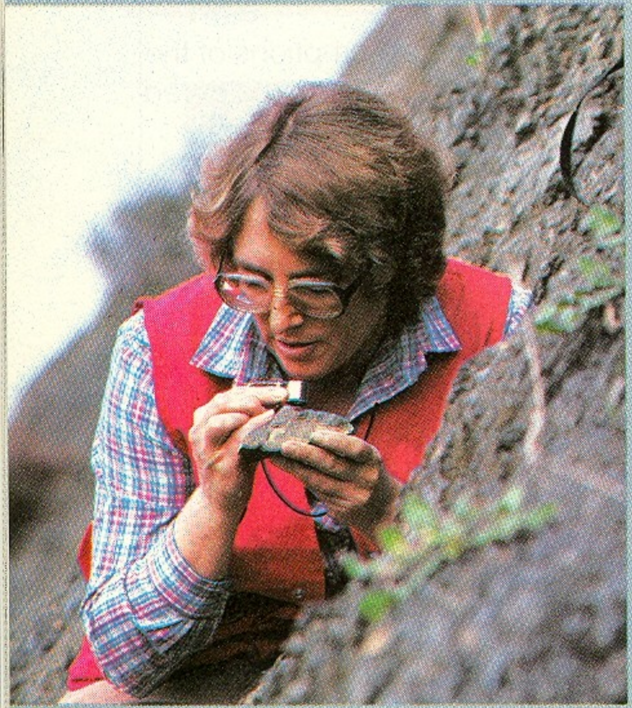
Petrologie



Petrologists can tell much about a rock just by looking at it.

Petrologist Petrologists (pi-TROL′-uh-jists) are scientists who specialize in the study of rocks. They obtain their samples from and below the surface of the earth. They have even obtained samples from the moon!

Petrologists work for colleges and universities, government agencies, oil companies, mining companies, and as private consultants.

People prepare themselves for this profession by many years of study. They usually major in geology in college and then complete further studies for advanced degrees in petrology. They also have to have a good background in mineralogy, chemistry, physics, mathematics, and statistics. Many petrologists got an early start by developing an interest in collecting rocks as a hobby.

Preparing to become a petrologist involves developing skills in science, math, reading, and good writing. The two most important attributes of any scientist apply to becoming a petrologist: 1) a person must be willing to work hard; and 2) a person should have an unending curiosity to know and understand more.

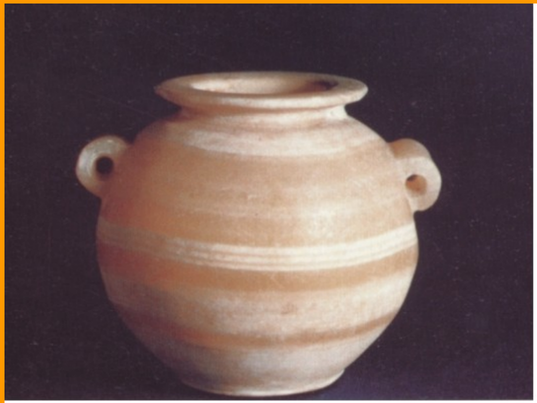
Aplikovaná - vědecká

Přírodní materiály – technické materiály

Lom v Gize – jámové dobývání

Abúsír – báze lomu s naznačenými bloky

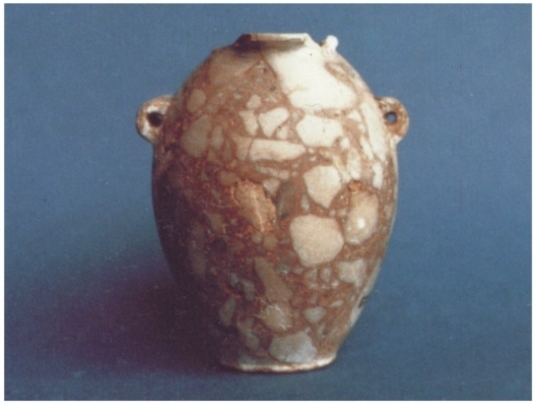
Různé typy nádob a surovin



1. Travertine (Aston 1994).

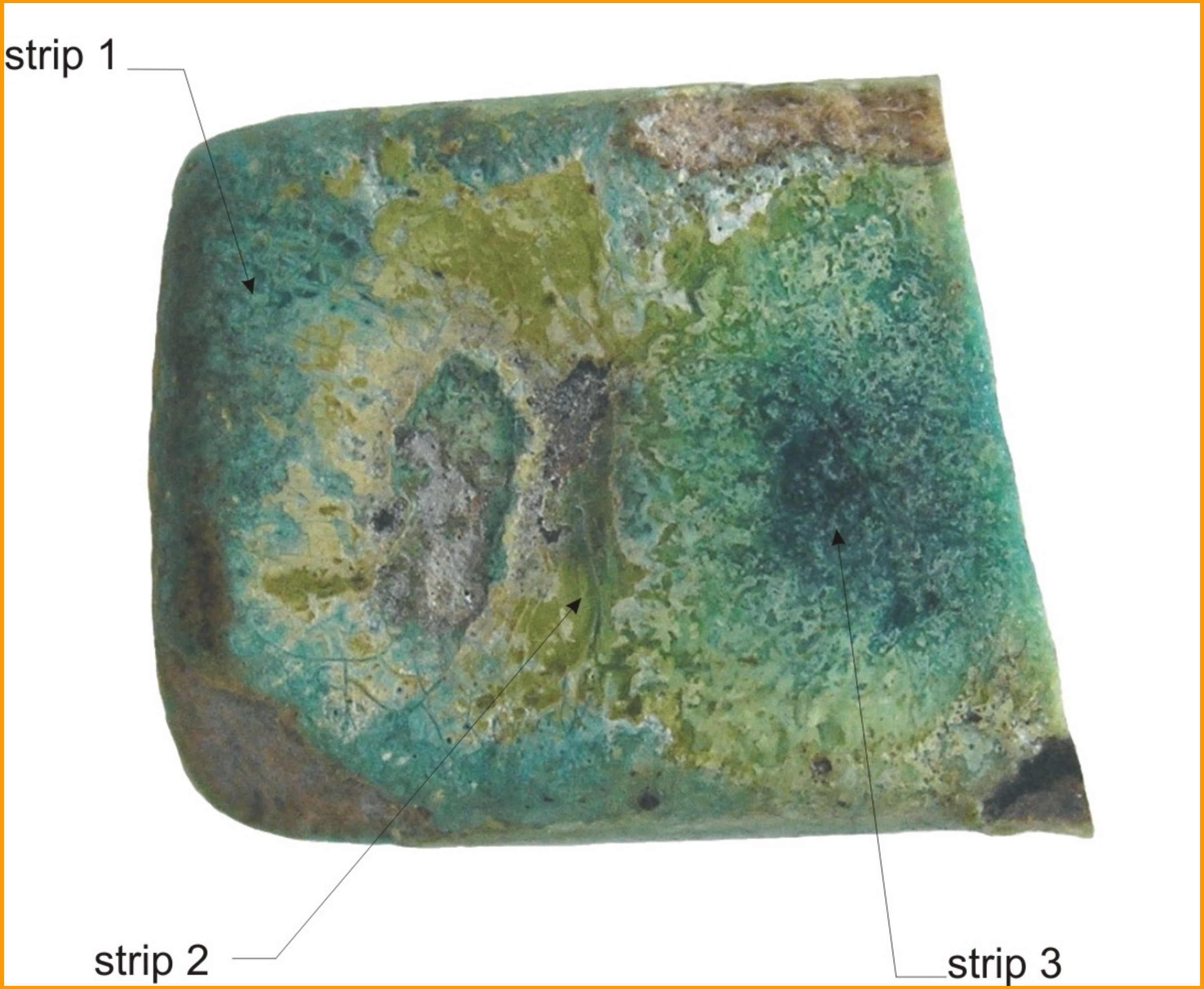
2. Alabaster - Gypsum (Aston 1994).

