

BRIEF CONTENTS

CHAPTER 1:	THE NATURE OF GEOLOGY	2
CHAPTER 2:	INVESTIGATING GEOLOGIC QUESTIONS	24
CHAPTER 3:	PLATE TECTONICS	50
CHAPTER 4:	EARTH MATERIALS	72
CHAPTER 5:	IGNEOUS ENVIRONMENTS	104
CHAPTER 6:	VOLCANOES AND VOLCANIC HAZARDS	136
CHAPTER 7:	SEDIMENTARY ENVIRONMENTS	168
CHAPTER 8:	DEFORMATION AND METAMORPHISM	202
CHAPTER 9:	GEOLOGIC TIME	234
CHAPTER 10:	THE SEAFLOOR AND CONTINENTAL MARGINS .	266
CHAPTER 11:	MOUNTAINS, BASINS, AND CONTINENTS	296
CHAPTER 12:	EARTHQUAKES AND EARTH'S INTERIOR	326
CHAPTER 13:	CLIMATE, WEATHER, AND THEIR INFLUENCES ON GEOLOGY	364
CHAPTER 14:	SHORELINES, GLACIERS, AND CHANGING SEA LEVELS	396
CHAPTER 15:	WEATHERING, SOIL, AND UNSTABLE SLOPES	436
CHAPTER 16:	RIVERS AND STREAMS	466
CHAPTER 17:	WATER RESOURCES	500
CHAPTER 18:	ENERGY AND MINERAL RESOURCES	526
CHAPTER 19:	GEOLOGY OF THE SOLAR SYSTEM	558





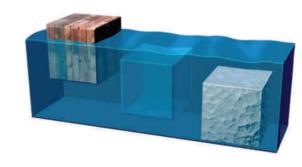
CONTENTS

Preface	xiv
Supplements	xxiii
Acknowledgments	xxvi
About the Authors	xxix

CHAPTER 1: THE NATURE OF GEOLOGY

1.0	The Nature of Geology	2
1.1	How Does Geology Influence Where and How We Live?	4
1.2	How Does Geology Help Explain Our World?	6
1.3	What Is Inside Earth?	8
1.4	What Processes Affect Our Planet?	10
1.5	How Do Rocks Form?	12
1.6	What Can Happen to a Rock?	14
1.7	How Do the Atmosphere, Water, and Life Interact with Earth's Surface?	16
1.8	What Is Earth's Place in the Solar System?	18
1.9	CONNECTIONS: How Is Geology Expressed in the Black Hills and in Rapid City?	20
1.10	INVESTIGATION: How Is Geology Affecting This Place?	22

2.2	How Do We Interpret Geologic Clues?	28
2.3	How Do We Depict Earth's Surface?	30
2.4	How Do We Depict Earth's Heights, Slopes, and Subsurface Geology?	32
2.5	How Are Geologic Problems Quantified?	34
2.6	How Do Geologists Refer to Rates and Time?	36
2.7	How Do We Investigate Geologic Questions?	38
2.8	How Do Scientific Ideas Get Established?	40
2.9	How Was the Hypothesis of Continental Drift Conceived and Received?	42
2.10	What Does a Geologist Do?	44
2.11	CONNECTIONS: How Did This Crater Form?	46
2.12	INVESTIGATION: What Is the Geologic History of Upheaval Dome?	48
	·	





CHAPTER 2: **INVESTIGATING GEOLOGIC QUESTIONS**

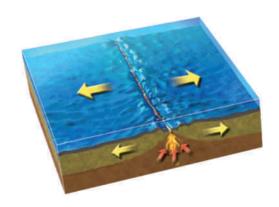
2.0 Investigating Geologic Questions	2
2.1 What Can We Observe in Landscapes?	2

24

CHAPTER 3: **PLATE TECTONICS**

50

3.0 Plate Tectonics	50
3.1 What Are the Major Features of Earth?	52
3.2 Where Do Earthquakes and Volcanoes Occur?	54
3.3 What Causes Tectonic Activity to Occur in Belts?	56
3.4 What Happens at Divergent Boundaries?	58

