
Contents

1	Introduction	1
1.1	Historical Aspect	1
1.2	Concept of Environmental Movement	3
1.3	Environmental Aspects of Karst Terrains	4
	References	4
	Part I Surface Geological and Geophysical Field Studies	5
2	Geology of Indurated Rocks, Unconsolidated Sedimentary Deposits and Karst Terrains	7
2.1	Introduction	7
2.2	Rock Composition and Rock Types	7
2.2.1	Rock Composition	7
2.2.2	Rock Types	8
2.3	Soils and Unconsolidated Deposits	15
2.3.1	Soils	15
2.3.2	Unconsolidated Deposits	18
2.4	Karst Terrains	26
2.4.1	Definition	26
2.4.2	Karst and Karstification	27
2.4.3	Karst and Speleogenetic Processes	27
2.4.4	How Important is Karst to Man's Environment?	27
2.4.5	Karst Features	28
2.4.6	Siting Landfills in Karst Terrains	28
	References	29
	Selected References	29
	Appendix 2.A · Appearance of Different Sizes of Sand and Silt	30
3	Topographic and Surface Geologic Maps	31
3.1	Topographic Maps	31
3.1.1	Longitude and Latitude	31
3.1.2	Land Office Grid System	32
3.2	Surface Geological Mapping	32
3.2.1	Scope	32
3.2.2	Geologic Maps in the USA	33
3.2.3	Geologic Maps in Canada	33
3.2.4	Digital Geological Maps	34
3.2.5	Aerial Photographic Maps	35
3.3	Geological Surveying Methods	37
3.3.1	Brunton Compass	37
3.3.2	Map-Scale Structures and Map Interpretation	39
3.3.3	Finding the Orientation of Planes	44
	References	45
	Selected References	46
	Appendix 3.A · Topographic Map Symbols	46
	Appendix 3.B · Symbols for Geologic Maps	48

4	Surface Geophysical Exploration Methods	51
4.1	Introduction	51
4.2	Magnetic Survey	51
4.3	Gravimetric Survey	51
4.4	Microgravity and Cavity Detection	52
4.5	Seismic Exploration Survey	53
4.5.1	Definition and Discussion	53
4.5.2	Seismic Refraction/Reflection Methods	55
4.5.3	Seismic Terms and Phenomena	56
4.6	Ground Penetrating Radar Methods	57
4.6.1	Definition and Basic Principles	57
4.6.2	Methodology	58
4.6.3	GPR Application	59
4.7	Remote Sensing and Satellite-Based Images	60
4.7.1	General	60
4.7.2	Remote Sensing and Geographic Information System (GIS)	61
4.7.3	Preliminary Evaluation of Remote Sensing/Alabama Highways	62
4.7.4	Satellite Hydrology	63
4.7.5	Applications in the Field of Hydrogeology	64
4.8	Geophysical Investigations in Karst Areas	69
4.8.1	Electrical Resistivity Tomography (ERT)	70
4.8.2	Earth Resistivity Tomography Used for Investigating Karst Hazards	70
4.8.3	Natural Potential Method (NP)	72
	References	75
	Selected References	76
Part II Subsurface Geological and Geophysical Methods		77
5	Characteristics of Sedimentary Rocks – Subsurface Geological Mapping and Computer Software Data Management Systems	79
5.1	Introduction	79
5.1.1	Test Drilling Contract	79
5.1.2	Geologic Samples and Driller's Logs	79
5.2	Rock Characteristics	80
5.2.1	The Megafeatures	80
5.2.2	Color Patterns	80
5.2.3	Rock Texture of Clastic Sediments	81
5.2.4	Rock Structure	84
5.2.5	Rock Luster	84
5.2.6	Mineral Accessories	84
5.3	Preparation of Well Logs	84
5.3.1	Types of Well Logs	84
5.3.2	Downhole Methods	87
5.3.3	Composite Well Logs	88
5.4	Stratigraphy and Structural Geology	88
5.4.1	Stratigraphy	88
5.4.2	Structural Geology	88
5.5	Subsurface Sections and Geological Maps	90
5.5.1	Isopach Maps	90
5.5.2	Facies Maps	90
5.6	Graphic Techniques and Representation	90
5.6.1	Scope	90
5.6.2	Geographic Information Systems (GIS)	91
5.6.3	Computer Software Data Management Systems	92
5.7	Duties and Responsibilities of the Subsurface Geologist	97
5.7.1	Correlation of Surface to Subsurface Stratigraphic Units	98

