Contents

Preface

page ix

1	Basic Pressure Concepts and Definitions		
	1.1	Introduction	1
	1.2	Basic Concepts	2
	1.3	Pore Pressure Gradient	5
	1.4	Overburden Stress	7
	1.5	Effective Vertical Stress and Terzaghi's Law	9
	1.6	Formation Pressure	12
	1.7	Casing Design	18
	1.8	Importance of Geopressure	19
2	Basic Continuum Mechanics and Its Relevance to Geopressure		
	2.1	Introduction	32
	2.2	Stresses and Forces in a Continuum	32
	2.3	Deformation and Strain	39
	2.4	Fundamental Laws of Continuum Mechanics	41
	2.5	Hooke's Law and Constitutive Equations	44
	2.6	Elasticity, Stress Path, and Rock Mechanics	54
	2.7	Poroelasticity	56
	2.8	Linear Stress-Strain Formulation for Poroelastic Media (Static	
		Poroelasticity)	59
	2.9	Mechanical Compaction from Plastic-Poroelastic Deformation	
		Principles	65
	2.10	Fracture Mechanics and Hydraulic Fracturing	71
	2.11	Rock Physics Basis for Detection and Estimation of Geopressure	75
3	Mechanisms of Geopressure		
	3.1	Introduction	84
	3.2	Stress Related: Vertical (Compaction Disequilibrium)	85
	3.3	Stress Related: Lateral (Associated with Compaction Disequilibrium)	96
	3.4	Chemical Diagenesis as a Geopressure Mechanism	97
	3.5	Kerogen Conversion and Hydrocarbon Generation as Mechanisms	
		of Geopressure	112