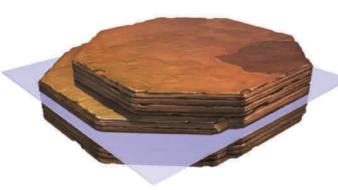






3.5 What Happens at Convergen	t Boundaries? 60
3.6 What Happens Along Transfo	orm Boundaries? 62
3.7 How Do Plates Move and Inte	eract? 64
3.8 What Geologic Features Doe Plate Tectonics Help Explain?3.9 CONNECTIONS: Why Is South South Place to Live?	66 th America Lopsided? 68
CHAPTER 4: EARTH MATERIALS	72
4.0 Earth Materials	72

4.1	What Is the Difference Between	
	a Rock and a Mineral?	74
4.2	How Are Minerals Put Together in Rocks?	76
4.3	How Do We Distinguish One Mineral from Another?	78
4.4	What Controls a Crystal's Shape?	80
4.5	What Causes Cleavage in Minerals?	82
4.6	How Are Minerals Classified?	84
4.7	What Is the Crystalline Structure of	
	Silicate Minerals?	86
4.8	What Are Some Common Silicate Minerals?	88
4.9	What Are Some Common Nonsilicate Minerals?	90
4.10	Where Are Different Minerals Abundant?	92
4.11	What Are the Building Blocks of Minerals?	94
4.12	How Do Atoms Bond Together?	96
4.13	How Do Chemical Reactions Help	
	Minerals Grow or Dissolve?	98
4.14	CONNECTIONS: How Are Minerals	
	Used in Society?	100
4.15	INVESTIGATION: What Minerals Would	
	You Use to Build a House?	102



CHAPTER 5: IGNEOUS ENVIRONMENTS

104



5.0	Igneous Environments	104
5.1	What Textures Do Igneous Rocks Display?	106
5.2	How Are Igneous Rocks Classified?	108
5.3	What Are Some Other Igneous Rocks?	110
5.4	How Do Temperature and Pressure Vary Inside Earth?	112
5.5	How Do Rocks Melt?	114
5.6	How Do Igneous Rocks Form?	116
5.7	How Does Magma Move?	118
5.8	How Does Magma Solidify?	120
5.9	How Does Magma Form Along Divergent Plate Boundaries?	122
5.10	How Does Magma Form Along Convergent Plate Boundaries?	124
5.11	How Is Magma Generated at Hot Spots and Other Sites Away from Plate Boundaries?	126
5.12	How Do Large Magma Chambers Form and How Are They Expressed in Landscapes?	128
5.13	How Are Small Intrusions Formed and Expressed in Landscapes?	130
5.14	CONNECTIONS: How Did the Sierra Nevada Form?	132
5.15	INVESTIGATION: What Types of Igneous Processes Are Occurring Here?	134

VII





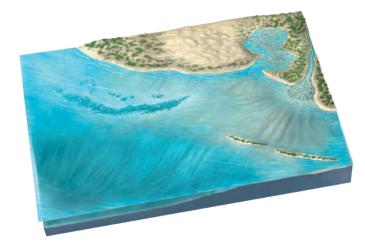
	APTER 6:	
	CANOES AND VOLCANIC	126
HA2	ZARDS	136
6.0	Volcanoes and Volcanic Hazards	136
	What Is and Is Not a Volcano?	138
	What Controls the Style of Eruption?	140
	What Features Characterize Scoria Cones	140
0.0	and Basaltic Lava Flows?	142
6.4	How Do Shield Volcanoes Form?	144
6.5	What Causes Flood Basalts?	146
6.6	What Are the Hazards of Basaltic Eruptions?	148
6.7	What Are Composite Volcanoes?	150
6.8	What Disasters Were Caused by	
	Composite Volcanoes?	152
6.9	How Do Volcanic Domes Form?	154
6.10	Why Does a Caldera Form?	156
6.11	What Disasters Were Related to Calderas?	158
6.12	What Areas Have the Highest Potential	
	for Volcanic Hazards?	160
6.13	How Do We Monitor Volcanoes?	162
6.14	CONNECTIONS: What Volcanic Hazards	
	Are Posed by Mount Rainier?	164
6.15	INVESTIGATION: How Would You Assess	
	Hazards on This Volcano?	166



