CONTENTS

GEOPHYSICS AND GEOCHEMISTRY

Geophysics and Geochemistry - Volume 1
No. of Pages: 344
ISBN: 978-1-84826-245-4 (eBook)
ISBN: 978-1-84826-636-0 (Print Volume)

Geophysics and Geochemistry - Volume 2
No. of Pages: 474
ISBN: 978-1-84826-246-1 (eBook)
ISBN: 978-1-84826-656-8 (Print Volume)

Geophysics and Geochemistry - Volume 3
No. of Pages: 455
ISBN: 978-1-84826-247-8 (eBook)
ISBN: 978-1-84826-662-9 (Print Volume)

For more information of e-book and Print Volume(s) order, please click here

Or contact: eolssunesco@gmail.com
CONTENTS

VOLUME I

Geophysics and Geochemistry
Jan Lastovicka, Institute of Atmospheric Physics, Prague, Czech Republic

1. Introduction
2. Why Study Geophysics and Geochemistry?
3. Structure of the Earth’s System
4. History of Geophysics and Geochemistry
5. Structure of the Solid Earth
6. Geodynamics, Tectonic Processes and Surface Processes
7. Seismology and Volcanology
8. Geothermics
9. Gravimetry and Shape of the Earth
10. Geomagnetism and Geoelectricity
11. Geochemistry
12. Aeronomy and Magnetosphere
13. Solar Wind
14. Planetology
15. Origin of the Earth, of Life, and Cosmochemistry
16. Prospects of Geophysics and Geochemistry

Foundations of Geophysics and Geochemistry
Jan Lastovicka, Institute of Atmospheric Physics, Prague, Czech Republic
Oldrich Novotny, Charles University, Prague, Czech Republic
Emil Jelinek, Charles University, Prague, Czech Republic

1. Introduction
2. History of Geophysics and Geochemistry
3. Branches of Geophysics and Geochemistry
   3.1. Gravimetry
      3.1.1. Gravity Field
      3.1.2. Fundamental Parameters and Relations
      3.1.3. Gravity Measurements and their Applications
      3.1.4. Earth Tides
   3.2. Seismology and the Structure of the Earth
      3.2.1. Basic Data on Earthquakes
      3.2.2. Strength of Earthquakes
      3.2.3. Seismic Waves
      3.2.4. Seismic Model of the Earth
   3.3. Geothermics
   3.4. Geodynamics
   3.5. Geomagnetism
      3.5.1. Internal (Main) Magnetic Field
      3.5.2. External Magnetic Field
      3.5.3. Magnetic Properties of Rocks and Paleomagnetism
   3.6. Geoelectricity
   3.7. Aeronomy
   3.8. Magnetospheric Physics and Solar Wind
      3.8.1. Magnetosphere
      3.8.2. Solar Wind
   3.9. Planetology
   3.10. Branches of Geochemistry
      3.10.1. Applied Geochemistry
### Branches of Geophysics

**Giovanni P. Gregori, CNR, Rome, Italy**

1. Science, the Earth Sciences, and the Environment
2. Disciplines in Geophysics
3. Formal Distinction within International Organizations
4. Boundary Disciplines
5. Societal Needs, Science Impact, and Selfconsciousness

### Geophysical Phenomena and Processes

**Giovanni P. Gregori, CNR, Rome, Italy**

1. Physical versus Nonphysical Forcing Factors
2. Couplings
   2.1. Thermal Coupling
   2.2. Gravitational Coupling
   2.3. Coupling by Matter Exchange
   2.4. Electromagnetic Coupling
3. Conclusions

### Geochemistry: Branches, Processes, Phenomena

**Scott M. McLennan, Department of Geosciences, State University of New York at Stony Brook, USA**

1. Introduction
2. Historical Foundations of Geochemistry
3. Branches of Geochemistry
4. The Data of Geochemistry
5. Cosmochemistry: Where Geochemistry Begins
6. The Periodic Table: A Geochemical Perspective
7. Isotopes, Reservoirs, and Ages
8. Geochemical Cycles
9. The Future of Geochemistry

### Geophysical Systems

**Jan Lastovicka, Institute of Atmospheric Physics, Prague, Czech Republic**

1. Introduction
2. Tectonics and Motion of Continents
3. Role of Terrestrial Heat
4. Volcanic Activity
5. Surface Processes in Interaction with Tectonic Processes
6. Coastal Processes
7. Interaction of Human Activity with Natural Processes

### Continents on the Move

**Adamantios Kilias, School of Geology, Aristoteles University of Thessaloniki, Thessaloniki, Greece**

1. Introduction
2. Earth’s Structure Today
   2.1. Earth’s Layers
      2.1.1. The Crust
      2.1.2. The Mantle
      2.1.3. The Core
   2.2. Tectonic Plates and Their Movements
3. Driving Mechanism
4. Vertical Movement of the Lithosphere
5. Continents and Growth of Continents
6. Lithospheric Circle—Continents' Motion
   6.1. From Vendia Continent to the Creation of Pangea Continent
   6.2. Pangea’s Evolutionary History
7. Evidence for Continent Motions
8. Discussion and Conclusions