3. Dolomite (Aston 1994).

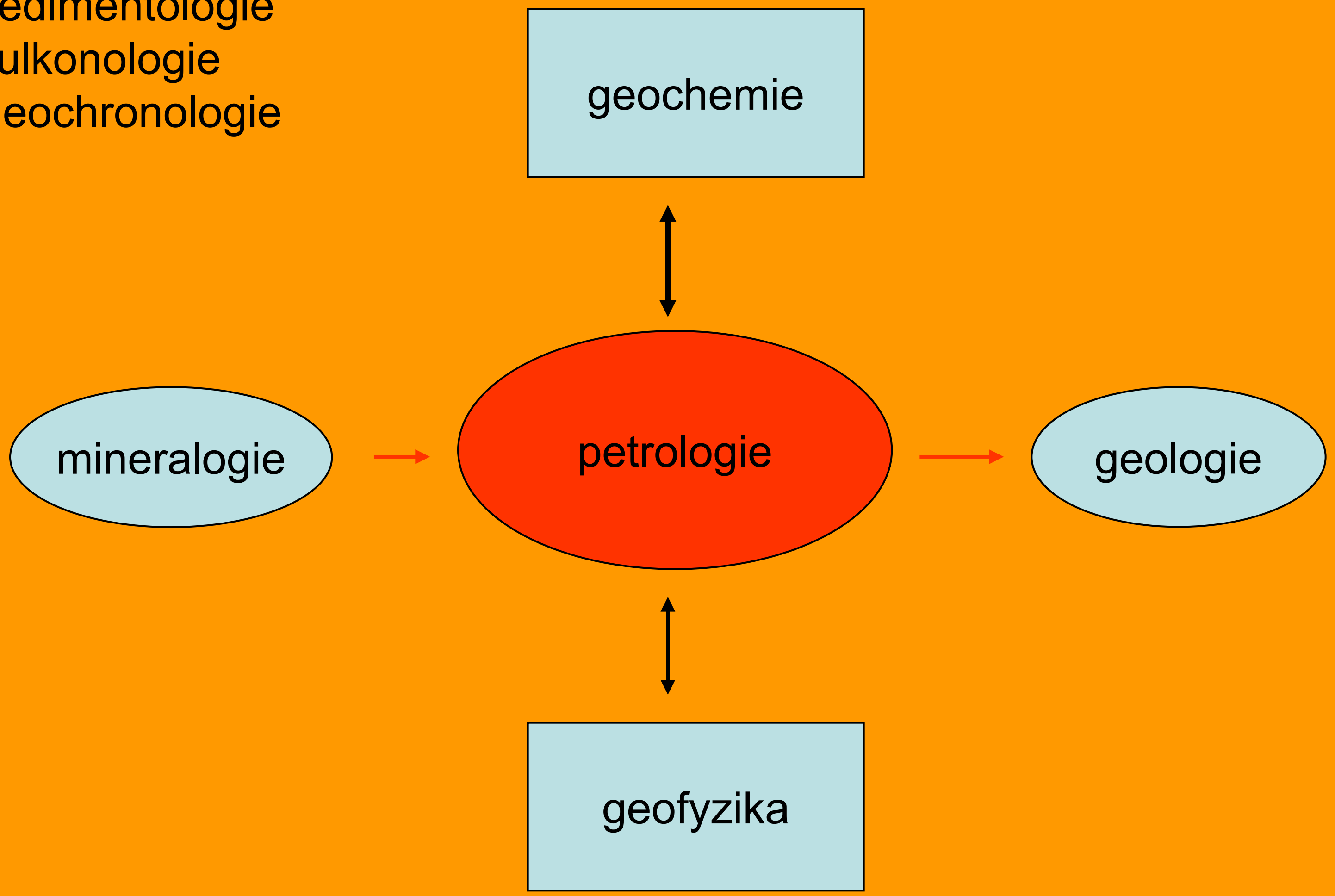


5. Red and White Limestone (Aston 1994).

4. Recrystallized Limestone (Aston 1994).


strip 1
strip 2
strip 3

Strukturní geologie
Sedimentologie
Vulkonologie
Geochronologie

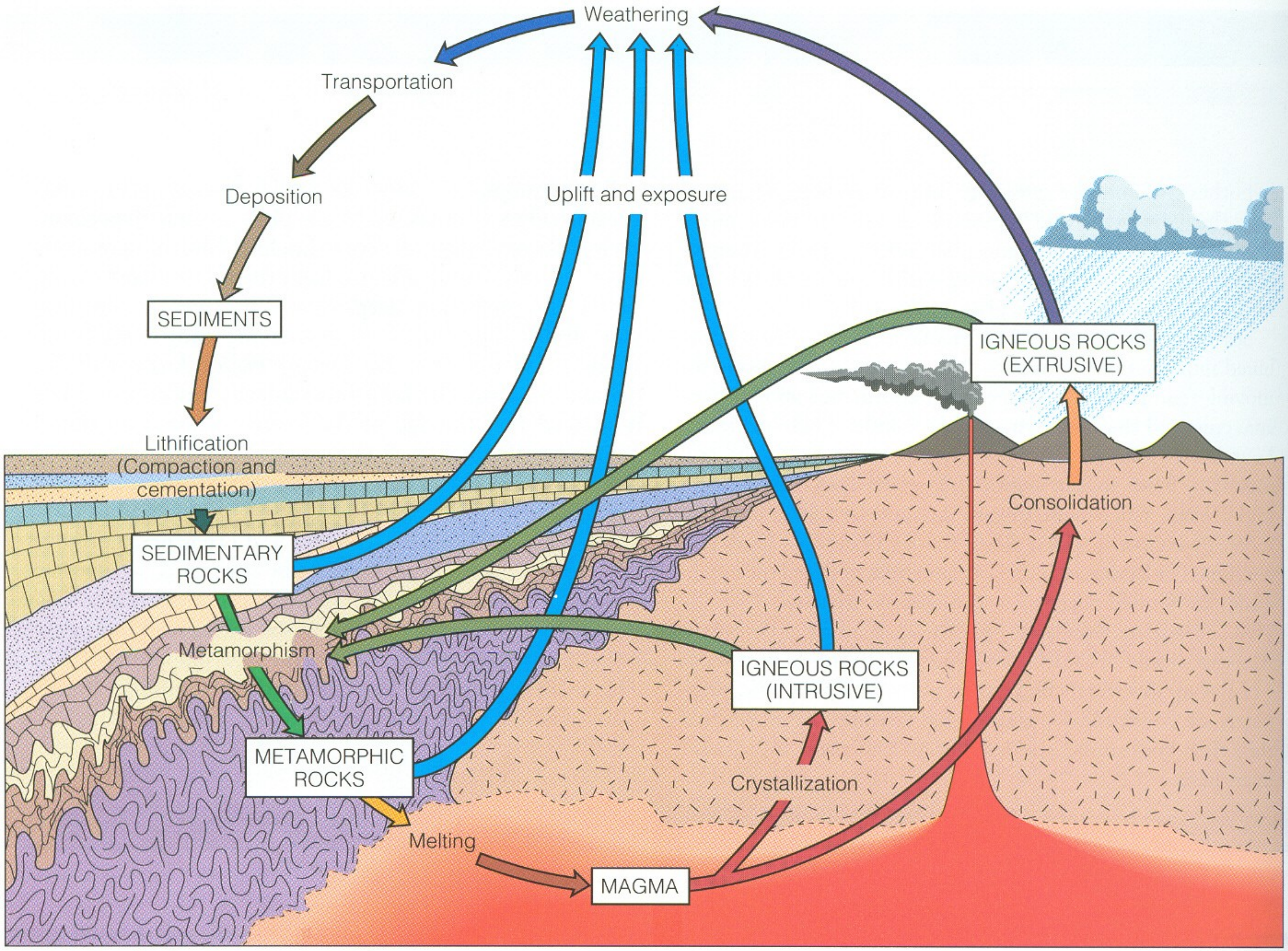


petrologie

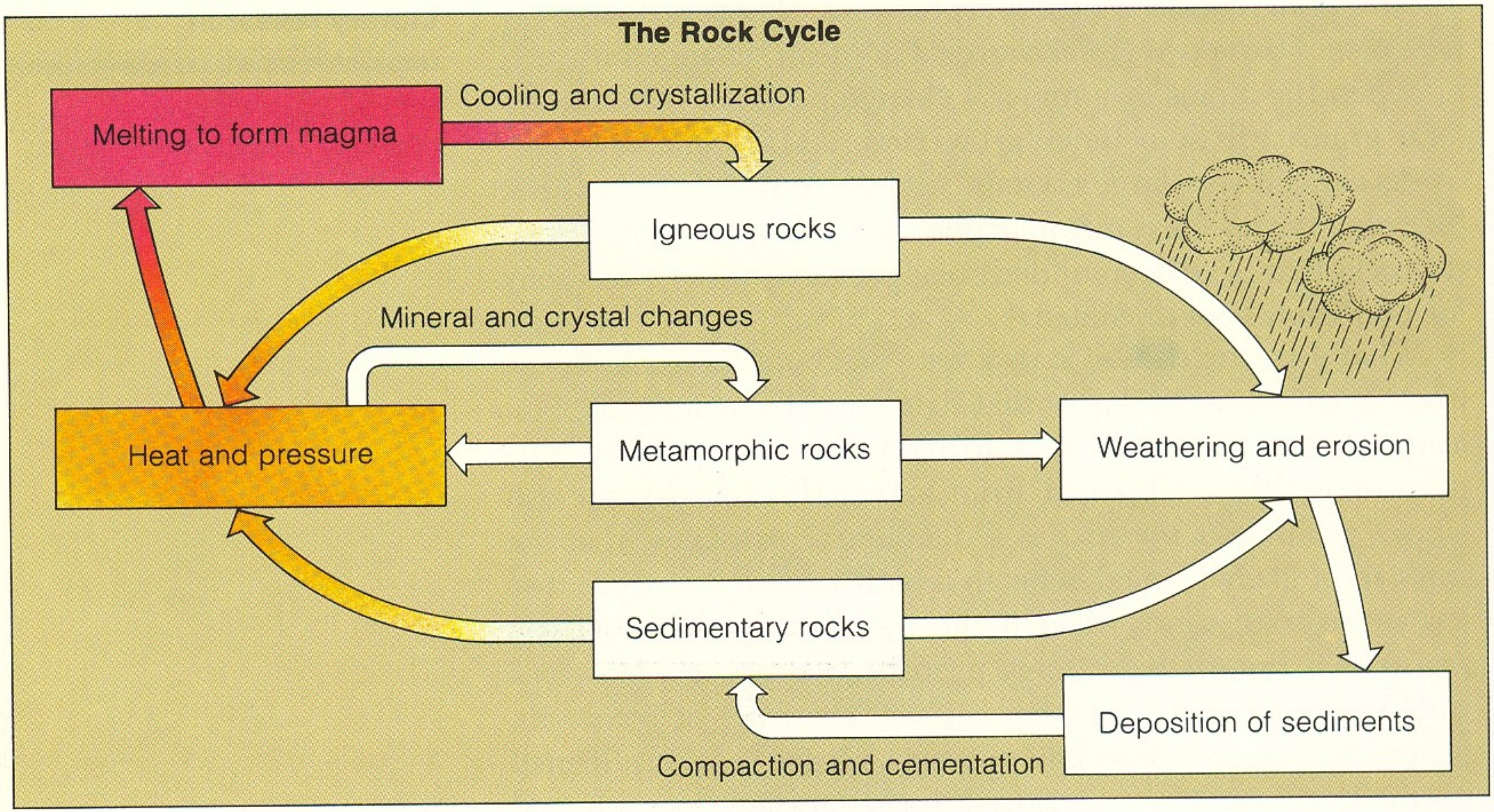
Magmatická, vyvřelé horniny

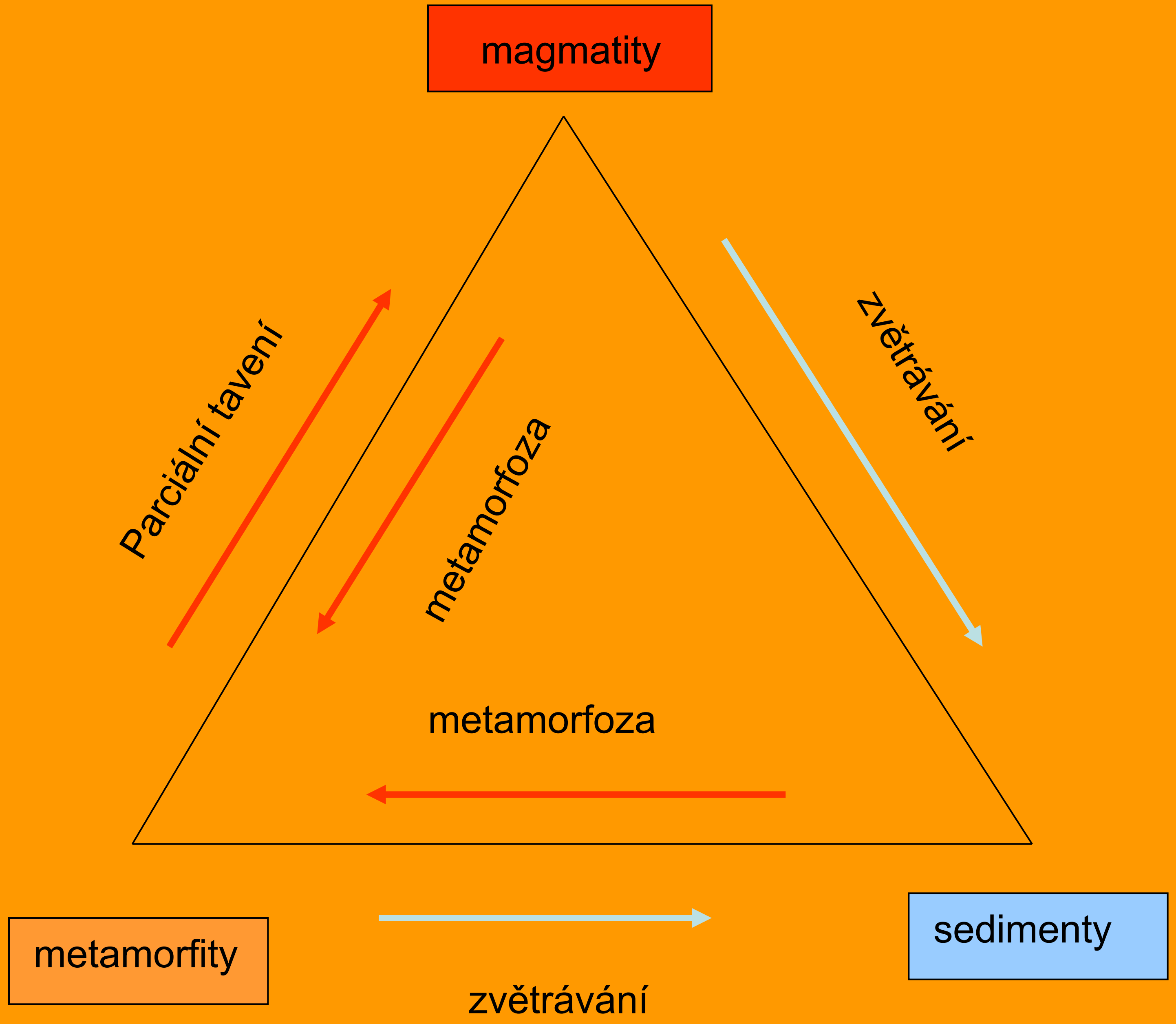
Metamorfní, metamorfované horniny

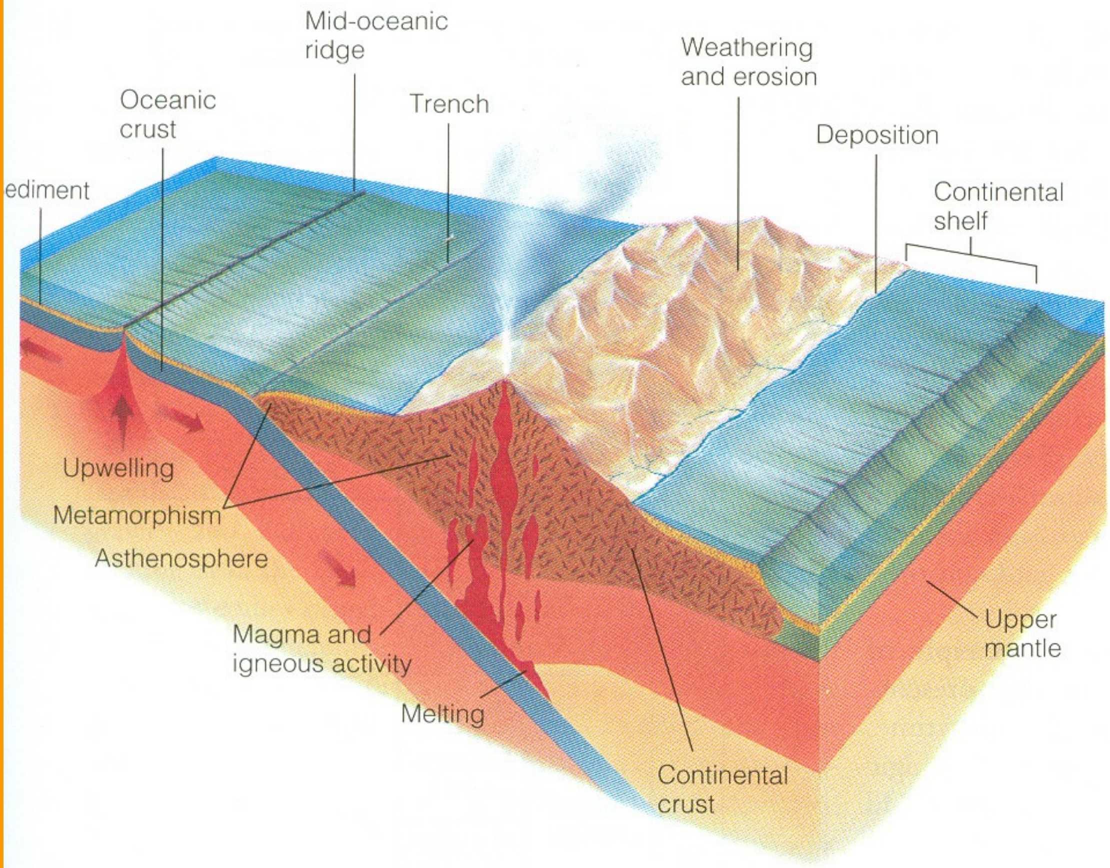
Sedimentární, sedimentární horniny



➢ FIGURE 1-16 The rock cycle showing the interrelationships between the Earth's internal and external processes and how each of the three major rock groups is related to the others.


The Rock Cycle
Melting to form magma
Cooling and crystallization
Igneous rocks
Mineral and crystal changes
Heat and pressure
Metamorphic rocks
Weathering and erosion
Sedimentary rocks
Deposition of sediments
Compaction and cementation


magmatity
Parciální tavení
metamorfoza
zvětrávání
metamorfoza
metamorfity
zvětrávání
sedimenty



▶ FIGURE 1-18 Plate tectonics and the rock cycle. The cross section shows how the three major rock groups—igneous, metamorphic, and sedimentary—are recycled through both the continental and oceanic regions.

Metody

terenní

laboratorní

Celohorninové

Chemické analýzy

Isotopické analýzy +
Datování

Studium těžkých
(akcesorických) minerálů

geofyzikální

Bodové nebo minerální

Studium výbrusů
Katodová luminiscence
Elektronová mikrosonda
LA ICP MS

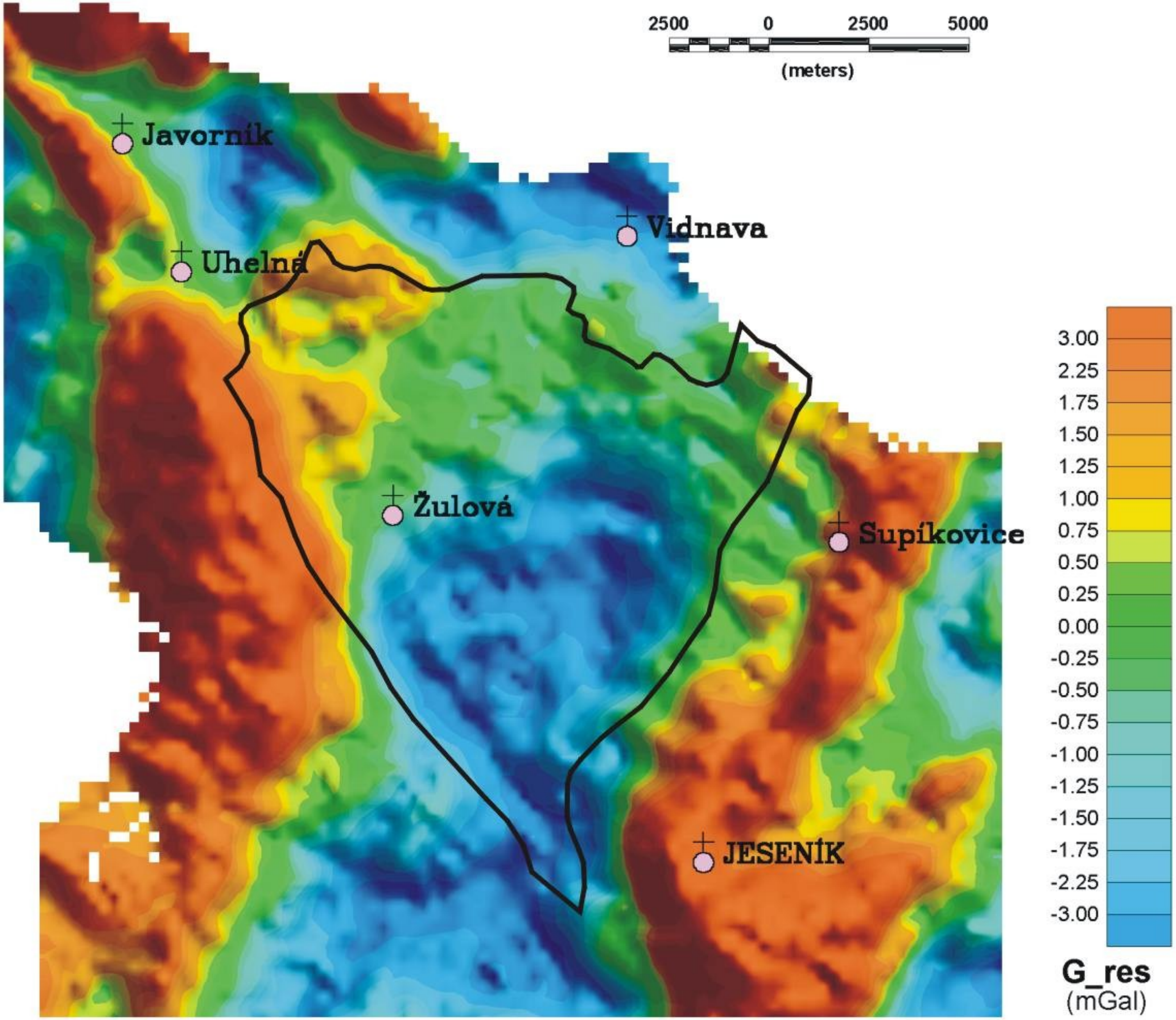

2500
0
2500
5000
(meters)
Javorník
Uhelná
Vidnava
Žulová
Supíkovice
JESENÍK
3.00
2.25
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
-2.25
-3.00
G_res
(mGal)

Fig 1.

41 (Anhedral) granular troctolite

Only a few of the plagioclases in this equigranular possess a face and none of the olivines do. The cry are therefore predominantly anhedral and the 'mo texture is granular.

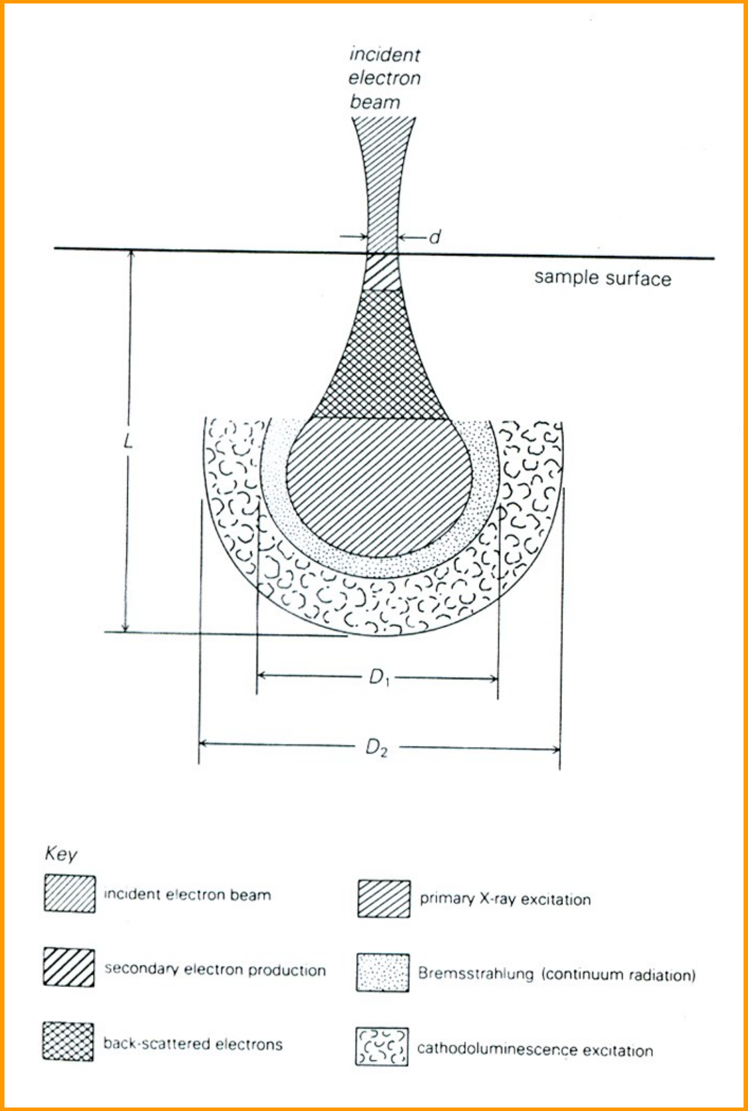
Troctolite from Garbh Bheinn intrusion, Skye, Scot magnification × 17, XPL.

Convolute zoning
This is a variety of multiple zoning in which some of the zones are erratic and have non-uniform thickness (see **97**).

