

Fig. 1.2 The QAP classification of the granitoid family after Streckeisen (1976). Trondhjemite (\equiv plagiogranite) (not labelled) is defined as a leucotonalite (Barker, 1979).

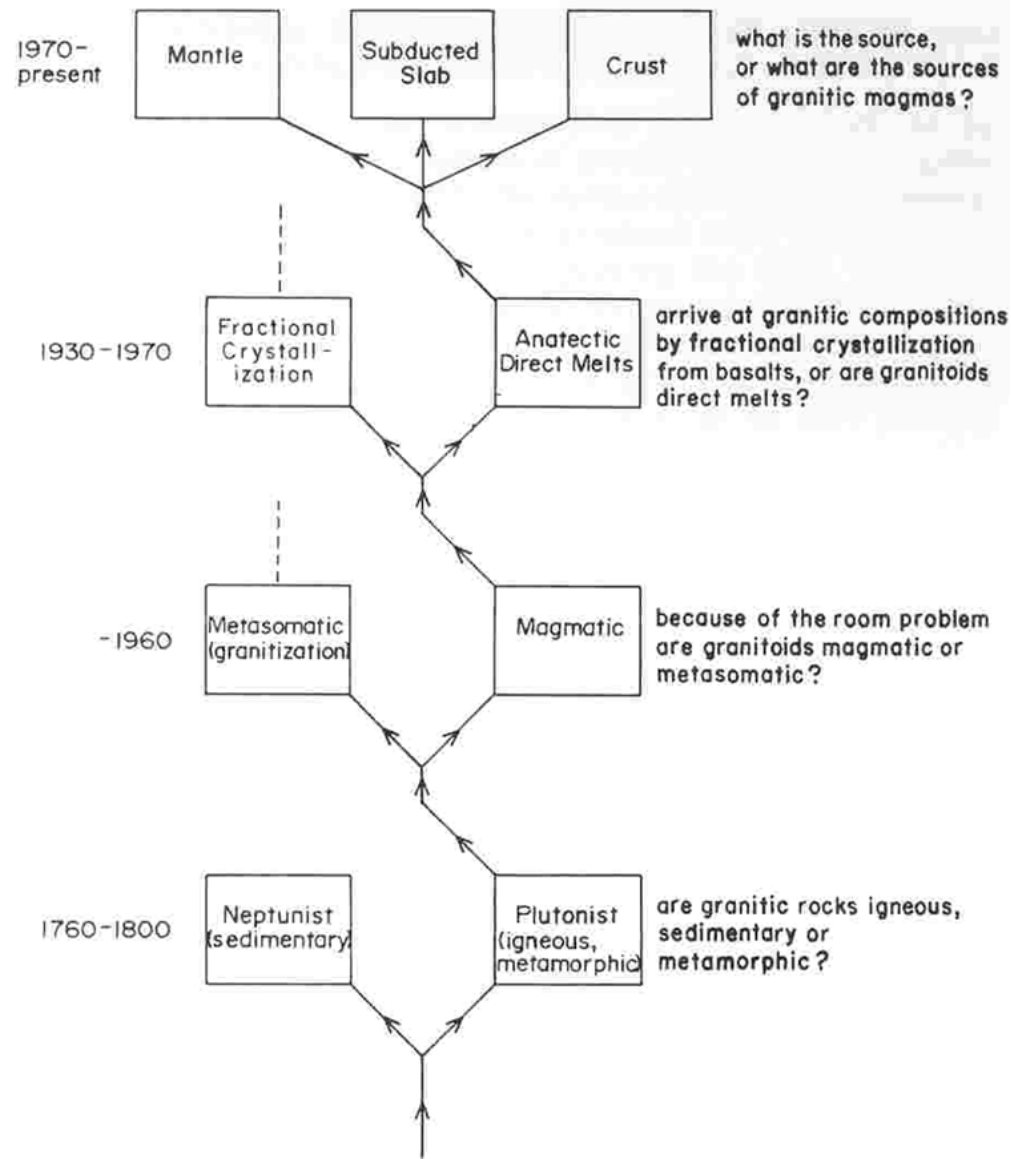
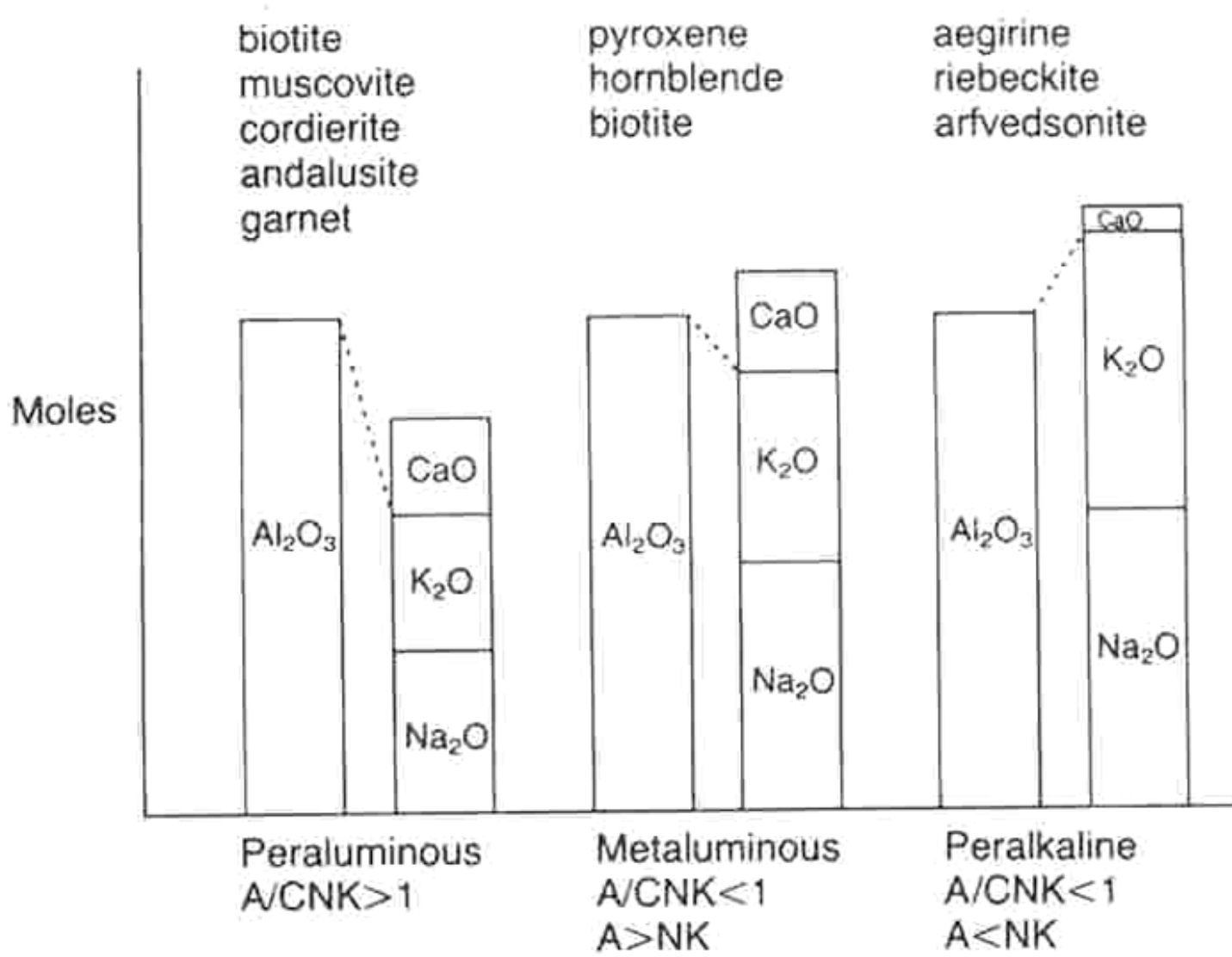