Tectonic Processes
Jean-Pierre Burg, Institute of Geology, ETH-Zurich, Switzerland

1. Introduction
2. Relative Plate Movements
   2.1. Plate Divergence
      2.1.1. Rifts: Plate Divergence in Continental Settings
      2.1.2. Passive Continental Margins
      2.1.3. Ridges: Plate Divergence in Oceanic Settings
   2.2. Plate Convergence
      2.2.1. Island Arc: Convergence in Intraoceanic Settings
      2.2.2. Convergence Between Oceanic and Continental Plates
      2.2.3. Collision Belts: Plate Convergence Along Continental Margins
      2.2.4. Origin of Orogens
   2.3. Strike-Slip Boundaries
      2.3.1. Ridge–Ridge Transform and Transcurrent Faults
      2.3.2. Ridge–Trench Transform
      2.3.3. Trench–Trench Transform
   2.4. Triple Junctions
      2.4.1. Ridge–Associated Triple Junctions
      2.4.2. Trench–Associated Triple Junctions
      2.4.3. Transform Fault–Associated Triple Junctions
3. Intraplate Deformation
   3.1. Distributed Normal Faulting in Continents
   3.2. Distributed Folding in Plates
   3.3. Distributed Strike-Slip Faulting in Continents
   3.4. Mantle Plumes and Hot Spots
4. Tectonic Forces
5. Conclusion

Tectonic and Surface Processes Interaction
Maria Cristina Pomposiello, Instituto de Geocronología y Geología Isotópica, INGEIS, (CONICET), Buenos Aires, Argentina
Monica G. Lopez de Luchi, Instituto de Geocronología y Geología Isotópica, INGEIS, (CONICET), Buenos Aires, Argentina
Eduardo A. Rossello, Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, (CONICET), Buenos Aires, Argentina

1. Introduction
2. Fundamental processes
   2.1. Endogene Processes
   2.2. Exogenic Processes
      2.2.1. Climate Controls
      2.2.2. Weathering
      2.2.3. Mass Wasting
      2.2.4. Running Water Erosion
      2.2.5. Glacial Erosion

©Encyclopedia of Life Support Systems (EOLSS)
2.2.6. Wind erosion

3. Endogene and Exogenetic Processes: Interactions
   3.1. Global Scale Interactions
   3.2. Regional Scale Interactions
      3.2.1. Passive Margins
      3.2.2. Convergent margins
   3.3. Areal Scale Processes
      3.3.1. Uplifting
      3.3.2. Earthquakes
      3.3.3. Volcanism

4. Conclusions

Geophysical Processes and Human Activities
Vladimír Rudajev, Institute of Rock Structure and Mechanics, Prague, Czech Republic

1. Introduction
2. Mining Induced Seismicity
   2.1. Location of Mining Tremors
   2.2. Seismic Energy
   2.3. Mechanism of Mining Tremor Foci
   2.4. Seismicity of Tremors
   2.5. Analysis of Time Series of Mining Tremors and Their Forecasting
3. Reservoir induced seismicity
   3.1. Common Characteristics of Induced Events
4. Slope Movements
   4.1. Characteristics of the Main Types of Slope Movements
   4.2. Triggering Conditions and Factors of Slope Movements
      4.2.1. Triggering conditions
      4.2.2. Natural and anthropogenic trigger factors
4. Technical Seismicity
   5.1. Dependence of Excitation on Sources of Technical Seismicity
6. Seismic hazard

Terrestrial Heat Flow
Vladimir Cermak, Geophysical Institute, Czech Academy of Sciences, Prague, Czech Republic

1. Introduction
2. History
3. Heat Flow
   3.1. Thermal conductivity
   3.2. Heat Production
4. Measurements of Heat Flow
5. Geothermal Maps
6. Heat Flow—Age Relationships
8. Global Heat Flow Representation
9. Mantle Heat Flow
10. Lithosphere Temperatures
11. Geothermics and Deep Drilling
12. Borehole and Climate

Structure and Function of Marine Shoreline Ecosystems
K.S. Jayappa, Mangalore University, Karnataka, India
Subba Rao D.V., Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada
1. Introduction
2. Shoreline Environments
   2.1. Tropical Coastal Environments
      2.1.1. Mangroves
      2.1.2. Corals
   2.2. Mid- and High-latitudinal Coasts
3. Coastal Depositional Features
   3.1. Beaches
   3.2. Spits and Bars
   3.3. Deltas
   3.4. Barrier Beaches/Islands
   3.5. Beach Ridges
   3.6. Coastal Lagoons
   3.7. Mud Flats
   3.8. Tidal Marshes and Salt Marshes
4. Marine Erosional Features
   4.1. Sea Cliffs
   4.2. Wave-cut Notches and Platforms
   4.3. Sea Arches, Stacks, and Islands
5. Littoral and Longshore Sediment Transport
   5.1. Evolution of Coastal Zones
   5.2. Zonation
      5.2.1. Sandy Beaches
      5.2.2. Rocky Shores
   5.3. Production
6. Issues
   6.1. Debris and Pollution
   6.2. Sea-level Change and Coastal Response
   6.3. Coastal Hazards and Disasters
   6.4. Coastal Erosion and its Management