CHAPTER 7:	
SEDIMENTARY ENVIRONMENTS	168

7.0 Sedimentary Environments	168
7.1 What Sedimentary Environments Occur on Land?	170
7.2 What Sedimentary Environments Are	
Near Shorelines and in Oceans?	172

7.3	Where Do Clasts Come From?	17
7.4	What Are the Characteristics of Clastic Sediments?	17
7.5	What Types of Rocks Do Clastic Sediments Form?	17
7.6	What Are Nonclastic Sedimentary Rocks and How Do They Form?	18
7.7	Why Do Sedimentary Rocks Have Layers?	18
7.8	Where Do Breccia and Conglomerate Form?	18
7.9	Where Does Sandstone Form?	18
7.10	How Do Fine-Grained Clastic Rocks Form?	18
7.11	How Do Carbonate Rocks Form?	19
7.12	How Do Changing Environments Create a Sequence of Different Kinds of Sediments?	19
7.13	How Do We Study Sedimentary Sequences?	19
7.14	Why Are Sediments and Sedimentary Rocks Important to Our Society?	19
7.15	CONNECTIONS: How Did Sedimentary Layers West of Denver Form?	19
7.16	INVESTIGATION: What Is the Sedimentary History of This Plateau?	20



CHAPTER 8:	
DEFORMATION AND	
METAMORPHISM	202

0.0	Deformation and Metamorphism	202
8.1	What Processes Can Deform and Change a Rock After It Forms?	204
8.2	How Do Rocks Respond to Stress, Temperature, and Fluid Pressure?	206
8.3	How Do Rocks Fracture?	208
8.4	What Are Different Types of Faults?	210

VIII



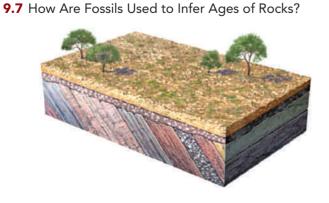
242

244

246

248

8.5 What Are Folds and How Are They Shaped?	212	
8.6 What Are Some Metamorphic Features?	214	
8.7 What Are Some Common Metamorphic Rocks?	216	
8.8 How Does Metamorphism Occur?	218	
8.9 Where Does Metamorphism Occur?	220	
8.10 What Types of Deformation and Metamorphism Occur in Extensional and Strike-Slip Settings?	222	
8.11 How Are Different Structures and Metamorphic Features Related?	224	
8.12 How Are Geologic Structures and Metamorphic Rocks Expressed in the Landscape?	226	
8.13 How Do We Study Geologic Structures and Metamorphic Features?	228	
8.14 CONNECTIONS: What Is the Structural and Metamorphic History of New England?	230	
8.15 INVESTIGATION: What Structural and Metamorphic Events Occurred Here?	232	
CHAPTER 9: GEOLOGIC TIME	234	
9.0 Geologic Time	234	
9.1 How Do We Infer the Relative Ages of Events?	236	
9.2 How Do We Study Ages of Landscapes?	238	
9.3 What Is the Significance of an Unconformity?	240	



9.4 How Are Ages Assigned to Rocks and Events?

9.6 How and Why Did Living Things Change

Through Geologic Time?

9.5 What Are Fossils?

9.8	How Was the Geologic Timescale Developed?	250
9.9	What Is the Evidence for the Age of Earth?	252
9.10	What Were Some Milestones in the Early History of Life on Earth?	254
9.11	What Were Some Milestones in the Later History of Life on Earth?	256
9.12	How Do We Reconstruct Geologic Histories?	258
9.13	Why Do We Investigate Geologic History?	260
9.14	CONNECTIONS: What Is the History of the Grand Canyon?	262
9.15	INVESTIGATION: What Is the Geologic History of This Place?	264

