Contents

1	The historical perspective: an ever changing emphasis	1
	The beginning The influence of Lyell The French tradition	1 2 4
	Sederholm to Read: a proposition sustained	4 5 8
	A universal debate	8
	Rosenbusch to Bowen: the alternative	9
	Daly to Cloos: considerations of space	13 14
	The shift from the great debate References and further reading	14
2	The categories of granitic rocks: the search for a genetic	
	typology	18
	The granite rocks	18
	Is categorization possible?	19
	Categorization by mode Categorization by rock series	20 22
	Categorization by source rock	24
	Categorization by tectonic setting	25
	Selected references	28
3	Granite as a chemical system: the experimental impact	29
	The possible and the impossible	29
	Granite systems	30
	Role of water On the contribution of mineral chemistry	31 35
	Further roles for the volatiles	33
	On melting: a preliminary statement	39
	Selected references	41
4	The physical nature of granitic magmas: a case of missing	
	information	42
	The nature of the granitic mush	42
	Suspensions, mushes and Bingham bodies	42
	Flow in granitic magmas: a first statement of a prejudice	46
	Flow in the mush: a preliminary comment on magma deformation Evidence from the sinking of stoped blocks	46 49
	A source control of mushiness: per magma ad migma	49 50
	Schlieren and banding: evidence of magma fluidity?	51
	Schlieren: the omnibus term	52
	Those mysterious orbs	55
	On banding due to deformation	57
	Per magma ad migma usque ad textus	58
	Selected references	59

CON	TENTS
-----	-------

5	The evolution of the granitic texture: a continuum of crystal growth	60
	Introduction On granitic texture in the magmatic context Textural geometry A fresh stereological approach: stereology The backcloth of theory and experiment Paragenetic sequences Individual case histories of minerals as a guide to processes The accessory minerals: a source of vital information A footnote on epidote Mafic minerals and the fugacity of oxygen and water The problem with muscovite A comment on the significance of zoning On big crystals of potassium feldspar More on myrmekite Rims and swapped rims Some special features of microgranites Microgranitic textures Importance of petrography Selected references	$\begin{array}{c} 60\\ 60\\ 60\\ 61\\ 62\\ 64\\ 66\\ 66\\ 67\\ 67\\ 68\\ 69\\ 70\\ 73\\ 74\\ 75\\ 75\\ 76\\ 77\\ 77\end{array}$
6	Differentiation in granitic magmas: zoning as an example of multifactorial processes at work	78
	Aspects of differentiation in granitic magmas: a multifactorial process Separating out of crystals from liquid or liquid from crystals Colateral processes: the recharge model Colateral processes: assimilation Late stages in the differentiation processes Genetic significance of zoning in plutons Pattern of zoning A specific example of sidewall boundary layer differentiation Some of the complexities of zonation Some more examples of zoned plutons Isotope ratios and zonation Selected references	78 79 81 82 83 84 85 86 87 91 95
7	The volcano-plutonic interface: not Read's hiatus	96
	Introduction Nature of the interface Evolution of silicic magma in subvolcanic magma chambers Examples from western North America Selected references	96 96 99 100 102
8	The evidence for restite: unmixing as an alternative hypothesis	103
	A statement in favour The debates An outcrop example of reality The Lachlan experience: suites and super-suites Granite types and their source rocks: Lachlan in particular Possible S-types in the European Hercynian: Italy in particular S-type melts Selected references	103 105 107 108 110 113 115 116

х

9	The mingling and mixing of granite with basalt: a third term	115
	in a multiple hypothesis	117
	Preamble: mixing and mingling Gabbro against granite Precursor appinite and diorite against granite Synplutonic pipes, net veins and magma pillows Synplutonic dykes Some possible alternatives: pseudo-dykes and relict dykes Crystal transfer: les dents de cheval The mafic enclaves themselves The processes of mingling, mixing and hybridization The science of mixing Bulk mixing at depth The enigmatic mixing zone revealed Selected references	117 118 121 121 123 125 127 129 132 135 136 138 139
10	Appinites, diatremes and granodiorites: the interaction of 'wet'	
10	basalt with granite	140
	Introduction Crystallization from a water-saturated magma The lamprophyre connection A chemically distinctive series Explosion breccias and diatremes Magma-rock interaction: a multiple source for the volatiles A model for appinite petrogenesis Appinites galore Selected references	140 142 145 145 147 149 150 151 153
11	Controls of upwelling and emplacement: the response of the	
	envelope: balloons, pistons and reality	154
	Preamble Fabric as a guide to flow or to deformation? The foliation in outcrop Effect of lithology A mere footnote on the effects of contact metamorphism Ductile shear belts, heat flux and granite intrusions Concordant plutons: diapirism or ballooning? Reservations on ballooning Magma blisters The sucking-in of magma: cavity-fill emplacement into extensional shear zones Zone-melting and granitization: a declared prejudice Discordant plutons: fracture propagation and control of intrusion The importance of giant dykes and sheets Interrelations and connections Plutons in three dimensions: different crustal environments The global tectonic frame and the mechanisms of emplacement Selected references	154 155 157 161 162 163 164 165 168 169 171 171 175 175 175 177 179 180
12	On the rates of emplacement, crystallization and cooling	182
	Introduction Measuring the cooling times Rates of the ascent of magma	182 182 185

