
Contents

1	The Scope of Modern Stratigraphy	1
1.1	The Importance of Stratigraphy	1
1.2	The Evolution of “Sophisticated Stratigraphy”	2
1.2.1	Beginnings (Nineteenth Century)	3
1.2.2	Cyclic Sedimentation (1932–1968)	3
1.2.3	Basin Analysis and the Big Picture (1948–1977)	4
1.2.4	The Meaning of “Facies” (1949–1973)	5
1.2.5	Fluid Hydraulics and Sedimentary Structures (1953–1976)	6
1.2.6	Early Studies of Modern Environments (1954–1972)	7
1.2.7	Facies Model Concept (1959–2010)	7
1.2.8	The Impact of the Plate-Tectonics Revolution on Basin Studies (1959–1988)	9
1.2.9	Unconformities and the Issue of Time in Stratigraphy (1909–1970)	11
1.2.10	Sequences and Seismic Stratigraphy (1963–1977)	13
1.2.11	Architectural Elements: Sedimentology in Two and Three Dimensions (1983–1990)	14
1.2.12	Sequence Stratigraphy (1986–1990)	14
1.2.13	Reconciling Facies Models with Sequence Stratigraphy (1990)	15
1.2.14	The Full Flowering of Modern Sequence-Stratigraphic Methods	16
1.2.15	Stratigraphy: The Modern Synthesis	17
1.3	Time in Stratigraphy	17
1.4	Types of Project and Data Problems	18
1.4.1	Regional Surface Stratigraphic Mapping Project	18
1.4.2	Local Stratigraphic-Sedimentologic Mapping Project	19
1.4.3	Regional Subsurface Mapping Project	20
1.4.4	Local Subsurface Mapping Project	23
1.5	Summary of Research and Reporting Procedures	24
	References	26
2	The Stratigraphic-Sedimentologic Data Base	33
2.1	Introduction	33
2.2	Describing Surface Stratigraphic Sections	33
2.2.1	Methods of Measuring and Recording the Data	34
2.2.2	Types of Field Observation	36
2.2.3	Sampling Plan	55
2.2.4	Plotting the Section	58
2.3	Describing Subsurface Stratigraphic Sections	60
2.3.1	Methods of Measuring and Recording the Data	60
2.3.2	Types of Cutting and Core Observation	62

2.3.3	Sampling Plan	64
2.3.4	Plotting the Section	64
2.4	Petrophysical Logs	65
2.4.1	Gamma Ray Log (GR)	66
2.4.2	Spontaneous Potential Log (SP)	67
2.4.3	Resistivity Logs	68
2.4.4	Sonic Log	69
2.4.5	Formation Density Log	70
2.4.6	Neutron Log	70
2.4.7	Crossplots	71
2.4.8	Integrating Cores and Wireline Logs.	74
	References	74
3	Facies Analysis.	77
3.1	Introduction.	77
3.2	The Meaning of Facies	77
3.3	Recognition and Definition of Facies Types.	79
3.3.1	Philosophy and Methods	79
3.3.2	Field Examples of Facies Schemes	80
3.3.3	Establishing a Facies Scheme.	82
3.3.4	Facies Architecture	84
3.4	Facies Associations and Models	87
3.4.1	The Association and Ordering of Facies	87
3.4.2	The Theory of Facies Models	89
3.4.3	The Present as the Key to the Past, and Vice Versa	91
3.4.4	To Classify and Codify, or Not?	94
3.4.5	Facies Analysis and Sequence Stratigraphy	96
3.5	Review of Environmental Criteria.	96
3.5.1	Grain Size and Texture	97
3.5.2	Petrology.	99
3.5.3	Bedding	103
3.5.4	Hydrodynamic Sedimentary Structures	104
3.5.5	Sediment Gravity Flows	115
3.5.6	Sedimentary Structures Produced by Hydrodynamic Erosion of the Bed	122
3.5.7	Liquefaction, Load and Fluid Loss Structures.	123
3.5.8	Paleoecology of Body Fossils	123
3.5.9	Ichnology	132
3.5.10	Vertical Profiles	134
3.5.11	Architectural Elements and Bounding Surfaces.	139
3.6	Conclusions and Scale Considerations.	151
	References	151
4	Facies Models	161
4.1	Introduction.	161
4.2	Clastic Environments	162
4.2.1	Fluvial Environments	162
4.2.2	Eolian Environments.	166
4.2.3	Lacustrine Environments	168
4.2.4	Glacial Environments	169
4.2.5	Coastal Wave- and Tide-Dominated Environments	172
4.2.6	Deltas	176

