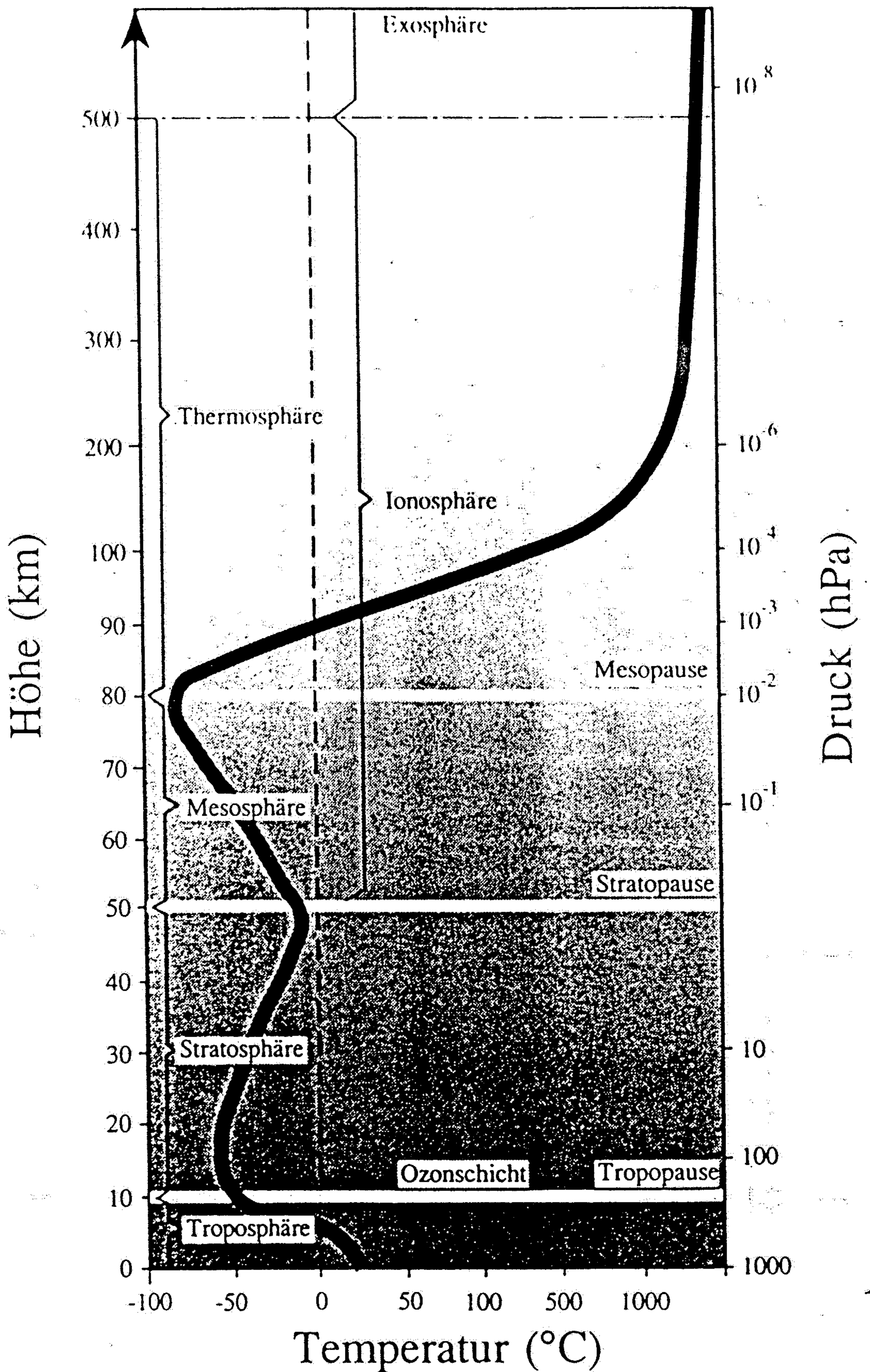


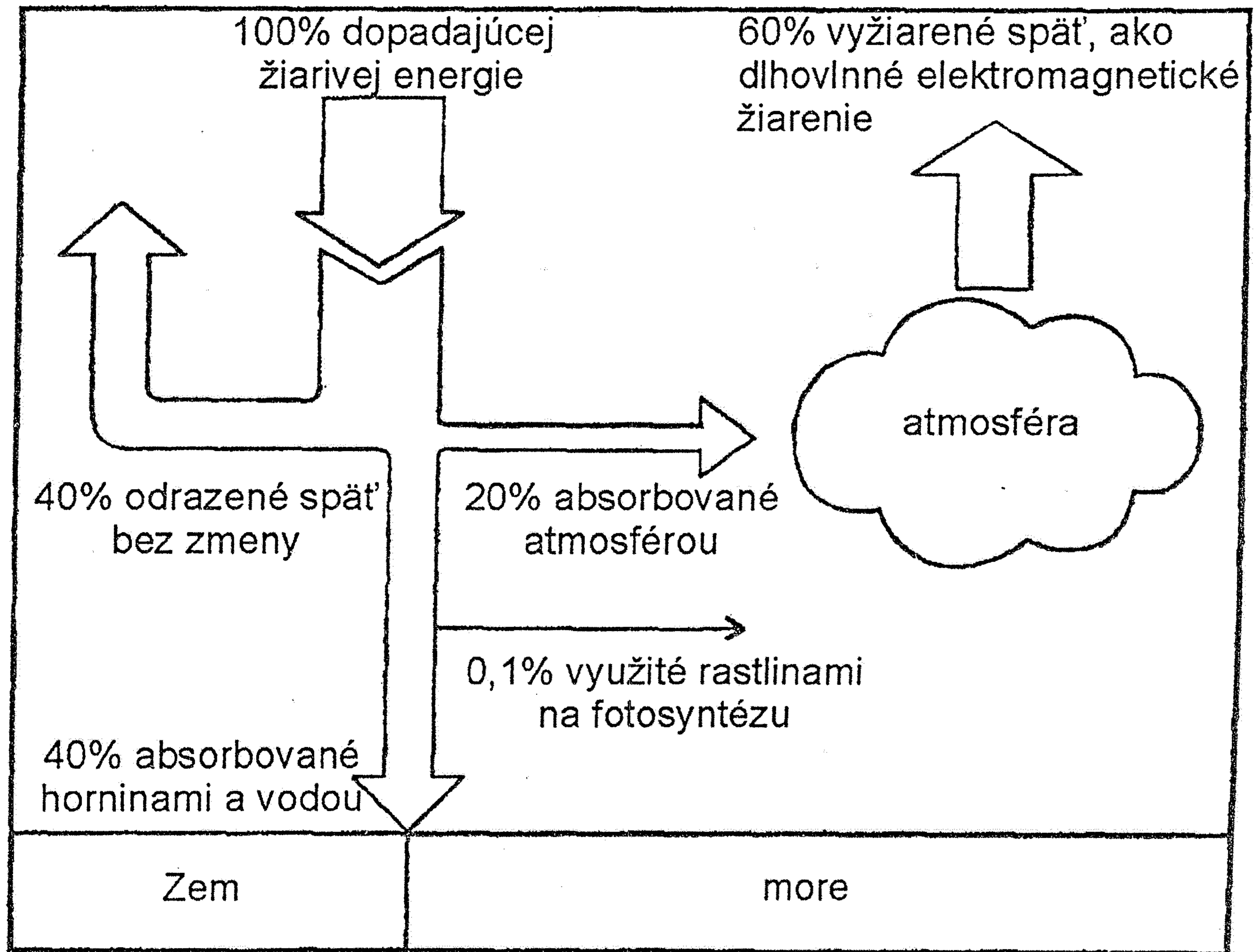
*Tab. 3.1. Prehľad odhadovaných globálnych vodných zdrojov (podľa Skinnera a Portera, 1987)*

Rezervoáry	Objem (v tis. km <sup>3</sup> )	Objem (v %)
Rieky	1,25	0,0001
Atmosféra	13	0,001
Pôdna vlhkosť	67	0,005
Sladkovodné jazerá	125	0,009
Slané jazerá a vnútorné moria	104	0,008
Podzemná voda (do 4 km hĺbky)	8 350	0,615
Ladovce	29 200	2,150
Oceány	1 320 000	97,212
Spolu	1 357 860	100,00



**Abb. 2.1**

Die Atmosphäre der Erde ist etwa 500 km mächtig. Der Temperaturverlauf in ihr ist durch die schwarze Linie angezeigt. Das uns direkt betreffende Wetter konzentriert sich in der Troposphäre.



*Obr. 4.4. Schéma teplotnej bilancie na Zem dopadajúceho slnečného žiarenia (upravené podľa Skinnera – Portera 1987)*

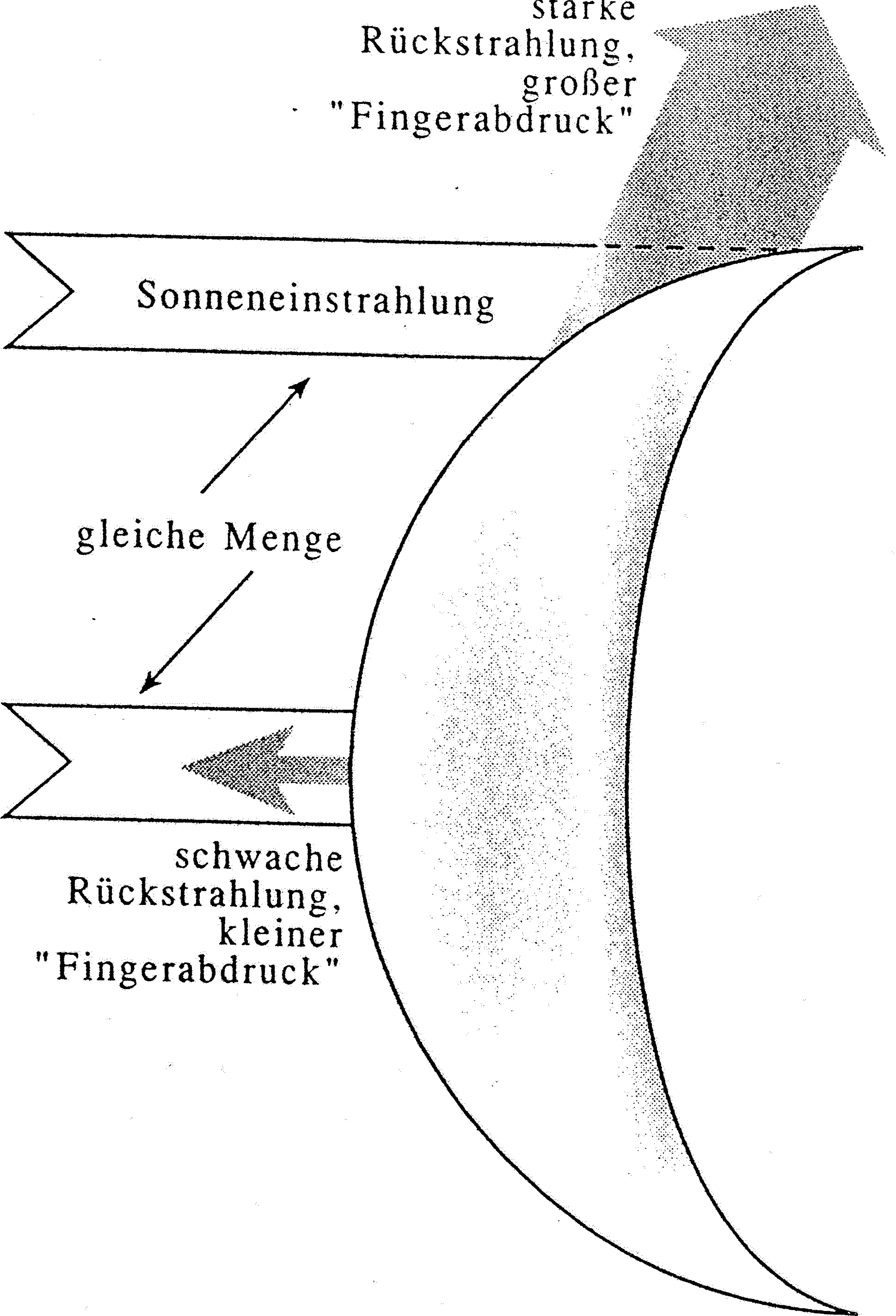
starke  
Rückstrahlung,  
großer  
"Fingerabdruck"

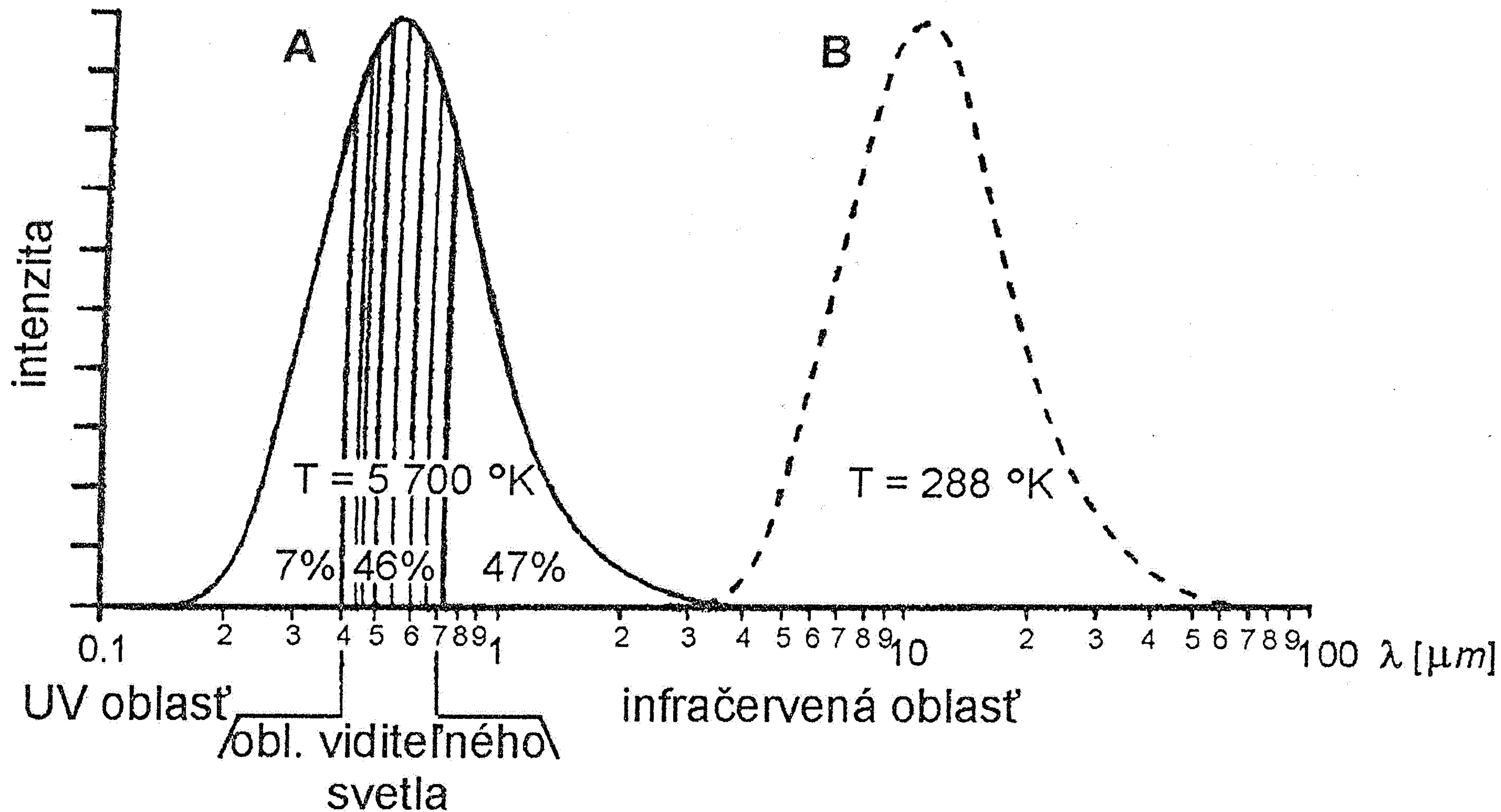
Sonneneinstrahlung

gleiche Menge

Sonneneinstrahlung

schwache  
Rückstrahlung,  
kleiner  
"Fingerabdruck"





*Obr. 4.3. Množstvo Zemou prijatej slnečnej energie (plná krivka) a Zemou vyžiarennej energie (čiarkovaná krivka) je približne rovnaké, spektrálne zloženie oboch žiarení je však podstatne rozdielne; zodpovedá priemernej povrchovej teplote Slnka (A) a Zeme (B). (upravené podľa Rybanského 1996)*

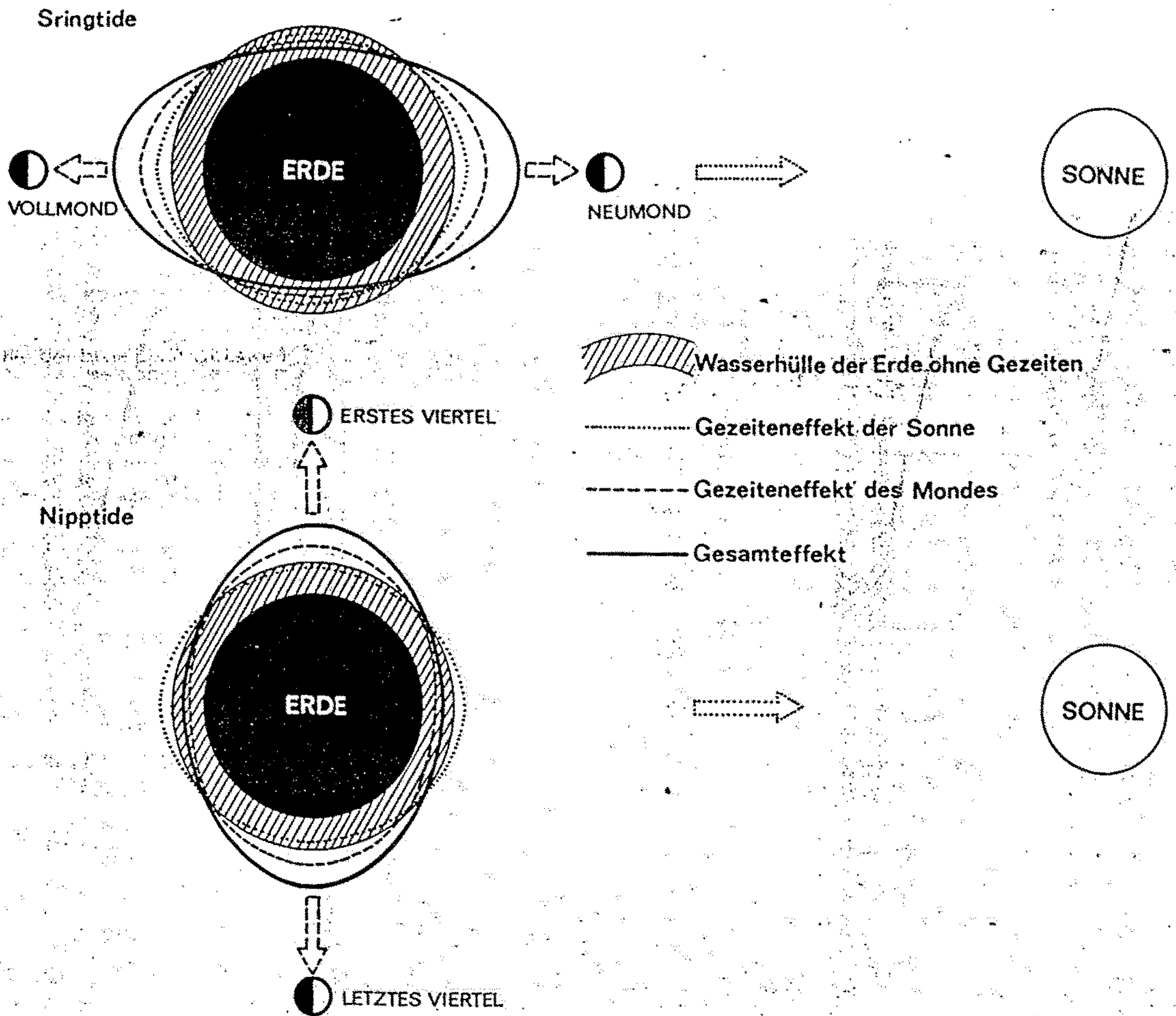


Abb. 8. Wenn Sonne, Mond und Erde sich in einer Richtung befinden, dann entstehen Springtiden, weil sich die Anziehungskräfte von Mond und Sonne summieren. Das ist bei Voll- und bei Neumond der Fall. Wenn Sonne, Erde und Mond sich im rechten Winkel zueinander befinden, dann entstehen Nipptiden, weil sich die Anziehungskräfte von Sonne und Mond gegenseitig schwächen (umgezeichnet nach SAGER 1959).