Index

About EOLSS

VOLUME II

Seismology and Volcanology
Ludmil Christoskov, Geophysical Institute of the Bulgarian Academy of Sciences, Sofia, Bulgaria

1. Seismology
   1.1. History and Development
   1.2. Main Problems and Trends
   1.3. Earth’s Earthquake Activity
   1.4. Elasticity and Seismic-Wave Equations
   1.5. Seismic Waves within Earth
   1.6. Earthquake Sources
      1.6.1. Conventional Source Models
      1.6.2. Magnitude, Seismic Moment, Energy, and Intensity
   1.7. Earthquake Prediction
2. Volcanology
   2.1. Historical Notes, Development, and Trends
   2.2. Some Principal Terms and Definitions
   2.3. Volcanic Activity on Earth
   2.4. Types of Volcanic Eruptions
Continental Crust

Irina M. Artemieva, Uppsala University, Sweden

1. Introduction
2. Methods of Continental Crust Studies
   2.1. Seismic Studies
   2.2. Geologic Mapping
   2.3. Petrologic Studies
   2.4. Heat Flow Studies
   2.5. Electromagnetic Studies
   2.6. Gravity Studies
   2.7. Laboratory Ultrasonic Measurements
   2.8. Continental Drilling
   2.9. Geochronology
3. Average Seismic Structure of Continental Crust
   3.1. Crustal Thickness and Seismic Velocities
   3.2. Crustal Reflectivity
   3.3. The Moho Discontinuity
4. Types of Continental Crust
   4.1. Shields and Platforms
   4.2. Collisional Orogens
   4.3. Continental Rifts and Extended Crust
   4.4. Continental Margins
5. Physical Properties of Continental Crust
   5.1. Seismic Velocities in Typical Crustal Rocks
   5.2. Seismic Anisotropy in Continental Crust
   5.3. Poisson’s Ratio
   5.4. Crustal Density
   5.5. Crustal Rheology, Brittle-Ductile Crust
6. Composition of Continental Crust
   6.1. Methods of Estimating Crustal Composition
   6.2. The Upper and Middle Continental Crust
   6.3. The Lower Continental Crust
7. Crustal Evolution
   7.1. Hypotheses for the Continental Crust Origin
   7.2. Age Distribution of Continental Crust
   7.3. The Formation of Continental Crust and Mantle Dynamics

The Oceanic Lithosphere

Javier Escartin, Laboratoire de Géosciences Marines, CNRS/IPGP, Paris, France

1. Background: Mid-Ocean Ridges and the Oceanic Lithosphere
2. Methods of Study of the Oceanic Lithosphere
3. Components of the Oceanic Lithosphere and Their Physical Properties
4. Structure of the Oceanic Lithosphere
   4.1. ‘Homogeneous’ lithosphere
   4.2. ‘Heterogeneous’ lithosphere
   4.3. Hot Spot Influenced Lithosphere
   4.4. Continent to Ocean Transition
5. Forming the Oceanic Lithosphere at the Ridge Axis
   5.1. ‘Magmatic’ Ridges
   5.2. ‘Amagmatic’ Ridges
6. The Rheology of the Oceanic Lithosphere
   6.1. Rock Mechanics and Rheology
   6.2. Effective Elastic Thickness: Flexure and Seismicity of the Oceanic Lithosphere
7. Fluids in the Oceanic Lithosphere: Electrical Conductivity Structure
# Mantle and Core of the Earth

Lev Pavlovich Vinnik, *Institute of Physics of the Earth, Moscow, Russia*

1. Introduction
2. Seismic Methods
   2.1. Seismic Waves
   2.2. Anisotropy and Anelasticity
   2.3. Seismic Tomography
3. Radial Structure of the Earth
   3.1. Radial Distribution of Seismic Velocities and Density
   3.2. Composition and Mineralogy
   3.3. Temperature
   3.4. Viscosity
4. Upper Mantle
   4.1. Lateral Heterogeneity of Zone B
   4.2. Seismic Anisotropy of Zone B
   4.3. Deep Structure and Processes in Subduction Zones
   4.4. Mantle Plumes
5. Lower Mantle
   5.1. Zone D
   5.2. Core–Mantle Boundary Region
6. Core
7. Conclusions

# Earthquake Ground Motion

Fabio Romanelli, *University of Trieste, Italy*

1. Introduction
   1.1. Measuring Ground Motion
   1.2. Intensity and Magnitude Scales
2. Theoretical Basis
   2.1. Equations of Elastic Motion
   2.2. Representation Theorem
3. Earthquake Ground Motion
   3.1. Source Effect
   3.2. Propagation Effect
     3.2.1. P and S Waves
     3.2.2. Rays and Modes
     3.2.3. Seismic Wave Attenuation
   3.3. Site Effect
     3.3.1. Methods for Laterally Heterogeneous Models