Fig. 1.6 Schematic flow chart to show the evolution of the granite problem over the past 200 years. Philosophical dead-ends have no exits; ideas that are largely discredited as general explanations, but which may still apply in specific cases, have dashed exit lines.

Table 1.1 Tripartite chemical classification of granitic rocks

<i>The granitoid family*</i>			
$\frac{QAP}{60\% > \text{Quartz} > 20\%}$ $\text{Alkali-feldspar}/(\text{Alkali-feldspar} + \text{Plagioclase}) = 0-1$			
	<i>Peraluminous</i>	<i>Metaluminous</i>	<i>Peralkaline</i>
Definition (Shand, 1947)	$A > CNK^{**}$	$CNK > A > NK^{**}$	$A < NK^{**}$
Characteristic minerals (Chapter 3)	aluminosilicates, cordierite, garnet, topaz, tourmaline, spinel, corundum	orthopyroxene, clinopyroxene, cummingtonite, hornblende, epidote	fayalitic olivine, aegirine, arfvedsonite, riebeckite
Other common minerals	biotite, muscovite	biotite, minor muscovite	minor biotite
Oxide minerals	ilmenite, tapiolite	magnetite	magnetite
Accessory minerals	apatite, zircon, monazite	apatite, zircon, titanite, allanite	apatite, zircon, titanite, allanite, fluorite, cryolite, pyrochlore
Other chemical features	$F/Cl > 3$	-	low CaO, Al ₂ O ₃ , H ₂ O, Ba, Sr, Eu high SiO ₂ , Fe/Mg, Na + K, Zr, Nb, Ta, ΣREEs, Y $F/Cl < 3$