CHAPTER 10: THE SEAFLOOR AND CONTINENTAL MARGINS 266

10.0	The Seafloor and Continental Margins	266
10.1	How Do We Explore the Seafloor?	268
10.2	How Is Paleomagnetism Used to	
	Study the Ocean Floor?	270
10.3	What Processes Occur at Mid-Ocean Ridges?	272
10.4	What Are Major Features of the Deep Ocean?	274
10.5	How Do Oceanic Islands, Seamounts, and Oceanic Plateaus Form?	276
10.6	What Processes Form Island Arcs?	278
10.7	How Did Smaller Seas of the Pacific Form?	280
10.8	How Did Smaller Seas Near Eurasia Form?	282
10.9	How Do Reefs and Coral Atolls Form?	284
10.10	What Is the Geology of Continental Margins?	286
10.11	How Do Marine Salt Deposits Form?	288
10.12	How Did Earth's Modern Oceans Evolve?	290
10.13	CONNECTIONS: How Did the Gulf of Mexico and the Caribbean Region Form?	292
10.14	INVESTIGATION: How Did These Ocean Features and Continental Margins Form?	294

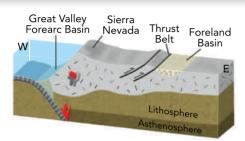


I



CHAPTER 11: MOUNTAINS, BASINS, AND CONTINENTS

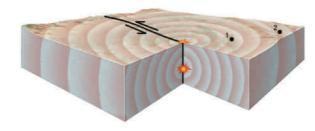
296



11.0	Mountains, Basins, and Continents	296
11.1	Why Are Some Regions High in Elevation?	298
11.2	Where Do Mountain Belts and High Regions Form?	300
11.3	How Do Local Mountains Form?	302
11.4	Where Do Basins Form?	304
11.5	How Do Mountains and Basins Form at Convergent Continental Margins?	306
11.6	How Does Continental Extension Occur?	308
11.7	What Are the Characteristics and History of Continental Hot Spots?	310
11.8	What Features Characterize the Interiors of Continents?	312
11.9	What Are Tectonic Terranes?	314
11.10	How Do Continents Form?	316
11.11	How Did the Continents Join and Split Apart?	318
11.12	CONNECTIONS: How Did the Appalachian and Ouachita Mountains Form?	320
11.13	CONNECTIONS: What Is the Geologic History of the Western United States?	322
11.14	INVESTIGATION: Where Will Mountains and Basins Form in This Region?	324

CHAPTER 12:	
EARTHQUAKES AND EARTH'S	
INTERIOR	326

12.0 Earthquakes and Earth's Interior	326
12.1 What Is an Earthquake?	328
12.2 How Does Faulting Cause Earthquakes?	330
12.3 Where Do Most Earthquakes Occur?	332



12.4	What Causes Earthquakes Along Plate	
	Boundaries and Within Plates?	334
12.5	How Do Earthquake Waves Travel?	336
12.6	How Do We Determine the Location	220
	and Size of an Earthquake?	338
12.7	How Do Earthquakes Cause Damage?	340
12.8	What Were Some Major North American	
	Earthquakes?	342
12.9	What Were Some Major World Earthquakes?	344
12.10	How Does a Tsunami Form and Cause Destruction?	346
12.11	How Do We Study Earthquakes in the Field?	348
12.12	Can Earthquakes Be Predicted?	350
12.13	What Is the Potential for Earthquakes Along the	
	San Andreas Fault?	352
12.14	How Do We Explore What Is Below Earth's Surface?	354
12.15	What Do Seismic Waves Indicate About	
	Earth's Interior?	356
12.16	How Do We Investigate Deep Processes?	358
12.17	CONNECTIONS: What Happened During the	
	Great Alaskan Earthquake of 1964?	360
12.18	INVESTIGATION: Where Did This Earthquake	
	Occur, and What Damage Might Be Expected?	362

CHAPTER 13: CLIMATE, WEATHER, AND THEIR INFLUENCES ON GEOLOGY 364

13.0 Climate, Weather, and Their Influences on Geology	364
13.1 What Causes Winds?	366
13.2 How Does Wind Transport Material?	368