# Earthquake Mechanics

Hong Kie Thio, *URS Corp., Pasadena, USA*

1. History—Earthquakes and Faults
   1.1. Distribution of Earthquakes
2. Description of Faults and Earthquakes
   2.1. Geological Description
     2.1.1. Geometry of faults
     2.1.2. Depth dependent fault structure and rheology
   2.2. Seismologic Description
     2.2.1. Elastic dislocation theory
     2.2.2. Earthquake intensity and magnitude
     2.2.3. Scaling relations
     2.2.4. Earthquake size distribution
2.2.5. Foreshocks and aftershocks

3. Methods of Studying Earthquakes

4. Physical Processes of Fault Development and Earthquakes
   4.1. Seismic rebound theory
   4.2. Seismic Gaps and Earthquake Recurrence
   4.3. Fault Development
   4.4. A Kinematic Source Model
   4.5. Earthquake Dynamics
      4.5.1. Crack theory
      4.5.2. Friction laws
   4.6. Energy Budget of Earthquakes

5. Seismology and Earthquake Rupture Models
   5.1. Stress Drop
   5.2. Radiated Energy
   5.3. Earthquake Complexity
   5.4. Deep Earthquakes

6. Implications for Seismic Hazard

**Frequency and Severity of Earthquakes: Earthquake and Volcanic Event Prediction**

Pier Francesco Biagi, *University of Bari, Italy*

1. Introduction
2. The Earthquake Threat
   2.1. Occurrences and Impact of Earthquakes
3. Earthquake Prediction
   3.1. Statistical Precursors
   3.2. Empirical Precursors
4. The Danger and Prediction of Volcanic Eruptions
   4.1. Reliability of Predictions

**Volcanology: Volcanic Activities, Chemistry and Effects on Environment**

Giuseppe De Natale, *Osservatorio Vesuviano-INGV, Naples, Italy*

1. Introduction
2. Volcanic Edifices
3. Mechanisms of Magma Formation and Transport
4. Magma Composition and Types of Eruptions
5. Classification of Eruptions
6. Pre-eruptive phenomena
7. Eruptive Products and Volcanic Hazard
8. Eruption Forecast

**Geomagnetism and Geoelectricity**

Ibrahim Abdel Razag Eltayeb, *Sultan Qaboos University, Muscat, Oman*

1. Introduction
2. The History of Studies of Magnetism
   2.1. The International Association of Geomagnetism and Aeronomy (IAGA)
   2.2. Magnetic Units
3. Measurement and Analysis of the Main Magnetic Field of Earth
   3.1. Measurement
      3.1.1. Presentation of Magnetic Data
      3.1.2. Instruments for Measuring the Magnetic Field
   3.2. Theoretical Analysis of the Main Magnetic Field
3.2.1. Spherical Harmonic Representation of Surface Field
3.2.2. Determination of the Spherical Harmonic Coefficients
3.2.3. The Dipole Field
3.3. Variations of the Main Magnetic Field
  3.3.1. The Secular Variation
4. The Origin of the Main Field
  4.1. The Energy Source of the Dynamo
  4.2. The Core Boundary
5. The Crustal Field
6. The Temporal Field
7. The Ancient Field
  7.1. Rock Magnetism
  7.2. Reversals of Field
8. The Electrical Field and Current
  8.1. Electrical Conductivity
9. Influence of Geomagnetism and Geoelectricity on Life
10. Conclusions

**Earth’s Magnetic Field**

Susan MacMillan, *British Geological Survey, Edinburgh, UK*

1. Introduction
2. Geomagnetic Field Observations
   2.1. Definitions
   2.2. Observatories
   2.3. Satellites
   2.4. Other Direct Observations
   2.5. Indirect Observations
3. Characteristics of Earth’s Magnetic Field
   3.1. Reversals
   3.2. The Present Magnetic Field
   3.3. Westward Drift
   3.4. Geomagnetic Jerks
   3.5. Crustal Magnetic Field
   3.6. Field Variations at Quiet Times
   3.7. Field Variations at Disturbed Times
4. Earth’s Magnetic Field as Both a Tool and a Hazard in the Modern World
   4.1. Navigation
   4.2. Directional Drilling
   4.3. Geomagnetically Induced Currents
   4.4. Satellite Operations
   4.5. Exploration Geophysics

**Electric Field of the Earth**

Antal Adam, *Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, Sopron, Hungary*
Laszlo Szarka, *Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, Sopron, Hungary*
Jozsef Vero, *Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, Sopron, Hungary*

