

Contents

	<i>Page</i>
Preface	xi
PART I GENERAL PRINCIPLES OF METAMORPHIC PETROGENESIS	
1 Introduction: preliminary ideas of metamorphism	3
1.1 Metamorphism, temperature and local equilibrium	3
1.2 Metamorphism, intergranular fluid and melting	6
1.3 Geologic causes of metamorphism in regions with a continental-type crust	10
1.4 Pressure of metamorphism	14
1.5 Bulk-rock compositions	16
1.6 The Scottish Highlands as a well investigated type regional metamorphic region	18
2 A new conceptual basis for metamorphic petrology: prograde and progressive metamorphism, isograds, isotherms and isobars	27
2.1 Temporal changes in P - T conditions during metamorphism	27
2.2 Progressive metamorphism, isograds, thermal-peak isotherms and isobars, and field P - T curves	35
2.3 Chemical reactions on isograds	44
2.4 Isograds and the composition of intergranular fluids	49
2.5 Isograds and instantaneous isotherms, and the polychronous origin of isograds	52
2.6 General models for isothermal and isogradic surfaces in the crust	58
3 Thermodynamic properties of metamorphic reactions	66
3.1 Phase rule, components and reactions	66
3.2 Classifications of metamorphic reactions	71
3.3 Thermodynamic symbols, concepts and units	73
3.4 Solid-solid reactions	75
3.5 Reactions that involve H_2O and/or CO_2	80

3.6	Oxidation–reduction reactions	87
3.7	Exchange reactions	94
4	Volatile substances in regional metamorphism	99
4.1	States of H_2O , CO_2 and other volatiles in rocks undergoing metamorphism	99
4.2	Fluid inclusions in metamorphic rocks	106
5	Composition–paragenesis diagrams	110
5.1	Mineralogical phase rules	110
5.2	Composition–paragenesis diagrams in general	112
5.3	Eskola's <i>ACF</i> and <i>A'KF</i> diagrams	120
5.4	J. B. Thompson's <i>AFM</i> diagram for metapelites	125
5.5	Applicability of the <i>AFM</i> diagram, and the effect of MnO and local variation of the chemical potential of H_2O	142
5.6	Thompson & Thompson's Al_2O_3 – $NaAlO_2$ – $KAlO_2$ diagram for metapelites	145
5.7	Composition–paragenesis diagrams for metabasites	148
6	Buffering of intergranular fluid and infiltration of externally derived fluid	151
6.1	Internal and external buffering	151
6.2	Internal buffering with regard to O_2	154
6.3	Prograde reactions under external and internal buffering with regard to H_2O and CO_2	155
6.4	Buffering with regard to H_2O and CO_2 in graphite-bearing pelitic metamorphic rocks	159
6.5	Compositions of internally buffered fluids in pelitic metamorphic rocks	162
6.6	Buffering with regard to H_2O and CO_2 in metabasic and calcareous rocks	170
6.7	Ferry's research on the fluid flow and infiltration during regional metamorphism in Maine	172
6.8	Formation of anomalously high-grade metamorphic areas by flow of a hot fluid in New Hampshire	180

PART II METAMORPHIC FACIES AND METAMORPHIC BELTS

7	The concept and system of metamorphic facies	184
7.1	Eskola's concept and system of metamorphic facies	184
7.2	Later changes in the concept and system of metamorphic facies	189
7.3	Difficulty in rigorously defining metamorphic facies	193
7.4	Tentatively accepted definition of metamorphic facies	194
8	Classification of regional metamorphism based on P/T ratio	198
8.1	The definition of three types of regional metamorphism based on P/T ratio	198
8.2	Diachronous progressiveness of metamorphism in accretionary complexes	203
8.3	Petrographic characteristics of progressive metamorphism of the three P/T ratio types	205
8.4	Geologic characteristics of the three P/T ratio types	211
9	Tectonothermal evolution of metamorphic belts	216
9.1	Paired metamorphic belts	216
9.2	Lower P/T ratio metamorphic belts in arc zones	219
9.3	High- P/T metamorphic complexes in subduction zones	223
9.4	Regional metamorphism in continental collision zones	229
9.5	Regional metamorphism in continental extension regions	237
10	Changes of paragenetic relations and of chemical compositions of solid-solution minerals in metapelites with temperature and pressure	239
10.1	Progressive changes of paragenetic relations in metapelites expressed in AFM diagrams	239
10.2	Effects of the presence of carbonates and the infiltration of externally derived aqueous fluid on low- and medium- P/T metamorphism of pelitic rocks	246
10.3	Progressive changes of paragenetic relations expressed in Al_2O_3 - $NaAlO_2$ - $KAlO_2$ diagrams	251
10.4	Petrogenetic grids	253
10.5	Prograde and progressive compositional changes of solid-solution minerals	258

CONTENTS

PART III INDIVIDUAL METAMORPHIC FACIES: THEIR PETROLOGICAL AND MINERALOGICAL CHARACTERISTICS

11	Metamorphic facies of low- and medium- <i>P/T</i> regional metamorphism	264
11.1	Zeolite facies	264
11.2	Prehnite-pumpellyite facies	274
11.3	Greenschist facies	276
11.4	Transitional states between the greenschist and amphibolite facies	280
11.5	Amphibolite facies	286
11.6	Granulite facies	290
12	Metamorphic facies characteristic of high- <i>P/T</i> regional metamorphism	307
12.1	A brief survey of the high- <i>P/T</i> metamorphic facies series	307
12.2	Lawsonite-albite-chlorite facies	308
12.3	Blueschist facies	310
12.4	Eclogite facies	318
13	Metamorphic facies characteristic of contact metamorphism	338
13.1	Diversity of contact metamorphism	338
13.2	Pyroxene-hornfels facies	340
13.3	Sanidinite facies	341
	Appendix I Symbols for mineral names used in this book	345
	Appendix II Glossary of metamorphic petrogenesis	347
	Appendix III A history of metamorphic petrology	355
	References	373
	Index	399