
Contents

Introduction	1
1 The Mineralogy of Illite – What is Illite?	3
1.1 Illite Definitions	3
1.1.1 Definitions of the Past	3
1.1.2 Definition Based on XRD Examination	5
1.1.3 Examples of Pure Illites	10
1.1.4 Examples of Illites in Natural Soils, Sediments and Sedimentary Rocks	12
1.1.5 Summary of One-Dimensional Analysis of Natural Minerals by XRD	17
1.2 Definition Based on Chemical Composition	18
1.2.1 Solid Solutions of Illite and Glauconite	18
1.2.2 Charge-Lowering Substitutions	20
1.2.3 The Crystal Structure of Illite and Solid Solution.....	23
1.2.4 The Theoretical Crystal Structure of Illite	31
1.3 Thermodynamic Stability of Illite	40
1.3.1 The Gibbs Free Energy of Formation of the Illite Phase ...	40
1.3.2 The Stability Field of the End-Member Illite Phase	45
1.4 The Growth of Illite Crystals	48
1.4.1 Crystal Shapes in Diagenetic Environments.....	48
1.4.2 Growth Mechanisms of Lath-Shaped Illite Crystals	52
1.4.3 Growth Processes for Plate-Shaped Crystals	56
1.5 A Working Definition of Illite.....	61
2 The Geology of Illite	63
2.1 Illite in Soils and Weathered Rocks	63
2.1.1 Occurrence of Illite in Soils	63
2.1.2 More Recent Studies.....	64
2.1.3 Early Formation of Illite in Weathered Granites	68
2.2 Illite in Diagenetic Series.....	76
2.2.1 Illite Formed During Early Sedimentary or Eodiagenetic Processes	76
2.2.2 The Origin of Illite in Shale Burial Diagenesis	79

2.2.3	Illite Crystallinity	85
2.2.4	Bentonite	97
2.2.5	Sandstones	100
2.3	Illite in Fossil and Active Geothermal Fields and Hydrothermal Alteration Zones.....	109
2.3.1	Sericite and Illite in Fossil Hydrothermal Systems	109
2.3.2	Instability of Muscovite Relative to Illite.....	113
2.3.3	Crystallochemical Characteristics of High-Temperature Illites (Sericite)	115
2.3.4	The Smectite-to-Illite Conversion in Geothermal Fields ..	119
2.4	The Illite Age Measurement	122
2.4.1	Fundamental Concepts	122
2.4.2	The K–Ar Apparent Age of Authigenic-Detrital Mineral Mixtures	125
2.4.3	Patterns of K–Ar Accumulation During Illite Growth Processes	129
2.4.4	Diagenesis of Bentonites	136
2.5	Summary	139
2.5.1	What is Illite?	139
2.5.2	Where Does Illite Form?	141
3	Dynamics of the Smectite-to-Illite Transformation	145
3.1	Experimental Studies	145
3.1.1	The Run Products in Whitney and Northrop's Experiments Using Bentonite	146
3.1.2	The Different Possible Interpretations of the Experiments	149
3.2	Kinetics of Experimental Transformations (Natural and Synthetic Starting Materials)	155
3.2.1	Kinetics of Illite Formation Using Synthetic, Chemical Compositions	155
3.2.2	Kinetics Using Natural Smectite Minerals	158
3.3	The Bulk Composition Effect (K ₂ O)	160
3.3.1	Natural Minerals	160
3.3.2	Multiparameter Kinetics.....	163
3.3.3	Formation of Muscovite at High KOH Concentrations: Shape and Polymorph	165
3.4	Kinetics of the Smectite-to-Illite Conversion Process in Natural Environments	166
3.4.1	Burial Diagenesis.....	167
3.4.2	The Dual Reaction Kinetic Model (Velde and Vasseur 1992)	168
3.4.3	Changes in Reaction Kinetics	170
3.5	Success and Failure of the Multiparameter Models	172
3.5.1	The Kinetic Model of Pytte and Reynolds (1989) (Thermal Metamorphism)	172

3.5.2	Drawbacks of Multi-Parameter Kinetic Models	172
3.6	Stability Controls (T , t , μ_x)	174
3.6.1	Comparison of Experimental Models and Natural Systems	174
3.6.2	Kinetic Parameter Values	174
3.6.3	Importance of Mineral Reactions	175
3.7	Summary	176
3.8	Application of Kinetics to K–Ar Dating	176
3.8.1	The Problem for K–Ar Dating of Illite from Shales.....	176
3.8.2	K–Ar Age and Mass Transfer During Smectite-to-Illite Conversion	178
3.8.3	An Example: The Balazuc Series (Renac 1994)	182
4	Applications	189
4.1	Exploration and Exploitation of Natural Resources	190
4.1.1	Geothermal Resources.....	190
4.1.2	Clays and Petroleum	198
4.1.3	Illite Crystallinity and Organic Matter	210
4.1.4	Ore Resources	212
4.2	Environmental Problems	226
4.2.1	Illite and Mixed-Layer Minerals in Soils: Questions of Fertility	226
4.2.2	Some Effects of Agricultural Practice and their Bearing upon the Loss of Illite Content in Soils.	230
4.2.3	Nuclear Waste Barriers – Strategy and Illite Mineralogy	240
	Glossary	249
	References	263
	Index	283

Illite

Origins, Evolution and Metamorphism

Meunier, A.; Velde, B.D.

2004, XVI, 288 p., Hardcover

ISBN: 978-3-540-20486-2