(b)

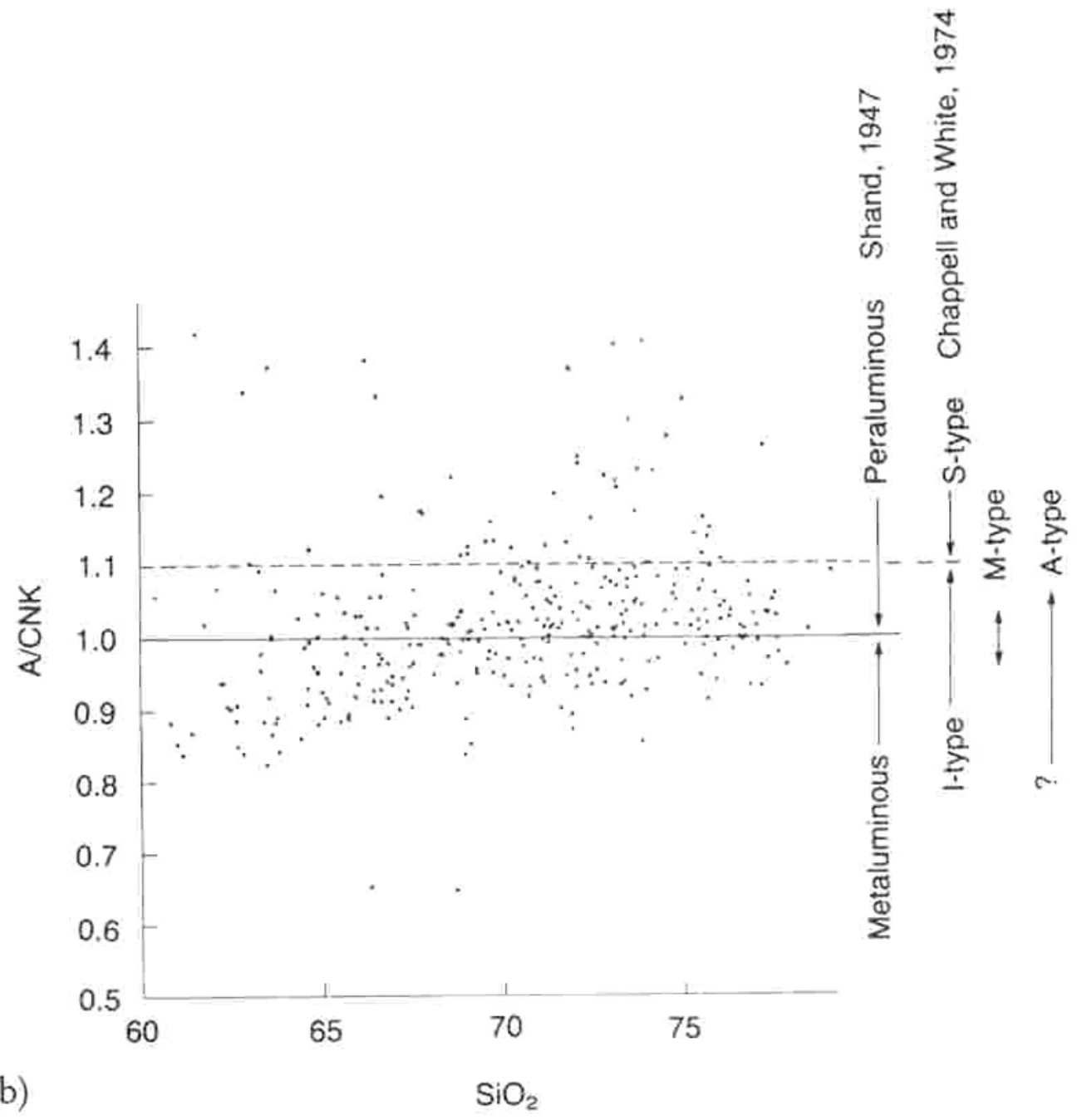
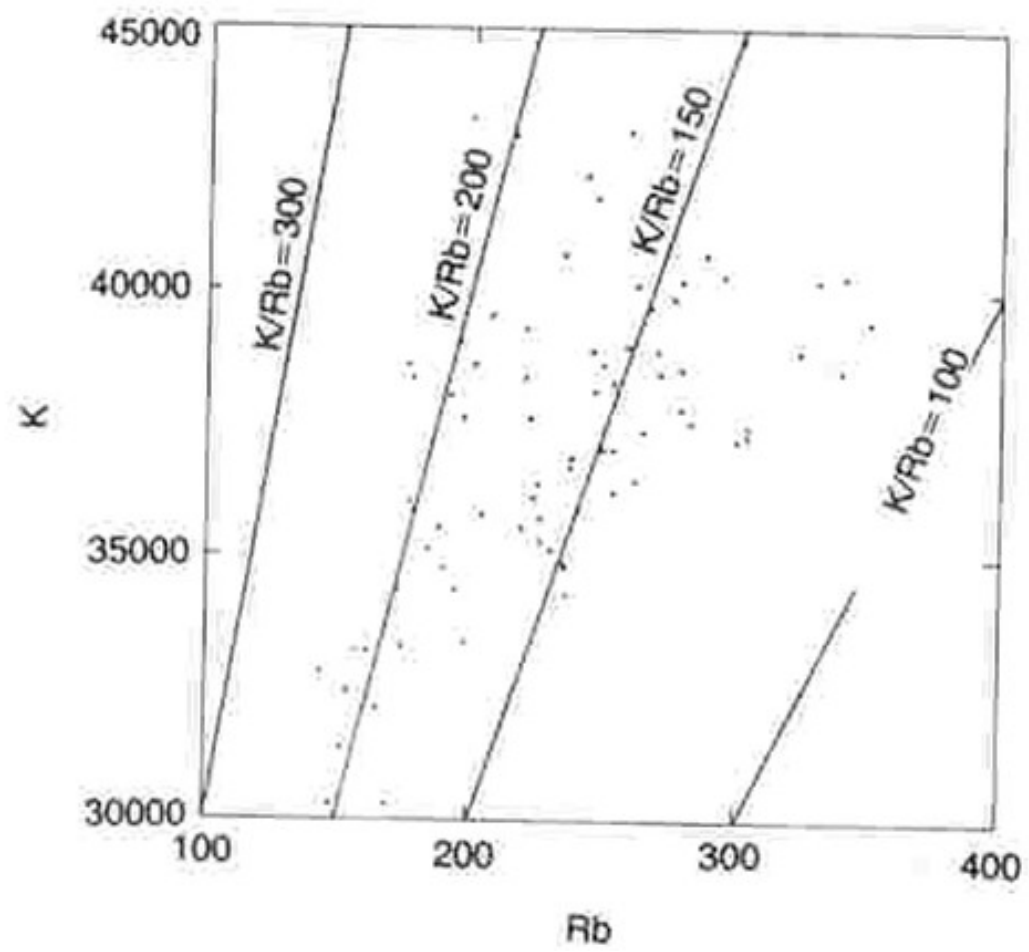