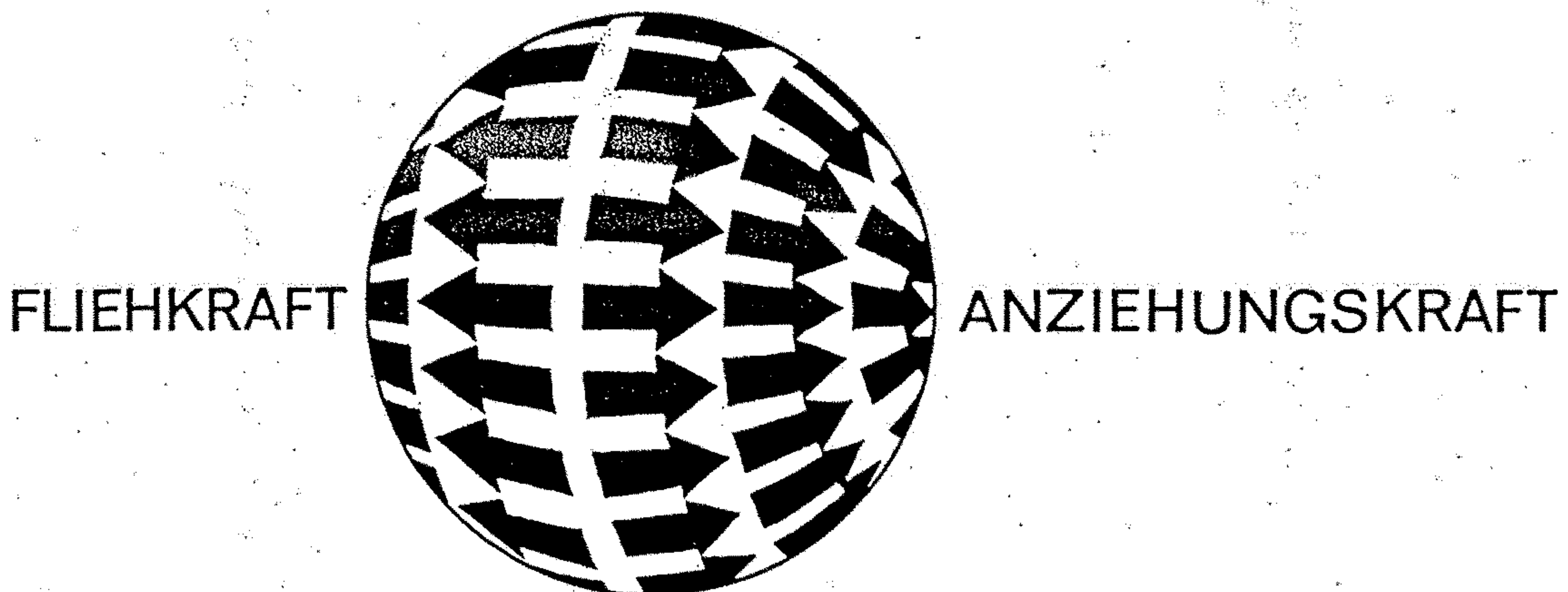
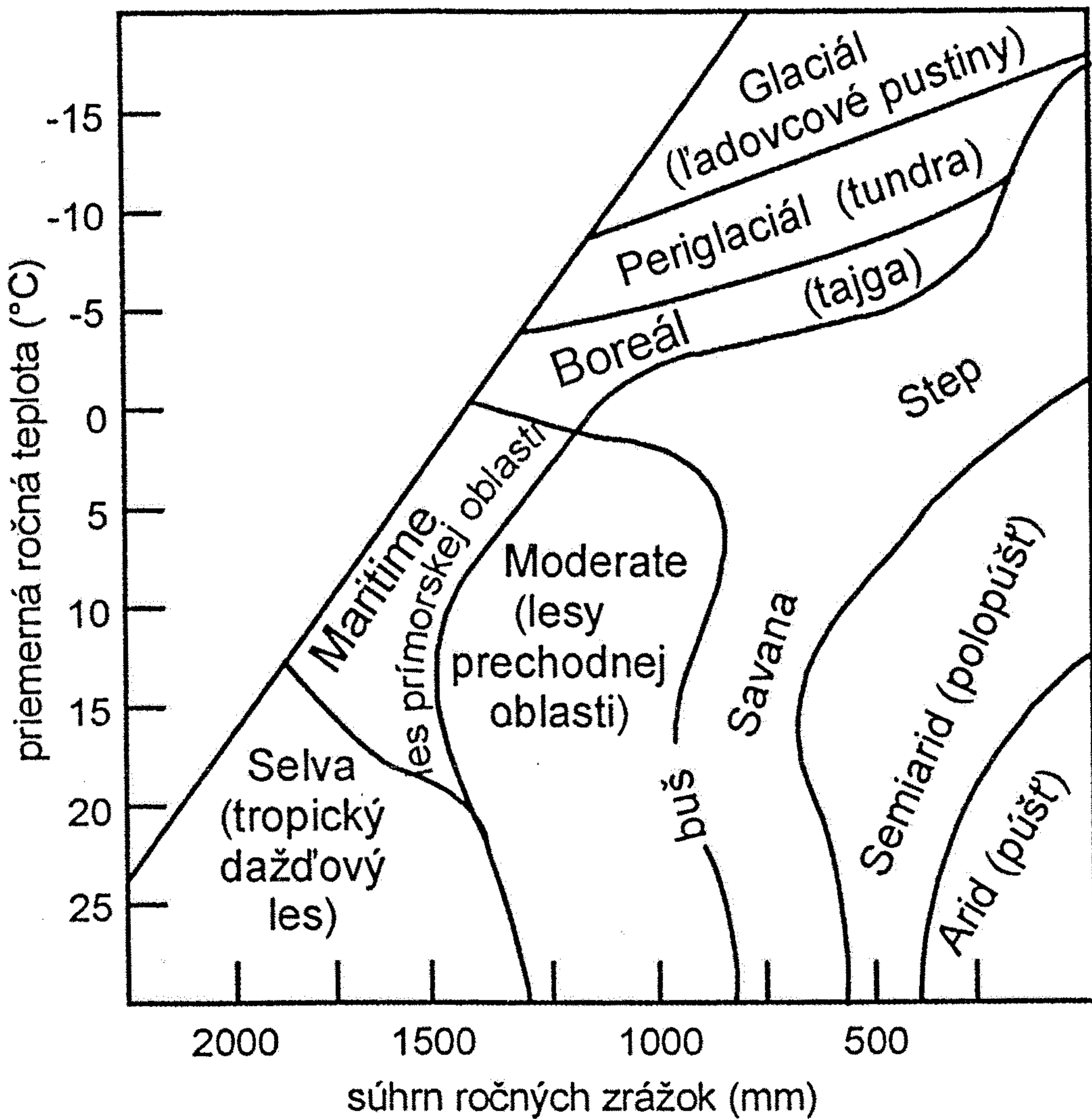
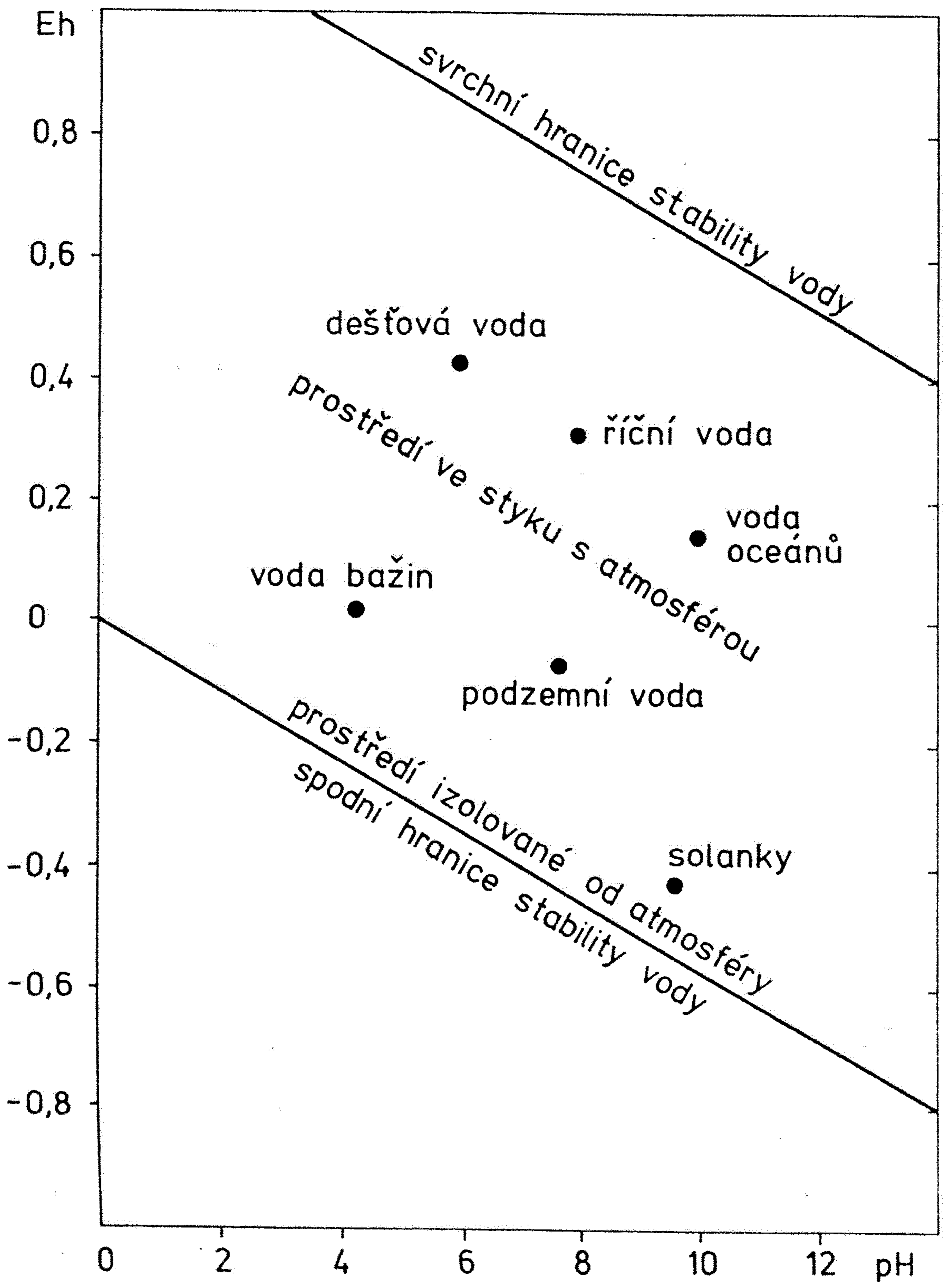


Abb. 7. Die Entstehung zweier Flutberge. Durch die stärkere Anziehungskraft des Mondes entsteht auf der zum Mond zugewandten Erdseite und durch die stärkere Fliehkraft des Zweikörpersystems Erde und Mond auf der vom Mond abgewandten Seite der Erde je ein Flutberg (umgezeichnet nach SAGER 1959).



*Morfogenetické a vegetačné oblasti. (upravené podľa*

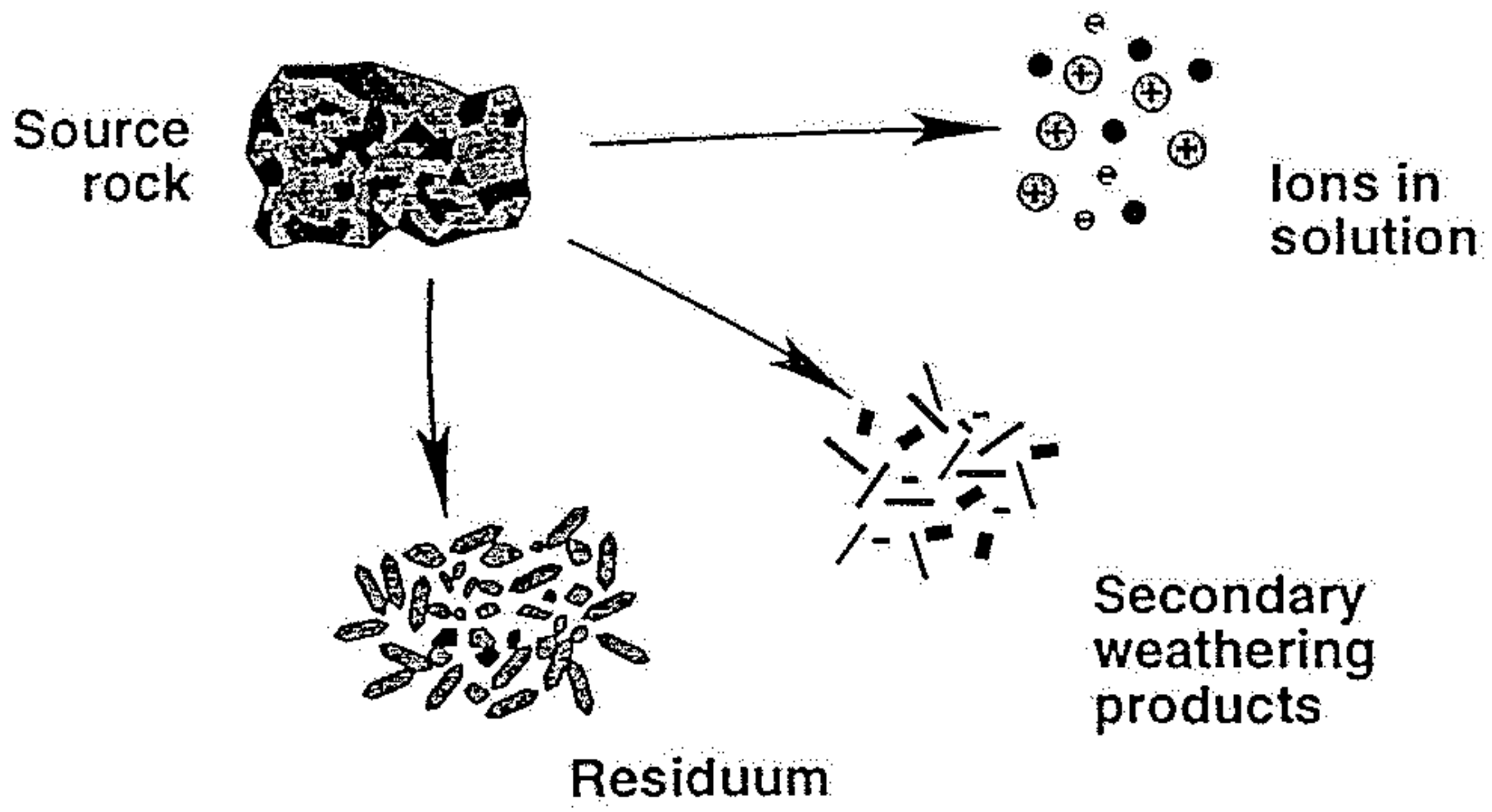
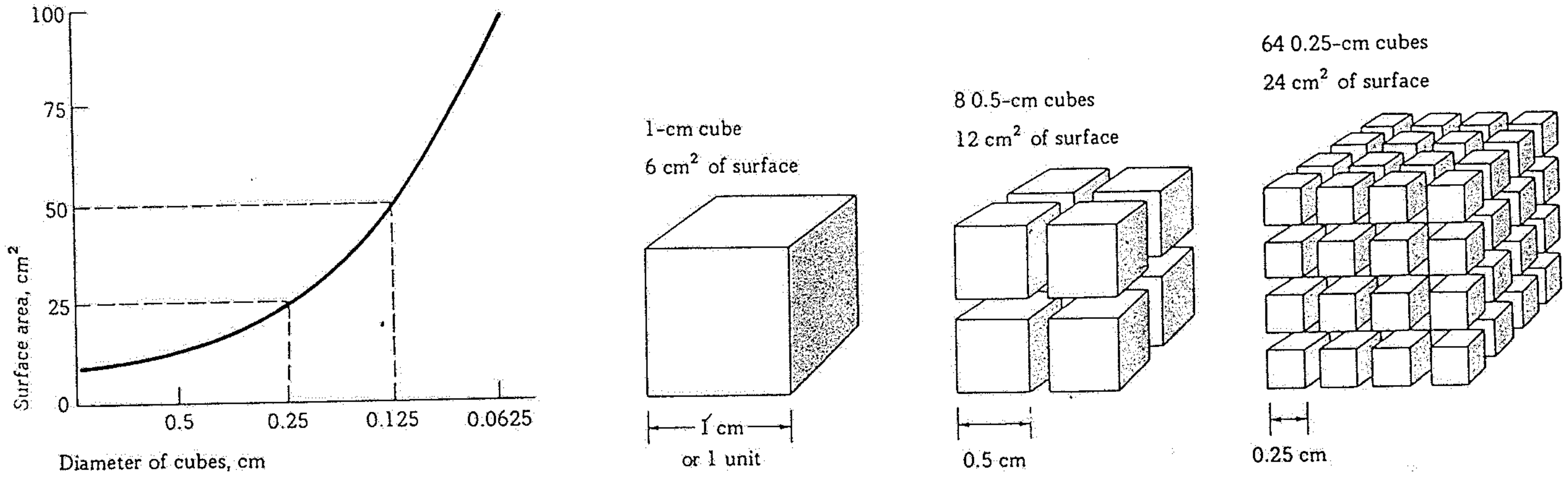
*Peltiera 1950 ex Keller 1987)*



