

GEOLOGY **FOR CIVIL** **ENGINEERS**

A.C. McLean C. D. Gribble

University of Glasgow



London
GEORGE ALLEN & UNWIN
Boston Sydney

Contents

<i>Preface to the second edition</i>	viii		
<i>Preface to the first edition</i>	ix		
<i>Acknowledgements</i>	xi		
1 Introduction	1		
1.1 Role of the engineer in the systematic exploration of a site	1		
1.2 Relevance of geology to civil engineering	2		
1.3 The science of geology	3		
1.4 The aims and organisation of this book	4		
2 Minerals and rocks	5		
2.1 The common rock-forming minerals	5		
2.1.1 The properties of minerals	5		
2.1.2 Silicate minerals	10		
2.1.3 Non-silicate minerals	25		
2.2 Rocks	28		
2.2.1 The nature of rocks	28		
2.2.2 Igneous rocks	28		
2.2.3 Igneous structures and forms	35		
2.2.4 Sedimentary rocks	42		
2.2.5 Metamorphic rocks	54		
3 Superficial deposits	60		
3.1 Soils	60		
3.2 Weathering	60		
3.2.1 Introduction	60		
3.2.2 Mechanical weathering	62		
3.2.3 Chemical weathering	63		
3.2.4 Biological weathering	64		
3.2.5 Role of vegetation	65		
3.2.6 Influence of climate	65		
3.3 Modern residual soils	66		
3.3.1 Soil development and engineering grades of weathering	66		
3.3.2 Soil description	66		
3.3.3 Soil terminology	69		
3.3.4 Classification of residual soils	69		
3.4 Transported superficial deposits	70		
3.4.1 Introduction	70		
3.4.2 Aeolian (windborne) deposits	72		
3.4.3 Alluvial (riverborne) deposits	72		
3.4.4 Erosion and deposition at the coast	75		
3.5 Glacial (iceborne) deposits	80		
3.5.1 Introduction	80		
3.5.2 The Pleistocene glaciation	80		
3.5.3 Glaciers and their flow	81		
3.5.4 Erosion by ice	83		
3.5.5 Deposition from ice	83		
3.5.6 Deposition from melt waters	86		
3.5.7 Late-glacial and postglacial phenomena	87		
3.5.8 Periglacial phenomena	88		
3.6 Landforms	90		
3.6.1 Erosional landforms	90		
3.6.2 Depositional landforms	93		
4 Distribution of rocks at and below the surface	95		
4.1 Introduction	95		
4.2 Geological maps and sections	95		
4.3 Nature and uses of stratigraphy	98		
4.3.1 Rock type and past environment	98		
4.3.2 The geological timescale	102		
4.3.3 Stratigraphic presentation of rocks in maps and reports	106		
4.4 Deformation of rocks (structural geology)	107		
4.4.1 Outcrops and subsurface structure	107		
4.4.2 Layers of uniform dip (horizontal, vertical and inclined strata)	108		
4.4.3 Folds	112		
4.4.4 Fractures in rocks	118		
4.4.5 Faults	121		
4.4.6 Joints	123		
4.4.7 Unconformity, overstep and onlap (overlap)	129		
4.5 Plate tectonics and seismicity	132		
4.5.1 Earth's layers and plates	132		
4.5.2 Magnitude and intensity of earthquakes	138		
4.5.3 Relationship of earthquakes to faults	139		
4.5.4 Prediction of earthquakes	141		
4.5.5 Seismic risk and problems for the engineer	142		
4.6 The continental crust	143		
4.6.1 Major crustal features	143		
4.6.2 The rocks of Britain	144		

5	<i>Subsurface (ground) water</i>	151
5.1	Behaviour of water in rocks and soils	151
5.1.1	Porosity, hydraulic conductivity and permeability	151
5.1.2	Darcy's Law	152
5.2	Natural circulation of subsurface water	154
5.2.1	Precipitation and its dispersal	154
5.2.2	Groundwater and the water table	155
5.2.3	Flow of groundwater	159
5.2.4	Geological controls on movement of subsurface water	160
5.2.5	Natural discharge of groundwater	164
5.3	Some practical engineering aspects of groundwater	167
5.3.1	Groundwater and engineering	167
5.3.2	Groundwater inventory	167
5.3.3	Siting and testing of individual wells	170
5.3.4	Drainage of groundwater	171
5.3.5	Disposal of toxic waste, and storage of fluids, underground	172
6	<i>Geological exploration of an engineering site</i>	177
6.1	General considerations	177
6.1.1	Introduction	177
6.1.2	Inductive reasoning	178
6.1.3	Systematic exploration of a site	180
6.2	Preliminary investigation	181
6.2.1	Sources of information for UK site investigation	181
6.2.2	Geology of the site	183
6.2.3	Old mineral workings	185
6.3	Applied geophysical surveys	189
6.3.1	Introduction	189
6.3.2	Seismic waves	191
6.3.3	Seismic-refraction method	194
6.3.4	Seismic-reflection method	199
6.3.5	Seismic surveys: case history	200
6.3.6	Electrical methods	202
6.3.7	Magnetic method	205
6.3.8	Gravity method	207
6.4	Drilling, boring, trenching and pitting	208
6.4.1	Drilling and boring	208
6.4.2	Trenching and pitting	213
6.4.3	Groundwater conditions	214

7	<i>Rocks and civil engineering</i>	216
7.1	Classification of rocks for engineering purposes	216
7.1.1	Classification of rocks by simple criteria	216
7.1.2	Engineering group classification of rocks	217
7.2	Engineering properties of rocks	220
7.2.1	Isotropism	220
7.2.2	Rock index properties	220
7.2.3	Rocks as aggregates	230
7.2.4	Characteristics of some common rock types as aggregates	233
7.3	Drilling, blasting and rock excavation	237
7.3.1	Rock properties related to drilling	237
7.3.2	Blasting techniques	238
7.3.3	Case history of rock excavation: the new Strome Road (A890), Wester Ross, Scotland	240
7.3.4	Test problem	243
8	<i>Principal geological factors affecting certain engineering projects</i>	247
8.1	Stability of slopes and cuttings	247
8.1.1	Geological factors affecting the stability of a new excavation	247
8.1.2	Other geological factors causing instability of existing slopes	248
8.1.3	Types of failure of soil slopes	248
8.1.4	Types of failure of natural rock slopes	251
8.1.5	Stabilisation of slopes	254
8.1.6	Case history: the Kishorn Dock excavation, Wester Ross, Scotland	255
8.2	Impounded surface water: geology of reservoir and dam sites	258
8.2.1	Leakage and other considerations	258
8.2.2	Case history: leakage from Clubbiedean Dam, Midlothian, Scotland	260
8.3	Geology of tunnels	262
8.3.1	Geological considerations in tunnelling	262
8.3.2	Methods of excavation	263
8.3.3	Complications arising from local geological conditions	264
8.3.4	Case history: the proposed Channel Tunnel	268
Appendix A	<i>Descriptions of some important soil groups</i>	272
Appendix B	<i>Hydraulic properties and pumping tests of an aquifer</i>	277

Appendix C	<i>The British Geological Survey and other government Geological Surveys</i>	280
Appendix D	<i>Exploring for old coal workings in the United Kingdom</i>	284
Appendix E	<i>The time-distance graph of first arrivals from a velocity model with two layers separated by a horizontal interface, and where V_2 is greater than V_1</i>	286
Appendix F	<i>Quality of aggregates</i>	288
Appendix G	<i>Aggregate quality and tests in different countries</i>	295
Appendix H	<i>Systematic description of rocks and rock discontinuities</i>	300
	<i>Index</i>	305