Table 1.2 Selected average compositions of peraluminous (Chayes, 1985), metaluminous (Chayes, 1985) and peralkaline (Chayes, 1985, with additional data) granitoid rocks

	<i>Peraluminous</i>	<i>Metaluminous</i>	<i>Peralkaline</i>
<i>n</i>	199	158	25
SiO ₂	71.45	67.43	74.01
TiO ₂	0.32	0.55	0.23
Al ₂ O ₃	14.76	14.67	11.59
FeO _T	2.49	4.13	3.08
MnO	0.13	0.12	0.10
MgO	0.78	1.64	0.55
CaO	2.01	3.53	0.48
Na ₂ O	3.72	3.72	4.33
K ₂ O	3.52	3.20	5.09
P ₂ O ₅	0.14	0.17	0.06
Total	99.32	99.16	99.52
A/CNK	1.10	0.93	0.86
NK/A	0.67	0.65	1.09



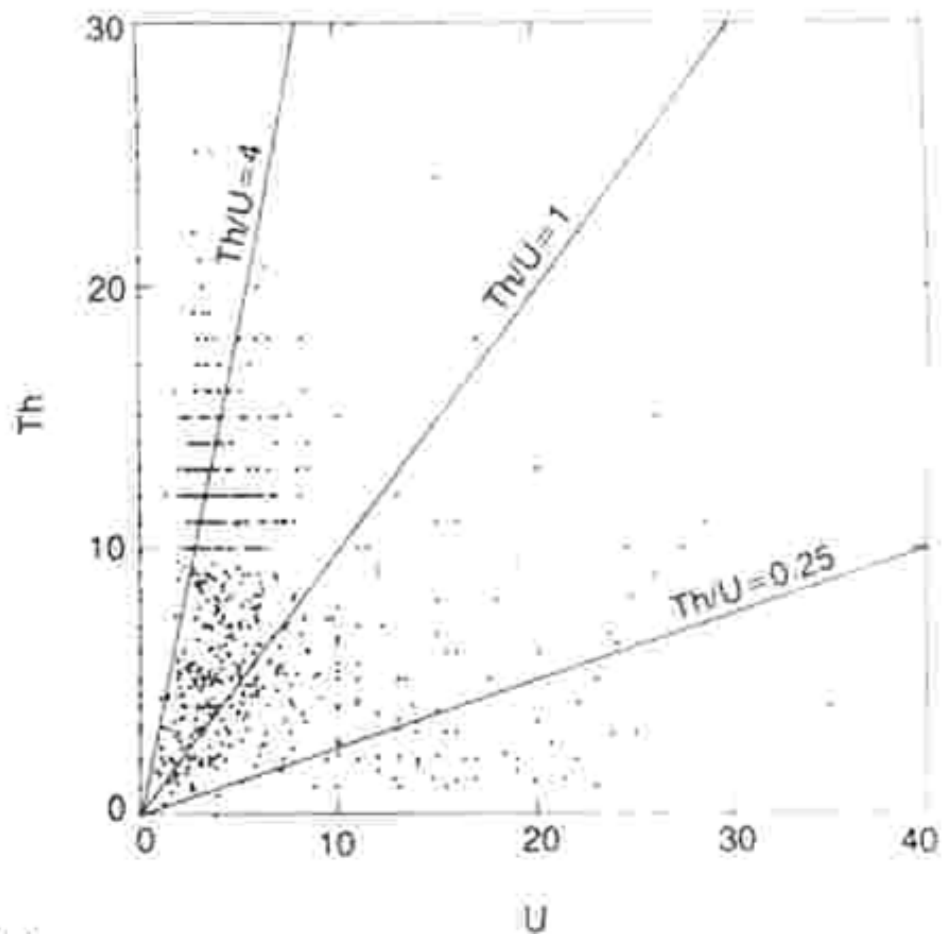


Table 4.4 Summary of the use of geochemical data to interpret the origin and evolution of granitoid rocks. The more capitalization in the 'Use' column, the greater the degree of usefulness of the elements

<i>Elements</i>	<i>Considerations</i>	<i>Use</i>
Major element concentrations	variation in major element concentrations normally reflects melt–crystal–fluid differentiation processes and contamination, but effectiveness to reveal information even about differentiation declines as the magma becomes trapped at the low temperature invariant point (Chapter 6); only if granitoids are primary magmas (unlikely) can the bulk compositions yield some indirect information about the source region	PROCESSES source
Trace element concentrations	trace element concentrations (ppm) are a function of their concentration in the source, the degree and style of partial melting, and all of the subsequent processes of melt–crystal–fluid differentiation	PROCESSES Source
Trace element ratios	with high degrees of partial melting of the source region (likely in the case of voluminous granitoids), trace element ratios in the melt fraction may be identical to those in the source and will remain so until some differentiation process removes one element relative to the other; identification of exactly which trace element ratios in the granitoid are still reliable indicators of the source is problematic	Processes Source

Table 4.4 *Continued*

<i>Elements</i>	<i>Considerations</i>	<i>Use</i>
Stable isotopic ratios	oxygen and sulphur isotopic ratios should reflect the ratios in the source region, but are highly vulnerable to contamination by, and re-equilibration with, the host rocks	Processes Source
Radiogenic isotopic ratios	no internal process of differentiation, except possibly for Soret diffusion or long times of evolution, should affect the radiogenic isotopic ratios (Sr, Nd, Pb); therefore the ratios should reflect those of the source region (except possibly for small degrees of partial melting not considered appropriate for granitoids); external reaction with wall-rocks (contamination) may disturb isotopic ratios inherited from source	processes SOURCE