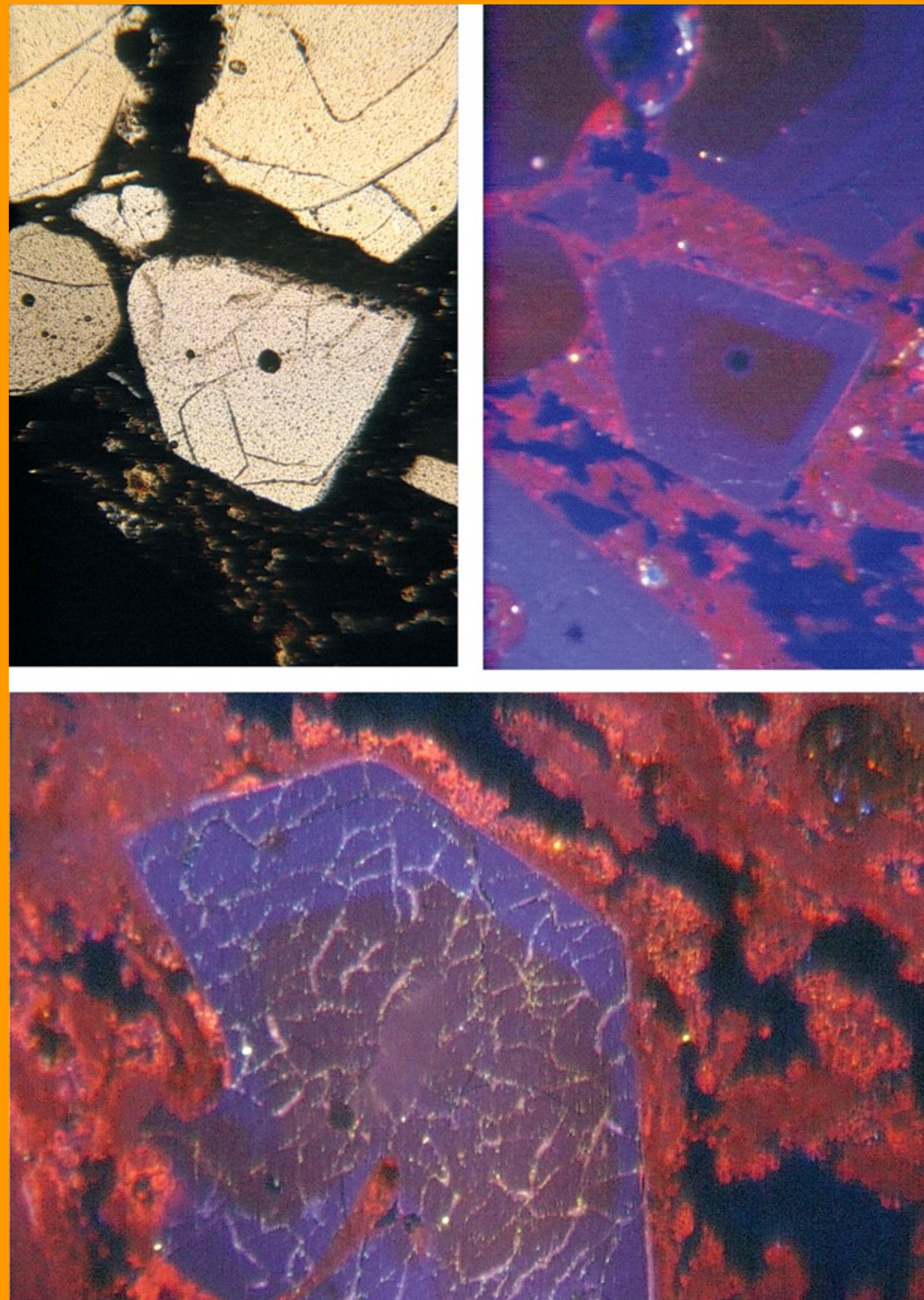
97 Zoned plagioclases

This photograph illustrates several styles of zoning in the two plagioclases comprising the glomerocryst. Combinations of discontinuous, oscillatory and convolute zoning are present, together with zoning picked out by a band of melt inclusions near the margins of both crystals.

Porphyritic andesite from Hakone volcano, Japan; magnification × 24, XPL.



Jevy vznikající při interakci dopadajícího zaostřeného svazku elektronů a pevné látky



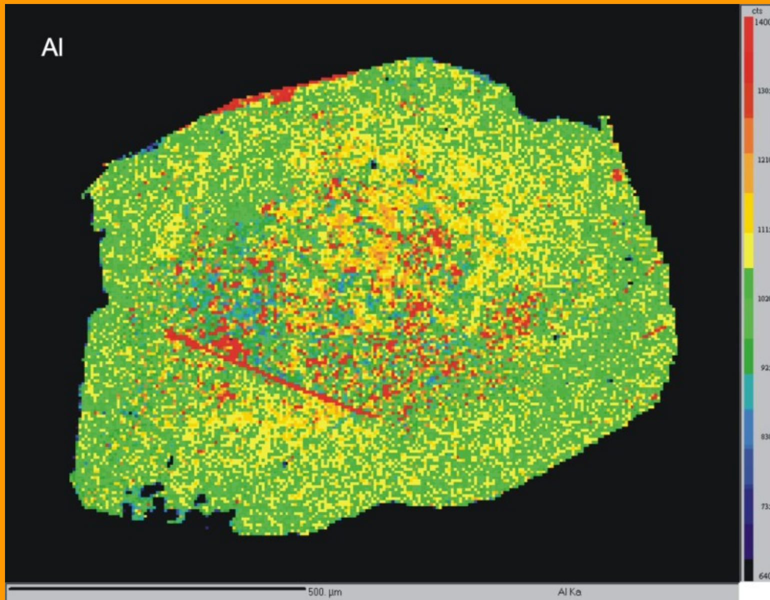


Fig 7

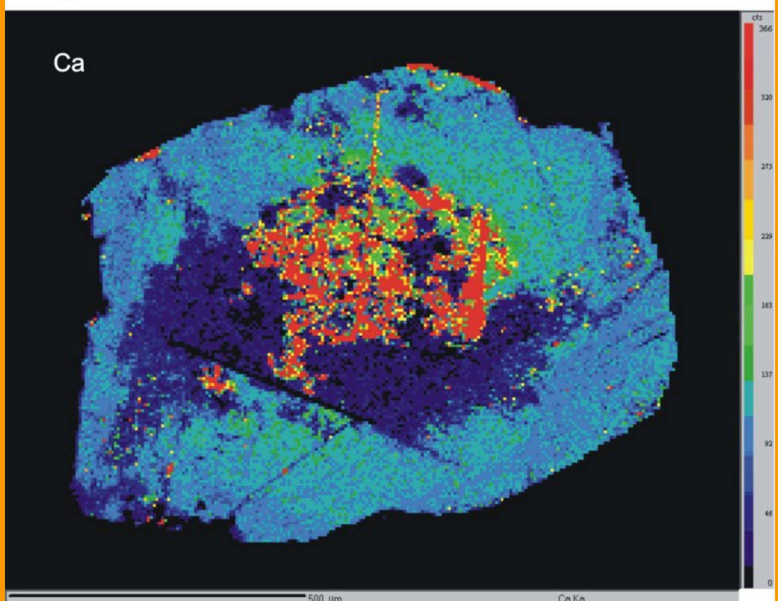


Fig 8

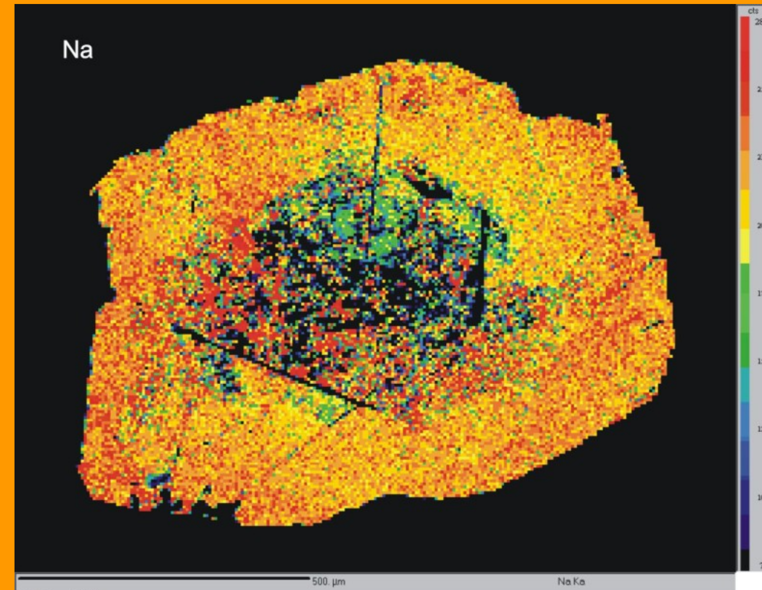


Fig 10

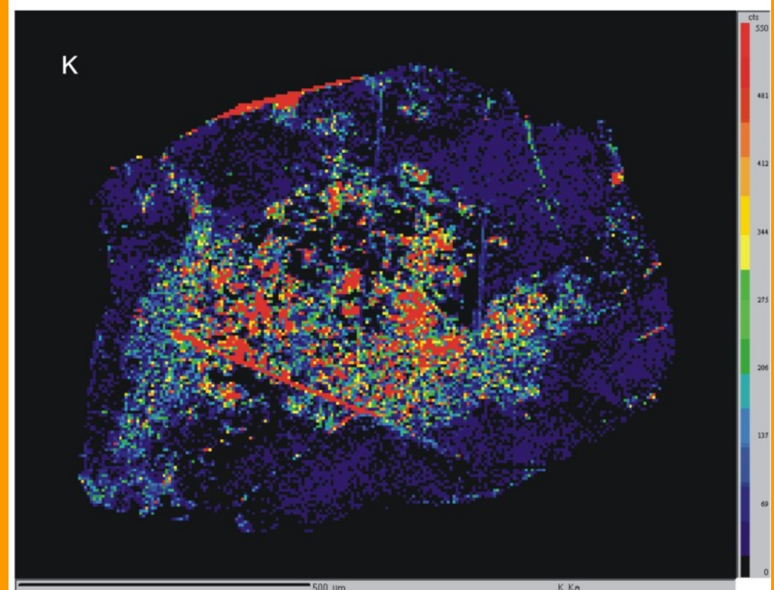


Fig 9

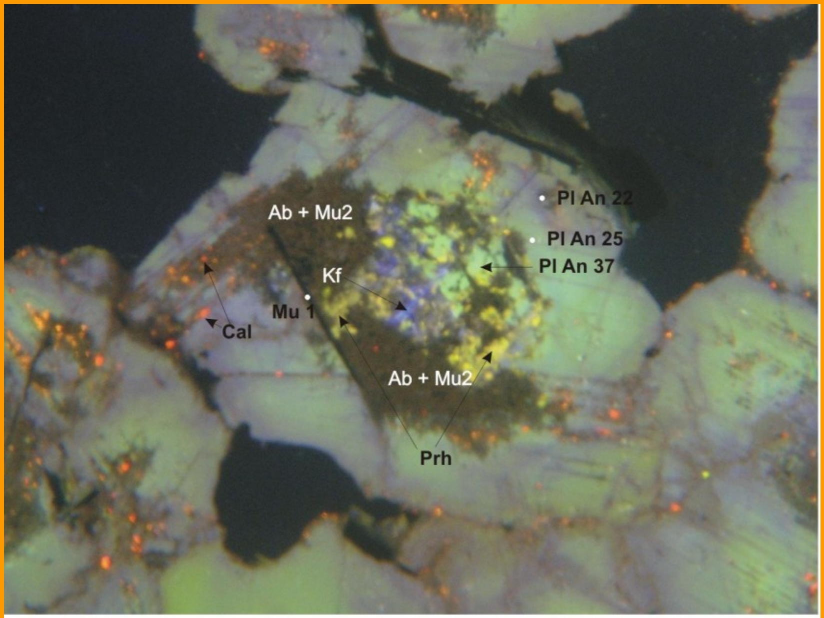


Fig 5

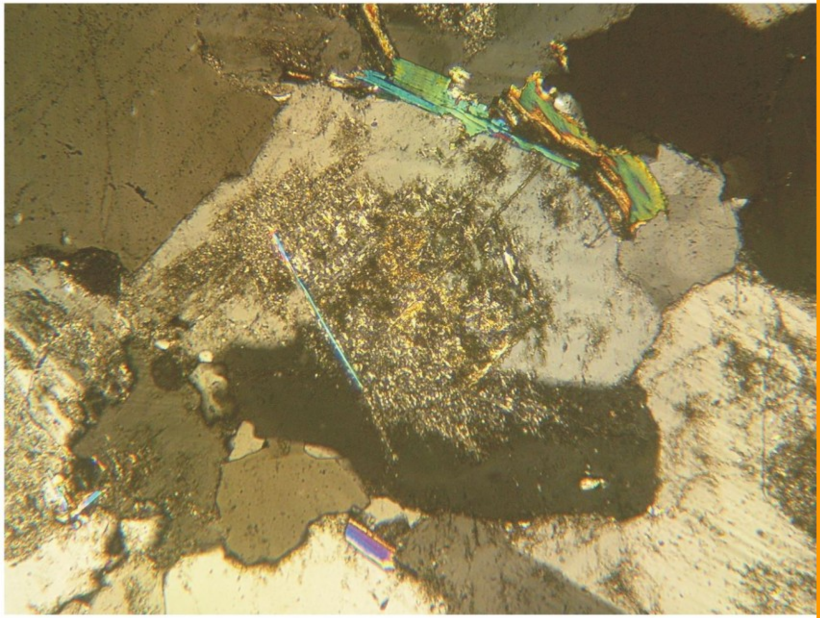


Fig 4

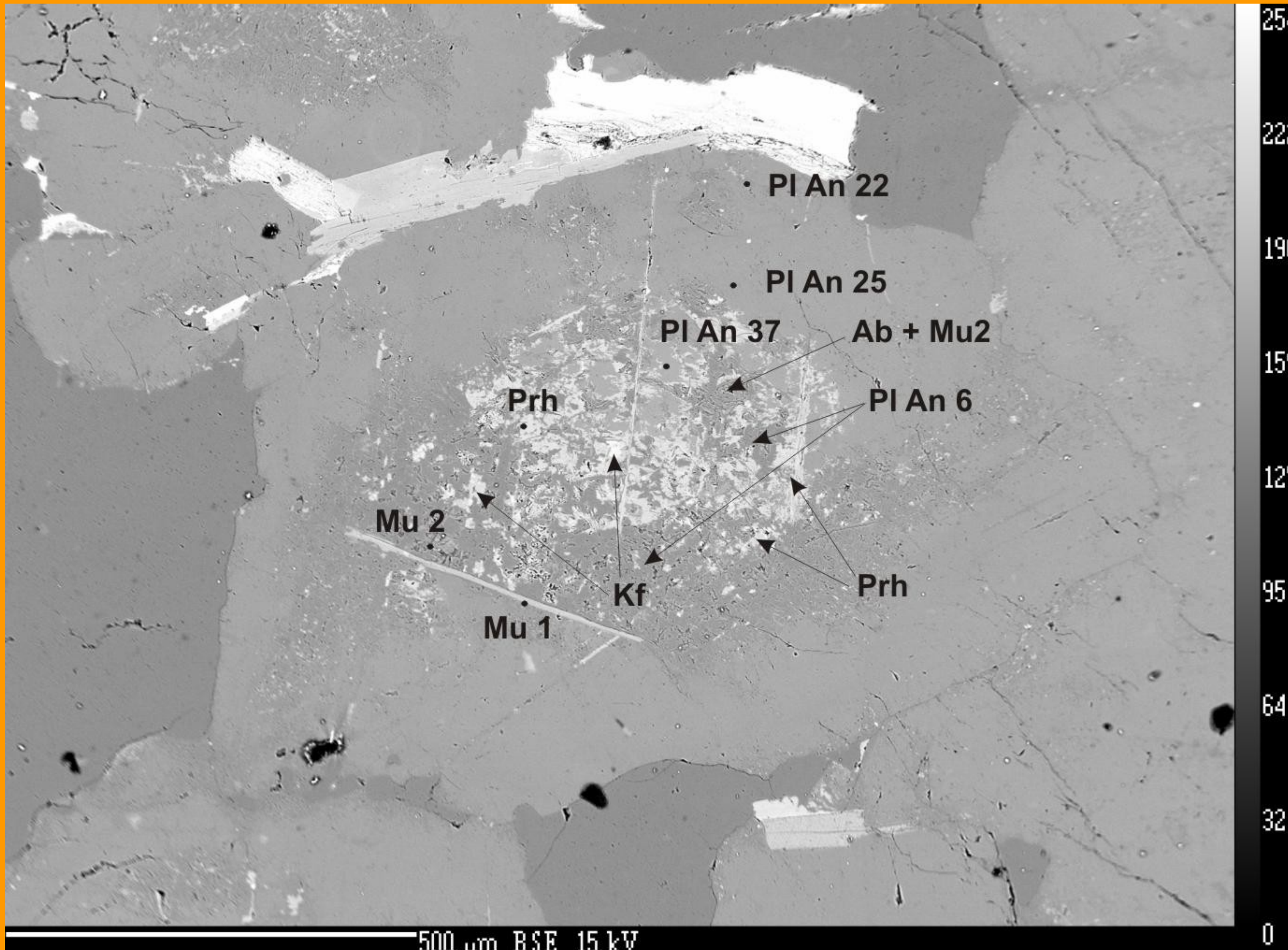
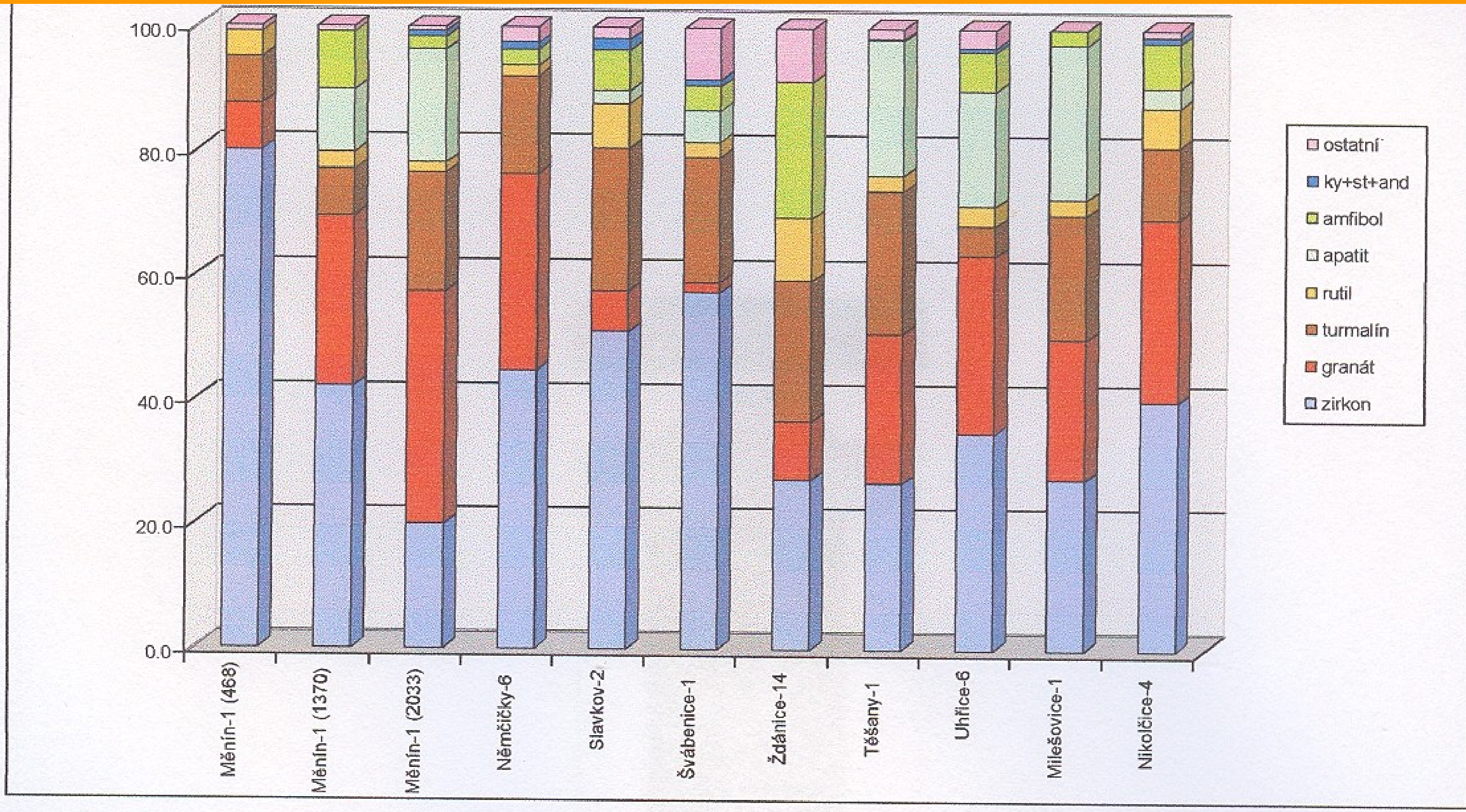
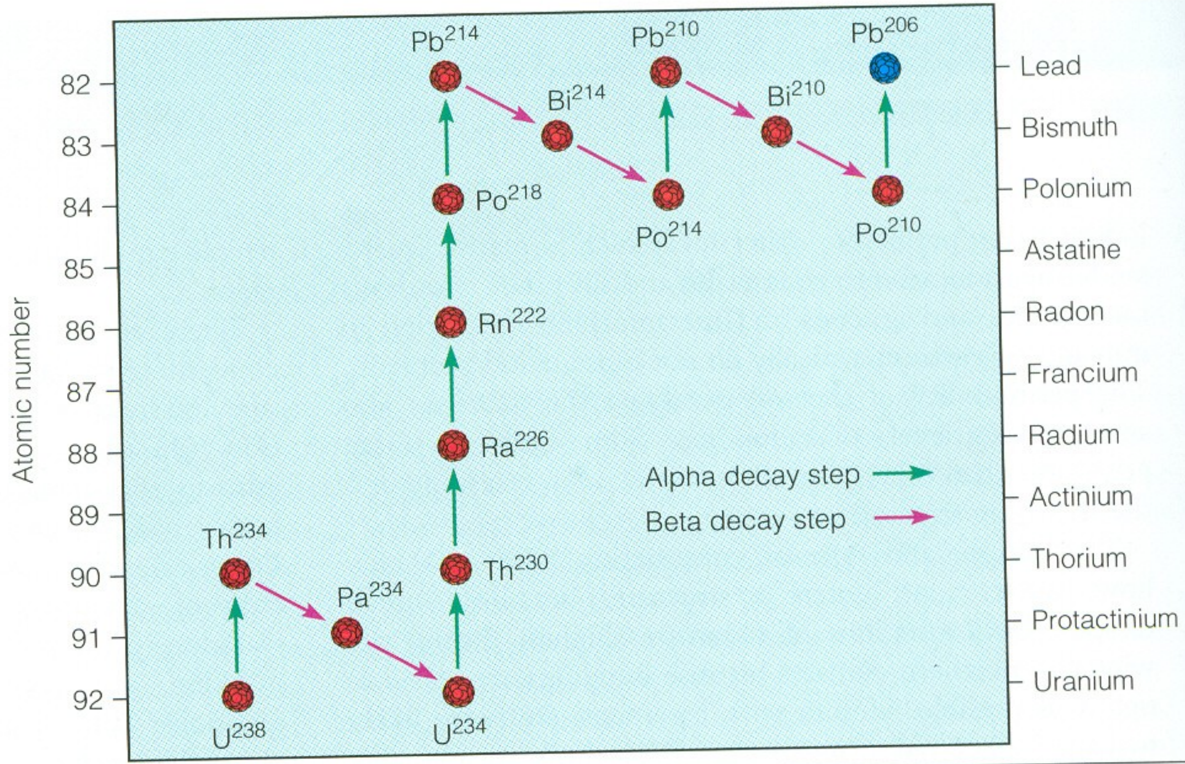