1. Introduction
2. The Electric Field as it Appears in Telluric and Magnetotelluric Studies
3. Methods for the Determination of the Geoelectric Structure(s) of the Earth
   3.1. About the Physical Properties of Earth Materials
   3.2. Theory of Electromagnetic Methods
3.3. Magnetotellurics (MT)
3.4. The Geomagnetic Deep Sounding (GDS)
3.5. The Telluric Method
3.6. Geoelectric and Electromagnetic Induction Methods with Artificial Source
3.7. Summary

4. Resistivity of Rocks and Minerals and its Distribution in Earth’s Interior
4.1. Resistivity of Rocks and Minerals
4.2. The Distribution of Resistivity in Earth’s Crust and Upper Mantle
   4.2.1. Carpatho-Pannonian Region
       4.2.1.1. General Geological Description
       4.2.1.2. Geoelectric Structure of the Sedimentary Basin and its Basement
       4.2.1.3. Transdanubian Conductivity Anomaly and its Tectonic Relations
       4.2.1.4. Carpathian Anomaly
       4.2.1.5. Conducting Layer in the Middle/Lower Crust
       4.2.1.6. Upper Mantle Conductor: Electric Asthenosphere
       4.2.2. Baltic (Scandinavian) or Fennoscandian Shield
           4.2.2.1. Geological-Geophysical Setting
           4.2.2.2. Geoelectric Structure of Finland
           4.2.2.3. Upper and Middle Crustal Conductors
           4.2.2.4. Lower Crustal Conductor
           4.2.2.5. The Electrical Asthenosphere

5. Conclusions

Rock Magnetism and Paleomagnetism
Mark J. Dekkers, Utrecht University, The Netherlands

1. Introduction
   1.1. Paleomagnetism
   1.2. Rock Magnetism
   1.3. Environmental Magnetism

2. Theoretical and Methodological Foundation
   2.1. Rock and Mineral Magnetism
       2.1.1. Intrinsic Magnetic Properties
       2.1.2. Relaxation Time and Domain State
   2.2. Paleomagnetism
       2.2.1. The Geocentric Axial Dipole Hypothesis
       2.2.2. Provenance of Magnetic Minerals
       2.2.3. NRM Acquisition Mechanisms
       2.2.4. Paleomagnetic Techniques
       2.2.5. Paleomagnetic and Magnetostratigraphic Studies
   2.3. Environmental Magnetism
       2.3.1. Low-Field or Initial Susceptibility ($\chi_0$)
       2.3.2. SP Particles and Frequency Dependence of $\chi_0$
       2.3.3. Anhysteretic Remanent Magnetization
       2.3.4. Isothermal Remanent Magnetization, Hysteresis Loops, and Related Parameters
       2.3.5. Magnetic Properties Above and Below Room Temperature
       2.3.6. Low-Temperature Oxidation
       2.3.7. Sources of Magnetic Minerals in Soils, Paleosols, and Lake Sediments
       2.3.8. Paleoclimatic and Archeological Applications and Pollution Assessment Studies

3. Future Developments
   3.1. Rock Magnetism
   3.2. Paleomagnetism
   3.3. Environmental Magnetism

4. Conclusion
1. Introduction
   1.1. General Remarks
   1.2. Energy Loss in the Core
2. Precessional Forcing
   2.1. Some Definitions
   2.2. The Case of no Inner Core and no Magnetic Field
   2.3. Generalizations: Future Directions
3. Basic State of the Core
   3.1. The Cooling Earth; the Adiabatic State
   3.2. Models of the Core
   3.3. Decoupling the core from the mantle
4. Gross Thermodynamics of the Fluid Core
   4.1. Energy Balance
   4.2. Entropy Balance
   4.3. The Early Earth
5. Magnetoconvection Theory
   5.1. Basic Equation in the Boussinesq Approximation
   5.2. Sources and Sinks: Boundary Conditions
   5.3. Fundamental Properties
6. Character of core Magnetoconvection
   6.1. Effects of the Coriolis Force
   6.2. Lorentz Forces and Coriolis Forces in Competition
   6.3. Stability of Strong Field States
7. Conclusions
4. Chemistry of the Ionosphere
5. Long-Term Trends of Aeronomical Parameters

Specific Features of the High Atmosphere
Gerd R. Sonnemann, *Leibniz Institute for Atmospheric Physics e.V. at the University of Rostock, Kühlungsborn, Germany*

1. Introduction
2. Energy and Dynamics of the Domain
3. Chemistry of the Domain
4. The Mystery of Water Vapor
5. Phenomena and Special Features of the Mesopause Region
6. Main differences Between the Low and High Atmosphere

Ionosphere and Upper Atmosphere Research with Radars
Jürgen Röttger, *Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany*

1. Introduction
2. Radar Observation Principles
3. Mesosphere, Lower Thermosphere and Meteor Observations
4. Studies of the Mesosphere with MST Radars
   4.1. D-region irregularities
5. Vertical Profiling of the Ionosphere with Ionosondes
6. Ionosphere Modifications
7. Oblique Incidence Ionospheric Sounding
8. Coherent Scatter Observations of E- and F-Region Irregularities
   8.1. E-region
      8.1.1. Auroral latitudes
      8.1.2. Middle latitudes
      8.1.3. Equatorial latitudes
   8.2. F-Region
      8.2.1. High latitudes
      8.2.2. Middle latitudes
      8.2.3. Equatorial latitudes
9. Ionospheric Profiling with Incoherent Scatter Radars
10. Sounding of the Topside Ionosphere and Magnetosphere
11. Conclusion