3.6 Chemical Diagenesis due to Gypsum-to-Anhydrite 119 Transformation 119 3.7 Charging through Subsurface Structures (Lateral Transfer of Fluids) 119 3.8 Hydrocarbon Buoyancy as a Cause of Overpressure 122 3.9 Hydraulic Head as a Cause of Overpressure (Erosion/Uplift, Elevation Related to Datum) 122 3.10 Aquathermal Pressuring as a Mechanism of Geopressure 127 3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 132 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 108 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 197 4.5 Measurement of Pore Pressure 197 4.5 Measurement of Pore Pressure 197 4.5 Measurement of Pore Pressure 197 4.5 Measurement of Pore Pressure 197	vi	Contents	
Transformation 119 3.7 Charging through Subsurface Structures (Lateral Transfer of Fluids) 119 3.8 Hydroulic Head as a Cause of Overpressure 122 3.9 Hydraulic Head as a Cause of Overpressure (Erosion/Uplift, Elevation Related to Datum) 126 3.10 Aquathermal Pressuring as a Mechanism of Geopressure 127 3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 133 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 135 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 17 4.5 Measurement of Pore Pressure 197 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Pressure 197 4.8 Overburden Stress Evaluation 4.9 Dere Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 206 </th <th></th> <th>3.6 Chemical Diagenesis due to Gypsum-to-Anhydrite</th> <th></th>		3.6 Chemical Diagenesis due to Gypsum-to-Anhydrite	
3.7 Charging through Subsurface Structures (Lateral Transfer of Fluids) 119 3.8 Hydrocarbon Buoyancy as a Cause of Overpressure 122 3.9 Hydraulic Head as a Cause of Overpressure (Erosion/Uplift, Elevation Related to Datum) 126 3.10 Aquathermal Pressuring as a Mechanism of Geopressure 127 3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 134 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 136 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 177 4.5 Measurement of Pore Pressure 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 206 4.9 Effect of Water Depth on Overburden and Fracture Pressure 107 4.9 Effect of Water Depth on Overburden and Fracture Pressure 116		Transformation	119
3.8 Hydrocarbon Buoyancy as a Cause of Overpressure 122 3.9 Hydraulic Head as a Cause of Overpressure (Erosion/Uplift, Elevation Related to Datum) 126 3.10 Aquathermal Pressuring as a Mcchanism of Geopressure 127 3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 136 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 133 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 183 4.5 Measurement of Pore Pressure 197 4.8 Overburden Stress Evaluation 200 200 201 201 4.9 Effect of Water Depth on Overburden and Fracture Pressure 197 4.8 204 210 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 211 4.11 Summary 215 5.1 Introduction <td></td> <td>3.7 Charging through Subsurface Structures (Lateral Transfer of Fluids)</td> <td>119</td>		3.7 Charging through Subsurface Structures (Lateral Transfer of Fluids)	119
3.9 Hydraulic Head as a Cause of Overpressure (Erosion/Uplift, Elevation Related to Datum) 126 3.10 Aquathermal Pressuring as a Mechanism of Geopressure 127 3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 131 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 133 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 188 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure 216 4.10 Temperature Evaluation (Direct and Indirect Methods) 216 4.10 Temperature Evaluation (Direct and Indirect Methods) 216 5.1 Introduction 218 5.1 Introduction		3.8 Hydrocarbon Buoyancy as a Cause of Overpressure	122
Elevation Related to Datum) 126 3.10 Aquathermal Pressuring as a Mechanism of Geopressure 127 3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 126 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 130 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 135 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 206 4.10 Temperature Evaluation (Direct and Indirect Methods) 216 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 216 5.1 Introduction 216 5.1 Seismic Velocity from Traveltime Analysis and Anisotropy 228		3.9 Hydraulic Head as a Cause of Overpressure (Erosion/Uplift,	
3.10 Aquathermal Pressuring as a Mechanism of Geopressure 127 3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 130 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 133 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 186 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 206 4.10 Temperature Evaluation (Direct and Indirect Methods) 216 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Seismic Velocity from Traveltime Analysis and Anisotropy 226 5.4 Seismic Velocity from Traveltime Analysis and Guidel		Elevation Related to Datum)	126
3.11 Osmotic Pressure as a Source of Geopressure 128 3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 130 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 133 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure 197 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 225		3.10 Aquathermal Pressuring as a Mechanism of Geopressure	127
3.12 Summary 128 4 Quantitative Geopressure Analysis Methods 130 4.1 Introduction 133 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 135 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 205 4.10 Temperature Evaluation (Direct and Indirect Methods) 216 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 <		3.11 Osmotic Pressure as a Source of Geopressure	128
4 Quantitative Geopressure Analysis Methods 133 4.1 Introduction 136 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 133 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Petfect of Water Depth on Overburden and Fracture Pressure Gradients 209 4.10 Temperature Evaluation (Direct and Indirect Methods) 216 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Modeling		3.12 Summary	128
4.1 Introduction 130 4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 133 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) 136 Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 180 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure 200 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 216 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 225 5.4 Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure	4	Quantitative Geopressure Analysis Methods	130
4.2 Normal Compaction Trends and Characteristics of Undercompacted Zones 133 4.3 Methods to Predict Geopressure 133 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 180 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 205 4.10 Temperature Evaluation (Direct and Indirect Methods) 216 5.1 Introduction 218 5.1 Introduction 218 5.2 Measurements of Velocity 226 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 225 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 <		4.1 Introduction	130
Zones1334.3Methods to Predict Geopressure1334.4Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work1754.5Measurement of Pore Pressure1864.6Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient1854.7Subsalt Pore Pressure and Fracture Pressure1974.8Overburden Stress Evaluation2004.9Effect of Water Depth on Overburden and Fracture Pressure Gradients2094.10Temperature Evaluation (Direct and Indirect Methods)2104.11Summary2155Seismic Methods to Predict and Detect Geopressure2185.1Introduction2185.2Measurements of Velocity2205.3Seismic Velocity from Traveltime Analysis and Anisotropy2285.4Seismic Velocity from Inversion2455.5Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure2776Integrating Seismic Imaging, Rock Physics, and Geopressure (CIP) Tomography for Pore Pressure Analysis2826.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications for Geopressure and Imaging with CIP Tomography2916.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3006.6Summary305		4.2 Normal Compaction Trends and Characteristics of Undercompacted	
4.3 Methods to Predict Geopressure 135 4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 186 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 200 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided		Zones	133
4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks) Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 180 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 209 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Gu		4.3 Methods to Predict Geopressure	135
Where Common Shale-Based Techniques Do Not Work 175 4.5 Measurement of Pore Pressure 180 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 209 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 225 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Appl		4.4 Pore Pressure Prediction in Carbonates (and Other Competent Rocks)	
4.5 Measurement of Pore Pressure 188 4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure 206 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 216 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography <t< td=""><td></td><td>Where Common Shale-Based Techniques Do Not Work</td><td>175</td></t<>		Where Common Shale-Based Techniques Do Not Work	175
4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient 185 4.7 Subsalt Pore Pressure and Fracture Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 209 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applicatio		4.5 Measurement of Pore Pressure	180
4.7 Subsait Pore Pressure and Practure Pressure 197 4.8 Overburden Stress Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 209 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure an		4.6 Leak-Off Test, Extended Leak-Off Test, and Fracture Gradient	185
4.3 Overburden Sitess Evaluation 200 4.9 Effect of Water Depth on Overburden and Fracture Pressure Gradients 209 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308		4.7 Subsalt Pole Plessure and Flacture Plessure	200
4.10 Entect of Water Depin on Overbuilden and Fracture Fressure Gradients 209 4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 213 5 Seismic Methods to Predict and Detect Geopressure 216 5.1 Introduction 216 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308 <td></td> <td>4.6 Overounden Suess Evaluation 4.9 Effect of Water Depth on Overburden and Eracture Pressure</td> <td>200</td>		4.6 Overounden Suess Evaluation 4.9 Effect of Water Depth on Overburden and Eracture Pressure	200
4.10 Temperature Evaluation (Direct and Indirect Methods) 210 4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308		Gradients	209
4.11 Summary 215 5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308		4.10 Temperature Evaluation (Direct and Indirect Methods)	210
5 Seismic Methods to Predict and Detect Geopressure 218 5.1 Introduction 218 5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308		4.11 Summary	215
5.1Introduction2185.2Measurements of Velocity2205.3Seismic Velocity from Traveltime Analysis and Anisotropy2285.4Seismic Velocity from Inversion2455.5Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure2776Integrating Seismic Imaging, Rock Physics, and Geopressure (CIP) Tomography for Pore Pressure Analysis2816.1Introduction2816.2Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis2826.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications and Imaging with FWI3066.6Summary308	5	Seismic Methods to Predict and Detect Geopressure	218
5.2 Measurements of Velocity 220 5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308		5.1 Introduction	218
5.3 Seismic Velocity from Traveltime Analysis and Anisotropy 228 5.4 Seismic Velocity from Inversion 245 5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308		5.2 Measurements of Velocity	220
5.4Seismic Velocity from Inversion2455.5Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure2776Integrating Seismic Imaging, Rock Physics, and Geopressure2816.1Introduction2816.2Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis2826.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308		5.3 Seismic Velocity from Traveltime Analysis and Anisotropy	228
5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications to Pore Pressure 277 6 Integrating Seismic Imaging, Rock Physics, and Geopressure 281 6.1 Introduction 281 6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis 282 6.3 Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography 291 6.4 Subsalt Pore Pressure Applications 297 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308		5.4 Seismic Velocity from Inversion	245
to Pore Pressure2776Integrating Seismic Imaging, Rock Physics, and Geopressure2816.1Introduction2816.2Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis2826.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308		5.5 Summary: Seismic Velocity Analysis and Guidelines for Applications	
6Integrating Seismic Imaging, Rock Physics, and Geopressure2816.1Introduction2816.1Introduction2816.2Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis2826.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308		to Pore Pressure	277
6.1Introduction2816.2Rock Physics Guided Velocity Modeling (RPGVM) with Reflection (CIP) Tomography for Pore Pressure Analysis2826.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308	6	Integrating Seismic Imaging, Rock Physics, and Geopressure	281
6.2Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis2826.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308		6.1 Introduction	281
6.3Example Applications of Rock Physics Guided Velocity Modeling for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308		6.2 Rock Physics Guided Velocity Modeling (<i>RPGVM</i>) with Reflection (CIP) Tomography for Pore Pressure Analysis	282
for Geopressure and Imaging with CIP Tomography2916.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308		6.3 Example Applications of Rock Physics Guided Velocity Modeling	_0_
6.4Subsalt Pore Pressure Applications2976.5Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI3066.6Summary308		for Geopressure and Imaging with CIP Tomography	291
 6.5 Rock Physics Guided Velocity Modeling for Pore Pressure and Imaging with FWI 306 6.6 Summary 308 		6.4 Subsalt Pore Pressure Applications	297
and Imaging with FWI 306 6.6 Summary 308		6.5 Rock Physics Guided Velocity Modeling for Pore Pressure	
6.6 Summary 308		and Imaging with FWI	306
•		6.6 Summary	308