5.7.2	Electrical Logging	98
5.7.3	Problem/Solutions in Deep Drilling Operations	98
5.7.4	Subsurface Data	98
5.7.5	Unconformities	100
	References	100
	Selected References	101
	Appendix 5.A · Lithologic Symbols for Cross and Columnar Sections	102
6	Drilling and Testing: Soil Samplers, Drilling Techniques, and Equipment	103
6.1	Introduction	103
6.2	Soil Sampling and Equipment	104
6.2.1	Split-Barrel Samplers	104
6.2.2	Thin-Wall or “Shelby Tube” Samplers	105
6.2.3	Specialized Soil Samplers	106
6.2.4	Core Samplers	109
6.3	Drilling Methods and Equipment for Installation of Test Wells	110
6.3.1	Hand Augers	110
6.3.2	Driven Wells	111
6.3.3	Jet Percussion	113
6.3.4	Solid-Flight Augers	115
6.3.5	Hollow-Stem Augers	115
6.3.6	Mud-Rotary Drilling	119
6.3.7	Air-Rotary Drilling	125
6.3.8	Air Rotary With Casing Driver	126
6.3.9	Dual-Wall Reverse Circulation	127
6.3.10	Cable Tool Drilling Method (Cable Tool Percussion)	128
6.3.11	Other Drilling Methods	130
6.4	Drilling Rigs and Drilling Tools	131
6.5	Design and Completion of Wells	131
6.5.1	Design Planning of Wells	131
6.5.2	Well Completion	133
6.6	Procedures and Problems in Industrial Drilling	135
6.6.1	Scope	136
6.6.2	Drilling Fluid Systems	136
6.6.3	Straight Hole Techniques	136
6.6.4	Setting Casing	137
6.6.5	Cementing	137
6.6.6	Fishing Operations	137
6.6.7	Geoprobe Systems	137
6.7	Field Notes, Safety and Precautions	137
6.7.1	Check List for Drilling and Well Development Work	137
6.7.2	Electrocution on the Drilling Rig	139
6.7.3	Safety on the Rig “Hard Hats and Safety Shoes”	139
6.7.4	Checklist for a Drilling Site	139
	References	140
	Selected References	140
	Appendix 6.A · Drilling Forms	141
	Appendix 6.B · Guide to U.S. Water Well Drilling Rigs	145
	Appendix 6.C · Well Inventory Forms	149
7	Geophysical Well Logging Methods and Interpretations	151
7.1	Geophysical Well Logging	151
7.2	Basics of Well Log Interpretations	151
7.2.1	Basic Concepts	151
7.2.2	Borehole Parameters	152
7.2.3	Formation Temperature (T_f)	153

7.2.4	Specific Log Types	153
7.2.5	Log Interpretation and Applications	162
	References	168
	Appendix 7.A · Electric Log Interpretations	169
	Appendix 7.B · Quantitative Interpretation of Specific Geophysical Well Logs	171
Part III Ground-Water Hydrology, Ground-Water Contamination, and Waste Management		175
8	Ground-Water Hydrology, Hydrogeologic Methods and Hydrogeologic Data Acquisition	177
8.1	Introduction	177
8.2	Ground-Water Hydrology	179
8.2.1	Hydraulic Properties of Granular Aquifers	179
8.2.2	Aquifer Testing	184
8.2.3	Hydraulic Testing and Characteristics of Aquifers	187
8.2.4	Pumping Test Plan	189
8.2.5	Well and Pump Renovation	192
8.3	Ground-Water Models	192
8.4	Hydrogeologic Methods and Equipment	193
8.4.1	Field Investigation	193
8.4.2	Ground-Water Measurements	193
8.4.3	Surface Hydrogeological Phenomena, and Discussion of Surface Components of the Hydrological Cycle	196
8.5	Acquisition of Hydrogeologic Data	202
8.5.1	Site Assessments	202
8.5.2	Surface-Water Hydrology	202
8.5.3	Preliminary Conceptual Model of a Site	203
8.5.4	Basic Data Checklist	203
8.5.5	Greenfield Siting	206
8.6	Karst Aquifers and Cave Patterns	206
8.7	Hydrological Mapping Techniques	208
8.8	Classification of Hydrological Maps	208
	References	210
	Selected References	211
	Appendix 8.A · Selected Photos of Field Instruments	212
	Appendix 8.B · A Site or Facility Characterization Using Electromagnetic Radiography (EMR)	213
	Appendix 8.C · Pumping Test Plan – Attachments: 8.C.1, 8.C.2, 8.C.3	219
	Appendix 8.D · Ground-Water Sampling, Analytical Procedures, and Decontamination of Equipment	224
9	Ground-Water Monitoring Wells, Contamination, and Waste Management	233
9.1	Ground-Water Flow in Granular and Fractured Rocks	233
9.1.1	Scope	233
9.1.2	Determination of the Direction and Rates of Ground-Water Flow in Granular Aquifers	233
9.1.3	State-of-the-Art For Modeling Two-Phase Flow in Fractured Rocks	233
9.1.4	Transport by Concentration Gradients/Definitions	234
9.2	Development of Ground-Water Monitoring Wells	234
9.2.1	Geologic and Hydrogeologic Conditions of a Site	234
9.2.2	Development of Ground-Water Monitoring Wells in Granular Aquifers (ASTM D-5521-94)	235