Magnetosphere and Its Coupling to Lower Layers
Tuija I. Pulkkinen, *Finnish Meteorological Institute, Helsinki, Finland*

1. Introduction
2. An Introduction to the Magnetosphere
   2.1. Historical Observations
   2.2. Magnetospheric Structure: Fields and Plasmas
   2.3. Magnetospheric Dynamics: Substorms and Storms
   2.4. Space Weather
3. Formation of the Magnetosphere
   3.1. Solar Wind—Magnetosphere Interaction
   3.2. Magnetospheric Topology and Global Plasma Flow Pattern
   3.3. Magnetospheric Plasma Regions
   3.4. High-Latitude Ionosphere
4. Dynamics of the Magnetosphere
   4.1. Magnetospheric Substorms
   4.2. Geomagnetic Storms
4.3. Relativistic Electron Acceleration

5. Solar Effects at Earth
   5.1. Long-Term Variations in Sun–Earth Connections
   5.2. Space Weather
      5.2.1. Space Weather Effects on Spacecraft
      5.2.2. Space Weather Effects on Ground Based Systems
      5.2.3. Space Weather Effects on Humans
      5.2.4. Space Weather Forecasts

6. Outstanding Issues

Index

About EOLSS

VOLUME III

Gravimetry
Milos Pick, Geophysical Institute of the Czech Academy of Sciences, Czech Republic.

Earth’s Gravity Field
Marija I. Yurkina, Central Scientific Research Institute of Geodesy, Aerofotogrammetry, and Cartography, Moscow, Russia
Milos Pick, Academy of Sciences, Prague, Czech Republic

©Encyclopedia of Life Support Systems (EOLSS)
3. Relation of the Geodetic System of Coordinates to Pizzetti’s System
4. Determining the System of Coordinates within Earth

Gravimetric Measurement Techniques
Vicki A. Childers, Marine Physics Branch, Naval Research Laboratory, USA

1. Introduction: Gravity Basics
2. Types of Gravity Meters
   2.1. Absolute Gravity Meters
      2.1.1. Pendulum Measurements
      2.1.2. Falling Body Instruments
   2.2. Relative Gravity Meters
      2.2.1. Gravity Sensors
         2.2.1.1. Inclined Zero Length Spring Sensors
         2.2.1.2. Quartz Spring
         2.2.1.3. Magnetic Levitation Devices
      2.2.2. Adaptations for Static and Dynamic Applications
         2.2.2.1. Static Meters
         2.2.2.2. Dynamic Meters
   2.3. Data Processing Methods
3. Gravity Gradiometry
   3.1. How the Gravity Gradient is Measured
   3.2. Relative Merits of Gradient Measurement
4. Gravity Measurement From Space
   4.1. Field Measurement at Satellite Altitude
      4.1.1. Satellite Tracking
      4.1.2. Mission Design Impacts Gravity Field Recovery
   4.2. Gravity from Satellite Altimetry
   4.3. Gravity Models
   4.4. Current and Future Missions
5. Future Directions

Applications of Gravimetry and Methods of Survey
Erwin Groten, Institute of Physical Geodesy, TU Darmstadt, Germany

1. Introduction
2. Gravity Representation of the Deformable Earth and its Models
3. Gravimetric Surveys Based on Various Space and Terrestrial Observations
   3.1. Terrestrial Gravimetry
      3.1.1. Absolute Gravimetry
      3.1.2. Relative Gravimetry
      3.1.3. Superconducting Gravimeters
      3.1.4. A Remark on Gradiometry
   3.2. Relative Gravimetry in Moving Vehicles
   3.3. Space Gravimetry
   3.4. Satellite-to-Satellite Techniques (SST) and Satellite Gradiometry
   3.5. The Use of Gravity Anomalies and Disturbances
   3.6. Borehole Gravimetric Surveys
   3.7. Lunar and Planetary Gravity Field Studies
   3.8. Applications
      3.8.1. Geoexploration and the Geometry of the Gravity Field
         3.8.1.1. Geodetic Applications
      3.8.2. A Remark on Navigation and Inertial Techniques
      3.8.3. Geodynamics
      3.8.4. A Remark on Loading
   3.9. Outlook and Conclusions
### Gravity Anomalies

Dinesh Chandra Mishra, *National Geophysical Research Institute, Hyderabad, India*