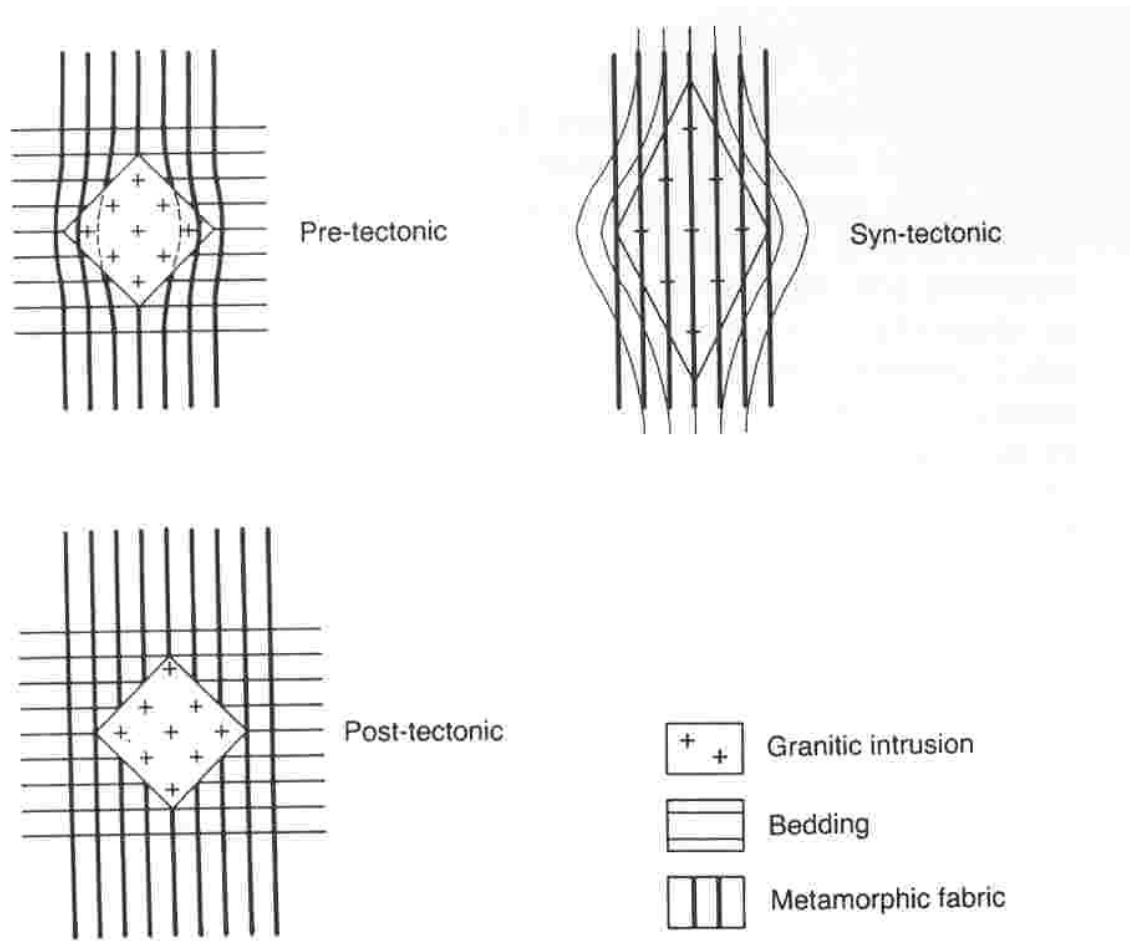
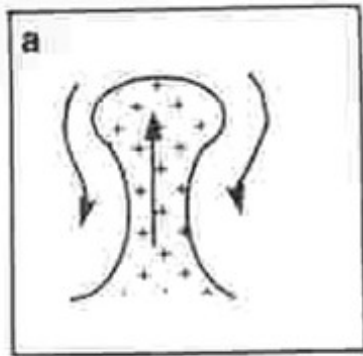


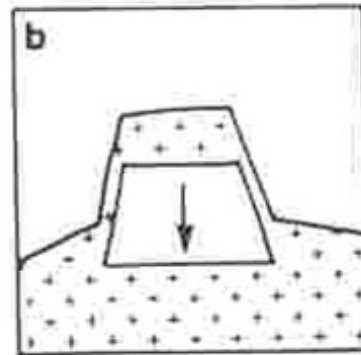
Fig. 2.3 Stylized relationship of granitic plutons to bedding and structure in country rocks. (The relationship between bedding and structure is arbitrary). A pre-tectonic pluton cuts bedding and deflects later metamorphic fabric, although marginal areas of the pluton may become deformed. A syn-tectonic pluton is conformable with bedding, and the metamorphic fabric penetrates the entire intrusive body. A post-tectonic pluton cuts both bedding and metamorphic fabric.