9.2.3	Development of Ground-Water Monitoring Wells in Karst and Fractured Rock Aquifers (ASTM D-5717-95)	235
9.2.4	Record-Keeping (U.S. EPA/4-89)	235
9.3	Types of Waste Disposal Facilities and Waste Characteristics	237
9.3.1	Types of Waste-Disposal Facilities (U.S. EPA 600/4-89)	237
9.3.2	Waste Characteristics	237
9.3.3	Seepage of Water at the Edges of Waste Disposal Sites	240
9.4	Sources of Pollution and Ground-Water Contamination	240
9.4.1	Air Pollution and Its Effects on Surface Water Resources	240
9.4.2	Sources of Pollution in Surface Water	242
9.4.3	Sources of Pollution to Aquifer Systems	242
9.4.4	Pollution to Karstic Aquifers	244
9.4.5	Protection of Water in Karst Against Pollution	246
9.5	Dye Tracing Techniques	247
9.5.1	Scope	247
9.5.2	Highlights in Karst History	247
9.5.3	Dye Tracers	247
9.5.4	Isotopic Tracers in Karst Aquifers	249
9.5.5	Quantitative Analysis of Tracer Tests	250
9.5.6	Evaluation of Dynamic Dispersion in Karst Aquifers	252
9.6	Waste Management, Rules and Regulations	253
9.6.1	Discussion	253
9.6.2	Identification of Wastes and Determination of Hazards	254
9.6.3	EPA Rules and Regulations	255
9.6.4	Federal Laws in the USA and Regulatory Standards	255
9.6.5	An Editorial Issue on USA Regulations	257
	References	257
	Selected References	258
	Appendix 9.A · A Study of Stream Water Runoff	259
Part IV Case Studies		261
10 A New Approach on the Nubian Sandstone Aquifer of the Western Desert of Egypt		263
10.1	Introduction	263
10.1.1	Subsurface Geology	263
10.1.2	Structural Geology	265
10.1.3	Petrophysical and Petrographical Studies	266
10.2	The Ground-Water Reservoir	269
10.3	The Analogue Rc-Integrator Model	271
10.4	The Digital Model	273
10.5	The River Nile of Egypt	274
10.5.1	Evolution of the River Nile	274
10.5.2	The River Nile Basin	276
10.6	Environmental Concerns	277
10.7	Local Activities	278
10.8	Conclusions	278
	References	278
	Appendix 10.A · Photos of the Western Desert of Egypt	279
11 Sulfate and Chloride Karstification and Its Economical Significance		281
11.1	Introduction	281
11.2	Fundamentals of Karstification	282
11.3	Geomechanical Models	282
11.4	Conclusion	285
	References	285

12 Occurrence of DNAPL near an Interceptor Well – Pump and Test Treatment for Remediation	287
12.1 Introduction	287
12.2 Background	287
12.3 Methodology	288
12.4 Hydrogeology of the Alluvial Aquifer	288
12.5 Discussion and Conceptual Model	290
12.6 Executive Summary	292
12.7 Conclusions	293
References	293
 Part V Technical Applications in the Field and Project Performance	295
 13 Laboratory Tests For Soils	297
13.1 Introduction	297
13.2 Particle Size Analysis of Soils	298
13.2.1 Scope	298
13.2.2 Wet Preparation of Soil Samples (ASTM D-2217)	298
13.2.3 Dry Preparation of Soil Samples (ASTM D-421)	299
13.2.4 Test Procedure of Particle Size Analysis (ASTM D-422)	299
13.3 Specific Gravity Method (D-854)	301
13.4 Atterberg Limits	305
13.4.1 Liquid Limit Test (ASTM D-4318-84)	305
13.4.2 Plastic Limit Test (ASTM D-4318-84)	306
13.4.3 The Shrinkage Limit Test (ASTM D-427)	306
13.4.4 Void Ratio	308
13.5 Permeability of Granular Soils under Constant Head (ASTM D-2434)	309
References	313
 14 Project Performance	315
14.1 Introduction	315
14.1.1 Project Proposal	315
14.1.2 Project Planning	316
14.1.3 Project and Report Quality Assurance	318
14.1.4 Types of Projects	318
14.1.5 Summary of Project Planning	319
14.2 Project Management	319
14.2.1 Management by Objectives	319
14.2.2 Position Descriptions and Performance Standards	320
14.2.3 Project Controls	320
14.2.4 Monitoring Progress	323
14.2.5 Project Completion	323
14.2.6 Roles and Responsibilities	325
14.2.7 Summary of Project Management	325
14.3 AIPG Bylaws and Code of Ethics	326
14.4 Project/Site Safety Precautions	326
14.5 Search for References	327
References	328
Selected References	328
Appendix 14.A · Sample Forms (Required for a Project)	329
Appendix 14.B · Project-Work Elements and Management Graphs	334
Appendix 14.C · Professional Services Agreement	340
 Index	357