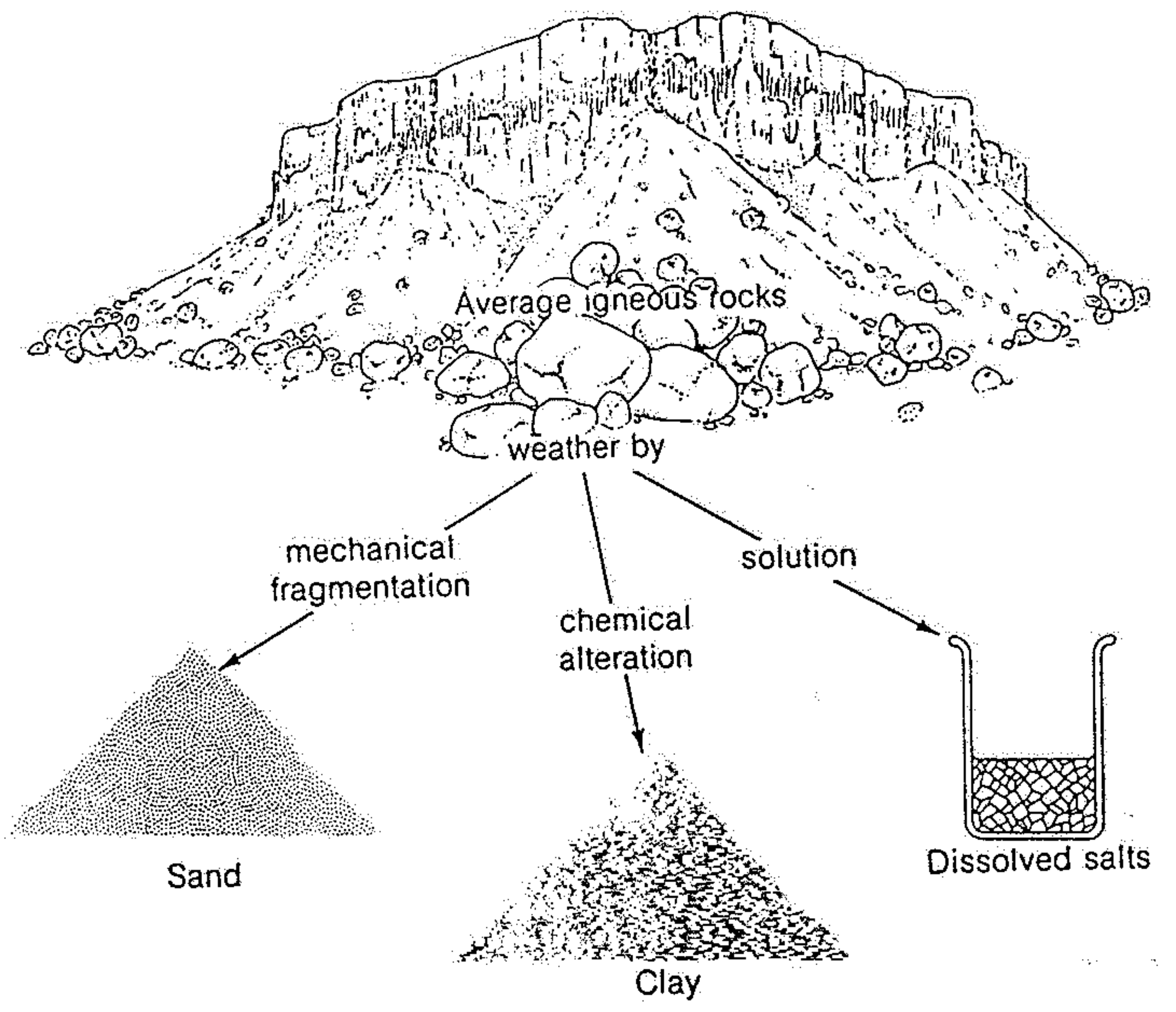
Obr. 191. Hodnoty pH a Eh hlavních přírodních prostředí. Průměrné hodnoty



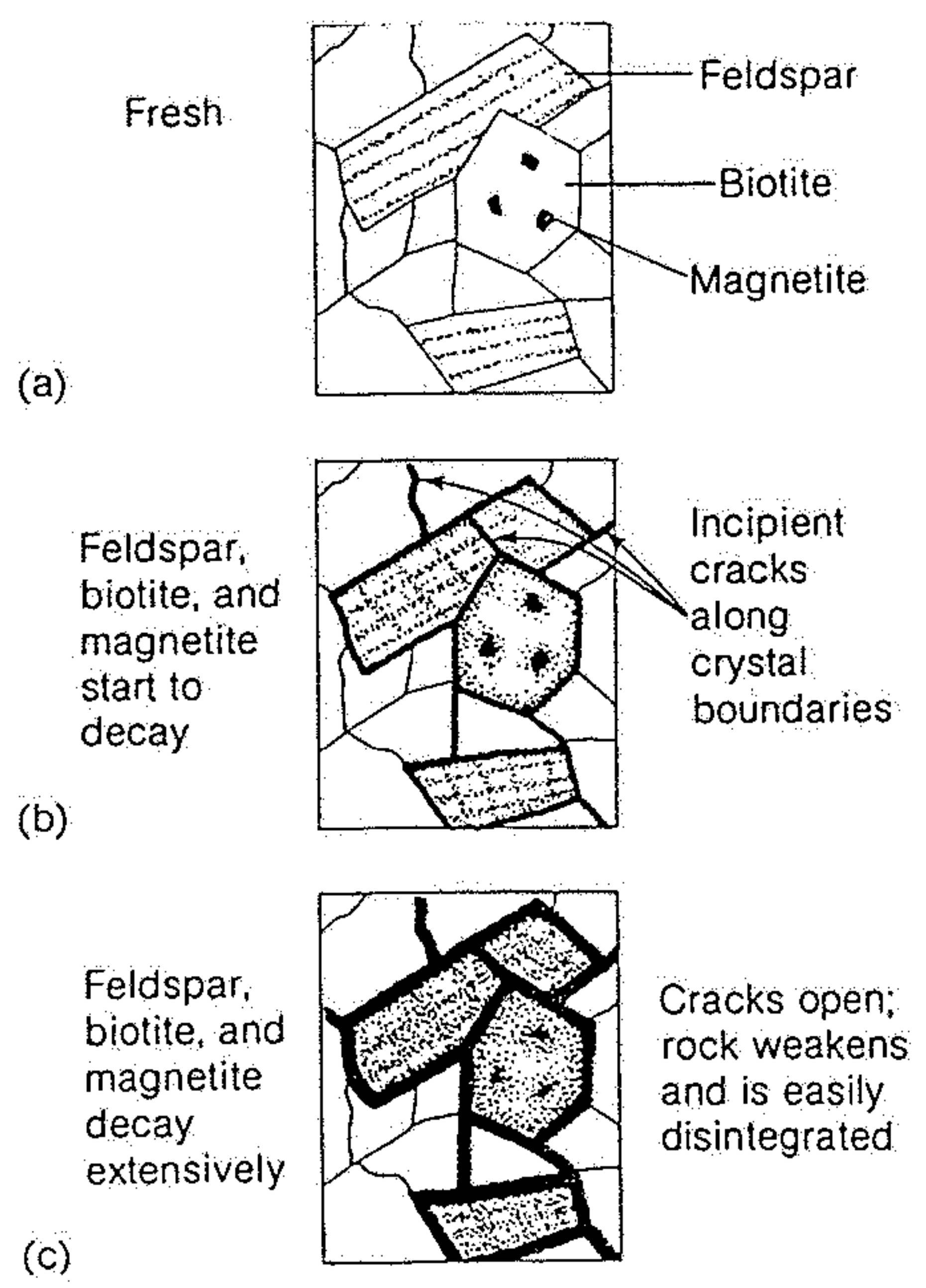
5.4 Relationships of volume, particle size, and surface area. In this illustration a cube 1 cm (or any other unit) on a side is divided into smaller and smaller units. The volume remains unchanged, but as the particle size decreases, the surface area increases. Because chemical weathering is confined to surfaces, the more finely a given volume of material is divided, the greater is the surface area exposed to chemical activity and the more rapid is the process of chemical weathering.



**Figure 8.1.** Chemical weathering results in the partitioning of rock components into three principal classes of weathering products: dissolved ions in solution, secondary weathering products, and incompletely weathered residuum.



**Figure 5-19**  
The chemical and physical processes of weathering transform the igneous rock into sand and clay particles and dissolved salts. The total volume of erosional debris produced is somewhat greater than the original, depending on the degree of chemical weathering, which adds carbon dioxide, water, and oxygen to the original composition.



**Figure 5-18**  
Microscopic views of stages in the disintegration of an igneous rock, such as granite. As chemical decay proceeds, grain boundaries weaken and the rock begins disintegrating into fragments.



Abb. 213. *Kugelförmiger und konzentrisch schalenförmiger Zerfall* von silurischem Diabas bei der Verwitterung. Vyskočilka südlich von Prag. Auf  $\frac{1}{2}$  verkleinert. Sammlung des Geologischen Instituts der Karlsuniversität. (Foto Dr. J. KUNSKÝ.)

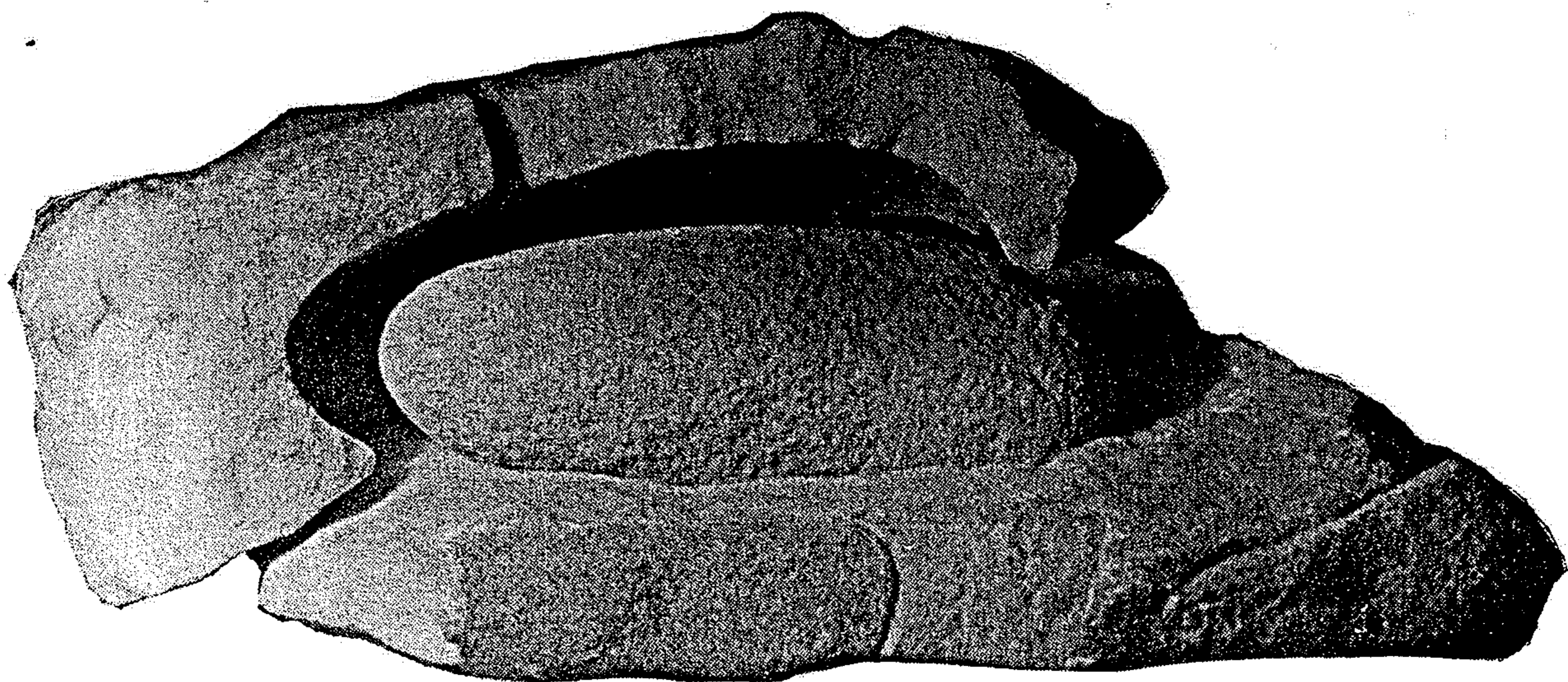
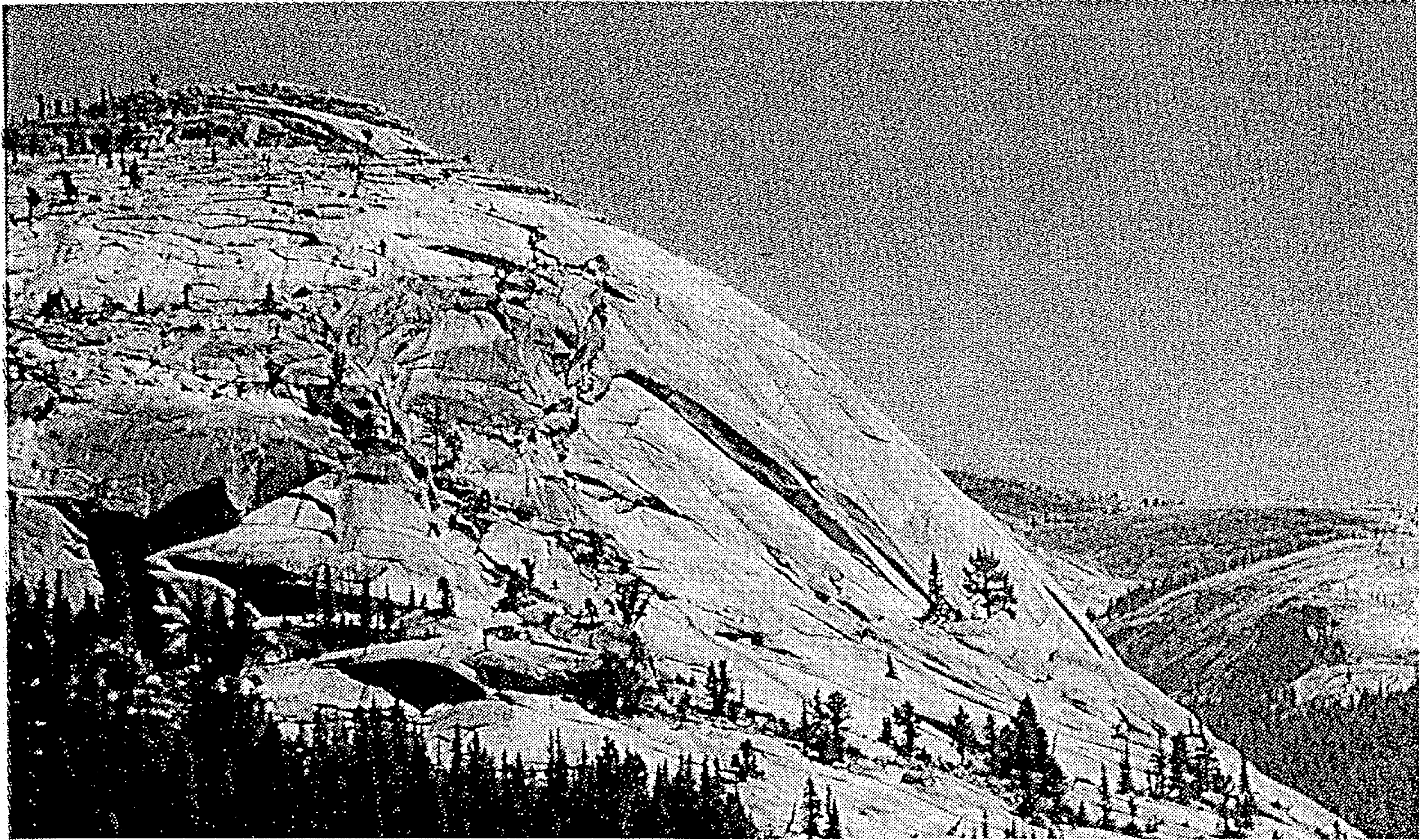


Abb. 214. *Entstehung eines Pseudogerölls durch Verwitterung* von Drabov-Quarzit. Ordoviz. dδ. Hřebeny bei Dobříš.  $\frac{2}{3}$  natürlicher Größe. Sammlung des Geologischen Instituts der Karlsuniversität. (Foto R. KETTNER.)

5.2 Dome-shaped landform, a gray-granite erosional remnant in the Sierra Nevada Mountains. The mountain stands about 300 m above the adjacent valley. Exfoliation plays a major role in forming most dome-shaped mountains. [Pamela Hemphill.]



5.1 Exfoliation of the Black Hill norite, a Cambro-Ordovician intrusion in southern Australia. [William C. Bradley.]

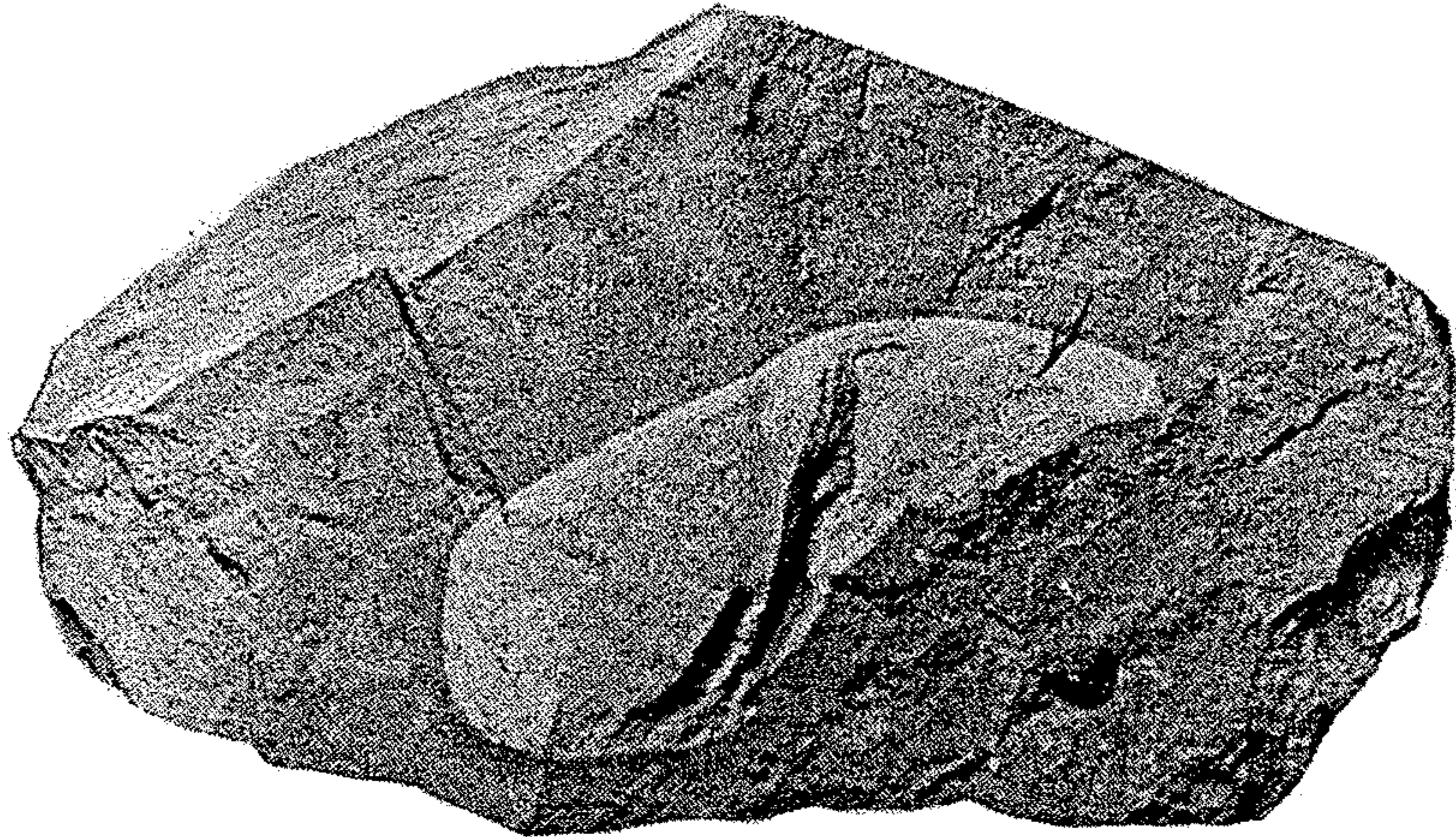


Abb. 210. *Verwitterung von Felsophyrit*. Unverwitterter Kern licht, verwittertes Gestein rotbraun. Kambrium, Křivoklát-Rokycany-Zone. Týřovice.  $\frac{1}{3}$  natürlicher Größe. Sammlung des Geologischen Instituts der Karlsuniversität. (Sammlung und Foto R. KETTNER.)