Pl An 22
Pl An 25
Pl An 37
Ab + Mu2
Prh
Pl An 6
Mu 2
Kf
Prh
Mu 1
500.µm BSE 15.kV
254
222
190
159
127
95
64
32
0

Fig 6



100.0
80.0
60.0
40.0
20.0
0.0
Měnín-1 (468)
Měnín-1 (1370)
Měnín-1 (2033)
Němčičky-6
Slavkov-2
Švábenice-1
Ždánice-14
Těšany-1
Uhřice-6
Milešovice-1
Nikolčice-4
ostatní
ky+st+and
amfibol
apatit
rutil
turmalín
granát
zirkon



▶ **FIGURE 8-19** Radioactive decay series for uranium 238 to lead 206. Radioactive uranium 238 decays to its stable end product, lead 206, by eight alpha and six beta decay steps. A number of different isotopes are produced as intermediate steps in the decay series.

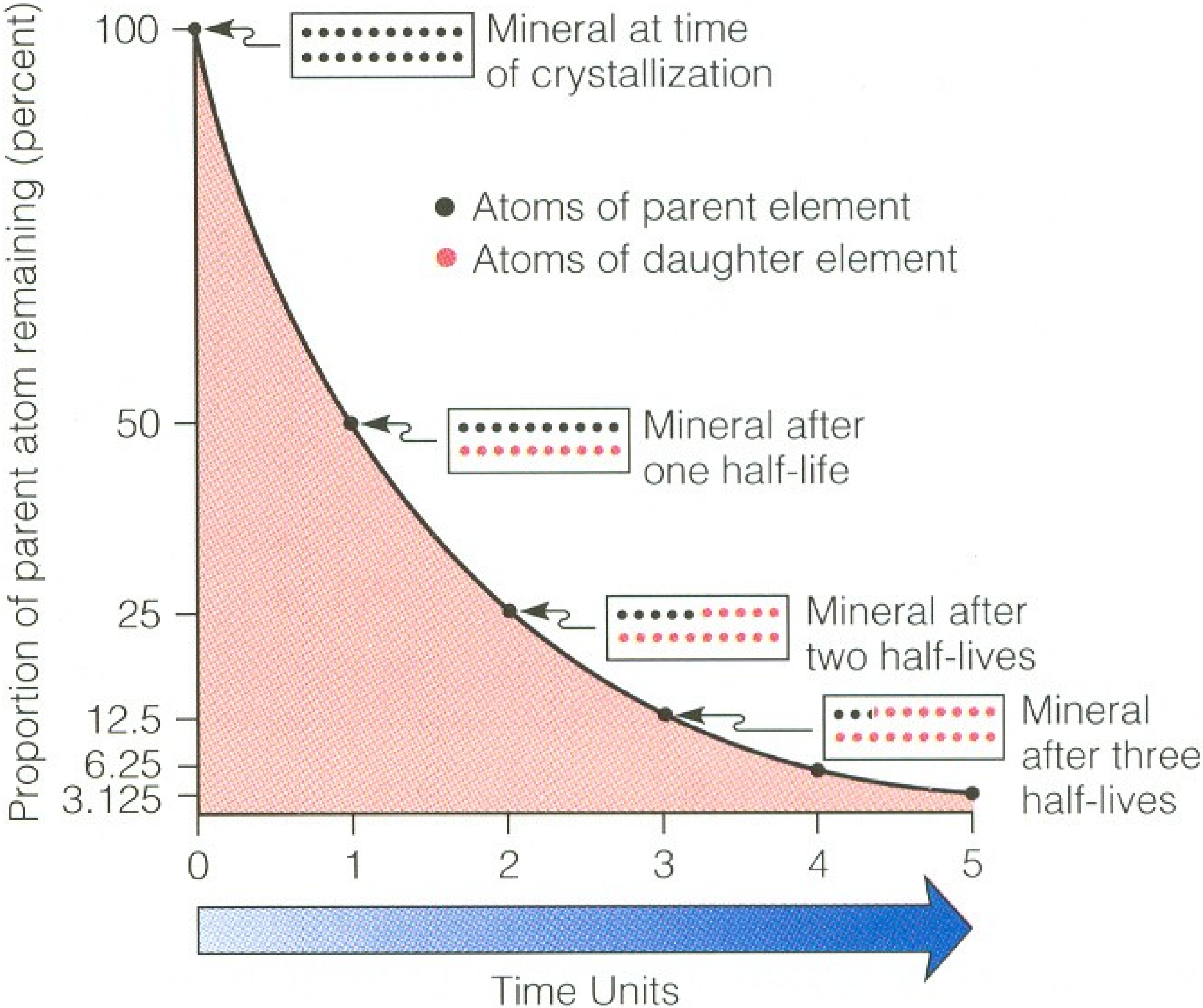
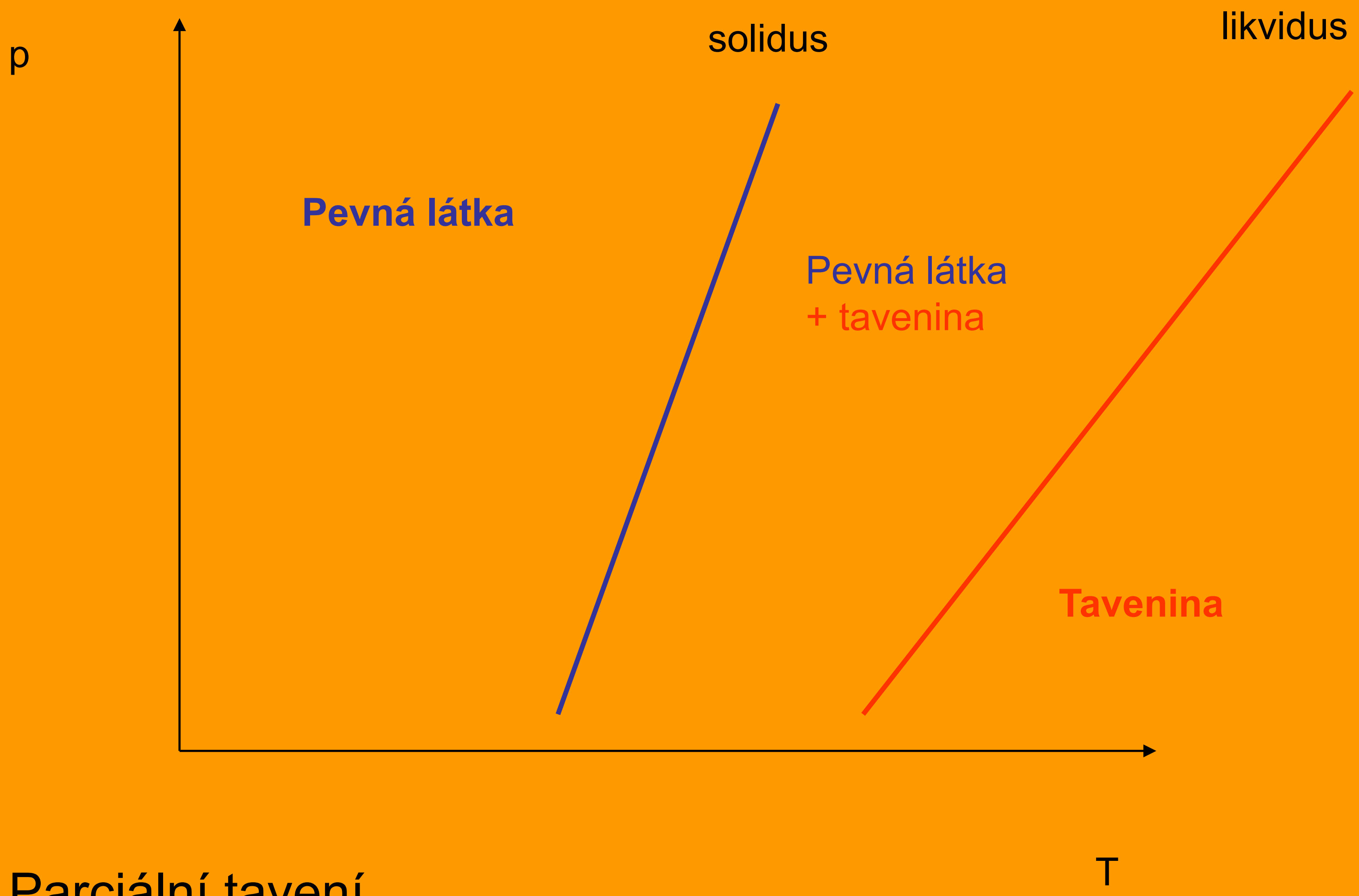
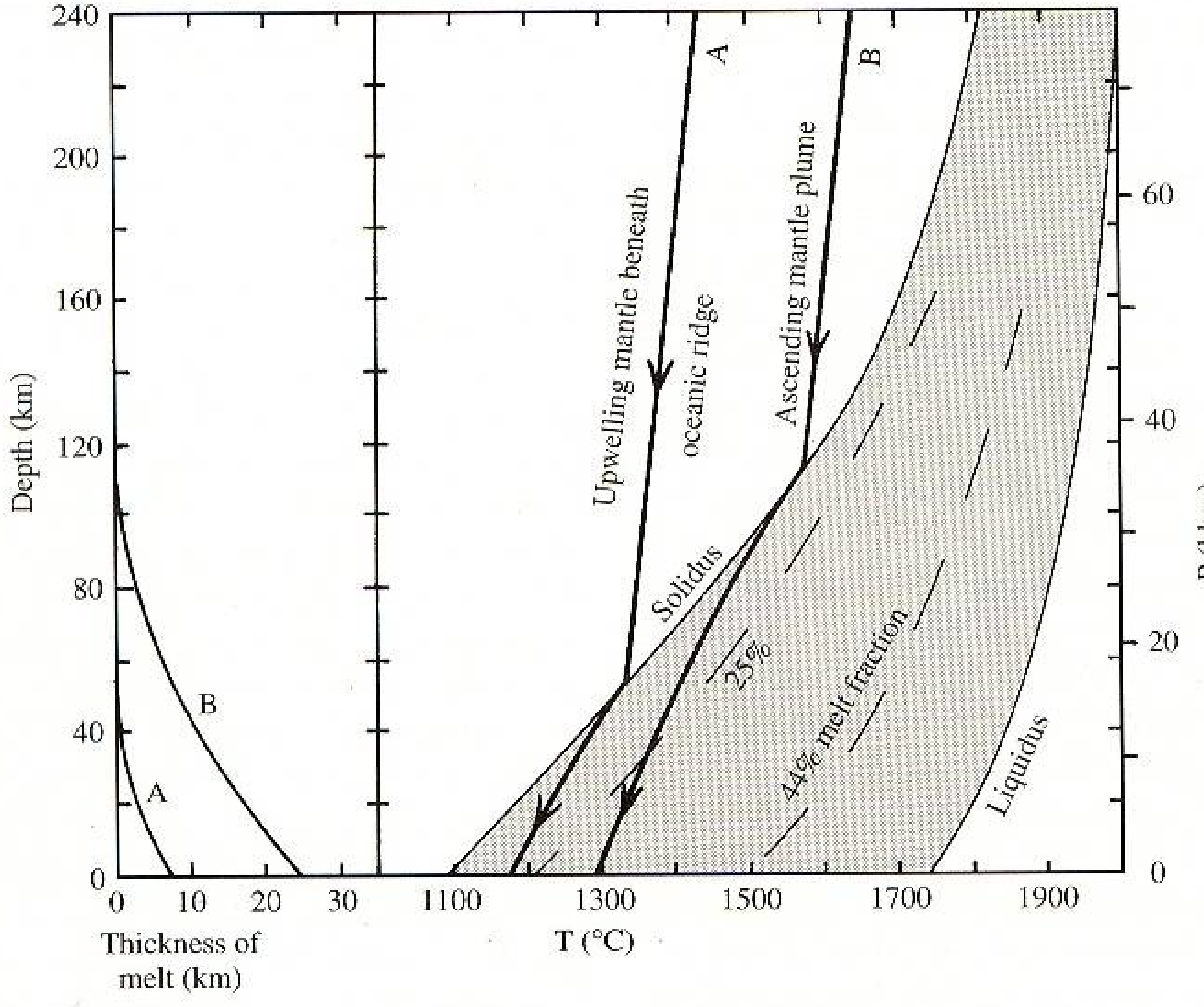

Proportion of parent atom remaining (percent)
100
50
25
12.5
6.25
3.125
0
1
2
3
4
5
Mineral at time of crystallization
Atoms of parent element
Atoms of daughter element
Mineral after one half-life
Mineral after two half-lives
Mineral after three half-lives
Time Units

TABLE 8-1 Five of the Principal Long-Lived Radioactive Isotope Pairs Used in Radiometric Dating