Х



Why Does It Rain and Snow?	370
How Do Hurricanes, Tornadoes, and Other Storms Develop?	372
How Do Ocean Currents Influence Climate?	374
What Causes Short-Term Climatic Variations?	376
What Controls the Location of Rain Forests?	378
What Are Deserts and How Do They Form?	380
What Features Are Common in Deserts?	382
What Is the Evidence for Global Warming?	384
What Factors Influence Global Warming?	386
What Is the Relationship Among Climate, Tectonics, and Landscape Evolution?	388
How Does Geology Influence Ecology?	390
CONNECTIONS: What Occurred During the Hurricane Seasons of 2004 and 2005? INVESTIGATION: What Kinds of Climate	392
and Weather Would Occur in This Place?	394
	How Do Hurricanes, Tornadoes, and Other Storms Develop? How Do Ocean Currents Influence Climate? What Causes Short-Term Climatic Variations? What Controls the Location of Rain Forests? What Are Deserts and How Do They Form? What Features Are Common in Deserts? What Is the Evidence for Global Warming? What Factors Influence Global Warming? What Is the Relationship Among Climate, Tectonics, and Landscape Evolution? How Does Geology Influence Ecology? CONNECTIONS: What Occurred During the Hurricane Seasons of 2004 and 2005? INVESTIGATION: What Kinds of Climate

CHAPTER 14: SHORELINES, GLACIERS, AND CHANGING SEA LEVELS



14.0 Shorelines, Glaciers, and Changing Sea Levels	396
14.1 What Processes Occur Along Shorelines?	398
14.2 What Causes High Tides and Low Tides?	400
14.3 How Do Waves Form and Propagate?	402
14.4 How Is Material Eroded, Transported, and Deposited Along Shorelines?	404
14.5 What Landforms Occur Along Shorelines?	406
14.6 What Are Some Challenges of Living Along Shorelines?	408
14.7 How Do Geologists Assess the Relative Risks of Different Stretches of Coastline?	410
14.8 What Happens When Sea Level Changes?	412

14.9	What Causes Changes in Sea Level?	414
14.10	What Are Glaciers?	416
14.11	How Do Glaciers Form, Move, and Vanish?	418
14.12	What Happens When Glaciers Erode into the Landscape?	420
14.13	What Features Do Glacial Sediments Form?	422
14.14	What Features Are Peripheral to Glaciers?	424
14.15	What Is the Evidence for Past Glaciations?	426
14.16	What Happened During Past Ice Ages?	428
14.17	What Starts and Stops Glacial Episodes?	430
14.18	CONNECTIONS: What Would Happen to Sea Level if the Ice in West Antarctica Melted?	432
14.19	INVESTIGATION: How Could an Episode of Global Warming or a Glacial Period Affect North America?	434

CHAPTER 15: WEATHERING, SOIL, AND UNSTABLE SLOPES 436

15.0 Weathering, Soil, and Unstable Slopes	436
15.1 What Physical Processes Affect Rocks Near the Surface?	438
15.2 How Do Chemical Processes Affect Rocks Near the Surface?	440
15.3 How Do Different Rocks and Minerals Weather?	442
15.4 What Factors Influence Weathering?	444
15.5 How Does Soil Form?	446
15.6 Why Is Soil Important to Society?	448
15.7 What Controls the Stability of Slopes?	450
15.8 How Do Slopes Fail?	452
15.9 How Does Material on Slopes Fall and Slide?	454
15 10 How Does Material Flow Down Slopes?	156



2



396



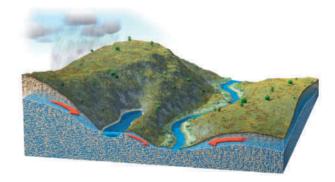
15.11	Where Do Slope Failures Occur in the U.S.?	458
15.12	How Do We Study Slope Failures and Assess the Risk for Future Events?	460
15.13	CONNECTIONS: What Is Happening with the Slumgullion Landslide in Colorado?	462
15.14	INVESTIGATION: Which Areas Have the Highest Risk of Slope Failure?	464