Table 2.2 Field characteristics relevant to the level of emplacement of granitoid intrusions. Plutons intruded at intermediate levels show transitional characteristics

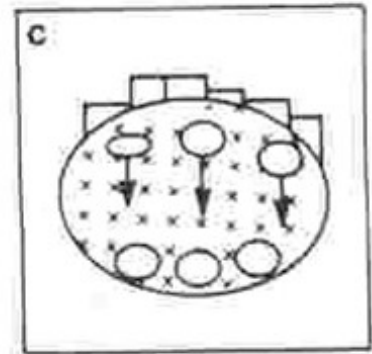
<i>Feature</i>	<i>Shallow intrusions</i>	<i>Deep-seated intrusions</i>
Contact relations with country rocks Pluton shapes	predominantly sharp and discordant discrete isotropic to mildly anisotropic plutons	predominantly diffuse and concordant domes, conformable sheets
Contact facies of the granitoid Internal structures	may be finer-grained internally controlled; structures unrelated to those in country rocks	no chilled margins externally imposed; structures similar to those in country rock
Textures	massive, may be porphyritic, granophyric	foliated, aphyric to augen gneisses
Regional metamorphic grade of country rocks	greenschist, lower amphibolite	upper amphibolite, granulite
Thermal aureole	prominent in rocks of suitable composition, e.g. pelites	obscure in most cases
Migmatites	local; restricted to contacts	regional (see Fig. 15-12 in Compton, 1985)
Other possible diagnostic (?) characteristics	miarolitic cavities; pegmatite dykes; hydrothermal alteration; granophyric textures; roof pendants; breccia dykes; cogenetic volcanic rocks nearby; abundant country rock xenoliths	



DIAPIRISM

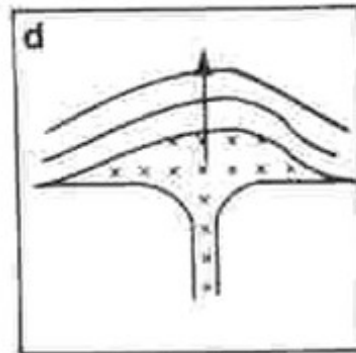


CAULDRON SUBSIDENCE



STOPING

COUNTRY ROCKS MOVE DOWN
(vertical cross-sections)



DOMING

COUNTRY ROCKS MOVE UP
(vertical cross-sections)

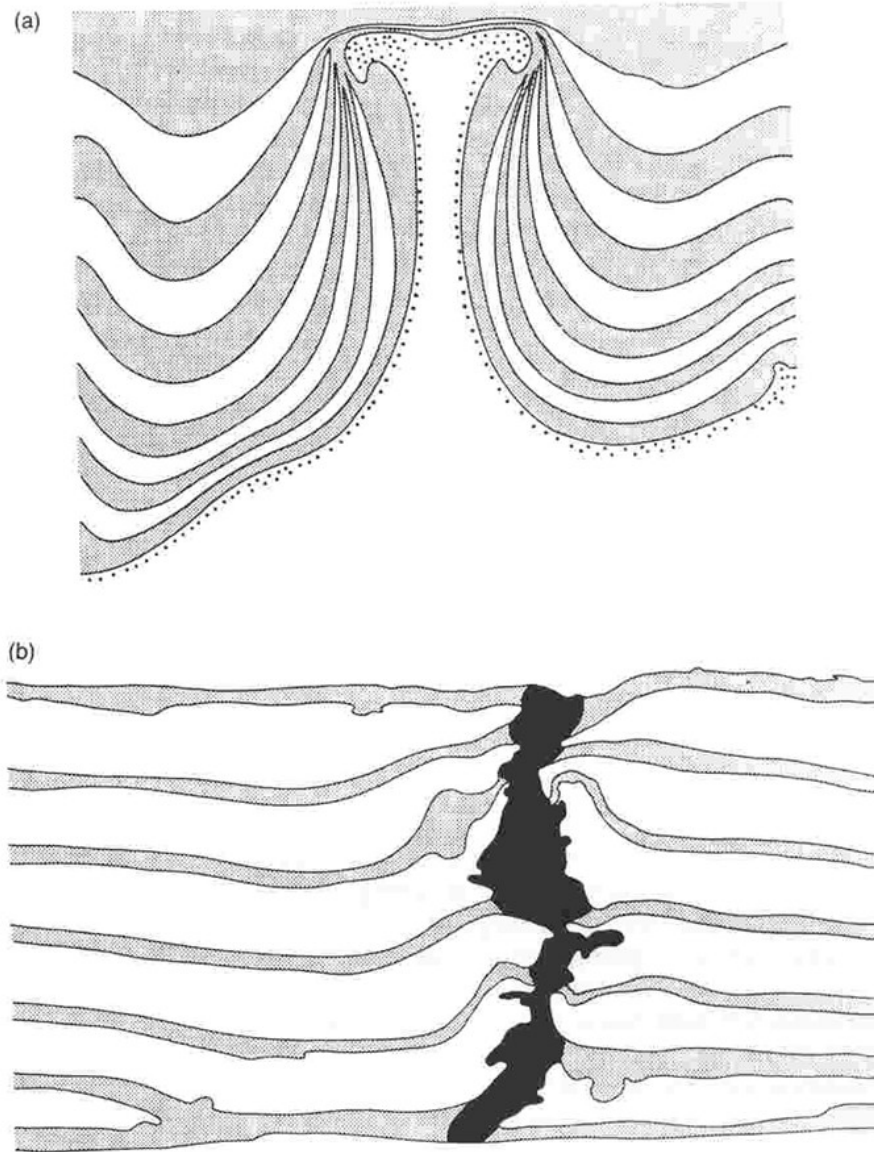


Fig. 2.14 Examples of experimentally modelled magma ascent (a) by diapirism and (b) by fracture exploitation (after Ramberg, 1981).