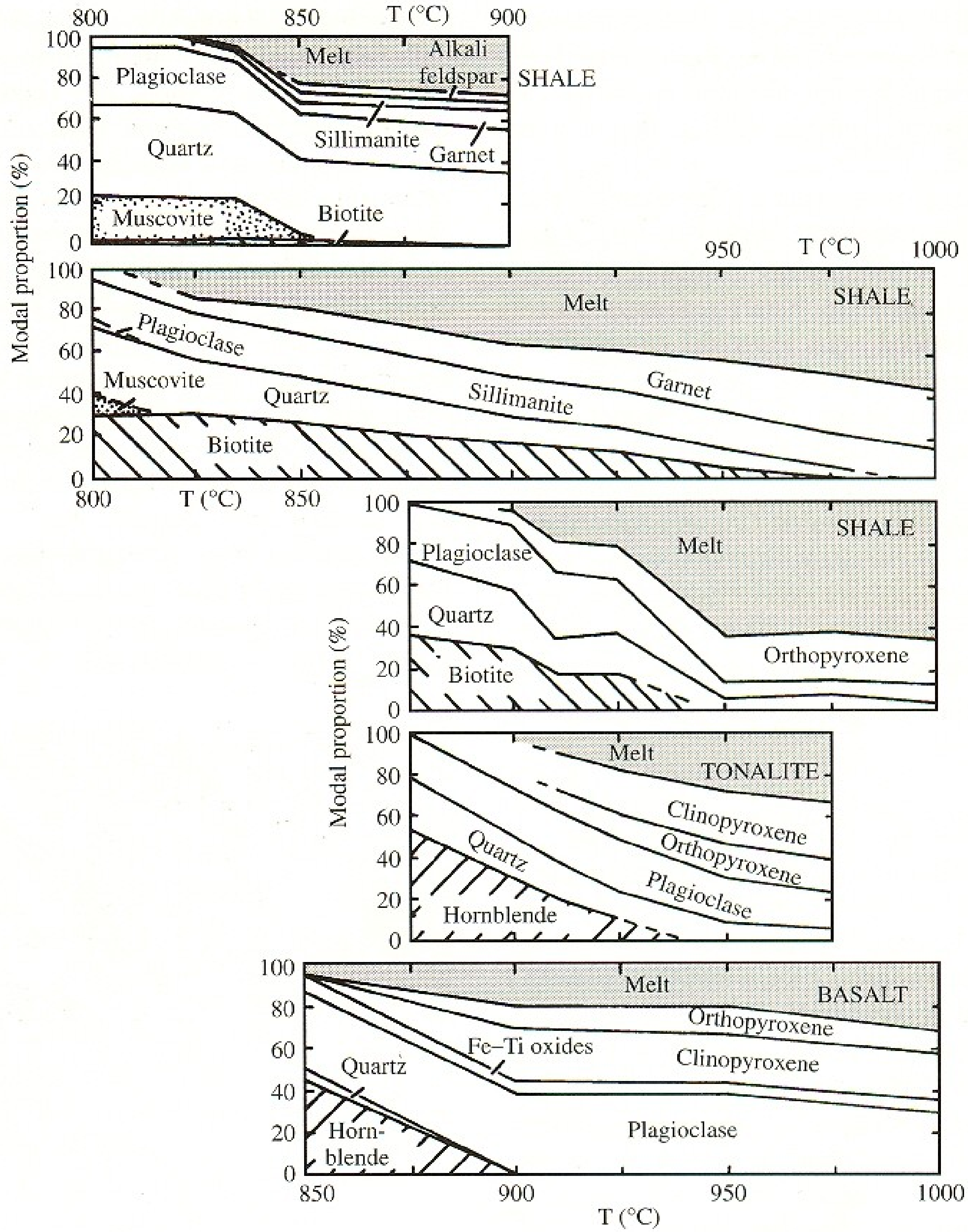
Isotopes: *Parent*	Isotopes: *Daughter*	Half-Life of Parent (Years)	Effective Dating Range (Years)	Minerals and Rocks That Can Be Dated
Uranium 238	Lead 206	4.5 billion	10 million to 4.6 billion	Zircon Uraninite
Uranium 235	Lead 207	704 million		
Thorium 232	Lead 208	14 billion		
Rubidium 87	Strontium 87	48.8 billion	10 million to 4.6 billion	Muscovite Biotite Potassium feldspar Whole metamorphic or igneous rock
Potassium 40	Argon 40	1.3 billion	100,000 to 4.6 billion	Glauconite Muscovite Biotite Hornblende Whole volcanic rock



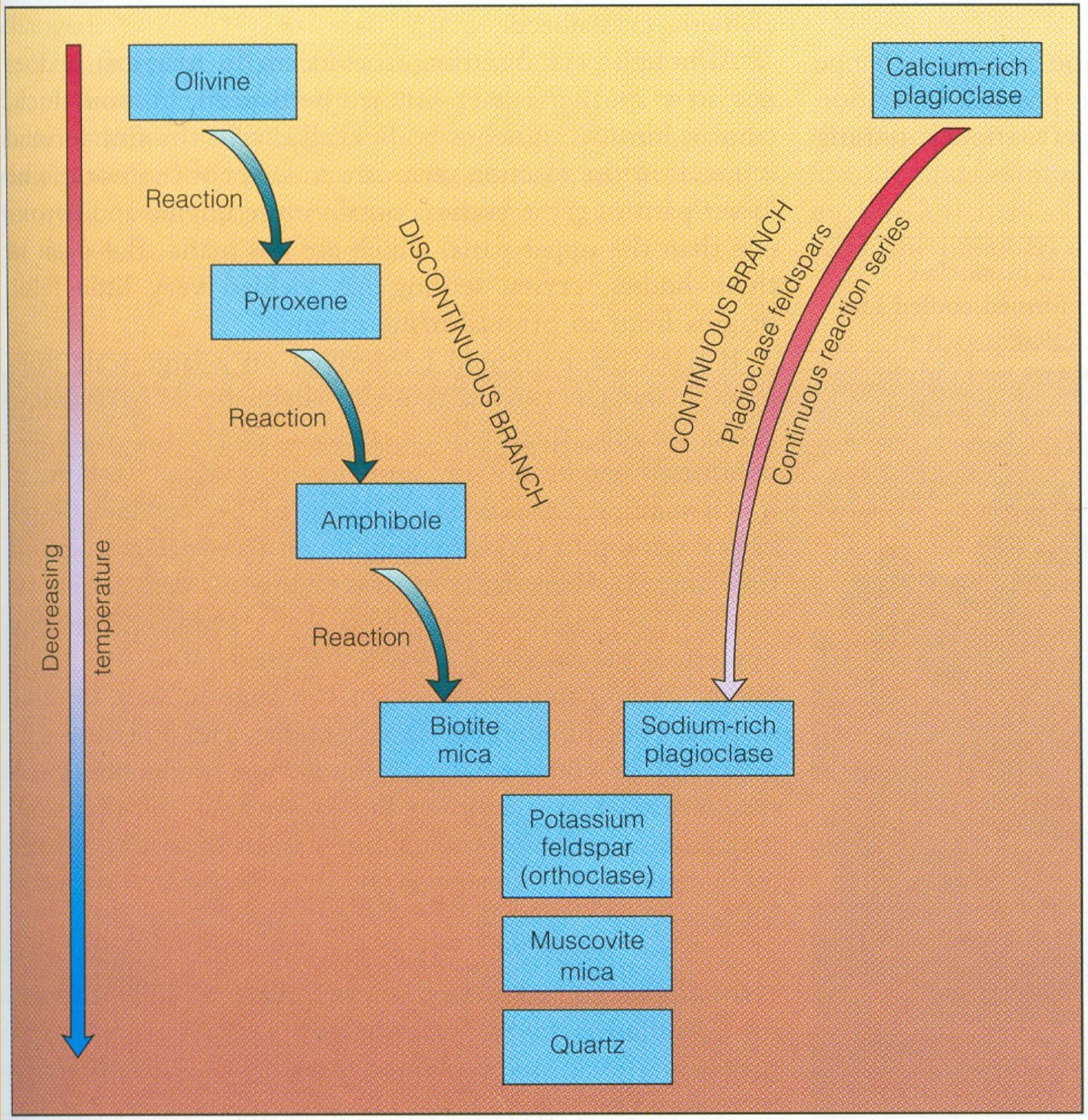
Parciální tavení



al melting of a model dry mantle peridotite. Compare Figure 11.4. Two hypothetical adiabatic *P* (depth)-*T* pat



800
850
T (°C)
900
100
80
60
40
20
0
Melt
Alkali feldspar
SHALE
Plagioclase
Quartz
Sillimanite
Garnet
Muscovite
Biotite
Modal proportion (%)
950
T (°C)
1000
SHALE
Melt
Plagioclase
Muscovite
Quartz
Sillimanite
Garnet
Biotite
800
T (°C)
850
SHALE
Melt
Plagioclase
Quartz
Biotite
Orthopyroxene
Modal proportion (%)
Melt
TONALITE
Clinopyroxene
Orthopyroxene
Quartz
Plagioclase
Hornblende
Melt
BASALT
Orthopyroxene
Fe–Ti oxides
Quartz
Clinopyroxene
Horn-blende
Plagioclase
850
900
950
1000
T (°C)



▶ FIGURE 3-6 Bowen's reaction series. Note that it consists of a discontinuous branch and a continuous branch.

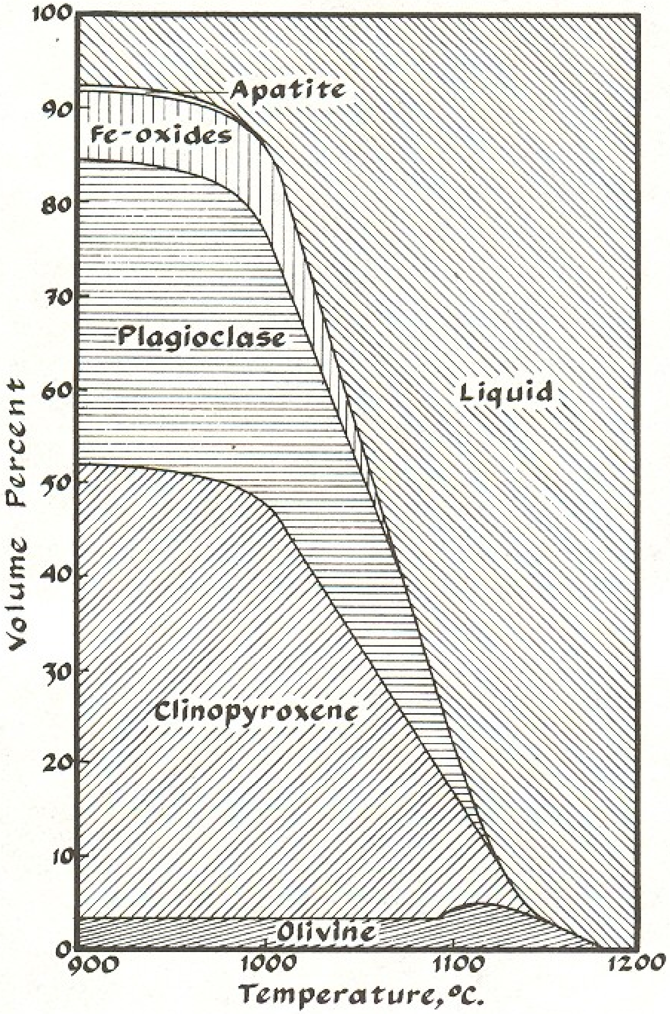
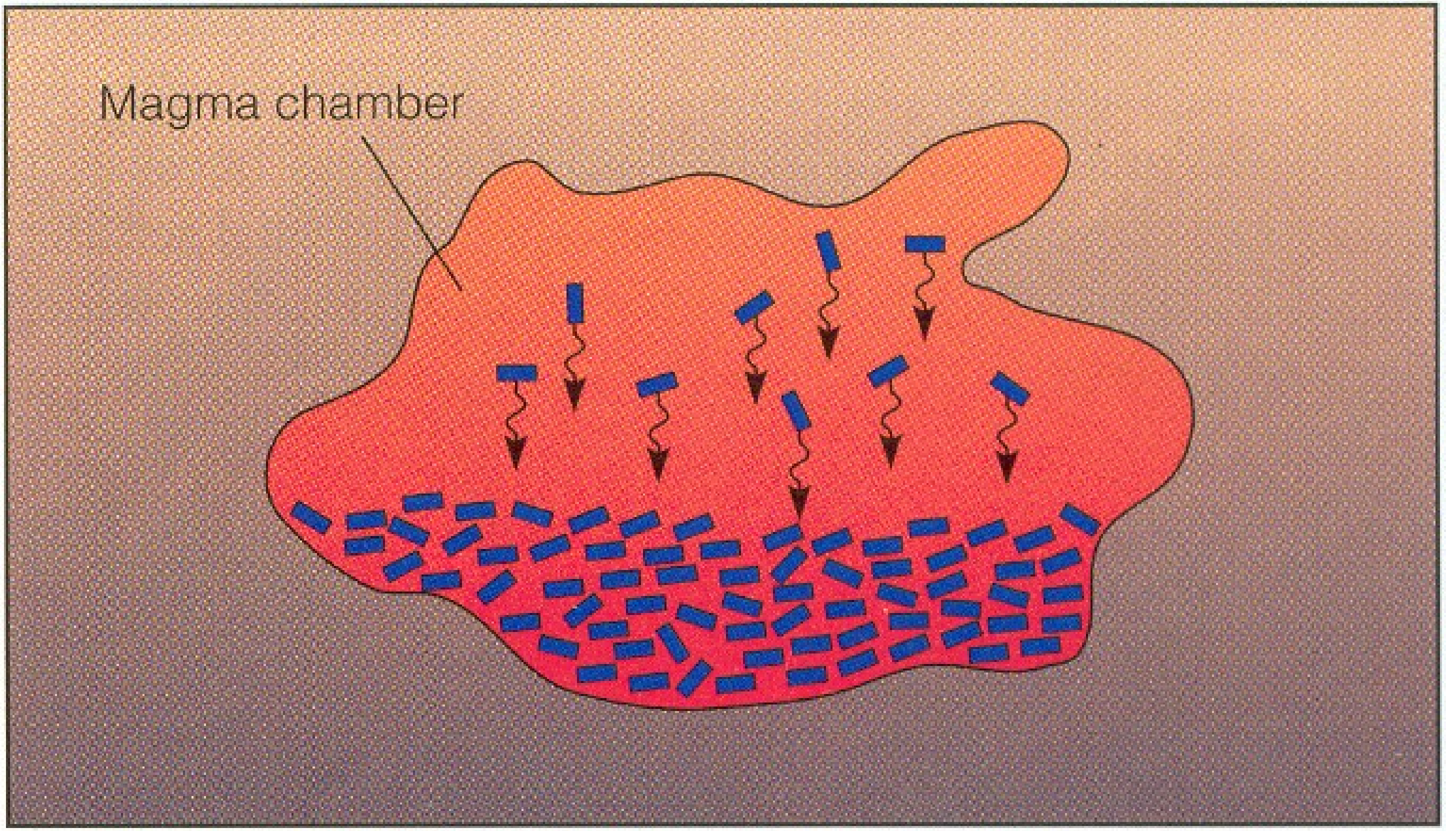
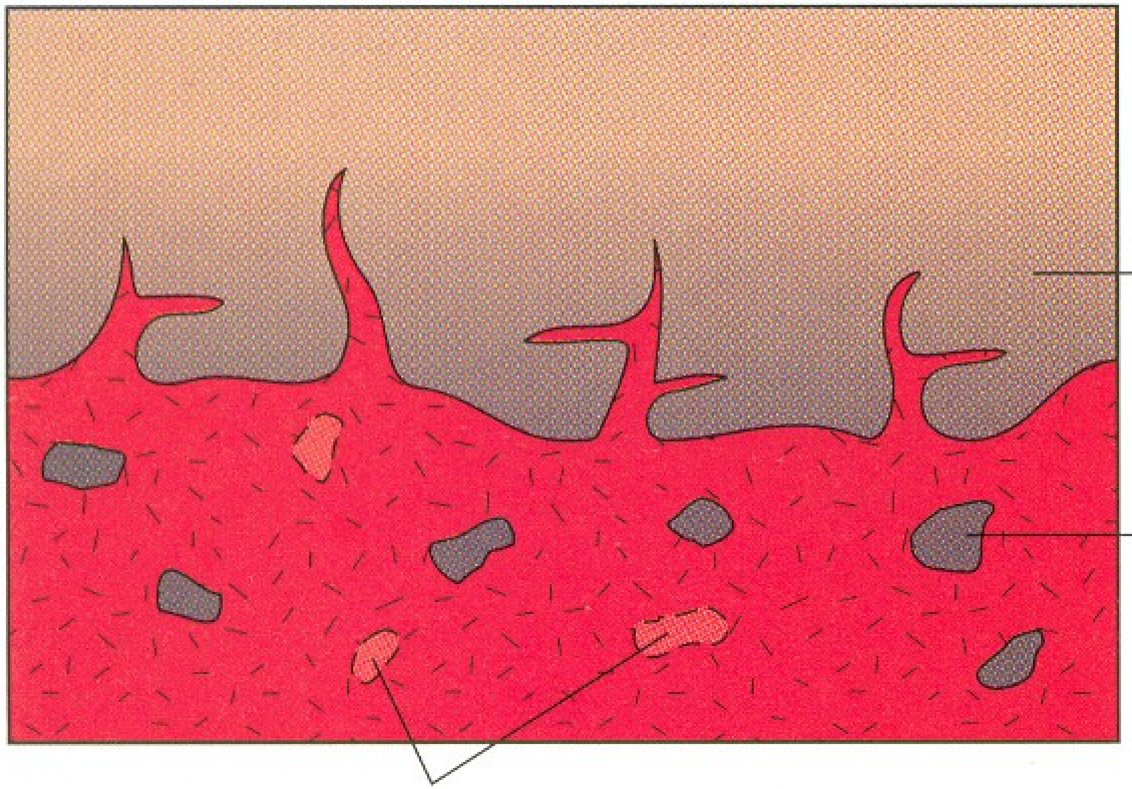


Figure 3–2 Proportions of crystals and liquid for a basalt such as that shown in Figure 3-1. Olivine was present as phenocrysts at the time of eruption and later was resorbed in the cooling magma. With falling temperature olivine was followed by clinopyroxene, plagioclase, magnetite, and ilmenite, and, finally, by apatite, and the proportion of liquid declined to less than 10 percent. The liquid indicated in the low-temperature range would be in the form of glass, as it is in the quenched samples recovered by drilling. If cooling were slower, the basalt would be entirely crystalline at all temperatures below about 1,000 degrees.



➢ FIGURE 3-8 Differentiation by crystal settling. Early-formed ferromagnesian minerals have a specific gravity greater than that of the magma so they settle and accumulate in the lower part of the magma chamber.



➢ FIGURE 3-9 As magma moves upward, fragments of country rock are dislodged and settle into the magma. If they have a lower melting temperature than the magma, they may b incorporated into the magma by assimilation. Incompletely assimilated pieces of country rock are inclusions.