1. Introduction
2. Free Air and Bouguer Gravity Anomalies
3. Separation of Gravity Anomalies
   3.1. Regional and Residual Gravity Fields
   3.2. Separation Based on Surrounding Values
   3.3. Polynomial Approximation
   3.4. Digital Filtering
4. Analytical Operations
   4.1. Continuation of the Gravity Field
   4.2. Derivatives of the Gravity Field
5. Isostasy
   5.1. Isostatic Regional and Residual Fields
   5.2. Admittance Analysis and Effective Elastic Thickness
6. Interpretation and Modeling
   6.1. Qualitative Interpretation and Some Approximate Estimates
   6.2. Quantitative Modeling Due to Some Simple shapes
      6.2.1. Sphere
      6.2.2. Horizontal Cylinder
      6.2.3. Vertical Cylinder
      6.2.4. Prism
      6.2.5. Contact
   6.3. Gravity Anomaly Due to an Arbitrary Shaped Two-dimensional Body
   6.4. Basement Relief Model
7. Applications
   7.1. Bouguer Anomaly of Godavari Basin, India
   7.2. Spectrum and Basement Relief
   7.3. Modeling of Bouguer Anomaly of Godavari Basin Along a Profile
   7.4. Some Special Applications

### Geochemistry and Cosmochemistry

Jonathan I. Lunine, *Lunar and Planetary Laboratory, The University of Arizona, Tucson, USA*

1. Introduction to Geochemistry and Cosmochemistry
2. Geologic Processes on the Earth
3. Plate Tectonics and the Carbon-silicate Cycle
4. Stable Isotope Climate Studies
5. Cosmochemical Materials
6. Principles of Radioisotopic Dating
7. Dynamical Simulations of the Growth of Planets
8. Origin of the Moon—Cosmochemical and Dynamical Constraints
9. Origin of Water on the Earth and Mars
10. Environmental Geochemistry
11. The Future of Geochemistry and Cosmochemistry

### Geochemical Origins of the Earth

Yutaka Abe, *University of Tokyo, Japan*

1. Formation of the Solar System
   1.1. Formation of the Protoplanetary Disk
   1.2. The Standard Model of Planetary Formation
   1.3. Age of the Solar System
2. Formation of the Earth
   2.1. The Composition of the Earth-Forming Materials
2.2. Nebular Gas
2.3. Size and Velocity of Planetesimals and Accretion Time
2.4. Planetesimal Impacts: Crater Formation
2.5. Impact Degassing
2.6. Impact melting: Magma Oceans and Magma Ponds
2.7. Impact Vaporization and Impact Erosion
3. Formation of the Atmosphere and Oceans
  3.1. The Timing of Atmosphere Formation and Constraints
  3.2. Three Types of Proto-Atmosphere
  3.3. Composition of the Proto-Atmosphere
  3.4. The Surface Temperature
  3.5. Escape of Atmosphere
  3.6. Formation of Oceans
  3.7. The Atmosphere After the Formation of Oceans
4. Early Crust and the Evolution of the Mantle
  4.1. Magma Ocean
  4.2. Chemical Differentiation of the Magma Ocean
  4.3. Early Crust and Mantle
5. Formation of the Core
  5.1. Mode of Core Formation
  5.2. Behavior of Siderophile Elements

---

Gaseous Geochemical Cycles
Martin Mihaljevic, Institute of Geochemistry, Mineralogy, and Mineral Resources, Charles University, Prague, Czech Republic

1. Introduction
2. Earth’s Atmosphere
3. Carbon
   3.1. Isotopes
   3.2. Compounds
   3.3. Major Carbon Reservoirs and Cycle
4. Nitrogen
   4.1. Isotopes and Compounds
   4.2. Major Nitrogen Reservoirs and Cycle
      4.2.1. Biological Transformation of Nitrogen Compounds
5. Oxygen
   5.1. Isotopes and Compounds
   5.2. Major Reservoirs
      5.2.1. Atmosphere
      5.2.2. Hydrosphere
   5.3. Oxygen Cycle
6. Sulfur
   6.1. Isotopes and Compounds
   6.2. Major Reservoirs, Cycle
7. Conclusion

---

Sedimentary Geochemistry
Jan Jehlicka, Institute of Geochemistry, Mineralogy, and Natural Resources, Charles University in Prague, Czech Republic

1. Introduction
2. Origin of Sedimentary Material
   2.1. Distribution of Elements as a Provenance Indicator
      2.1.1. Isotopes
   2.2. Organic Matter as Provenance Indicator

©Encyclopedia of Life Support Systems (EOLSS)
3. Sedimentation
   3.1. Siliciclastic Sediments
   3.2. Carbonates
   3.3. Siliceous Sediments
   3.4. Iron- and Manganese-rich Sediments
   3.5. Phosphates
   3.6. Evaporites
   3.7. Black Shales
4. Transformation
   4.1. Rock Diagenesis
   4.2. Organic Matter Evolution
      4.2.1. Coal
      4.2.2. Petroleum
5. Conclusions