CONTENTS

xi

CONT	ENTS
------	------

	Times of generation and the accumulation of magmas Eisodicity and periodicity of emplacement Differing rates in response to tectonic environment Selected reference	186 187 190 190
13	Oceanic plagiogranite: rarely seen but genetically important	191
	Granite in the ocean floor Selected reference	191 192
14	Cordilleran-type batholiths: magmatism and crust formation	
	at a plate edge	193
	Introduction	193
	Batholiths and marginal basins	194
	The example of the Huarmey-Cañete Basin	195 198
	Basin and batholith coincidence The precursor gabbros	198
	Anatomy of a batholith: a multiple intrusion	200
	Suites, super-suites and pulses	202
	Evolution of the magmas	205
	Origin of the magmas: a two-stage model	208 211
	Cordilleran batholiths in South and North America The Peninsular Ranges Batholith	211
	The Sierra Nevada Batholith	212
	An interim conclusion	216
	Selected references	217
15	Intraplate magmatism: mainly the A-type, alkali feldspar	
	granites	218
	The nature of intracratonic magmatism in general	218 218 218
		218 218 220
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics	218 218 220 221
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions	218 218 220 221 223
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models	218 218 220 221 223 223
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons	218 218 220 221 223
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models	218 218 220 221 223 223 224
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica	218 218 220 221 223 223 224 226 228 229
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia	218 218 220 221 223 223 224 226 228 229 230
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type	218 218 220 221 223 223 224 226 228 229 230 231
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type Alkali feldspar syenites and granites in the oceanic islands	218 218 220 221 223 223 224 226 228 229 230 231 234
	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type	218 218 220 221 223 223 224 226 228 229 230 231
16	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type Alkali feldspar syenites and granites in the oceanic islands A kind of conclusion	218 218 220 221 223 223 224 226 228 229 230 231 234 234
16	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type Alkali feldspar syenites and granites in the oceanic islands A kind of conclusion Selected references Migmatites: are they a source of granitic plutons? Migmatites and granites	218 218 220 221 223 223 224 226 228 229 230 231 234 236 237 238 238
16	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type Alkali feldspar syenites and granites in the oceanic islands A kind of conclusion Selected references Migmatites: are they a source of granitic plutons?	218 218 220 221 223 223 224 226 228 229 230 231 234 236 237 238 238 238
16	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type Alkali feldspar syenites and granites in the oceanic islands A kind of conclusion Selected references Migmatites: are they a source of granitic plutons? Migmatites and granites The nature of migmatites Open or closed systems	218 218 220 221 223 223 224 226 228 229 230 231 234 236 237 238 238 238 238 238
16	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type Alkali feldspar syenites and granites in the oceanic islands A kind of conclusion Selected references Migmatites and granites The nature of migmatites Open or closed systems The origin of the granitic <i>lits</i> : mass balance in migmatites	218 218 220 221 223 223 224 226 228 229 230 231 234 236 237 238 238 238 238 238 238 238 238
16	The nature of intracratonic magmatism in general Is there a unique A-type? Geochemical characteristics Mineralogical characteristics Texture: the result of subsolidus reactions A range of petrogenic models Alkali feldspar granites within the cratons Alkali feldspar granites within the cratons Alkali feldspar granites within the rifts: The Oslo Graben The Tertiary central complexes of the British Isles Alkali feldspar granites in an immediately post-orogenic setting: Corsica Alkali feldspar granites in south-east Australia Rapakivi: a genuine A-type Alkali feldspar syenites and granites in the oceanic islands A kind of conclusion Selected references Migmatites: are they a source of granitic plutons? Migmatites and granites The nature of migmatites Open or closed systems	218 218 220 221 223 223 224 226 228 229 230 231 234 236 237 238 238 238 238 238

xii

	Anatectic migmatites and granitic magmas	246
	The fate of the schlieric restite	251 251
	Migmatites and granulites Another interim geological conclusion	251
	Selected references	252
17	The waning stages: the role of volatiles in the genesis of	
	pegmatites and metal ores	254
	pegmatites and metar ores	204
	Introduction	254
	The origin of the fugitive constituents	254
	The isotopes of hydrogen and oxygen	256
	The concentration process On volatile concentration and the origin of pegmatites and aplites	257 258
	The geochemical consequences of the addition of a vapour phase	238
	Late stage metasomatism	261
	On the typicality of metallization	262
	The copper porphyries: garnering ore-forming metals from the mantle	263
	Garnering ore-forming metals from the crust: a geochemical heritage	266
	Uplift and erosion: a complication or a cause?	268
	Selected references	269
18	The sources of granitic magmas in their various global	
	tectonic niches	270
	Introduction	270
	A comment on the use of radiogenic isotopes	270
	The plagiogranites of the mid-ocean ridges	271
	The M-type quartz diorites of the oceanic island arcs	272
	Tonalites and granodiorites of the continent margin arcs	273
	The Andes	273
	Baja California	274
	Sierra Nevada The granodiorites and granites of the active hinterlands of marginal arcs	275 277
	Idaho	277
	The Lachlan example of the way in which granites image their source	279
	The Caledonian example	280
	A multiplicity of settings and sources in a resurgent orogen	283
	Expanded plutonic sequences in collision zones	284
	The leucogranites of the High Himalayas	284
	Intra-plate granites of the continent and oceans	286
	The origin of the very ancient tonalites	287 291
	Selected references	291
19	A kind of conclusion: a search for order among multifactorial	
	processes and multifarious interactions	292
	Selected reference	297
Bibliography		298
Index		317

CONTENTS

xiii