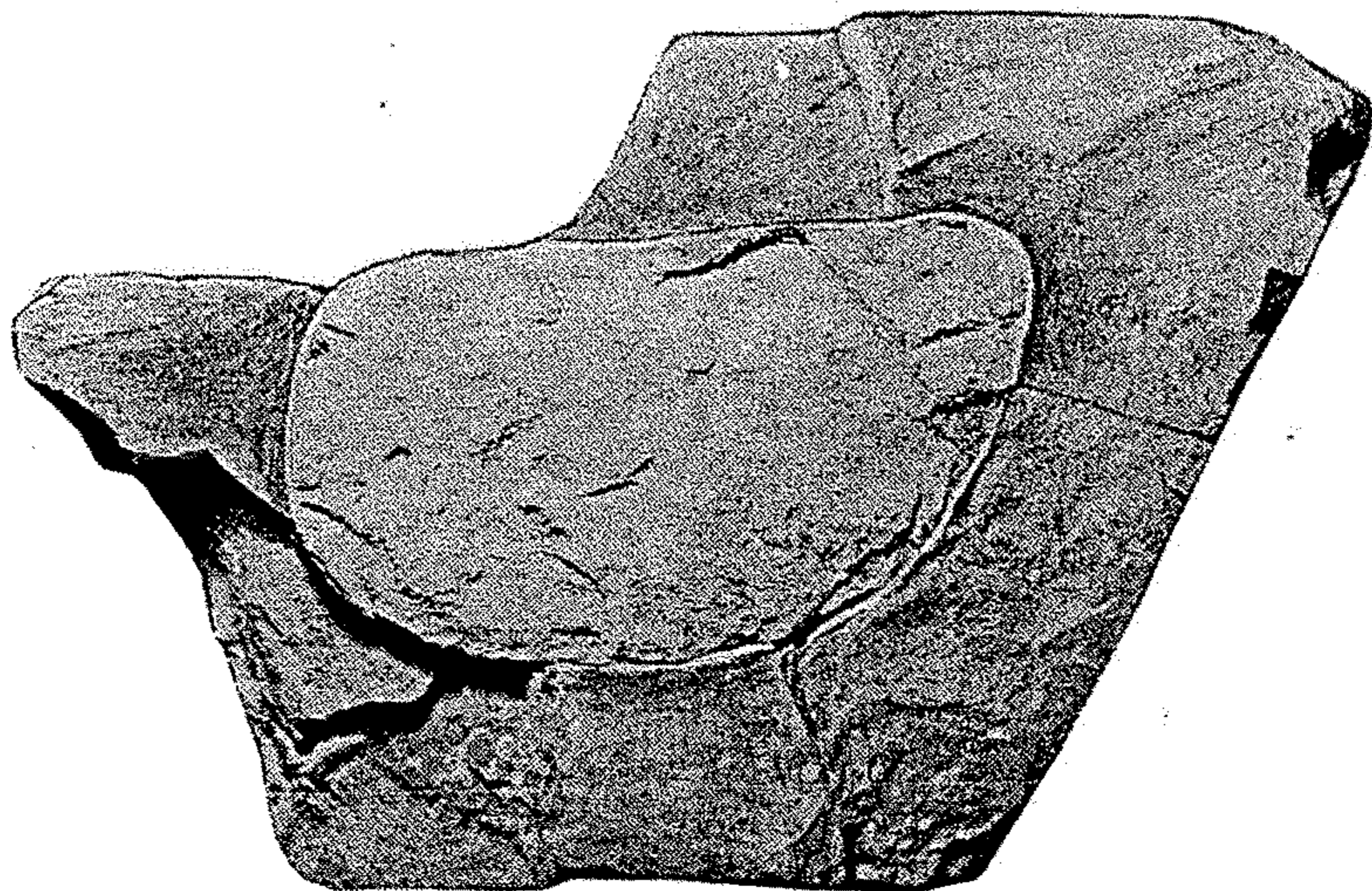


Abb. 211. *Verwitterung des Osek-Kvãner Schiefers* ( $d\gamma$ ) des böhmischen Ordovicium. Vokovicer Ziegelei bei Prag.  $\frac{2}{3}$  natürlicher Größe. Gesammelt vom Autor. Sammlung des Geologischen Instituts der Karlsuniversität. (Foto R. KETTNER.)

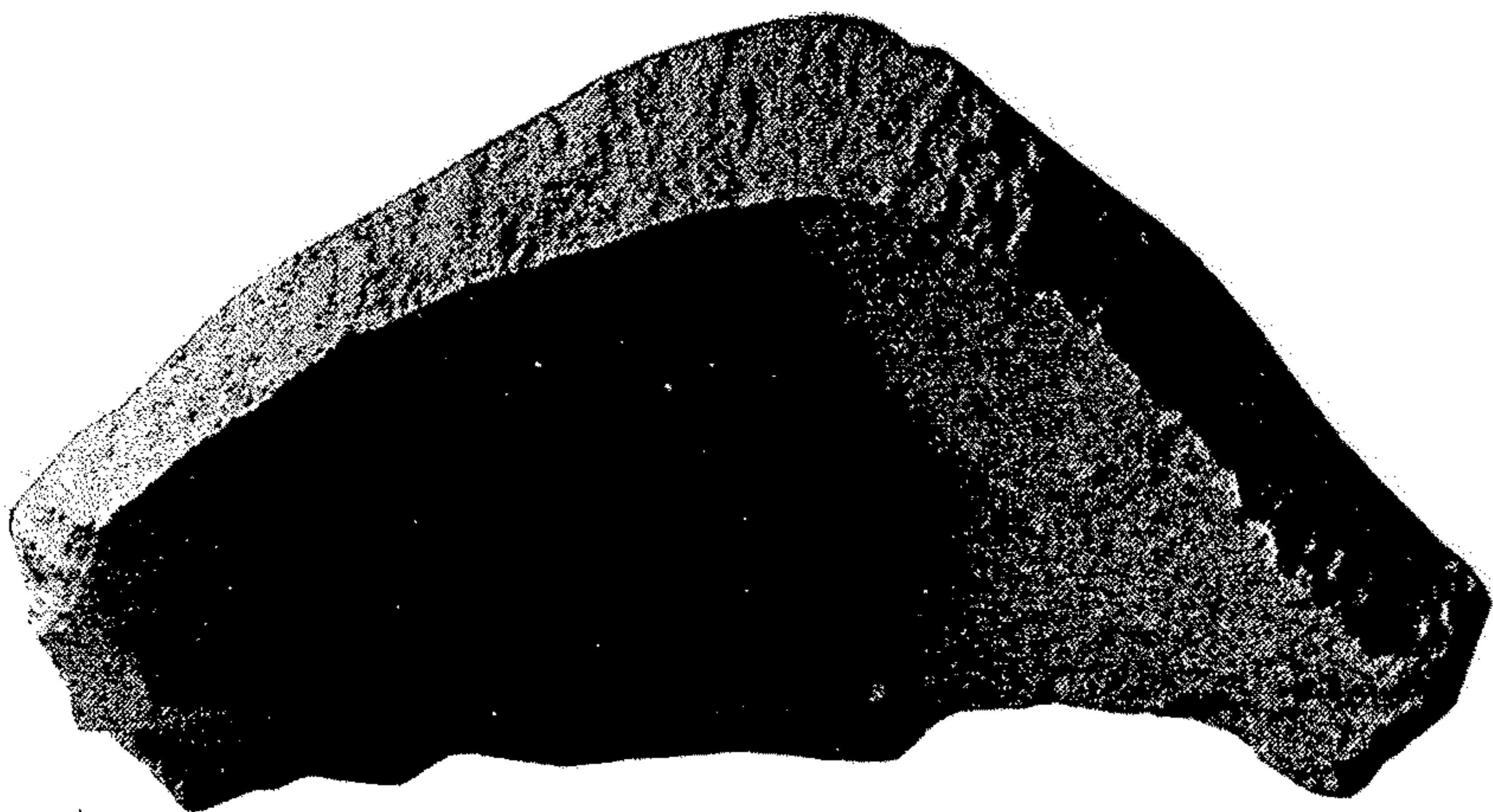
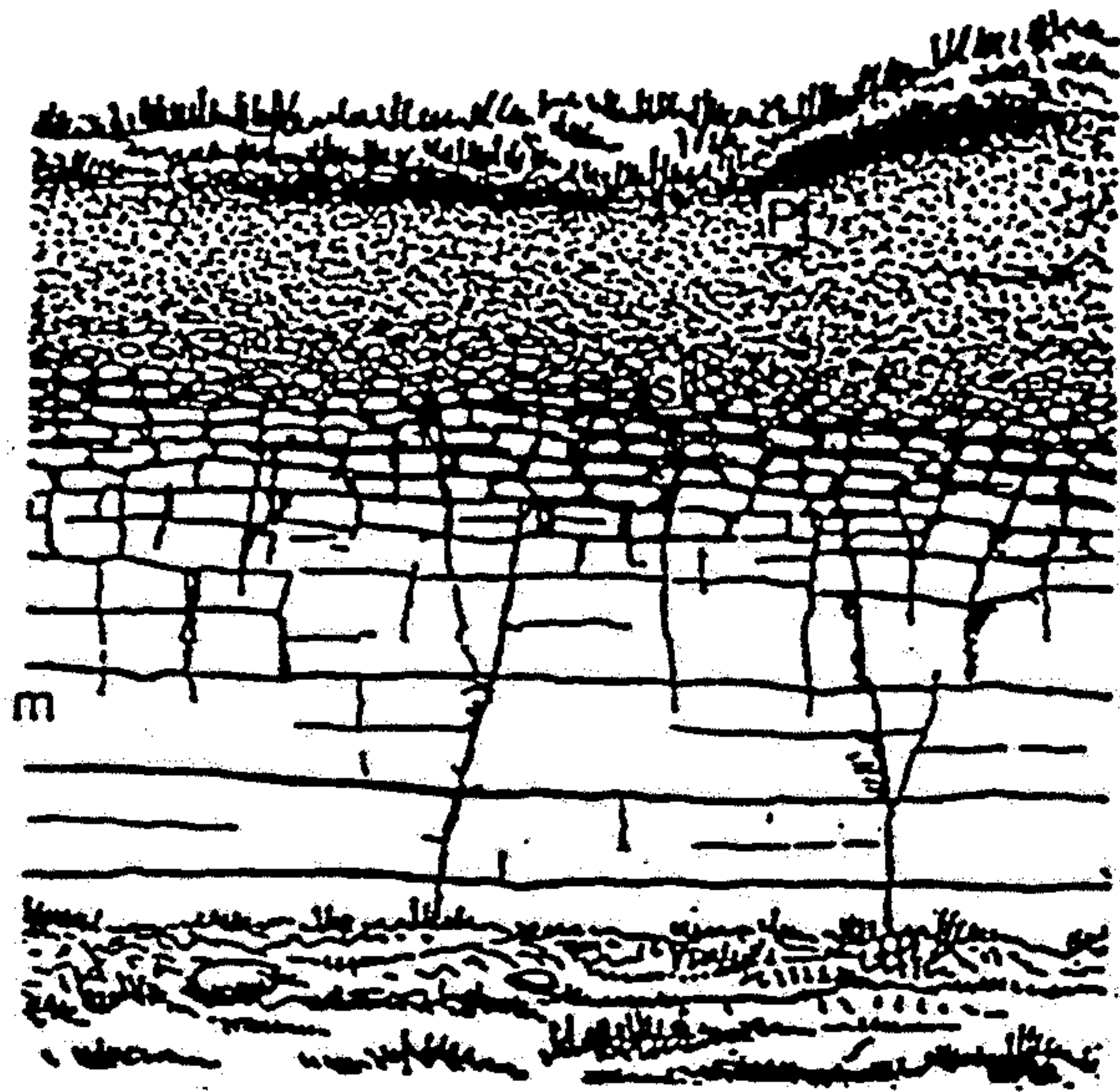
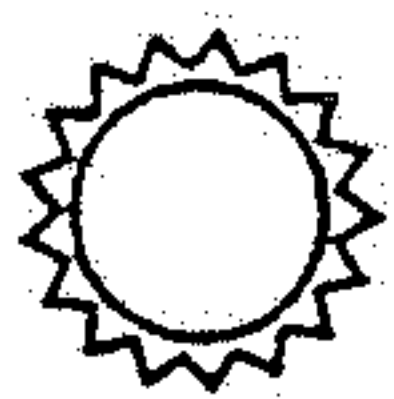


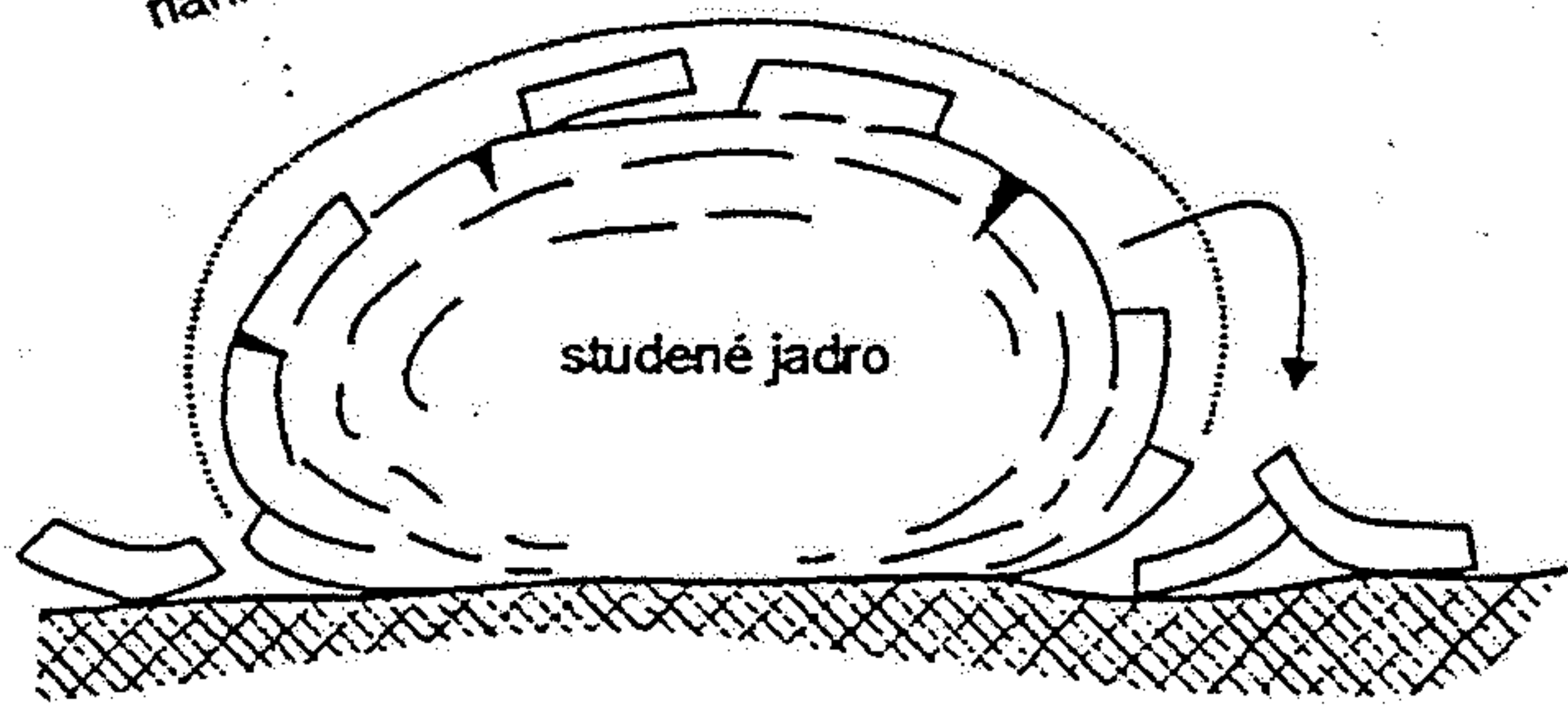
Abb. 212. *Schalenförmiger Zerfall des Andesits* bei der Verwitterung. Nezdence in Südostmähren.  $\frac{1}{5}$  natürlicher Größe. Sammlung des Geologischen Instituts der Karlsuniversität. (Foto R. KETTNER.)



Obr. 11.4. Zvetralinový plášť - elúvium je z nepremiestnenej zvetraliny (rezidua) matečnej horniny. Pevná skala (m) prechádza pri povrchu do kamenitej zvetraliny "skryvky" (lomarský výraz) a vyššie do reziduálnej pôdy s ornicou (P). — doplniť.