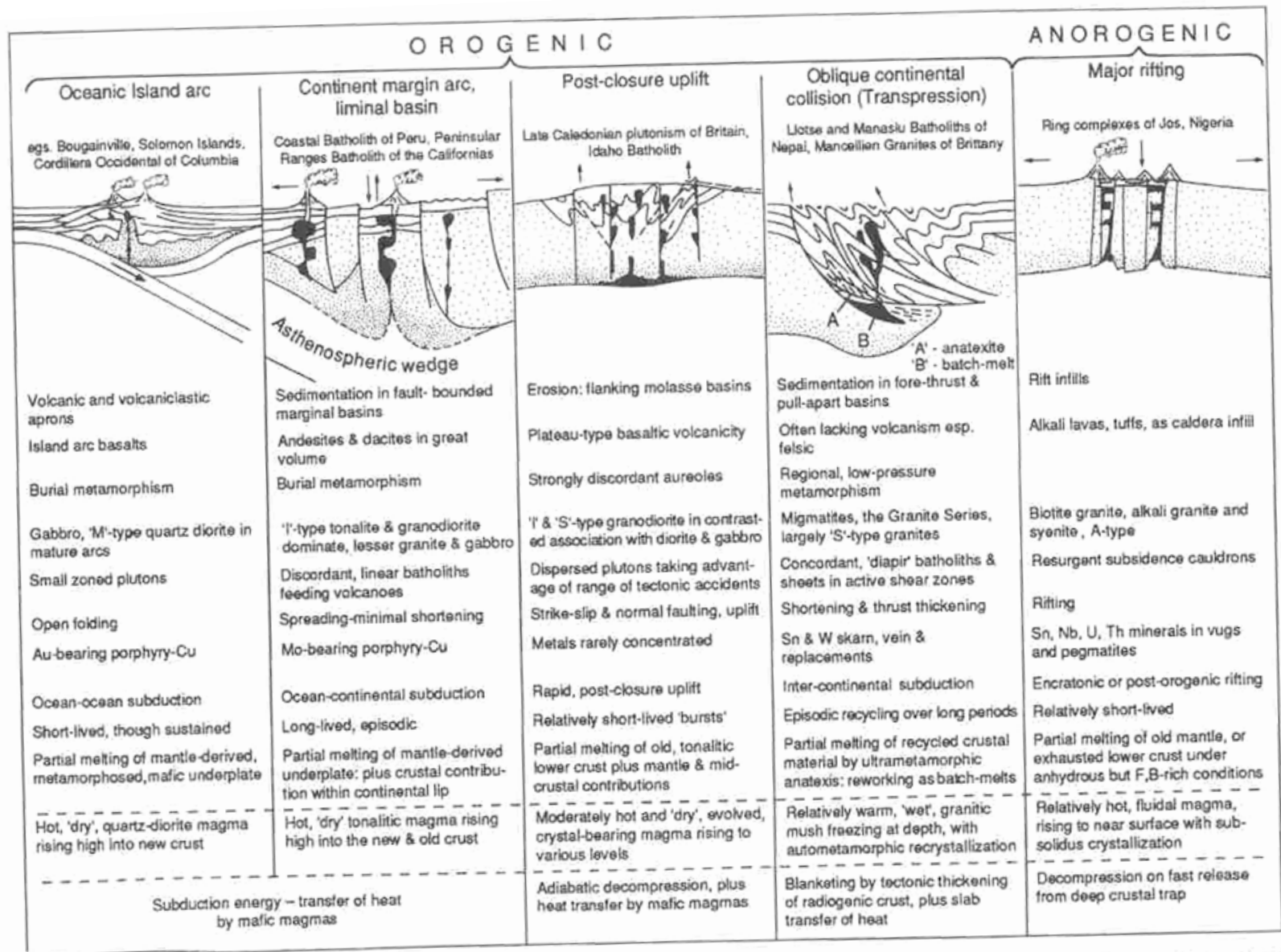


Figure 19.1 The granitic rocks in their contrasted tectonic niches. After Pitcher, W.S. (1987); see also Brew, D.A. (1992).