

Contents

Foreword	V
Preface	VII
Chapter 1: Introduction	1
Chapter 2: Definition	3
CONSEQUENCES	3
LIMITATIONS	5
Chapter 3: Rheological stratification of the mantle	7
LITHOSPHERE	7
Introduction	7
Definition	7
Thickness	9
Thermal structure of the oceanic lithosphere	9
Topographic expression of the thermal structure	10
Elasticity of the lithosphere	10
Depth of the low-velocity zone	11
Comparison of oceanic and continental lithosphere	12
Mechanical properties	13
ASTHENOSPHERE	14
Definition	14
Structure and thickness	15
Mechanical properties	15
The long-wavelength gravity anomalies and the upper mantle	16
THE LITHOSPHERE AS A STRESS-GUIDE	17
THE DRIVING MECHANISM	18
Chapter 4: Kinematics of relative movements	19
INTRODUCTION	19
INSTANTANEOUS MOVEMENTS	20
On a plane earth	20
Triple point junction	25
Change of relative motion of plates	26
On a spherical earth	28
Triple point junction	32
KINEMATICS OF FINITE MOTIONS	33
Introduction	33
Theory of finite rotations	34
Evolution of triple point junction	38
MEASUREMENTS OF INSTANTANEOUS MOVEMENTS	39

Methods of measurements of relative velocity	40
Vine and Matthews method	40
Topographic method	48
Method of Brune	53
Geodetic methods	55
Length of sinking zone method	62
Methods of measurement of direction of relative motion	64
The transform-fault method	64
Fault-plane solution method	68
Calculation of instantaneous relative angular velocity between plates and estimation of errors	73
Introduction	73
Angular velocities	74
Errors in angular velocities	78
PRESENT WORLDWIDE KINEMATIC PATTERN.	80
Six-plate model: limitations	80
Present knowledge	84
Circum-Pacific plate boundaries	84
Arctic, Atlantic and Indian plate boundaries	91
The Alpine-Himalayan mostly consuming zone	93
Twelve-plate model	94
Kinematic pattern of the Red Sea and East Africa revisited	95
MEASUREMENTS OF FINITE MOVEMENTS	103
Fitting of past accreting plate boundaries	103
Magnetic anomalies and continental edges	103
Polar paths	107
Derivation of past relative displacements	108
Past plate boundaries	112
Use of fossil transform faults	115
One fossil transform fault	115
Several fossil transform faults	117
Methods of computation	121
Determination of kinematic pattern	122
Marginal fracture ridges	122
Topological inferences	123
"Hot spots" and relative motion	124
 Chapter 5: Movements relative to a frame external to the plates	 127
INTRODUCTION	127
REFERENCE FRAMES	128
"ABSOLUTE" MOVEMENT DETERMINATION	134
Paleomagnetic pole determination	134
Paleomagnetic pole	134
Difficulties of determination	136
Paleomagnetism in oceans	138
The seamount method	139
Study of magnetic anomaly profiles across cylindrical structures	143
Study of two-dimensional magnetic anomaly surveys	150
PALEOMAGNETIC SYNTHESIS	150
 Chapter 6: Processes at accreting plate boundaries	 155
INTRODUCTION	155
CREATION AND EVOLUTION OF OCEANIC LITHOSPHERE	157

Model	157
Choice of physical parameters	164
Fit to distribution of heat flow and topography	166
More complex models	170
THE CREATION OF THE OCEANIC CRUST	172
Introduction	172
Seismic structure of the crust	173
"Average" structure	173
Sedimentary layer	175
Basement layer	175
Oceanic layer	176
Moho discontinuity	180
Composition of the crust	184
Mid-ocean ridge	184
Iceland	185
Chemical zonation of lithosphere	186
Tectonic activity at the boundary	188
Width of intrusion zone	188
The creation of the topographic relief: the rift valley	191
The seismic activity	195
CONTINENTAL RIFTS	196
Introduction	196
The Rhine graben as an example of continental rift	198
CONTINENTAL MARGINS	201
Introduction	201
Thermal evolution	203
Loading by sediments and hot creep	206
Limit continental-oceanic crust	207
Chapter 7: Processes at consuming plate boundaries	209
INTRODUCTION	209
SINKING PLATE MODEL	210
Introduction	210
Thermal regime of sinking lithospheric plate	212
McKenzie's analytical solution for the temperature structure of the plate	212
Heat generation due to shear along the plate	215
Heat generation due to shear at shallow depth: marginal accretion	218
Conclusion	219
STRUCTURE OF TRENCHES AND ASSOCIATED ISLAND ARCS AND CORDILLERAS	219
Introduction	219
Surface manifestations	220
Topography	220
Curvature of the arcs	227
Sediment	229
Magnetics	235
Gravity	235
Deep manifestations: seismicity	240
Introduction	240
Schematic model of plate seismicity	242
Geometry of the overridden plate	243
Thrust faulting	246
Distribution of stresses in the sinking plate	250
Surface manifestation behind consuming plate boundaries	251

Volcanic and plutonic activity	252
Metamorphism	255
Vertical tectonics and accretion of deformed sediments near the consuming plate boundary	256
“Mélanges”, ophiolites and HP/LT metamorphism	258
Plate accretion behind consuming plate boundaries: marginal basins	259
CONSUMPTION OF CONTINENT-BEARING LITHOSPHERE	262
PLATE TECTONICS AND GEOLOGY	269
Appendix	277
References	279