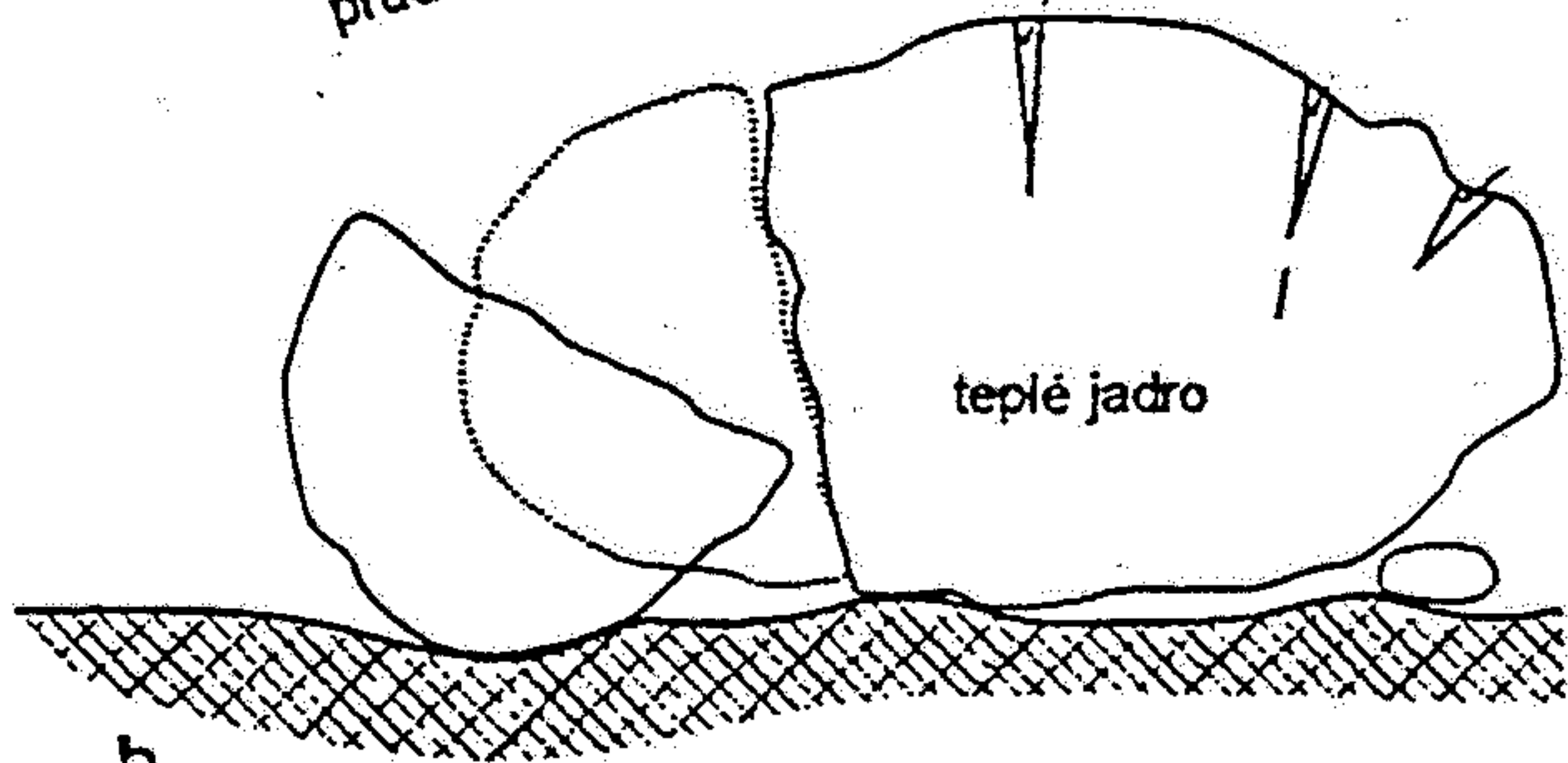
náhle ohriatie povrchu



a



prudké ochladenie povrchu



b

Obr. 11.6. a) Deskvamácia - olupovanie hornín vyvolané oslnením, b) mrazové (termické) pukanie prudkým ochladením povrchu skál

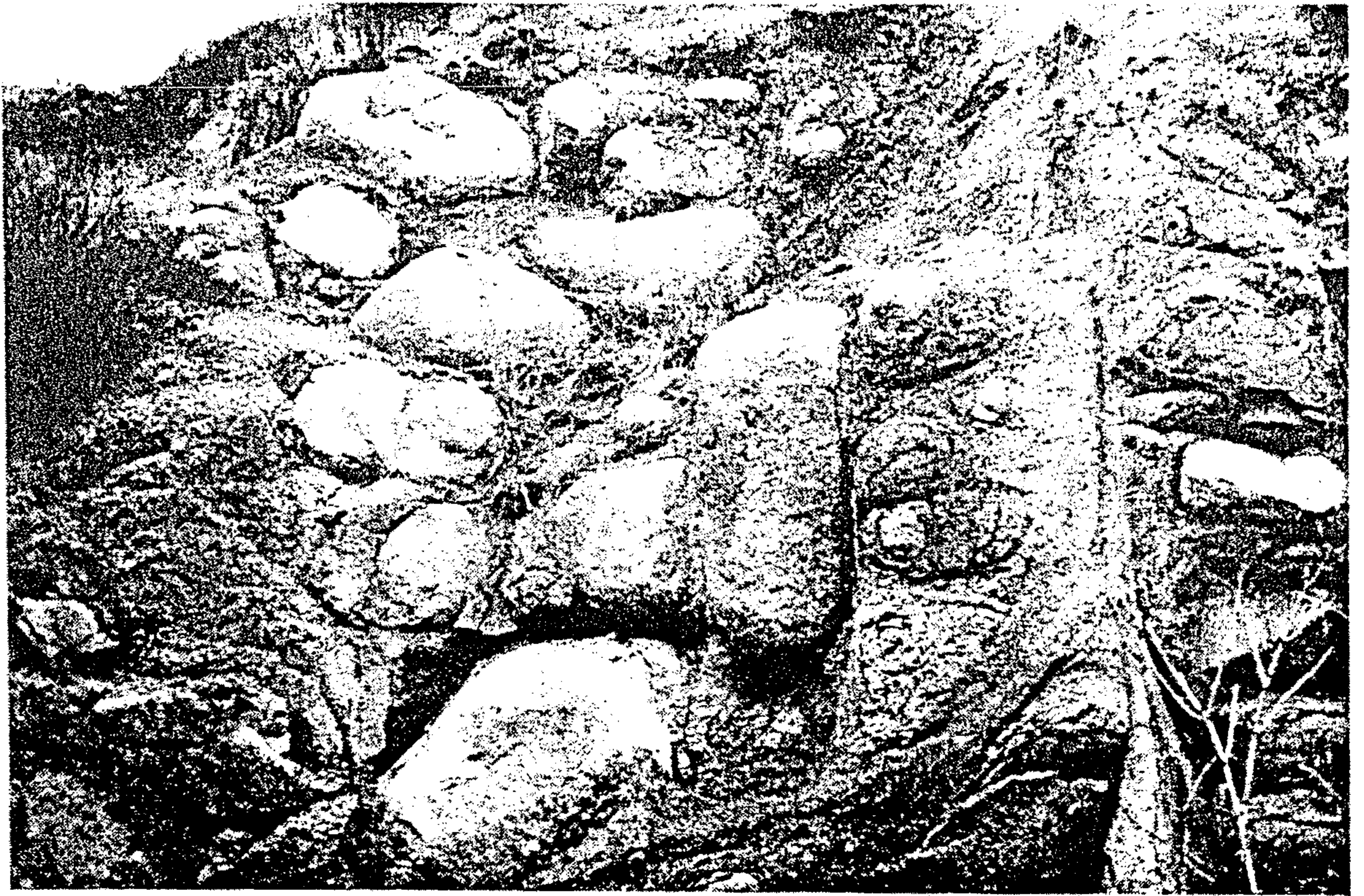


Abb. 223. *Kugelförmiger Zerfall bei der Verwitterung von Gabbrodiorit. Dunavičky östlich von Netvořice. (Foto R. KETTNER.)*



Abb. 232. *Zerfall und Verwitterung von Basalt nördlich von Chuchelná bei Semily. (Foto Dr. J. SVOBODA.)*

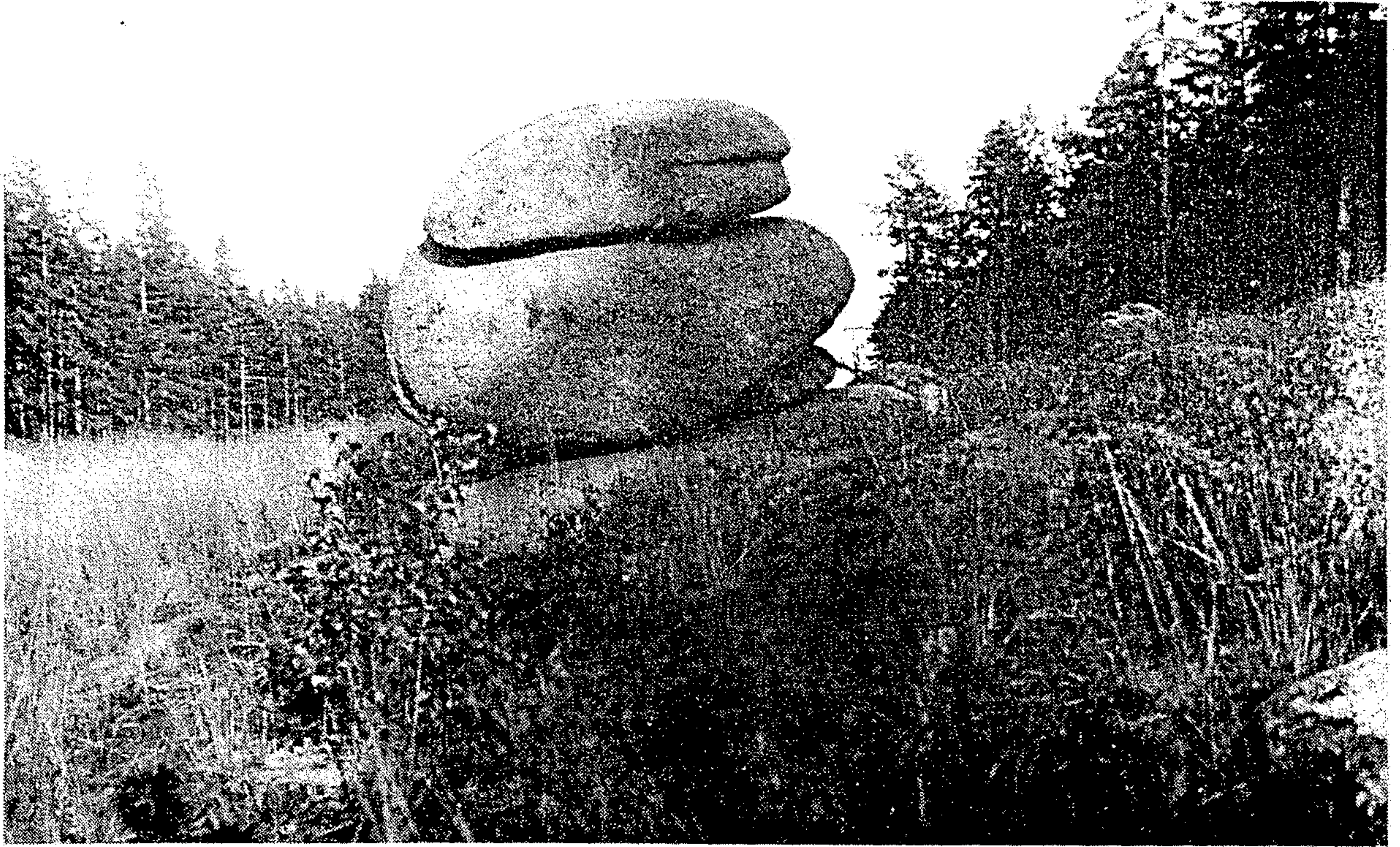


Abb. 228. Granitblock bei Žihle in Westböhmen (Beispiel der Granitverwitterung).  
(Foto R. KETTNER.)

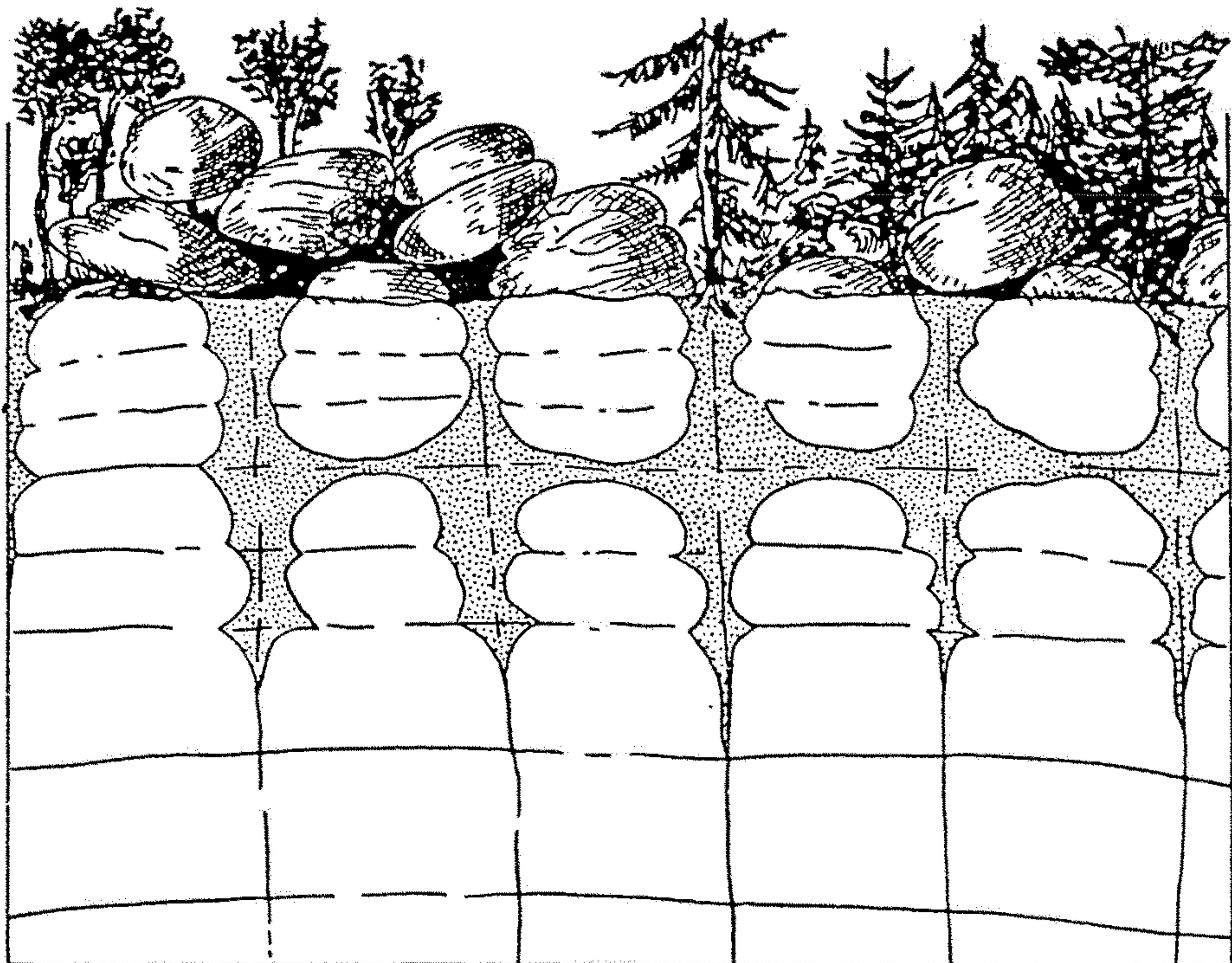


Abb. 225. Schematische Veranschaulichung der *Verwitterung* und des *Zerfalls* von *Granit* und der Entstehung von *Granitblöcken* an der *Erdoberfläche*. (Original.)

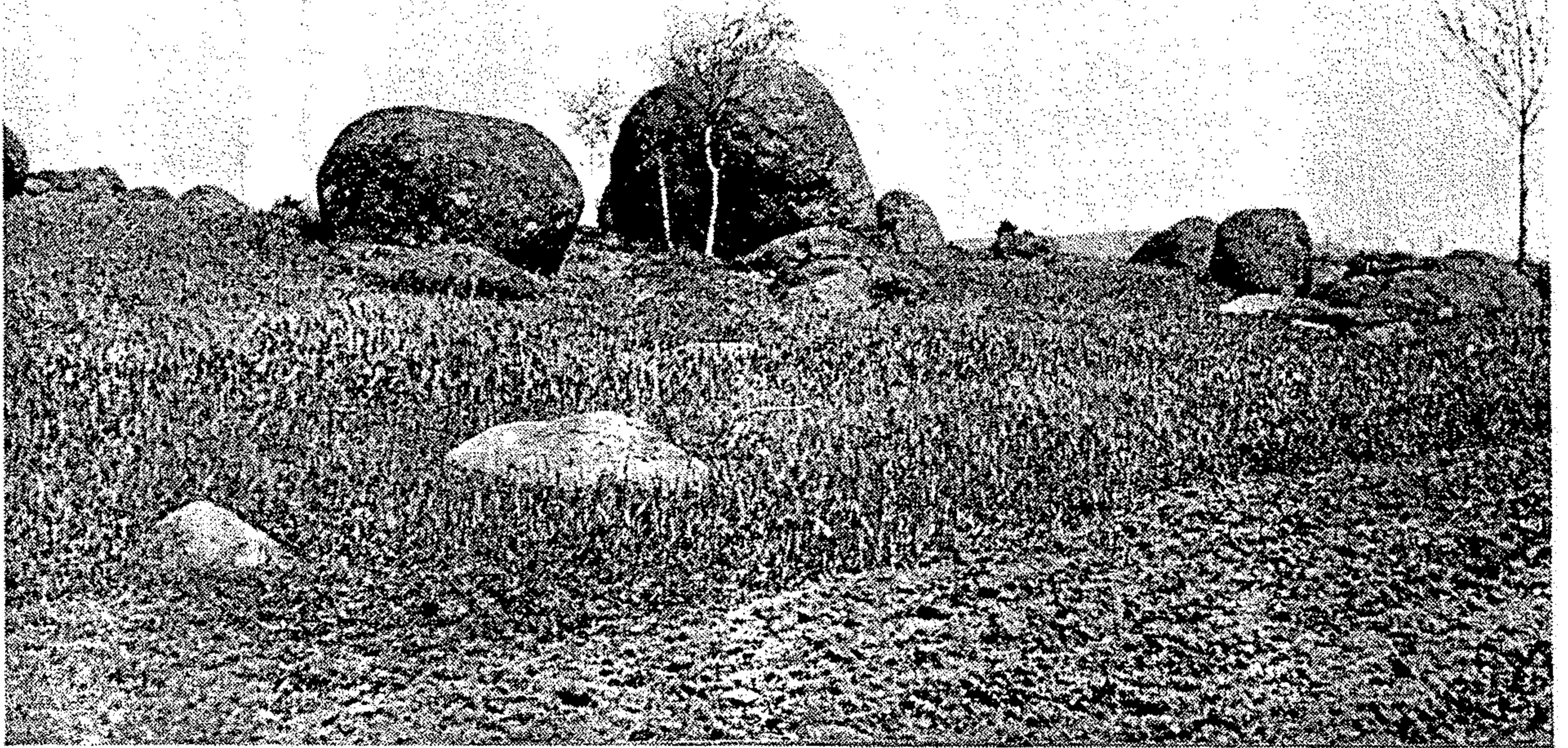


Abb. 226. *Granitblöcke* bei Petrovice unweit Sedlčany, die nach Denudation der verwitterten Granitpartien auf der Erdoberfläche zurückblieben. (Foto R. KETTNER.)



Abb. 227. „Teufelskanzel“ bei Petrovice unweit Sedlčany. *Granitwackelstein*. (Foto R. KETTNER.)