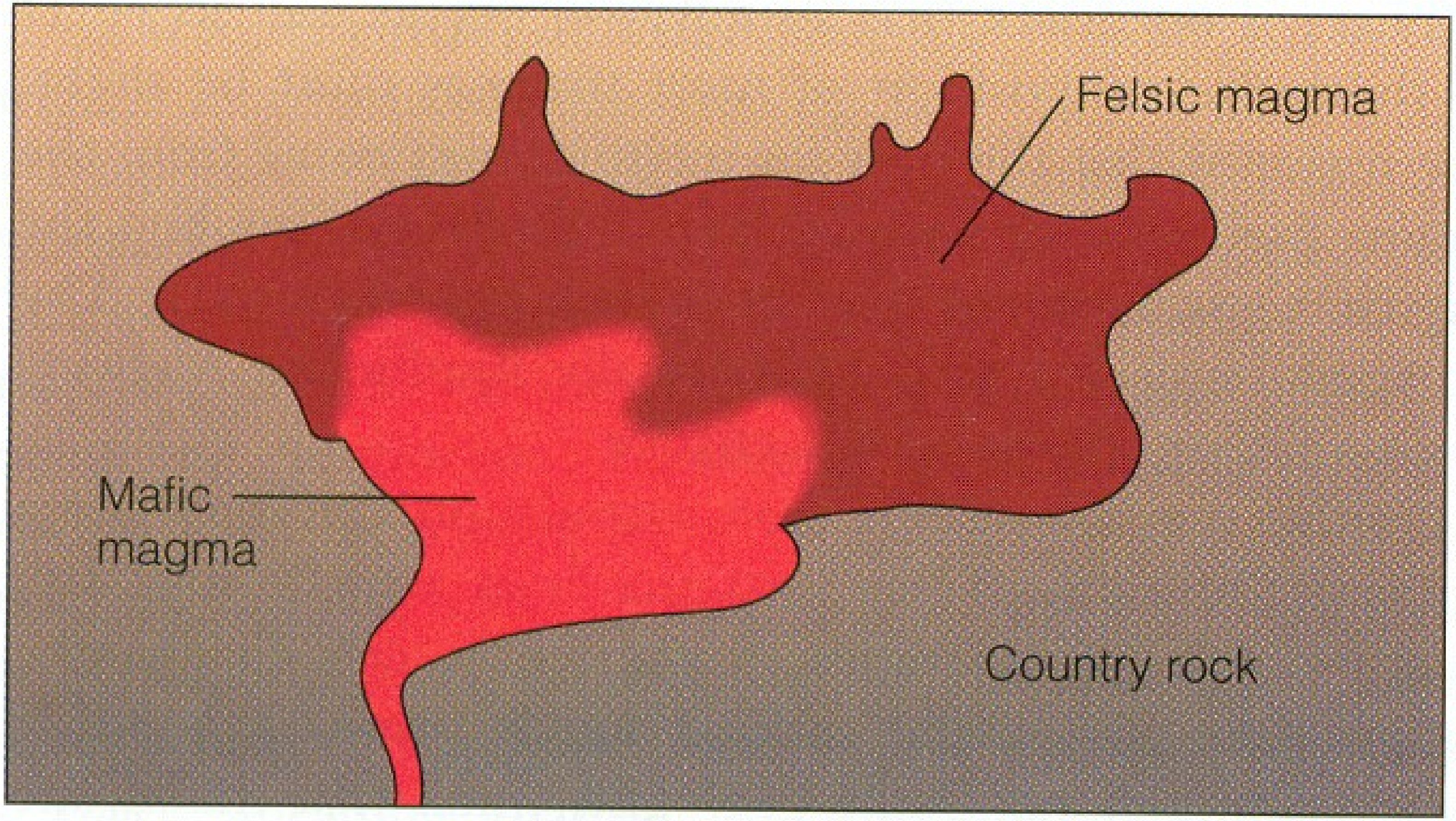
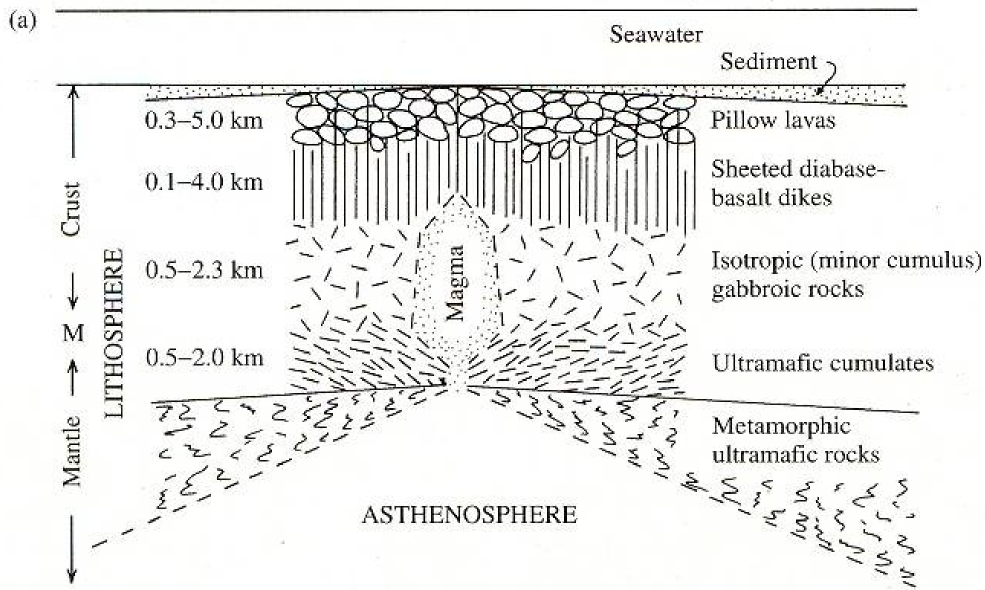
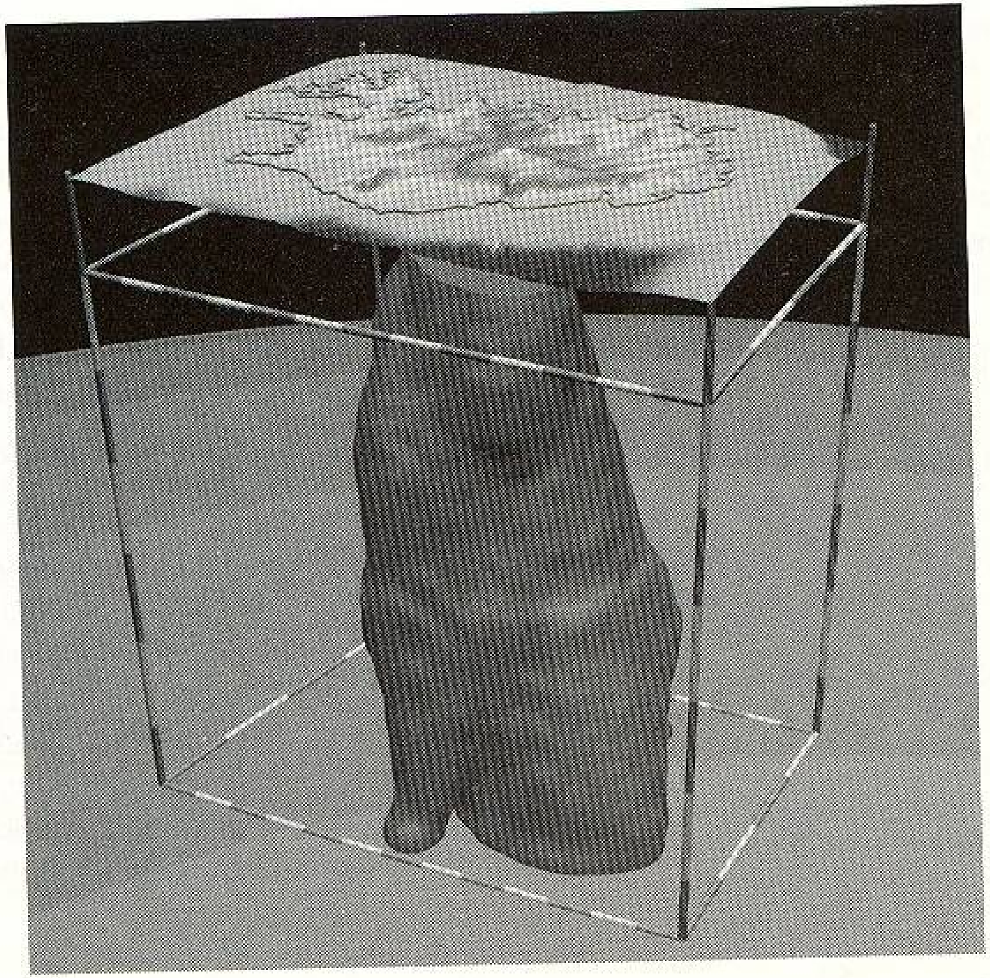


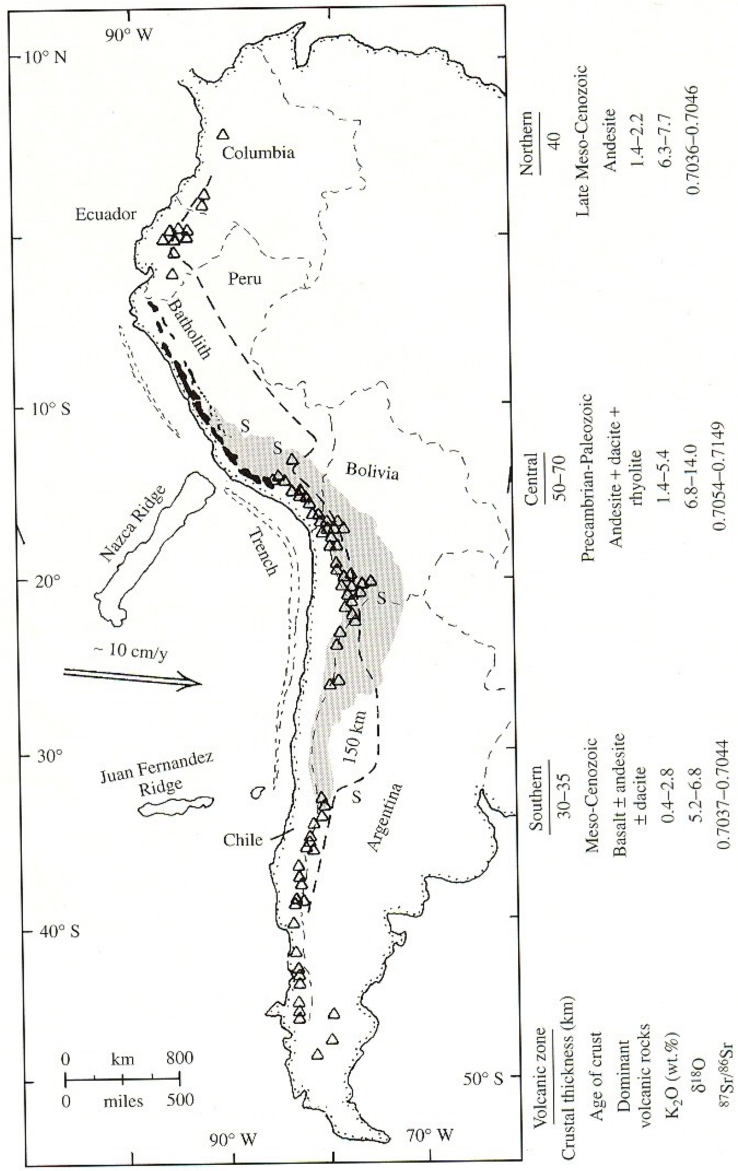
FIGURE 3-11 Magma mixing. Two rising magmas mix and produce a magma with a composition different from either of the parent magmas.



13.1 Oceanic lithosphere consisting of crust and underlying mantle. (a) Highly idealized cross section at a spreading ridge. Note that the seismic M-discontinuity between crust and higher-velocity ultramafic mantle is here drawn at the top of the ultramafic cumulates whereas the petrologic discontinuity between magmatic crust and metamorphic mantle lies 0.5–2.0 km deeper. (b) Heat flow from the seafloor as a function of its age. One heat flow unit (HFU) = 0.0418 W/m^2. Shaded area approximates distribution of observed values of heat flow perturbed by advective circulation of seawater through the crust. Solid line is the theoretical heat flow according to a model in which the lithosphere is cooling by conduction only. (c) Schematic geologic cross section through the upper lithosphere (ignoring surface topographic characteristics and structural complications) showing increasing thickness of sediment with age away from crest of ridge; deepening of seafloor away from ridge crest due to cooling and thermal contraction of lithosphere; approximately uniform thickness of layers 2 and 3 of basalt and gabbro, which together with sediment constitute the **oceanic crust;** and the underlying ultramafic rocks of the uppermost mantle. Advective circulation of seawater through the upper part of hot crust diminishes away from ridge crest. (d) The lithosphere beneath the basalt-gabbro crust is a thickening lid of cooling peridotitic mantle covering the hotter asthenosphere. Light lines are highly schematic isotherms suggesting that the base of the lithosphere, deepening with respect to age, is essentially an isothermal solidus surface. Dashed heavier lines indicate possible directions of flow of the asthenosphere away from axis of the rise: Stippled area under the crest is the approximate location of a zone of advanced partial melting (compare Figure 13.4). Note difference in depth scales in (c) and (d). (b–d Redrawn from Anderson et al., 1977.)



3.6 Seismic image of the Iceland mantle plume. (Courtesy of Cecily Wolfe.) The approximately 300-km-diameter plume to a depth of 410 km beneath Iceland. Other seismic data suggest a perturbed 660-km discontinuity that distinguishes the upper from the lower mantle (Figure 1.3), indicating that the plume ascends from the lower mantle, in contrast to the convective pattern beneath normal oceanic ridges (Figure 13.4).



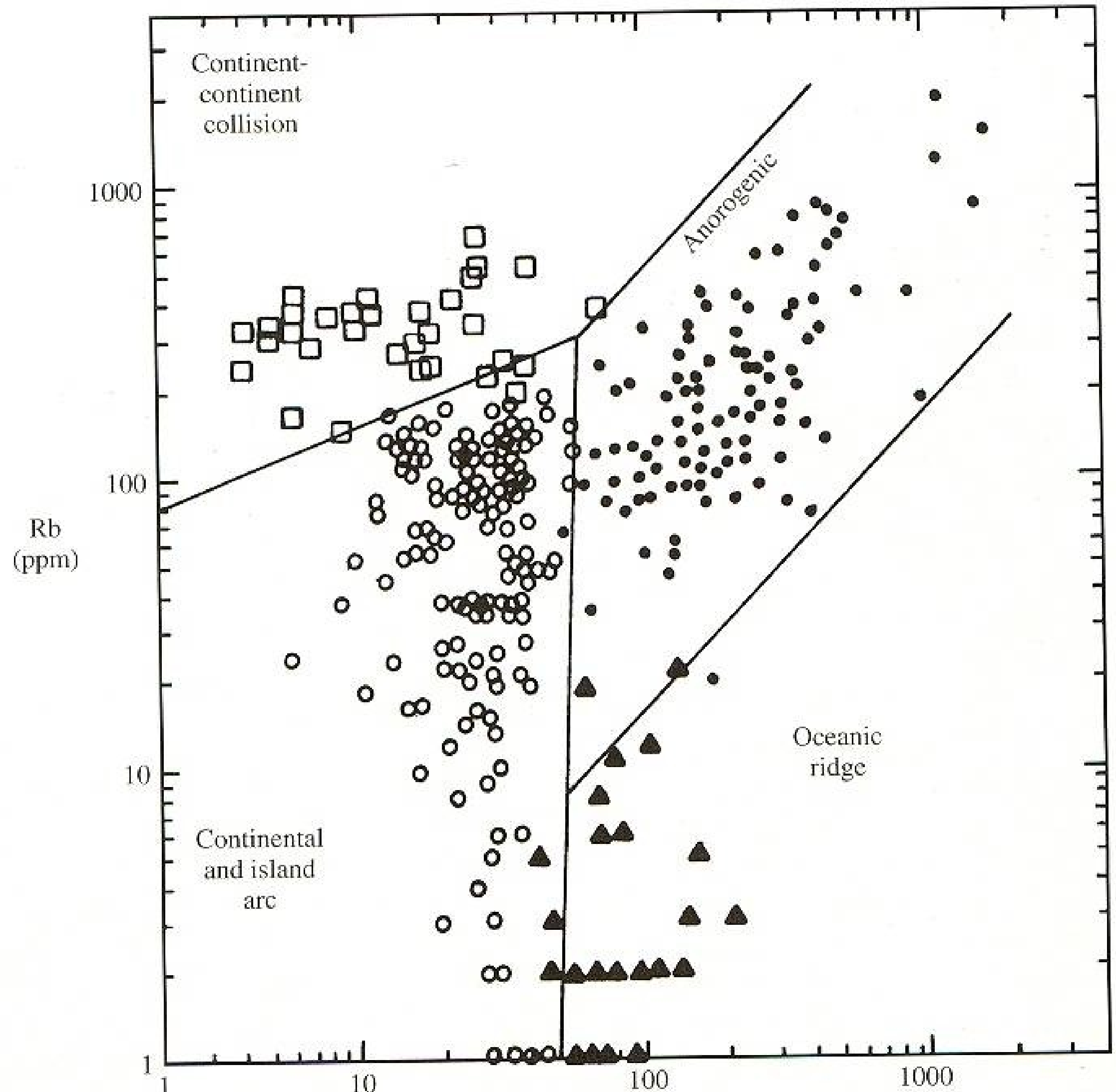
13.28 Western South America magmatic arc. Coastal Peruvian batholith (black) is Cretaceous next to coast and Cenozoic inland. Triangles, Holocene (active) volcanoes. Heavy dashed line, position of 150 km-depth contour on top of Wadati-Benioff seismic zone showing two segments of arc where slab subducts only 5–10°, precluding active volcanism. Shaded, area of average elevation >3 km and to as much as about 7 km, including Altiplano in Bolivia and southern Peru and Puna in northern Chile and Argentina. The notes along the right side contrast the three active volcanic arc segments. S, shoshonitic volcanic centers. (Redrawn from Wilson, 1989; Jordan et al., 1983.)