		Contents	vi	
7	Moth	node for Pore Pressure Detection: Well Longing and Drilling		
,	Menious for Fressure Detection, well Logging and Diminig Parameters			
	7 1	Introduction	31	
	7.1	Logging Tools	31	
	7.2	Pore Pressure from Well Logging Methods	31	
	7.5	Recommendations on Use of Wireline Logs for Pore Pressure	51.	
	/.1	Analysis	32	
	7.5	Drilling Parameters for Pore Pressure Analysis	32	
8	Gravity and EM Field Methods Aiding Pore Pressure Prediction			
	8.1	Introduction	33	
	8.2	Gravity Method	33	
	8.3	Electromagnetic Method	34	
	8.4	Joint Inversion	34	
	8.5	Concluding Remarks	34	
9	Geop	ressure Detection and Prediction in Real Time	34	
	9.1	Introduction	34	
	9.2	Strategy for Real-Time Update and Prediction Ahead of the Bit	34	
	9.3	Pore Pressure Prediction Methods in Real-Time	35	
	9.4	Seismic-While-Drilling Technology for Real-Time Pore Pressure Prediction	35	
	95	Geopressure Prediction in Real-Time Using Basin Modeling	36	
	9.6	Summary	36	
10	Geopressure Prediction Using Basin History Modeling			
	10.1	Introduction: Basin and Petroleum System Modeling	36	
	10.2	Governing Equations for Mathematical Basin Modeling	36	
	10.3	Basin Modeling: Compaction, Diagenesis, and Overpressure	37	
	10.4	Basin Modeling in 3D	38	
11	Geohazard Prediction and Detection			
	11.1	Introduction: What Is Geohazard?	392	
	11.2	Shallow-Waterflow-Sands (SWF)	39.	
	11.3	Shallow Gas as Geohazard	41	
	11.4	Gas Hydrate as Geohazard	414	
	11.5	Geohazard Mitigation (Dynamic Kill Drill or DKD Procedure)	41	
	11.6	Recommendations for Detection of Geohazards	419	
	11.7	Concluding Remarks	42	
12	Petroleum Geomechanics and the Role of Geopressure			
	12.1	Introduction	42	
	12.2	Borehole Stability and Pore Pressure	423	