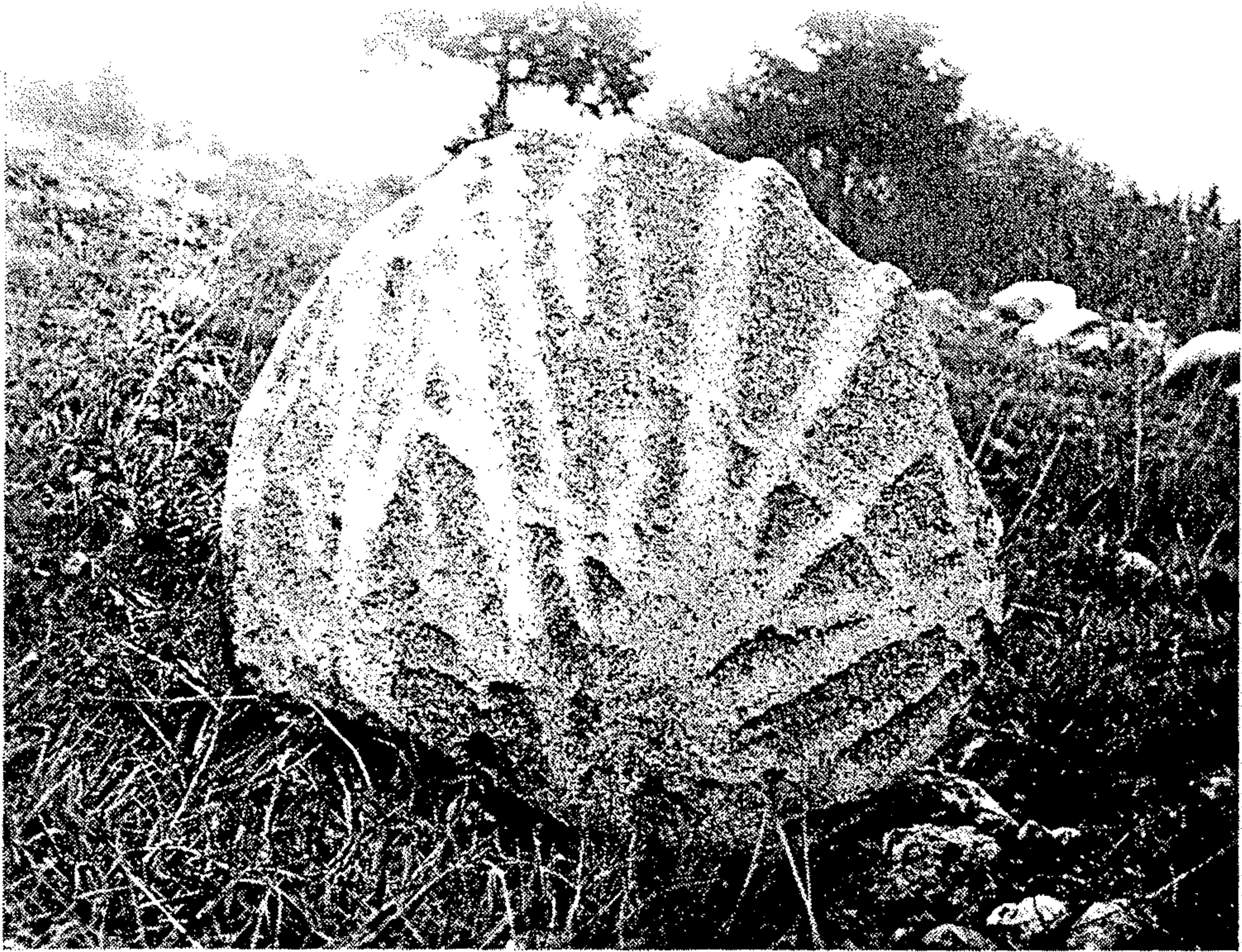


Abb. 217



Abb. 217 und 218. Rippenartige und gesimsartige Auswitterung hydrothermal umgewandelter Granitpartien an Granitblöcken vom Ďumbier. Svatojanská dolina in der Niederen Tatra. (Foto Dr. V. ZOUBEK.)



Abb. 215. *Herauswitterung von Aplitgängen aus Granit.* Aus dem Moldauschotter bei Orlik.  $\frac{2}{5}$  natürlicher Größe. Sammlung des Geologischen Instituts der Karlsuniversität. (Sammlung und Foto R. KETTNER.)

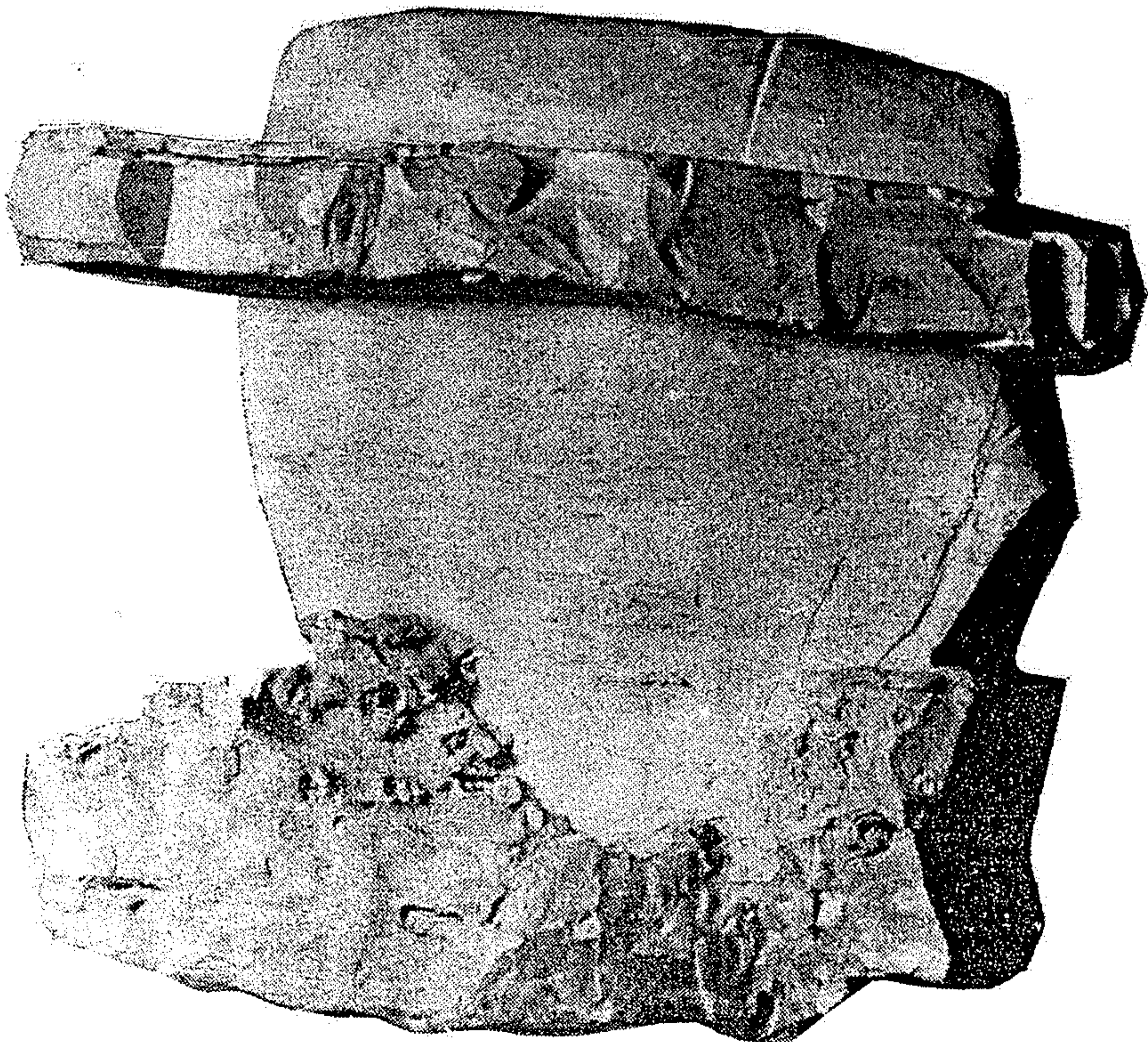


Abb. 216. *Auswitterung von Hornstein aus Kreidekalken.* Rockland Station, Australien.  $\frac{2}{5}$  natürlicher Größe. Aus den Sammlungen des verstorbenen Prof. Dr. G. V. DANEŠ. Sammlung des Geologischen Instituts der Karlsuniversität. (Foto R. KETTNER.)



Abb. 219. Verwitterung von aus der *Umwandlung algonkischer Schiefer* am Kontakt mit Granit entstandenem *Kontakthornfels*. Die gesimsartige Verwitterung der Oberfläche entspricht der ursprünglichen Hornfelsschichtung. Tal der Kocába bei Rybník südlich von Dobříš. Sammlung des Geologischen Instituts der Karlsuniversität. (Sammlung und Foto R. KETTNER.)

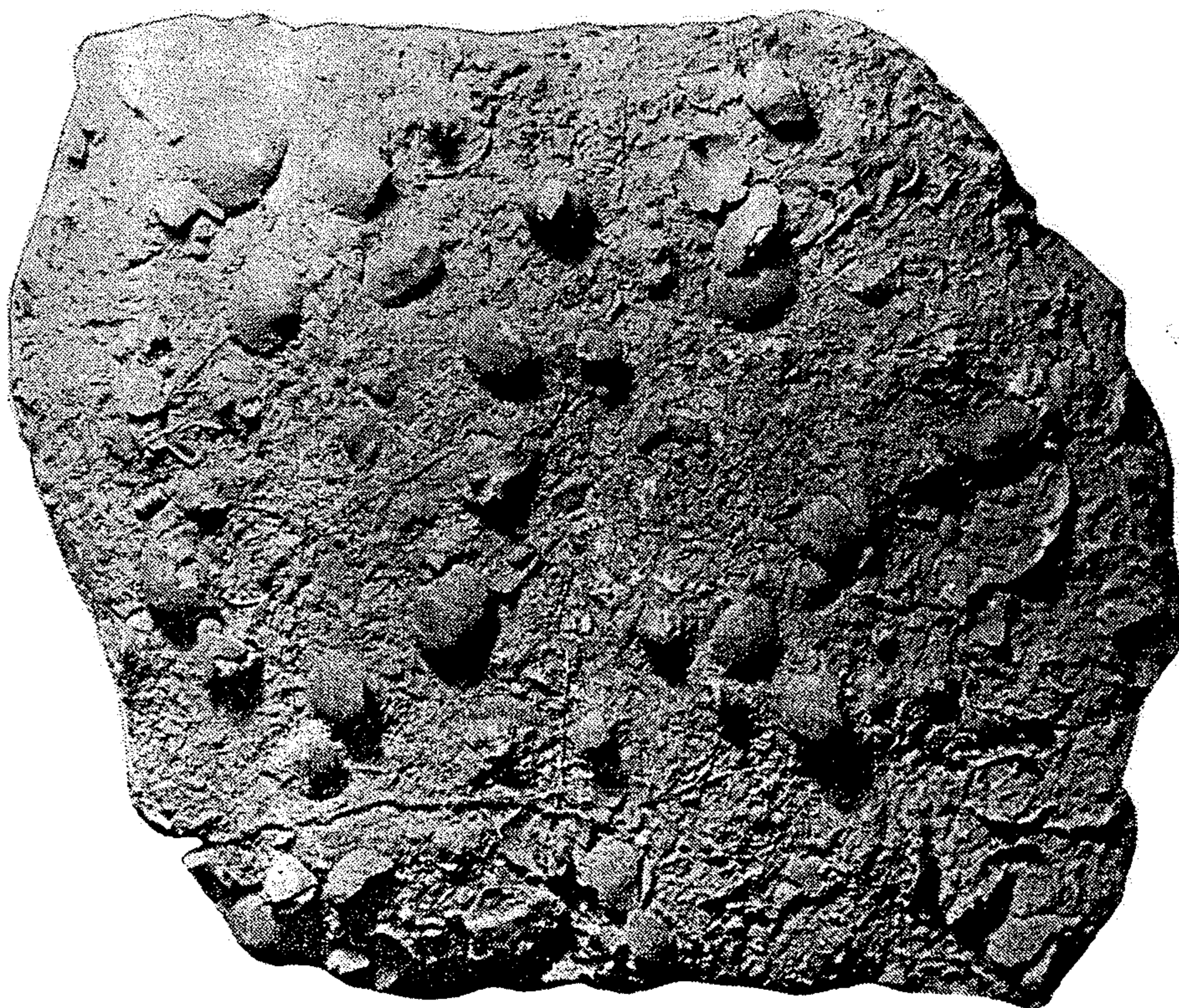


Abb. 220. Auswitterung von *Brachiopoden* aus einem Kalk des Ordovizium. Decorah shale, Umgebung von St. Louis (Missouri, USA). Auf  $\frac{1}{2}$  verkleinert. Gesammelt vom Autor. Sammlung des Geologischen Instituts der Karlsuniversität. (Foto R. KETTNER.)

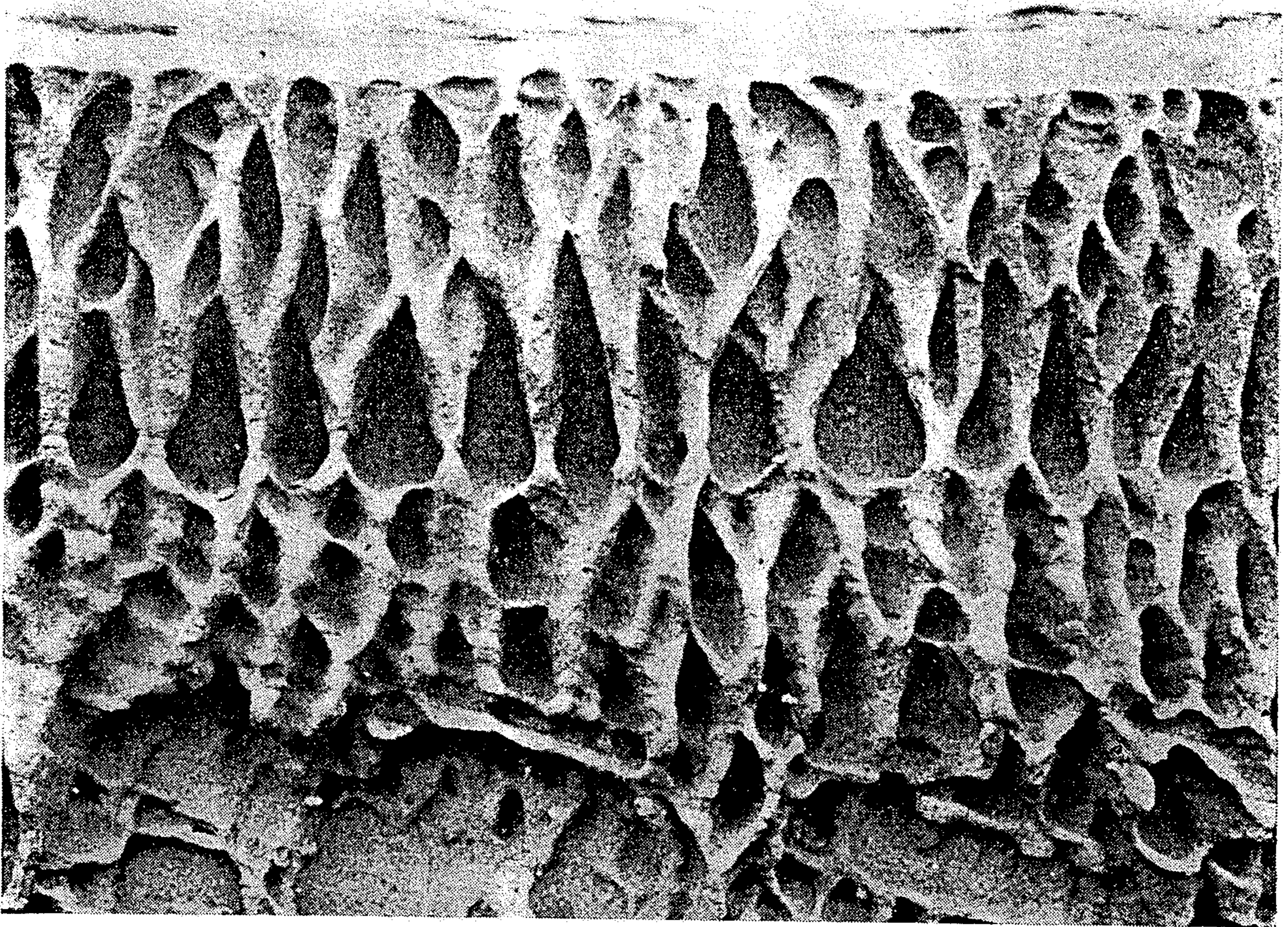


Abb. 234. *Buntsandstein* mit wabenförmiger Verwitterungsoberfläche. Drachenfels bei Busenberg. (Foto A. BAUER. Entnommen aus E. KAYSER, Lehrbuch der Geologie, Band 1.)

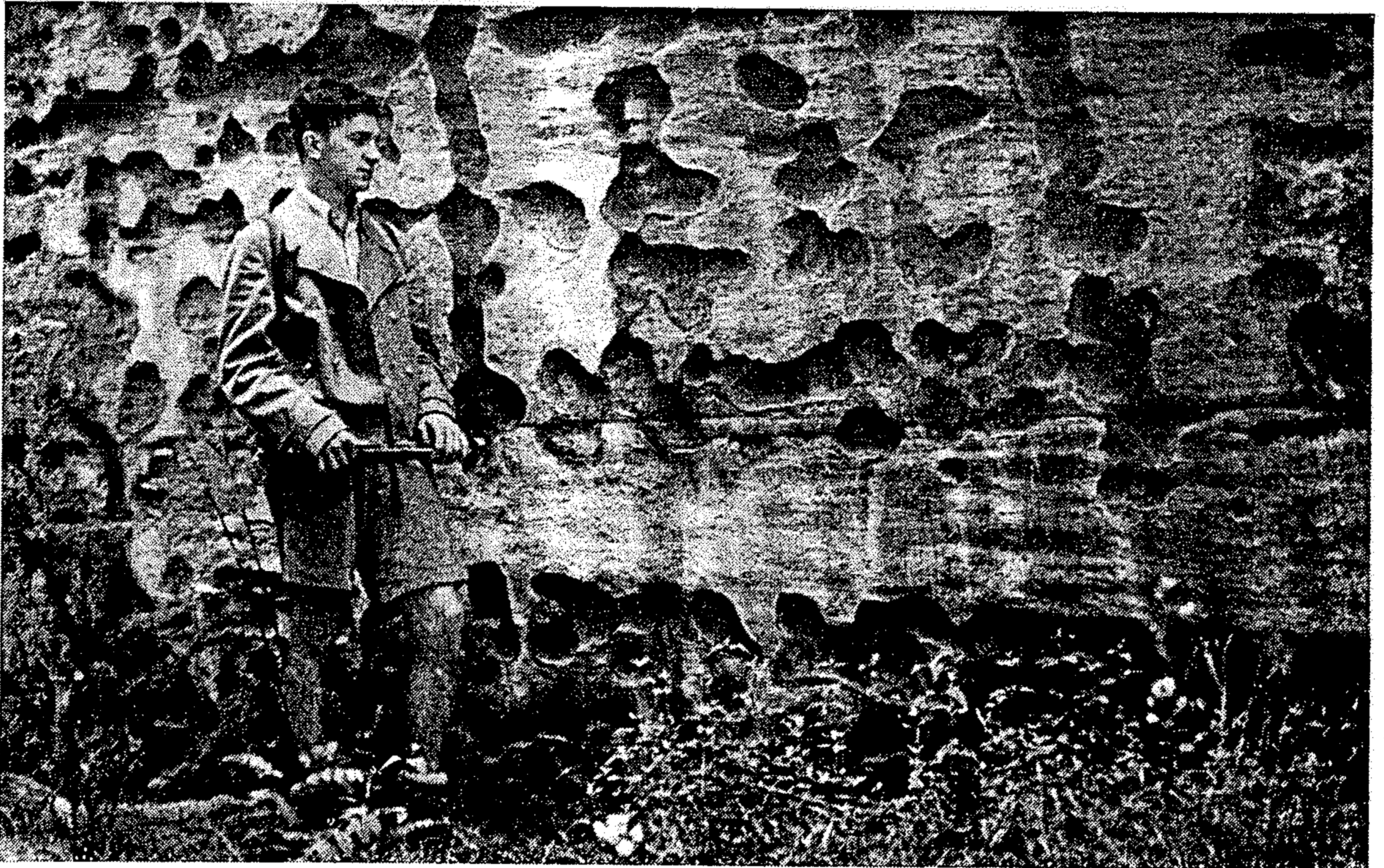


Abb. 235. *Beginnende wabenförmige Verwitterung* von Arkosen der Karbonzeit in einer Wand unter der Eisenbahnlinie nördlich von Kralupy an der Moldau. (Foto R. KETTNER.)