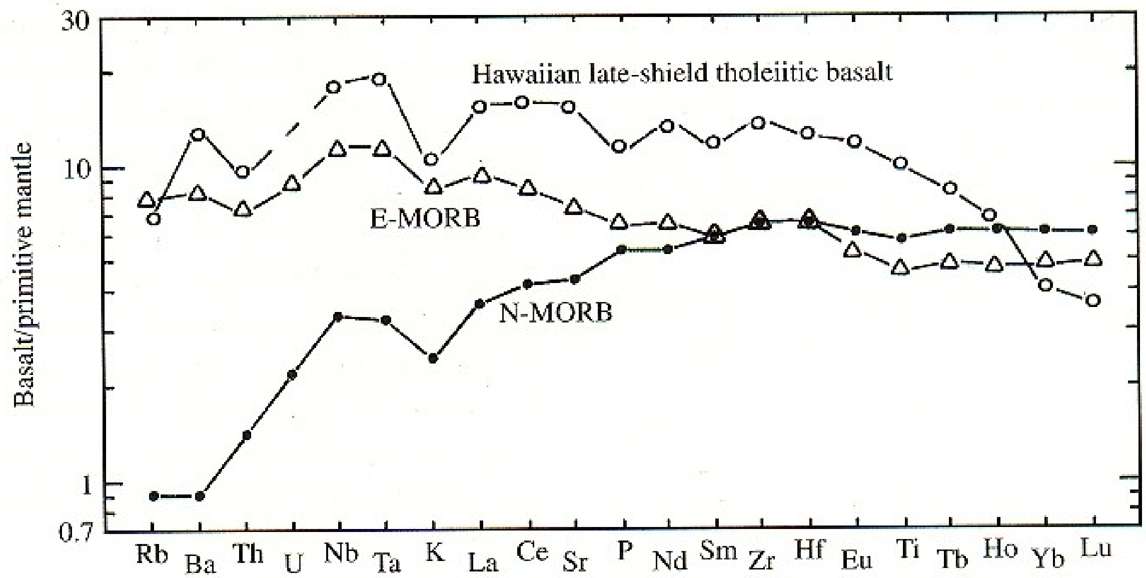
Table 13.1. Average Chemical and Normative Composition of N-MORB and Trace Elements (ppm) for N-MORB and E-MORB

	N-MORB		N-MORB
SiO_2	49.93	*Or*	1.00
TiO_2	1.51	*Ab*	22.06
Al_2O_3	15.90	*An*	31.14
FeO	10.43	*Di*	21.04
MnO	0.17	*Hy*	15.55
MgO	7.56	*Ol*	2.47
CaO	11.62	*Mt*	3.89
Na_2O	2.61	*Il*	2.87
K_2O	0.17	*Ap*	0.19
P_2O_5	0.08		

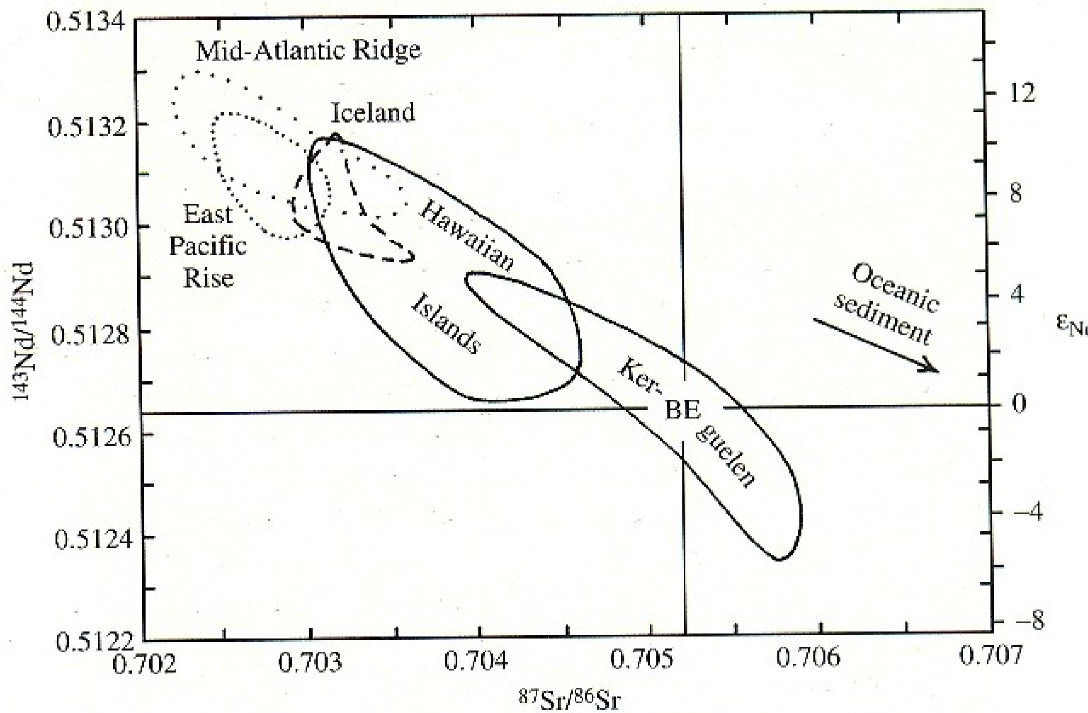
	N-MORB	E-MORB
Cs	0.007	0.063
Rb	0.56	5.04
Ba	6.3	57
Th	0.12	0.6
U	0.47	0.18
Nb	2.33	8.3
Ta	0.132	0.47
La	2.5	6.3
Ce	7.5	15
Sr	90	155
Nd	7.3	9
Sm	2.63	2.6
Zr	74	73
Eu	1.02	0.91
Gd	3.68	2.97
Dy	4.55	3.55
Y	28	22
Yb	3.05	2.37
Lu	0.455	0.354

Top, major oxides from McKenzie and O'Nions (1991); bottom, data from Sun and McDonough (1989).

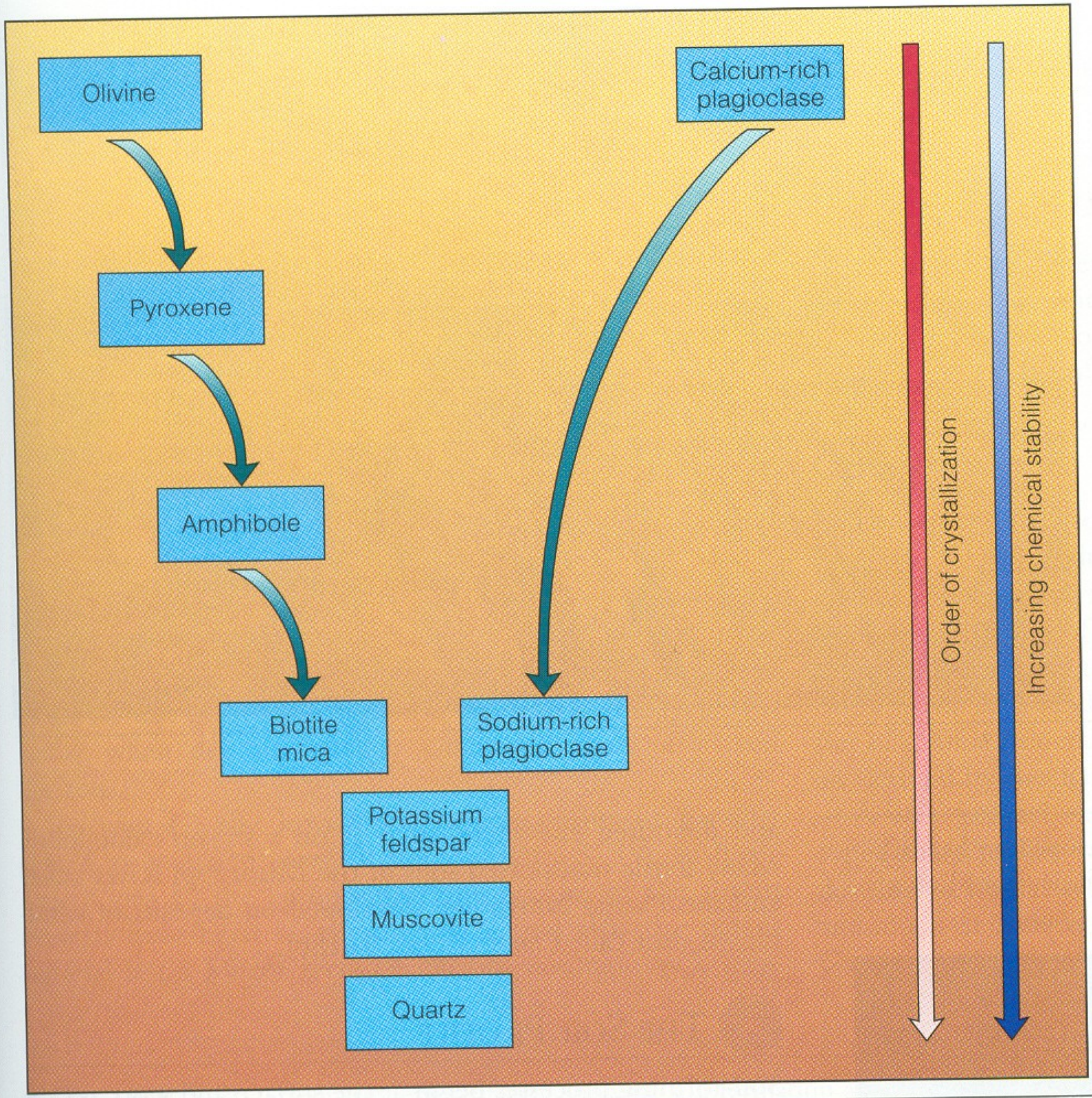

Continent-
continent
collision
Anorogenic
Rb
(ppm)
Oceanic
ridge
Continental
and island
arc
1000
100
10
1
1
10
100
1000



13.2 Primitive-mantle-normalized trace element patterns of oceanic tholeiitic basalts. Decreasing element incompatibility in mafic magmas from left to right. MORB data and normalizing values from Sun and McDonough (1989). Hawaiian tholeiite from Table 13.3.

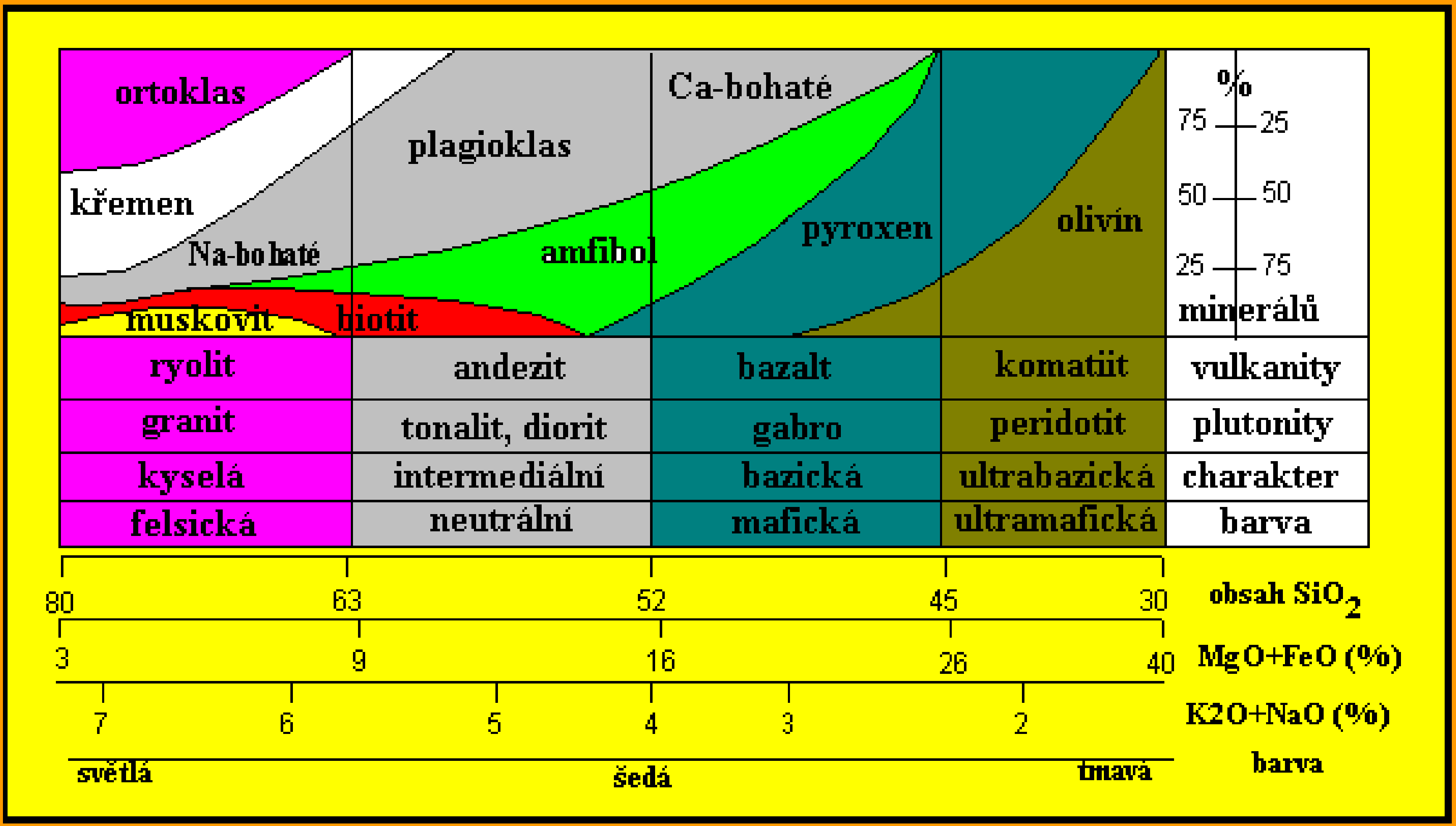


13.8 Isotope ratio diagram for oceanic volcanic rocks showing fields of oceanic island groups, East Pacific Rise MORB, Mid-Atlantic Ridg MORB, and oceanic sediment (off diagram). BE, isotopic ratios in bulk silicate earth. Compare Figure 2.27. (Redrawn from Wilso 1989.)

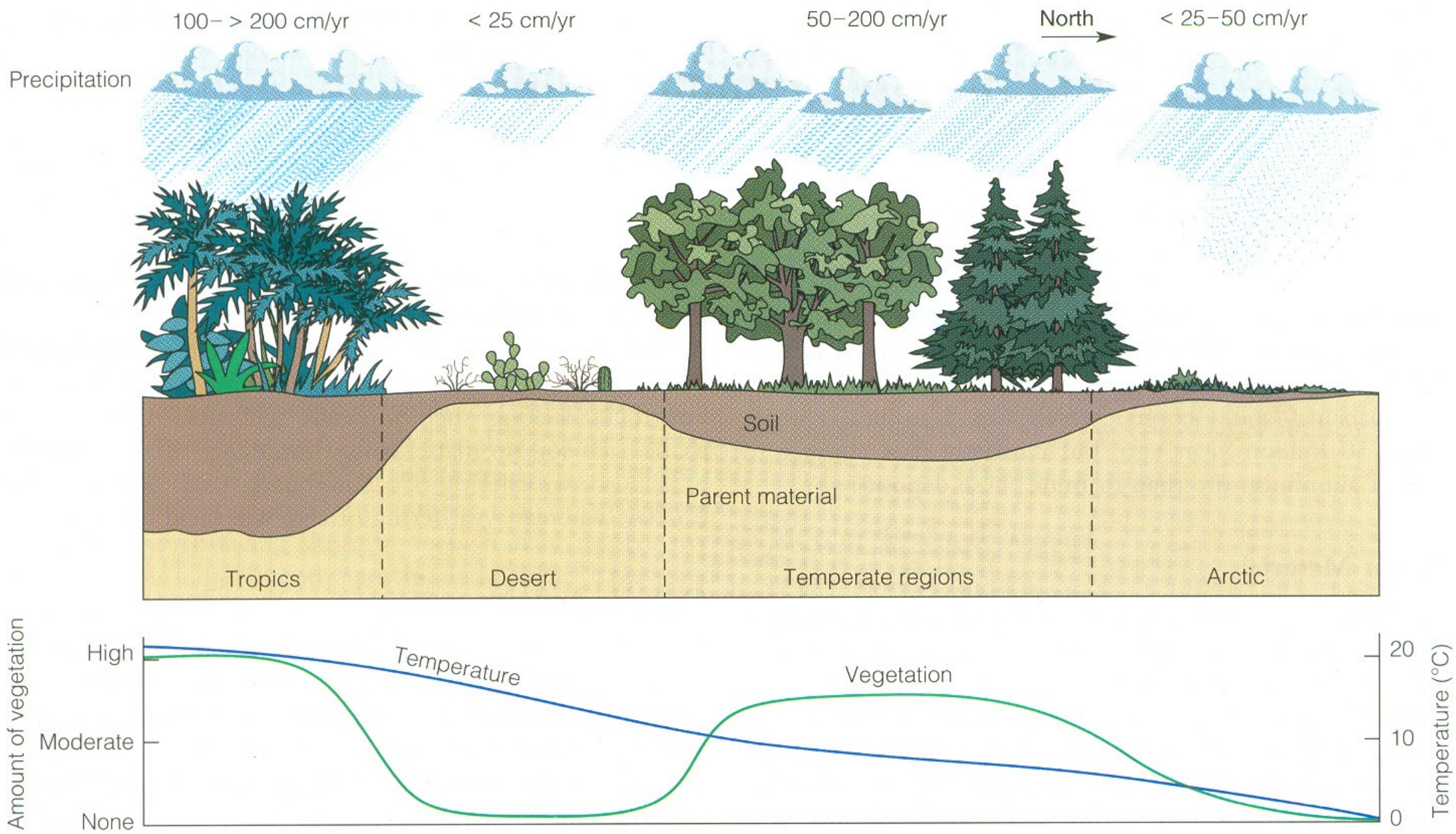


▶ FIGURE 5-15 Bowen's reaction series and chemical stability. The minerals forming first in this series are most out of equilibrium with their conditions of formation and are most chemically unstable.