Stable Isotope Geochemistry
Ian D. Clark, University of Ottawa, Ottawa, Canada

1. Background
2. Elements, Nuclides, and Stable Isotopes
3. The Mass Spectrometer and Isotope Ratio Measurement
4. Isotope Fractionation
5. Temperature and Fractionation
6. Stable Isotopes in the Hydrologic Cycle
7. $^{18}$O in Crustal Rocks
8. $^{13}$C and Carbon Cycling
9. $^{15}$N Cycling in Watersheds
10. $^{34}$S and the Sulfur Cycle
11. Chlorine and Bromine Isotopes
12. Light Lithophile Elements: $\delta^6$Li and $\delta^{11}$B

Environmental Geochemistry
Peggy A. O'Day, Arizona State University, Tempe, AZ, USA

1. Introduction
2. Time and Space Scales
3. Chemical Principles
   3.1. Equilibrium Thermodynamics
   3.2. Kinetics and Mass Transfer
4. Geochemical Partitioning
5. Environmental Contaminants
   5.1. Organic Compounds
   5.2. Inorganic Contaminants
   5.3. Biological Contaminants
6. Environmental Change and Human Impact

Cosmochemistry
Petr Jakes, Charles University, Prague, Czech Republic

1. Introduction
2. Origin of the Elements
   2.1. Big Bang Event
   2.2. The Chemistry of Star Formation
   2.3. Stars, Novae, and Supernovae
   2.4. Composition of Cosmic Dust
3. Classification of Chemical Elements
4. Composition of the Solar System
   4.1. Solar Nebula and Comets
   4.2. Planetary Materials
      4.2.1. Carbonaceous Chondrites
      4.2.2. Chondrites
      4.2.3. Extrasolar Material
      4.2.4. Interplanetary Dust Particles (IDP)
5. Processes Recorded in Meteorites
   5.1. Condensation
   5.2. Thermal Metamorphosis
   5.3. Igneous Activity
   5.4. Alteration
   5.5. Shock Effects
   5.6. Irradiation Effects
7. Origin of Life a Cosmochemical View

Planetology - Comparative Planetology of Earth-like Planets and Astrobiology 283
Bernard H. Foing, ESA Chief Scientist, ESTEC/SCI-SR, Noordwijk, The Netherlands

1. Introduction
2. Comparative Planetology
   2.1. Lunar research and exploitation
      2.1.1. A new fleet of lunar robotic missions
      2.1.2. What does the Moon tells us about our origin?
   2.2. Mars research
      2.2.1. Mars and the Earth
      2.2.2. Water on Mars
      2.3. Impact crater research
   2.4. Earth-like Planetary environments for life
3. Astrobiology
   3.1. Origin of dust and organics
   3.2. Experimental studies of Evolution of Organics in Space
   3.3. Mars and organics in a simulation chamber
   3.4. Search for Martian life
   3.5. Miniaturized life sensors
4. Future exploration of Earth-like Planets and Moons

The Solar System 295
Wing-Huen Ip, National Central University, Chung-Li, Taiwan

1. Introduction
2. Accretion
3. Dust Condensation
4. Planetesimals
5. Planetary Accretion
6. The Edgeworth–Kuiper Belt
7. Satellite Formation
8. Origin of Atmospheres
9. Origin of Life
10. Extrasolar Planetary Systems

Comparative Planetology 307
Tilman Spohn, Institut für Planetologie, Münster, Germany
### GEOPHYSICS AND GEOCHEMISTRY

**Doris Breuer, Institut für Planetologie, Münster, Germany**  
**Philippe Lognonne, Institute de Physique du Globe de Paris, France**

1. Introduction  
2. Planet and Satellite Orbits and Rotation States  
3. Composition and Interior Structure of Planets  
4. Surfaces and Atmospheres  
5. Energy Balance and Evolution  
6. Magnetic Fields and Field Generation  
7. Conclusions

**Planetary Satellites, Asteroids, Comets and Meteors**  
**Duncan Steel, University of Salford, UK**

1. Introduction  
2. Planetary satellites  
3. Asteroids  
4. Comets  
5. Meteoroids and meteors

**Solar Wind and Interplanetary Magnetic Field**  
**Rainer W. Schwenn, Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, Germany**

1. Basic Concepts  
2. Sun and Heliosphere at Times of Solar Activity Minimum  
   2.1. Typical Solar Wind and its Sources  
   2.2. The Ballerina Model  
   2.3. Solar Wind Stream Structure  
   2.4. The Two Basic States of the Solar Wind  
      2.4.1. Differences  
      2.4.2. Communities  
   2.5. Solar Wind Acceleration and Expansion  
   2.6. Solar Wind Streams and Their Interactions  
      2.6.1. Corotating Interaction Regions in the Inner Heliosphere  
      2.6.2. Towards the Outer Heliosphere  
3. The "Active" Solar Wind and Transient Phenomena  
   3.1. Coronal Mass Ejections (CMEs)  
   3.2. Different Types of CMEs  
   3.3. Interplanetary Effects of CMEs  
   3.4. Flares, CMEs, and Space Weather  
4. Slow Variations  
5. Conclusions

**Index**  
381

**About EOLSS**  
389