
3.5. Drift Current Density.....	149
3.5.1. Magnetization.....	149
3.5.2. Net Current Density.....	150
3.5.3. Total Current in the Radiation Belt.....	152
3.6. Magnetic Field Perturbations: The Smooth Particle Distribution.....	152
3.7. The Discontinuous Distribution.....	154
3.8. Other Particle Distributions.....	157
4. Comparison with Experimental Results.....	166
4.1. Summary of the Data.....	166
4.2. Comparison with Experiment.....	166
5. Decay of a Ring Current.....	169
Appendix I. Diamagnetic Toroid.....	173
Appendix II. Self-consistent Field.....	178
Appendix III. Mathematical Appendix.....	179

* Also University of Maryland, College Park, Maryland.

Appendix IV. Liouville's Theorem and the Geomagnetic Field.....	183
Acknowledgments.....	186
List of Symbols.....	186
References.....	188

CELESTIAL GEODESY

W. M. Kaula

Theoretical Division, Goddard Space Flight Center, National Aeronautics
and Space Administration, Greenbelt, Maryland

	<i>Page</i>
1. Introduction	192
2. Orbit Analysis	193
2.1. General	194
2.1.1. Dynamical Principles	194
2.1.2. Characteristics of Methods of Solution	202
2.2. Empirical Orbits	205
2.3. Numerical Integration	207
2.4. General Theories: Close Satellite Problem	208
2.4.1. Perturbing Function	209
2.4.2. Dynamical Intermediary Theories	210
2.4.3. Geometrical Intermediary Theories	213
2.4.4. Comparison of Theories	216
2.4.5. Special Problems	217
2.5. General Theories: Lunar Problem	218
2.6. Terrestrial Gravitational Effects	221
2.6.1. Perturbing Function and Integration	221
2.6.2. Secular and Long-Period Terms	223
2.6.3. Daily and Short-Period Terms	227
2.6.4. Tidal Effects	229
2.6.5. Relativistic Effects	230
2.7. Nongravitational Effects	232
2.7.1. Mechanical Drag	232
2.7.2. Electromagnetic Effects	235
2.7.3. Radiation Pressure	236
2.7.4. Observed Variations and Theoretical Models of the Atmosphere .	237
2.7.5. Orbital Accuracy Implications	240
3. Geometrical Considerations and Error Analysis	241
3.1. Coordinate Systems	241
3.1.1. General Definitions and Notations	241
3.1.2. Time and the Precise Definition of Coordinates	243
3.2. Observation Equations	246
3.3. Configuration Evaluation	250
4. Rocket and Artificial Satellite Techniques	252
4.1. General	252
4.1.1. Vehicles	252
4.1.2. Timing	253
4.1.3. Orientation	255
4.2. Optical Techniques	255
4.2.1. Attenuation and Illumination	255
4.2.2. Refraction and Aberration	258

4.2.3. Theodolites.....	259
4.2.4. Cameras.....	259
4.2.5. Satellite Photogrammetry.....	261
4.3. Radio Techniques.....	262
4.3.1. Environmental Effects on Propagation.....	262
4.3.2. Interferometry.....	266
4.3.3. Doppler.....	267
4.3.4. Ranging.....	267
5. Lunar Techniques.....	269
5.1. Lunar Topography Effects.....	269
5.2. Eclipses.....	269
5.3. Occultations.....	269
5.4. Lunar Camera.....	270
5.5. Radar Ranging.....	270
6. Combination of Celestial and Terrestrial Geodesy.....	271
6.1. Coordinate Forms and Units.....	271
6.2. Comparison of Observational Results.....	272
7. Geophysical Implications.....	275
Acknowledgments.....	277
List of Symbols.....	277
References.....	281

THE PROBLEM OF THE MANTLE-CRUST MIX: LATERAL INHOMOGENEITY IN THE UPPERMOST PART OF THE EARTH'S MANTLE*†

Kenneth L. Cook

Department of Geophysics, University of Utah, Salt Lake City, Utah

	<i>Page</i>
1. Introduction	296
2. Definitions	297
3. Velocity Considerations	299
3.1. Variation of Velocity with Density	299
3.2. Variation of Velocity with Crystalline Rock Type	300
3.3. Variation of Velocity with Depth	303
4. Statement of the Problem	303
5. Summary of Data	306
6. Mid-oceanic Ridge System	308
6.1. Mid-Atlantic Ridge	310
6.2. Arctic Mid-oceanic Ridge	312
6.3. Mid-Indian Ridge	313
6.4. East Pacific Rise	313
7. Island Arcs	315
7.1. Caribbean Arc	315
7.2. Southern Antilles Arc	317
7.3. Tonga-New Zealand Arc	318
7.4. Japanese Arc	318
7.5. Western Part of Mediterranean Sea	319
7.6. Other Island Arcs	319
8. Continents	320
8.1. Continental Rift Areas	320
8.1.1. Gulf of Aden	320
8.1.2. Red Sea	320
8.1.3. East African Rift System	320
8.2. Western Part of North America	321
8.2.1. Rift System	322
8.2.2. Basin and Range Province	325
8.2.3. Colorado Plateau	328
8.2.4. Montana	330
8.2.5. Central Plateau of Mexico	331
8.3. Summary of Continents	331
9. A Suggested Model for the Active Tectonic Belts	332
10. Evidence for Convection Currents	334

* Contribution No. 37, Department of Geophysics, University of Utah.

† A condensation of this paper was presented at the annual meetings of the Utah Academy of Science, Arts, and Letters, Provo, Utah, on April 14, 1961 and the American Geophysical Union, Washington, D. C., April 18-21, 1961.

11. Example of Model.....	335
12. Other Implications of the Model.....	337
12.1. Trends of Basin and Range Faults.....	338
12.2. Heat Flow.....	338
12.3. Difficulties with the Model.....	338
12.4. Possible Fracture Zone.....	339
12.5. Explanation of Gutenberg Low-Velocity Layer.....	341
13. Problems Concerning the Mohorovičić Discontinuity.....	345
14. Abrupt or Gradational Boundary.....	346
15. Depth of Isostatic Compensation	347
16. Area of Mantle-Crust Mix.....	347
17. Summary.....	348
Acknowledgments.....	350
References.....	350