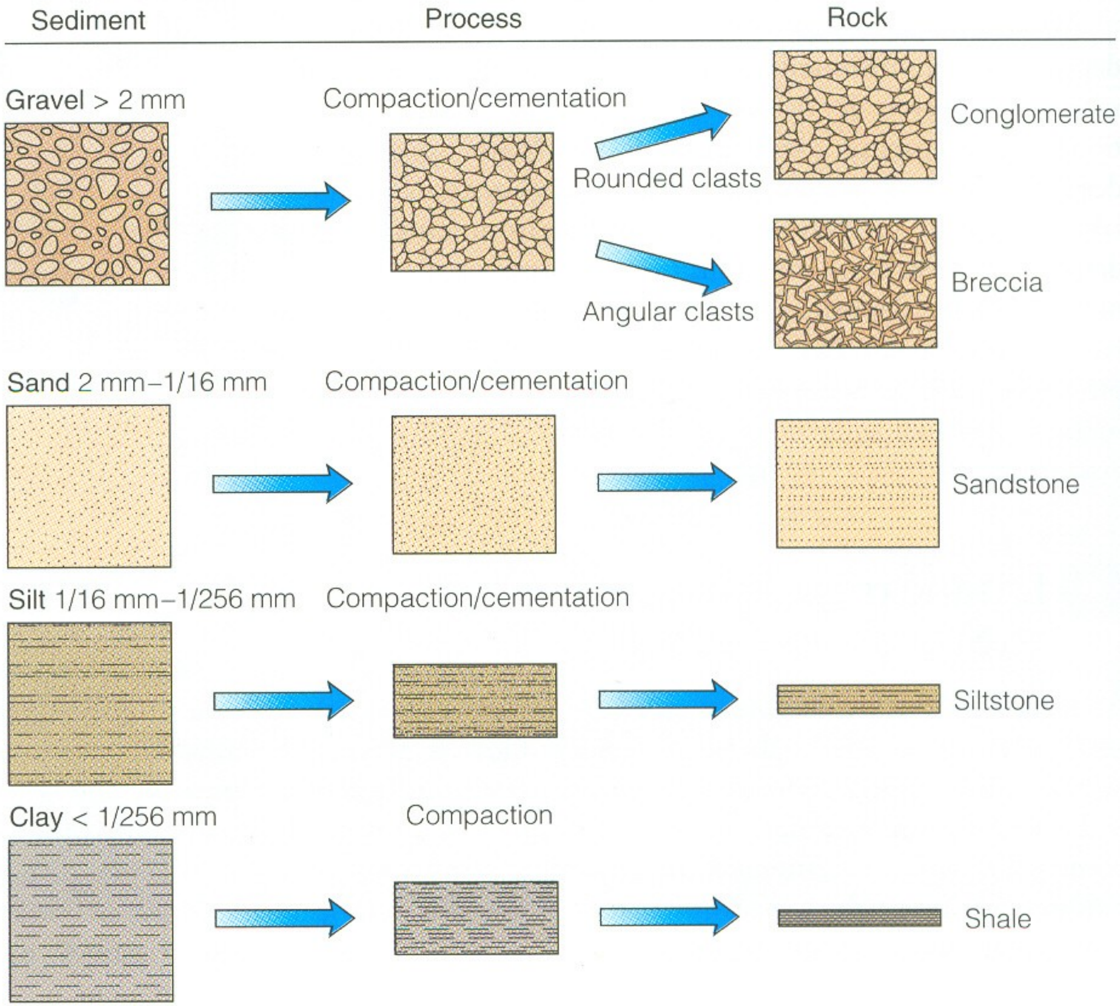
Schéma klasifikace magmatických hornin na základě chemického složení (podle obsahu SiO2). V rámci schématu jsou zahrnuty i hlavní představitelé hornin acidních, intermediálních, bazických a ultrabazických.



▶ FIGURE 5-20 Schematic representation showing soil formation as a function of the relationships between climate and vegetation, which alter parent material over time. Soil-forming processes operate most vigorously where precipitation and temperatures are high.



► FIGURE 6-6 Lithification of detrital sediments by compaction and cementation to form sedimentary rocks.



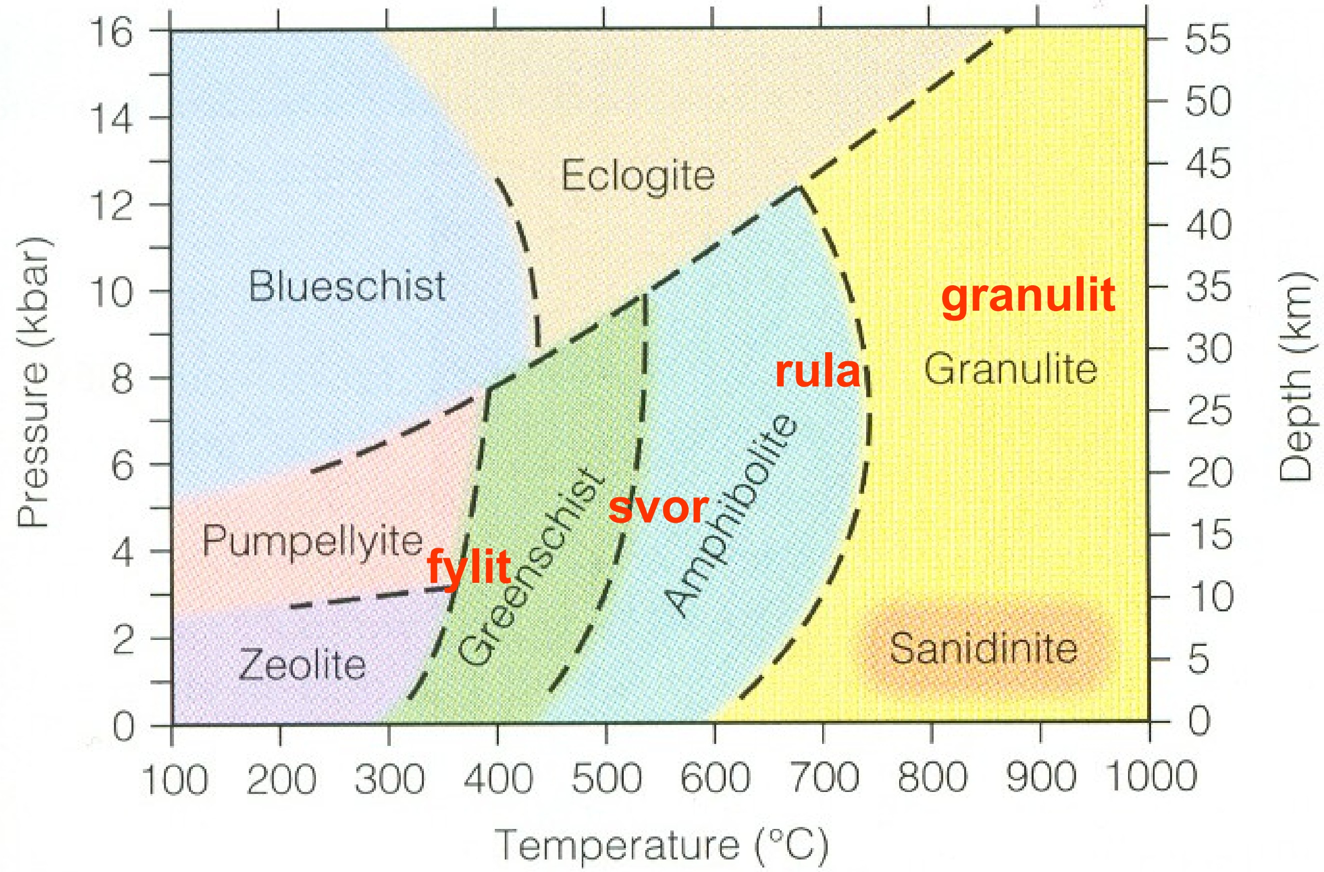
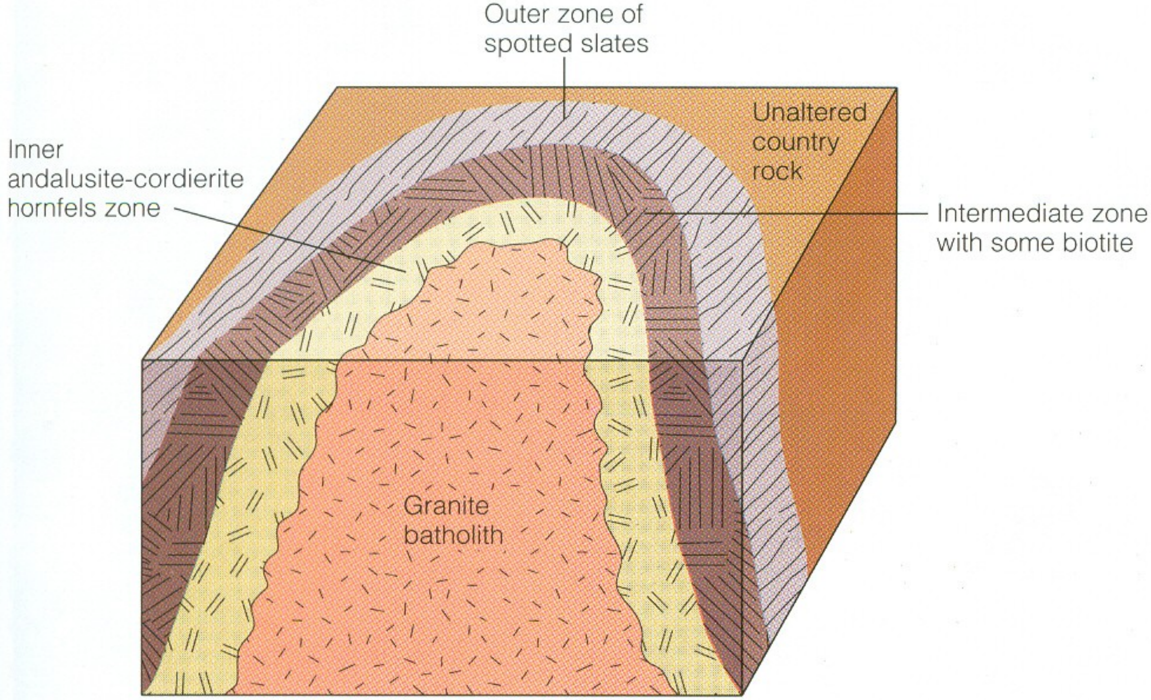


FIGURE 7-19 A pressure-temperature diagram showing where various metamorphic facies occur. A facies is characterized by a particular mineral assemblage that formed under the same broad temperature-pressure conditions. Each facies is named after its most characteristic rock or mineral.

Fylit, svor, rula event. granulit představují progradní vývoj metapelitů,
Zelená břidlice amfibolit metabazitů, modrá břidlice a eglogit HP vývoj metabazitů



▶ **FIGURE 7-6** A metamorphic aureole typically surrounds igneous intrusions. The metamorphic aureole around this idealized granite batholith contains three zones of mineral assemblages reflecting the decreases in temperature with distance from the intrusion. An andalusite- cordierite hornfels forms the inner zone adjacent to the batholith. This is followed by an intermediate zone of extensive recrystallization in which some biotite develops, and farthest from the intrusion is the outer zone, which is characterized by spotted slates.

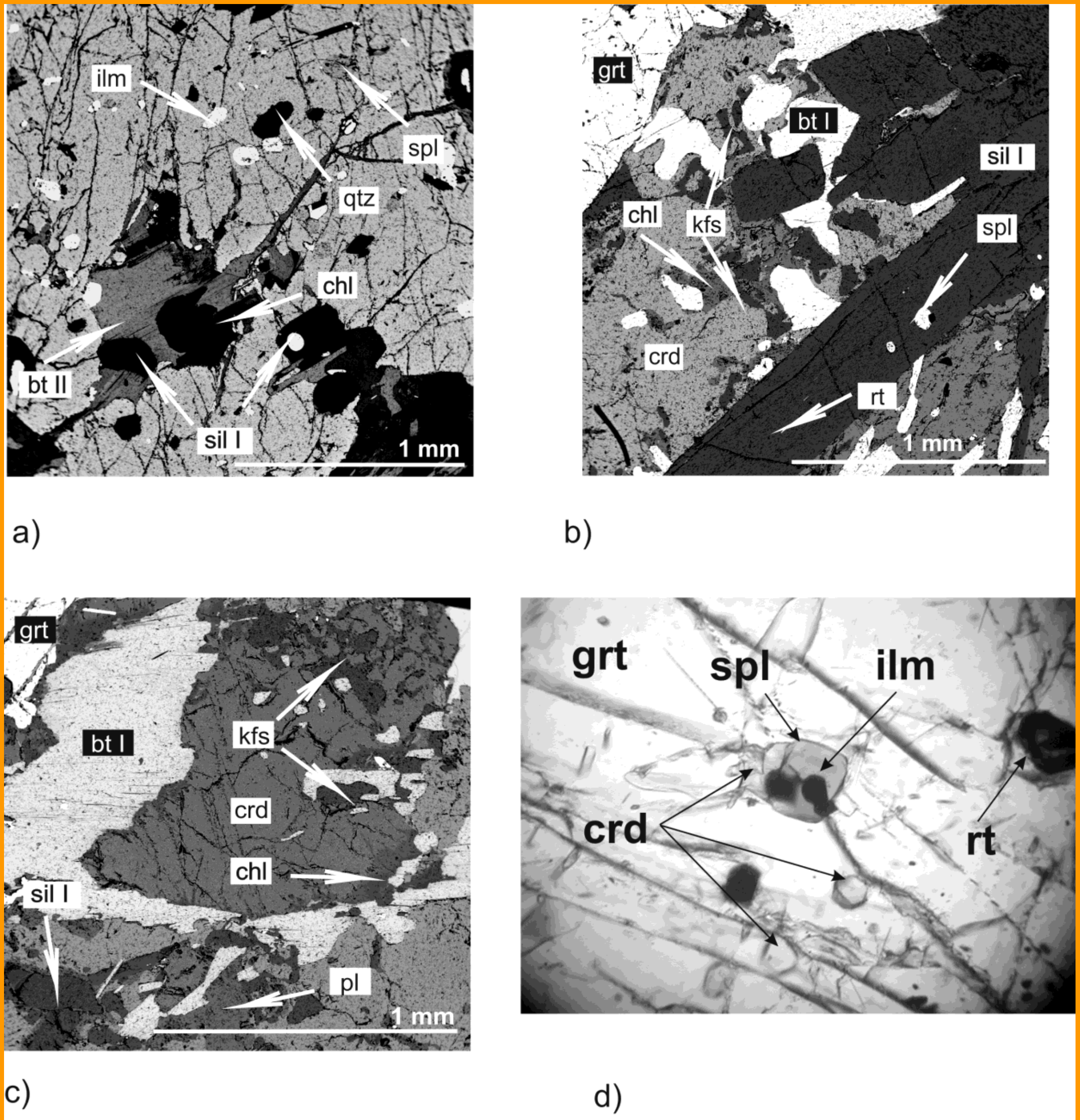

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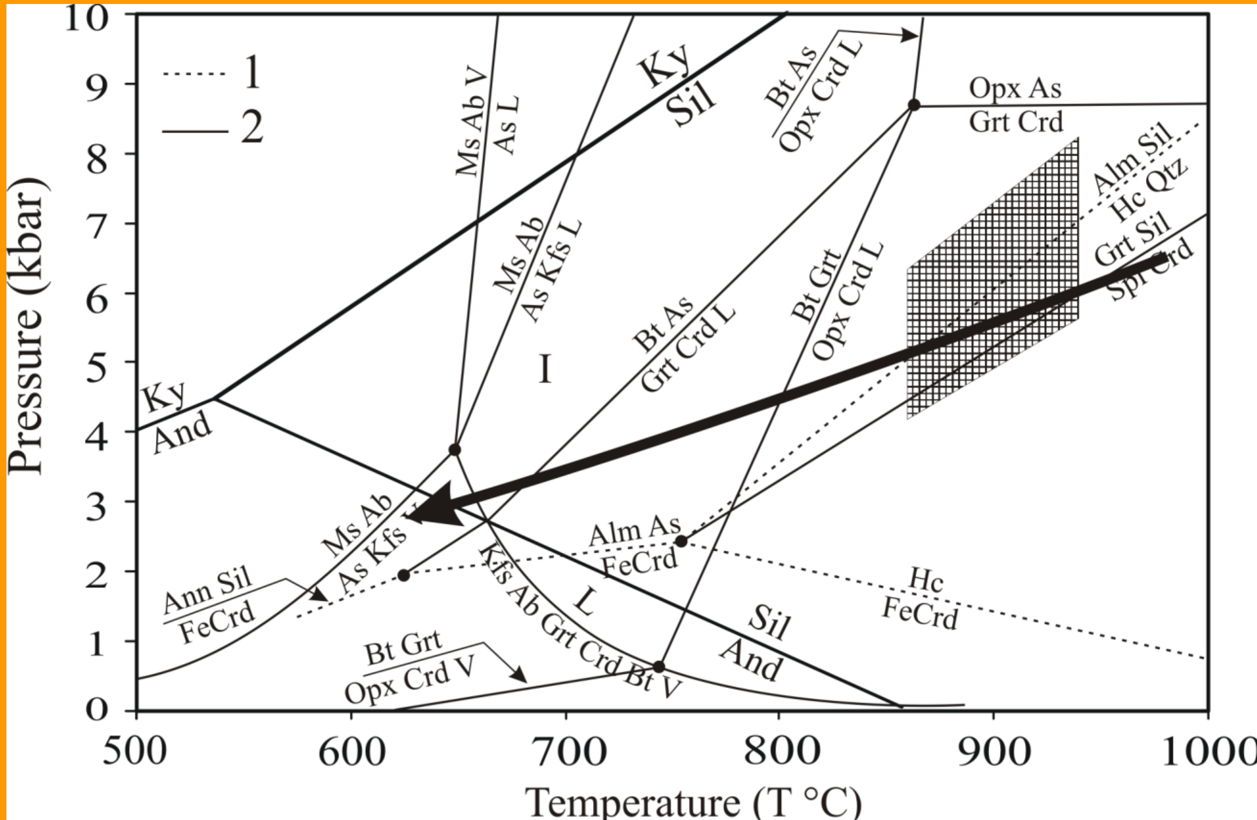
Fig. 2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Bt Grt
Opx Crd L
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Hc Qtz
Grt Sil
Spl Crd
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Ms Ab
As Kfs V
Ann Sil
FeCrd
Alm As
FeCrd
Hc
FeCrd
Kfs Ab Grt Crd Bt V
L
Bt Grt
Opx Crd V
Pressure (kbar)
Temperature (T °C)

Fig. 5