CHAPTER 16: RIVERS AND STREAMS 466



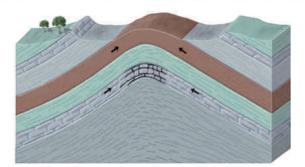
16.0	Rivers and Streams	466
16.1	What Are River Systems?	468
16.2	How Do Rivers Transport Sediment and Erode Their Channels?	470
16.3	How Do River Systems Change Downstream or Over Short Time Frames?	472
16.4	What Factors Influence Profiles of Rivers?	474
16.5	Why Do Rivers and Streams Have Curves?	476
16.6	What Features Characterize Mountain Rivers and Streams?	478
16.7	What Features Characterize Braided Rivers?	480
16.8	What Features Characterize Low-Gradient Rivers?	482
16.9	What Happens When a River Reaches	
	Its Base Level?	484
16.10	How Do Rivers Change Over Time?	486
16.11	What Happens During River Incision?	488
16.12	What Is and What Is Not a Flood?	490
16.13	What Were Some Devastating Floods?	492
16.14	How Do We Measure Floods?	494
16.15	CONNECTIONS: How Does the Colorado River Change as It Flows Across the Landscape?	496
16.16	INVESTIGATION: How Would Flooding Affect This Place?	498
16.16	INVESTIGATION: How Would Flooding Affect	49

CHAPTER 17: WATER RESOURCES	500
17.0 Water Resources	500
17.1 Where Does Water Occur on Our Planet?	502
17.2 How Do We Use Freshwater?	504
17.3 Where Is Groundwater Found?	506
17.4 How and Where Does Groundwater Flow?	508
17.5 What Is the Relationship Between Surface Water and Groundwater?	510
17.6 What Features Form When Groundwater Interacts with Limestone?	512
17.7 How Do We Explore for Groundwater?	514
17.8 What Problems Are Associated with Groundwater Pumping?	516
17.9 How Can Water Become Contaminated?	518
17.10 How Does Groundwater Contamination Move and How Do We Clean It Up?	520
17.11 CONNECTIONS: What Is Going On with the Ogallala Aquifer?	522
17.12 INVESTIGATION: Who Polluted Surface Water and Groundwater in This Place?	524



CHAPTER 18: ENERGY AND MINERAL RESOURCES	526
18.0 Energy and Mineral Resources	526
18.1 How Do Oil and Natural Gas Form?	528
18.2 In What Settings Are Oil and Gas Trapped?	530
18.3 How Do Coal and Coal-Bed Methane Form?	532
18.4 What Are Other Types of Hydrocarbons?	534
18.5 How Do We Explore for Fossil Fuels?	536





18.6 How Is Nuclear Energy Produced?	538
18.7 How Is Water Used to Generate Electricity?	540
18.8 What Are Some Alternative Energy Sources?	542
18.9 What Are Mineral Deposits and How Do They Form?	544
18.10 How Do Precious Metal Deposits Form?	546
18.11 How Do Base Metal Deposits Form?	548
18.12 How Do We Explore for Mineral Deposits?	550
18.13 Why Are Industrial Rocks and Minerals So Important to Society?	552
18.14 CONNECTIONS: Why Is Wyoming So Rich in Energy Resources?	554
18.15 INVESTIGATION: Where Would You Explore for Fossil Fuels in This Place?	556



19.4 What Is the Geology of Our Moon?	56
19.5 What Is Observed on Jupiter and Its Moons?	568
19.6 What Is Observed on Saturn and Its Moons?	570
19.7 What Is the Geology of the Outer Planets and Their Moons?	572
19.8 CONNECTIONS: What Have We Learned About Mars?	574
19.9 INVESTIGATION: How and When Did Geologic Features on This Alien World Form?	576

CHAPTER 19: GEOLOGY OF THE SOLAR SYSTEM 558

19.0 Geology of the Solar System	558
19.1 How Do We Explore Other Planets and Moons?	560
19.2 Why Is Each Planet and Moon Different?	562
19.3 What Is the Geology of the Inner Planets?	564

Glossary	G-1
Credits	C-1
Index	I-1
Shaded Relief Map of the United States	I-18
Map of the World	Inside Front Cover
Tapestry of Time Map of North America	Inside Back Cover