4.2.7	Estuaries	182
4.2.8	Continental Shelf Environment.	183
4.2.9	Continental Slope and Deep Basin Environment.	185
4.3	Carbonate Environments	190
4.3.1	Conditions of Carbonate Sedimentation.	190
4.3.2	Platforms and Reefs	196
4.3.3	Tidal Sedimentation	201
4.3.4	Carbonate Slopes	203
4.4	Evaporites	206
	References	210
5	Sequence Stratigraphy	215
5.1	Introduction	215
5.2	Elements of the Model	216
5.2.1	Accommodation and Supply	217
5.2.2	Stratigraphic Architecture	217
5.2.3	Depositional Systems and Systems Tracts	224
5.3	Sequence Models in Clastic and Carbonate Settings	225
5.3.1	Marine Clastic Depositional Systems and Systems Tracts	225
5.3.2	Nonmarine Depositional Systems	233
5.3.3	Carbonate Depositional Systems.	237
5.4	Conclusions.	241
	References	241
6	Basin Mapping Methods.	245
6.1	Introduction	245
6.2	Stratigraphic Mapping with Petrophysical Logs	246
6.2.1	Log Shape and Electrofacies	246
6.2.2	Examples of Stratigraphic Reconstructions.	249
6.2.3	Problems and Solutions.	251
6.3	Seismic Stratigraphy	254
6.3.1	The Nature of the Seismic Record	255
6.3.2	Constructing Regional Stratigraphies.	263
6.3.3	Seismic Facies	268
6.3.4	Seismic Geomorphology	272
6.4	Directional Drilling and Geosteering	276
6.5	Older Methods: Isopleth Contouring	278
6.6	Mapping on the Basis of Detrital Composition.	280
6.6.1	Clastic Petrofacies	280
6.6.2	Provenance Studies Using Detrital Zircons	288
6.6.3	Chemostratigraphy	290
6.7	Paleocurrent Analysis	292
6.7.1	Introduction	292
6.7.2	Types of Paleocurrent Indicators	293
6.7.3	Data Collection and Processing	297
6.7.4	The Bedform Hierarchy.	299
6.7.5	Environment and Paleoslope Interpretations	300
	References	305
7	Stratigraphy: The Modern Synthesis.	311
7.1	Introduction	311
7.2	Types of Stratigraphic Unit	313
7.3	The Six Steps Involved in Dating and Correlation	315

7.4	Lithostratigraphy	316
7.4.1	Types of Lithostratigraphic Units and Their Definition	317
7.4.2	The Names of Lithostratigraphic Units	319
7.5	Biostratigraphy	320
7.5.1	The Nature of the Biostratigraphic Record	320
7.5.2	Biochronology: Zones and Datums	326
7.5.3	Diachroneity of the Biostratigraphic Record	329
7.5.4	Quantitative Methods in Biochronology	331
7.6	Unconformity-Bounded Units	334
7.7	The Development of Formal Definitions for Sequence Stratigraphy	335
7.8	Chronostratigraphy and Geochronometry	343
7.8.1	The Emergence of Modern Methods	343
7.8.2	Determining the Numerical (“Absolute”) Age of a Stratigraphic Horizon	345
7.8.3	Stages and Boundaries	351
7.8.4	Event Stratigraphy	355
7.8.5	Absolute Ages: Their Accuracy and Precision	355
7.8.6	The Current State of the Global Stratigraphic Sections and Points (GSSP) Concept, and Standardization of the Chronostratigraphic Scale	357
7.8.7	Cyclostratigraphy and Astrochronology	359
	References	364
8	The Future of Time	371
8.1	Introduction	371
8.2	Where We Are Now and How We Got Here	372
8.3	A Natural Hierarchy of Sedimentary Processes	375
8.4	Sedimentation Rates	378
8.5	The Fractal-Like Character of Sedimentary Accumulation	382
8.6	Apparent Anomalies of High Sedimentation Rate Versus Slow Rate of Accommodation Generation	384
8.7	Accommodation and Preservation	385
8.7.1	Preservation at a Scale of Seconds to Months	387
8.7.2	Preservation at a Scale of Years to Thousands of Years	387
8.7.3	Preservation at the Scale of Tens of Thousands to Hundreds of Thousands of Years	388
8.7.4	Preservation at the Scale of Millions of Years	389
8.8	Implications of Missing Time for Modern Stratigraphic Methods	390
8.8.1	Sequence Stratigraphy	390
8.8.2	Implications for Stratigraphic Continuity, the Concept of Correlation and the Principal of the GSSP	390
8.8.3	Discussion	391
8.9	An Example of the Evaluation of Missing Time: The Mesaverde Group of the Book Cliffs, Utah	392
8.9.1	Chronostratigraphy of the Mesaverde Group	393
8.9.2	Chronostratigraphy of the Spring Canyon and Aberdeen Members	396
8.9.3	The Representation of Time in a Coastal Clastic Succession	398
8.9.4	Sequence Stratigraphy of the Nonmarine Facies of the Blackhawk Formation and Castlegate Sandstone	399
8.9.5	The Representation of Time in a Fluvial Succession	401
8.9.6	Conclusions	403

8.10	The Future of Conventional Chronostratigraphy	404
8.10.1	Current Examples of Outstanding Work	404
8.10.2	The Use of Wheeler Diagrams	410
8.10.3	Improving Accuracy and Precision	413
8.11	High-Resolution Event Stratigraphy, Cyclostratigraphy and Astrochronology.	416
8.12	Conclusions.	424
	References	426
	Author Index	435
	Subject Index	443

<http://www.springer.com/978-3-319-24302-3>

Stratigraphy: A Modern Synthesis

Miall, A.D.

2016, XVII, 454 p. 367 illus., 142 illus. in color.,

Hardcover

ISBN: 978-3-319-24302-3