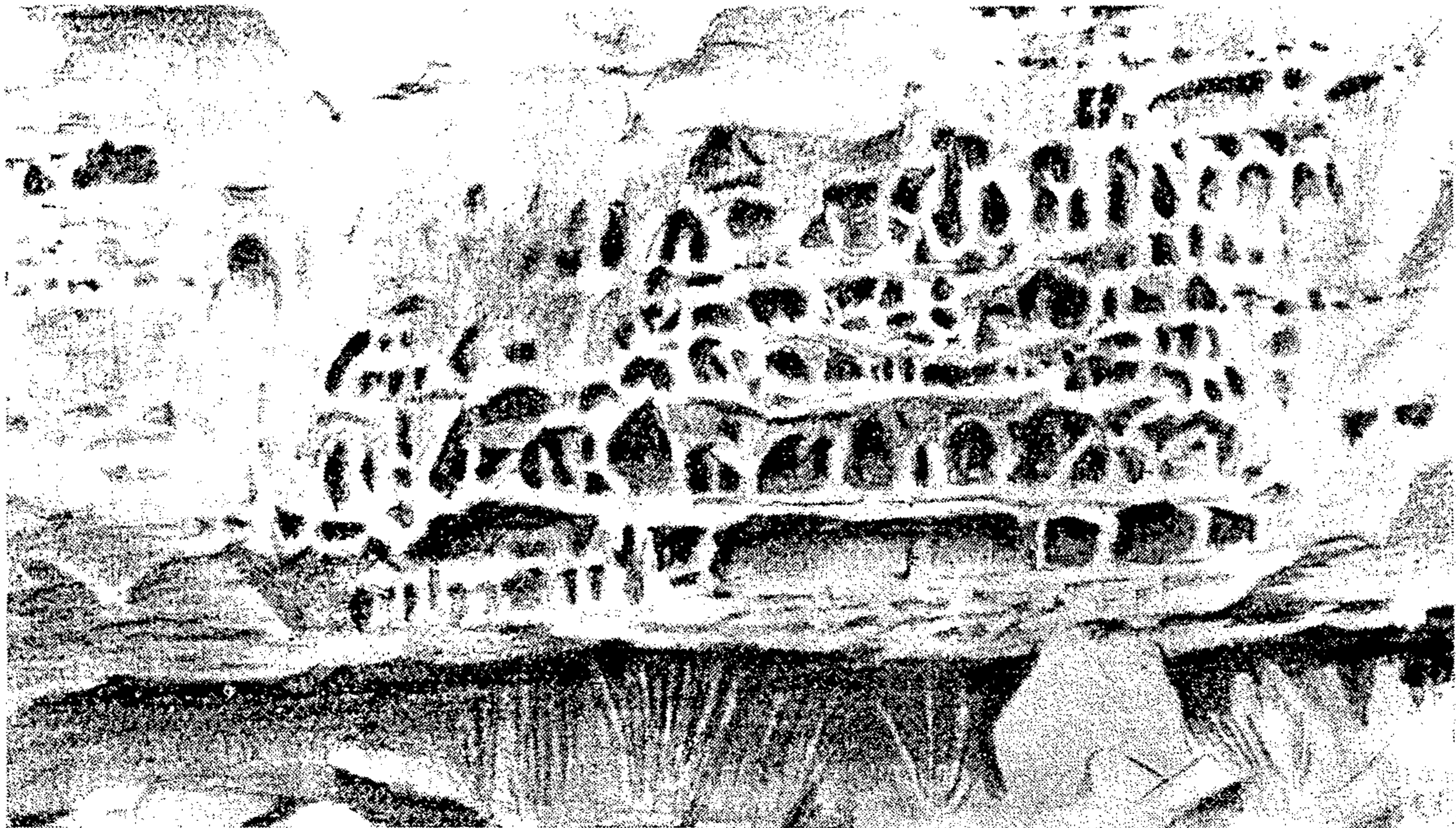
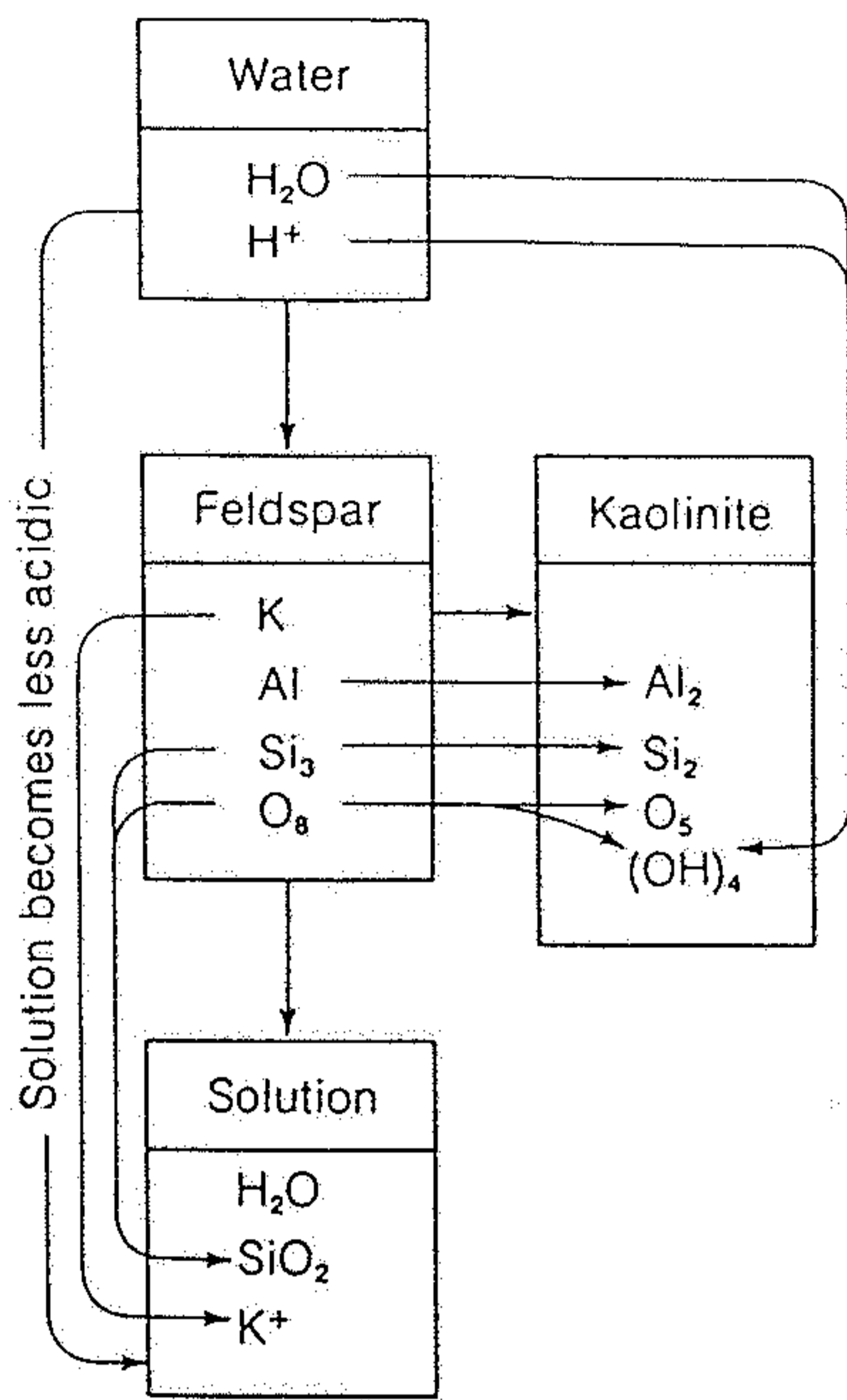


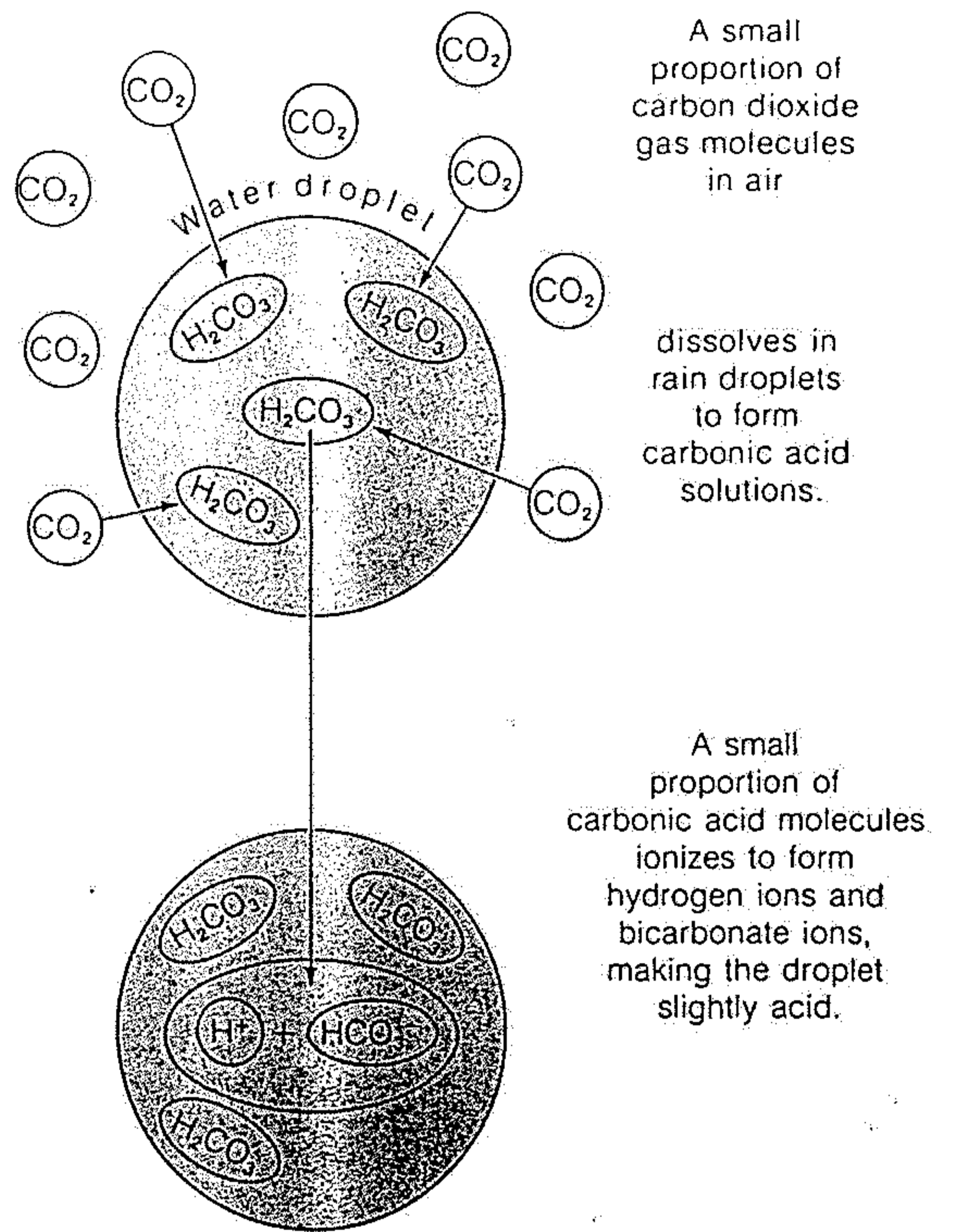
Abb. 236. *Steingitter* einer Sandsteinoberfläche in Arizona. Nach J. WALTHER. (Entnommen aus E. KAYSER, Lehrbuch der Geologie, Band I.)



Abb. 237. *Wabenförmige Verwitterung* von Quadersandsteinen der Kreideformation. Kokořín-Tal. (Foto R. KETTNER.)



The flow of material in the alteration of feldspar to kaolinite by the dissolving action of water. Some water and some hydrogen ions ( $H^+$ ) are absorbed into the kaolinite structure, but all of the potassium ( $K^+$ ) and some of the silica ( $SiO_2$ ) end up in solution.



The formation of carbonic acid in rain by the dissolution of carbon dioxide gas molecules in water droplets in the atmosphere. Once dissolved, the carbon dioxide reacts with water to form carbonic acid, which then ionizes to form hydrogen and bicarbonate ions. This slightly acid rain is far less acid than the acid rains that contain dissolved sulfur gases, which produce sulfuric acid.

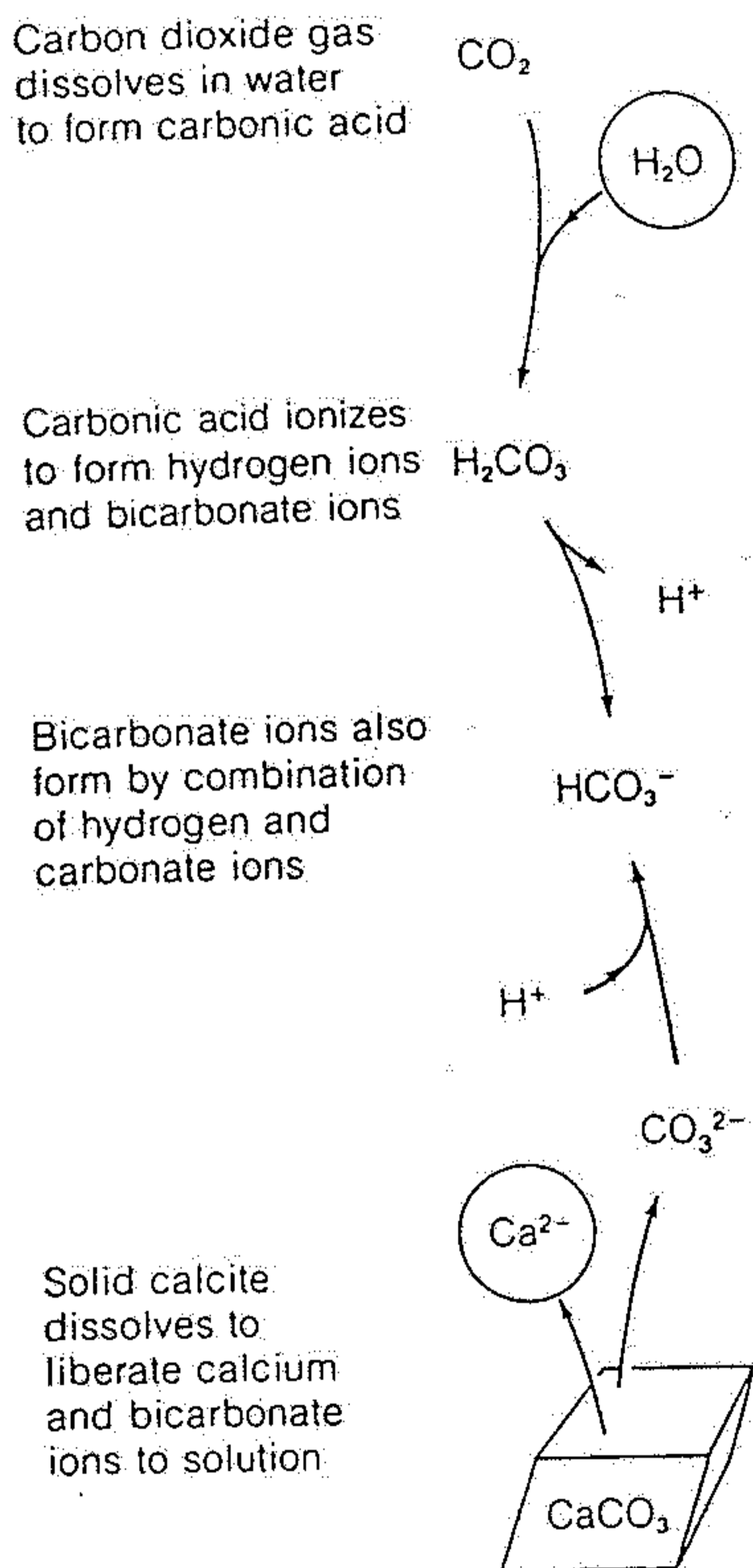


Figure 5-8

The general scheme by which calcite or other carbonate minerals dissolve in water containing dissolved carbon dioxide. The reactions are all reversible, and the system should be visualized with all reactions operating at the same time to produce the general net tendency shown by the arrows.

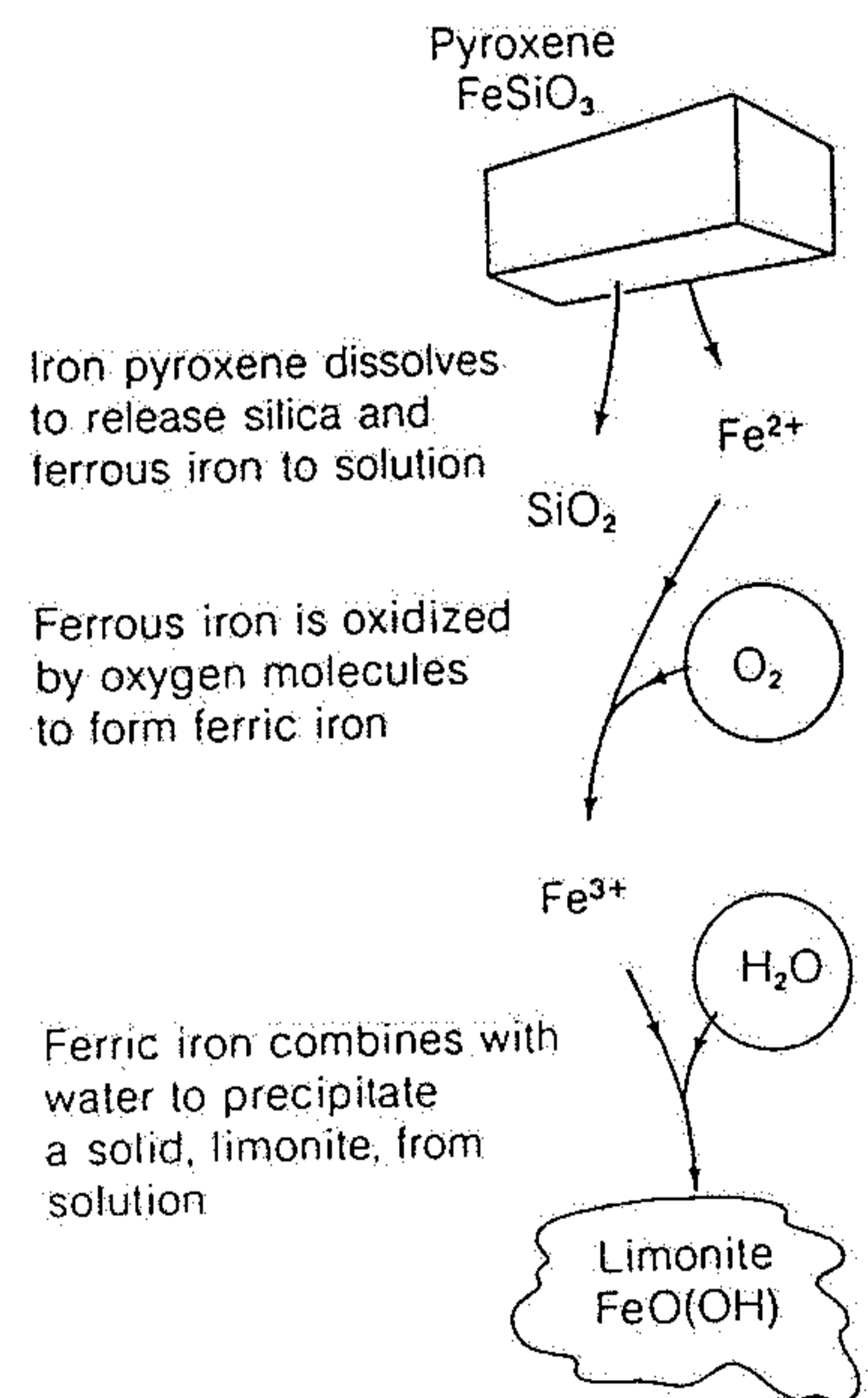


Figure 5-10

The general scheme by which an iron-rich silicate mineral, such as pyroxene, weathers. In the presence of oxygen and water, as at the Earth's surface, these reactions proceed sequentially and irreversibly.