viii	Contents			
	12.3	Petroleum Geomechanics Modeling	428	
	12.4	4D Geomechanics and 4D Earth Model Building	446	
	12.5	Summary	451	
13	Guidelines for Best Practices: Geopressure Prediction and Analysis			
	13.1	Introduction	452	
	13.2	Subsurface Geological Habitat for Geopressure (Geology)	453	
	13.3	Physics of Pore Pressure Generation (Models)	458	
	13.4	Technology for Subsurface Prediction (Tools)	461	
	13.5	Uncertainty Analysis	468	
14	Recent Advances in Geopressure Prediction and Detection Technology			
	and the Road Ahead			
	14.1	Introduction	479	
	14.2	Seismic Technology	479	
	14.3	Models That Relate Velocity to Pore Pressure	481	
	14.4	Seismic Velocity Analysis for Pore Pressure Prediction:		
		What We Have Learned and the Road Ahead	482	
	14.5	Pore Pressure Prediction in Real-Time	486	
	14.6	Integration of Disciplines	487	
	14.7	Data Analytics and Machine Learning	487	
	14.8	Summary	490	
	Appendices			
	A	Empirical Relations for Fluid (Brine, Oil, Gas) Properties	491	
	B	Basic Definitions	496	
	C	Dimensionless Coordinate Transformation of 1D Basin Modeling		
]	Equation	498	
	References		501	
	Inde	x	532	

Color plates can be found between pages 268 and 269.