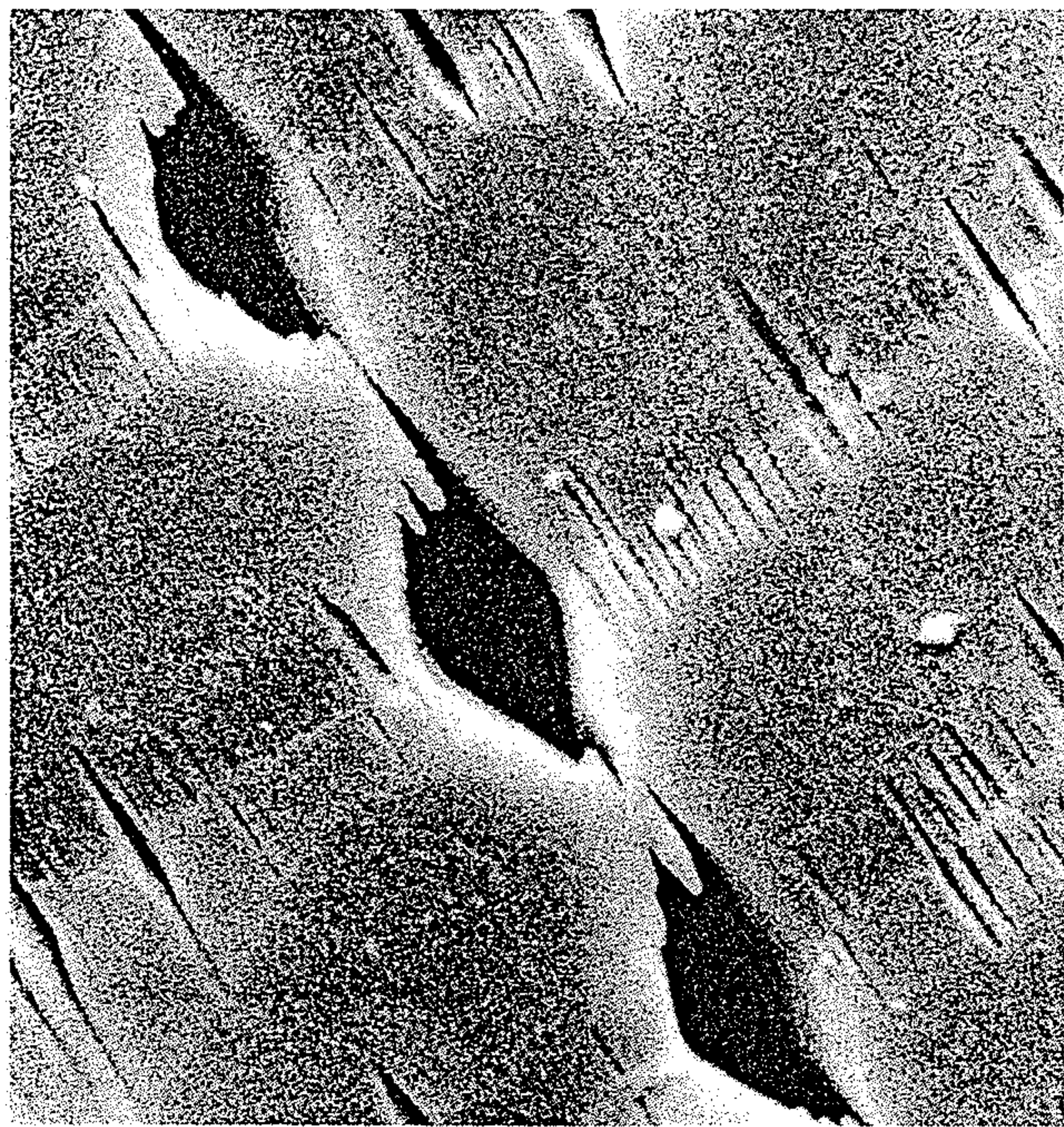
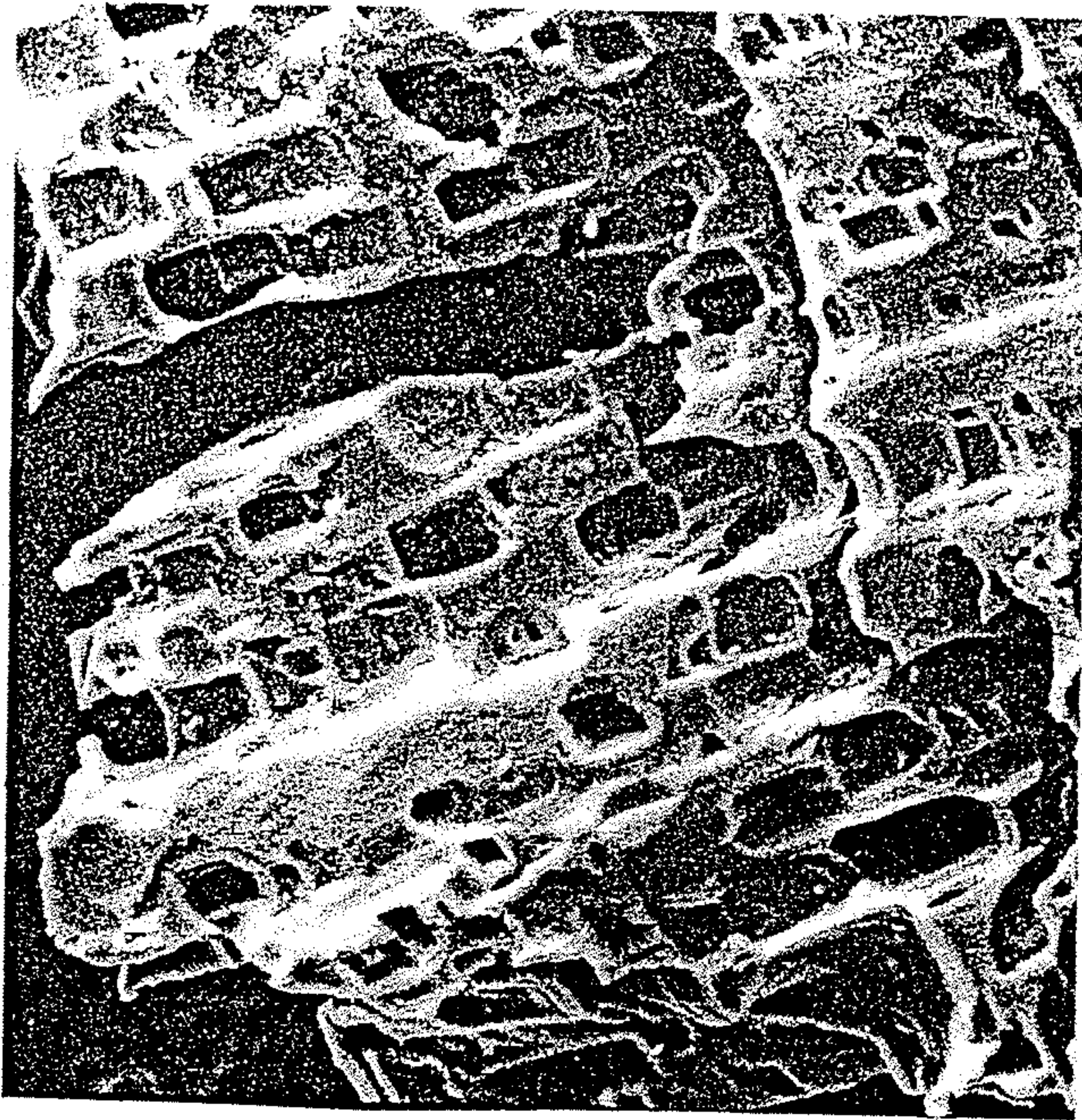
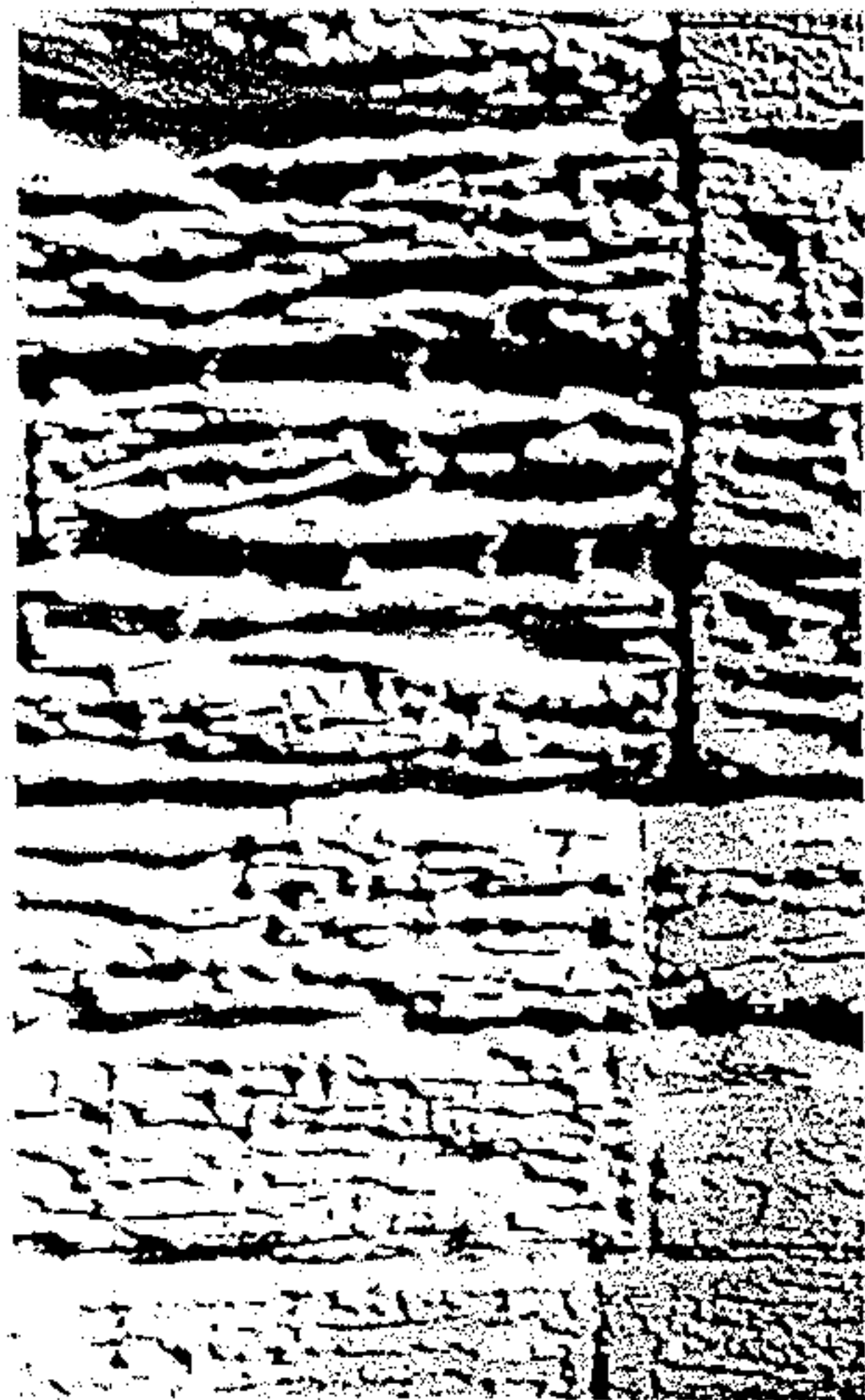


Figure 5-2

Scanning electron micrograph of an etched and corroded feldspar produced by dissolution in a soil. [From "Mechanism of Feldspar Weathering: Some Observational Evidence," by R. A. Berner and G. R. Holdren, Jr., *Geology*, v. 5, p. 369. Copyright © 1977, Geological Society of America.]

(a)



(a)

(b)

Figure 5-7

Weathered limestone blocks of a Roman aqueduct about 2000 years old show the pitted, etched surface caused by chemical solution. (a) One of the arches. (b) A closeup of a number of blocks. Pont du Gard, Provence, France. [Photos by R. Siever.]



(b)

Figure 5-9

Scanning electron micrographs of pitted and etched pyroxene grains from soils. (a) Lens-shaped etched pits on augite (a Ca, Na, Mg, Fe, Al pyroxene). (b) A crystal of hypersthene (an Mg, Fe pyroxene) showing cracks resulting from merging of etch pits. [From "Dissolution of Pyroxenes and Amphiboles during Weathering," by R. A. Berner, E. L. Sjöberg, M. A. Velbel, and M. D. Krom, *Science*, v. 207, pp. 1205-1206. Copyright © 1980, American Association for the Advancement of Science.]

Tab. 11.1. Produkty chemického zvetrávania bežných horninotvorných minerálov

Primárny minerál	Chemické zloženie	Sekundárne minerály	Zvyšok v roztoku
Olivín	$(\text{Fe}, \text{Mg})_2\text{SiO}_4$	limonit $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ hematit $\text{Fe}_2\text{O}_3$ kremeň $\text{SiO}_2$	Si v roztoku + rozpusťné uhličitaný Fe a Mg
Pyroxény Amfiboly Biotit	Fe – Mg – Ca (alumo)silikáty	kalcit $\text{CaCO}_3$ hematit, limonit, ílové minerály	v roztoku Si a rozpusťné uhličitaný Ca a Mg
Anortit	$\text{CaAl}_2\text{Si}_2\text{O}_8$	kremeň, kalcit	rozpusťné karbonáty
Albit	$\text{NaAlSi}_3\text{O}_8$	ílové minerály (kaolinit)	Ca a Na + kremík v roztoku
Ortoklas	$\text{KAlSi}_3\text{O}_8$	ílové minerály, kaolinit, kremeň	Si v roztoku, rozpusťný uhličitan K

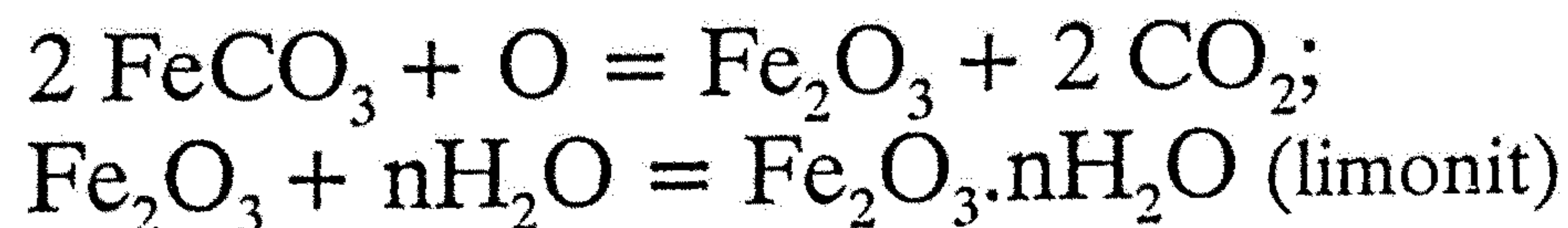
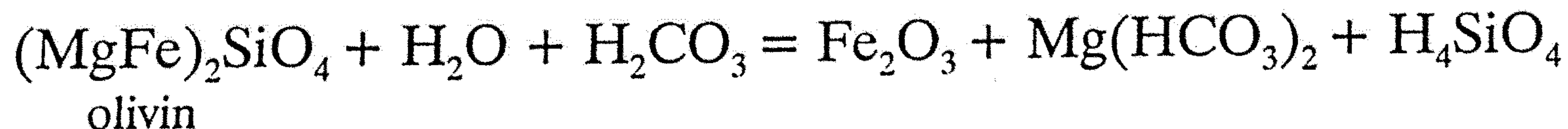


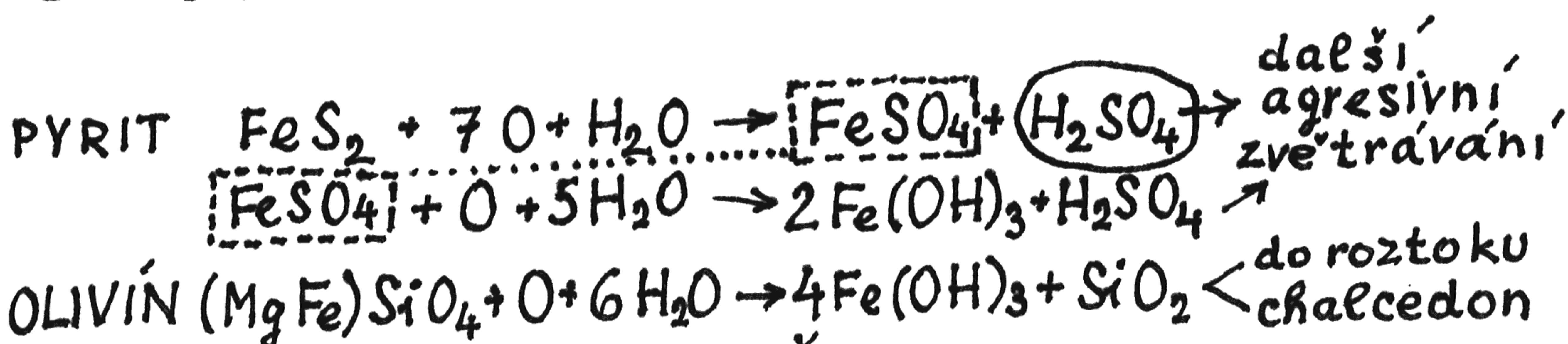


TABLE 5.1

## Chemical-Weathering Products of Common Rock-Forming Silicate Minerals

Mineral	Composition	Important decomposition products	
		Minerals	Others
Quartz	$\text{SiO}_2$	Quartz grains	Minor silica in solution
Feldspars:			
Orthoclase (or K-spar)	$\text{K(AlSi}_3\text{O}_8)$	Clay Silica	Potassium in solution Some silica in solution
Albite (sodium plagioclase)	$\text{Na(AlSi}_3\text{O}_8)$	Clay	Some silica and sodium in solution
Anorthite (calcium plagioclase)	$\text{Ca(Al}_2\text{Si}_2\text{O}_8)$	Silica Calcite	Aluminum and calcium in solution
Ferromagnesian:			
Biotite	Fe, Mg, Ca silicates of Al	Clay	Calcium and magnesium in solution
Augite		Hematite	
Hornblende		Limonite Silica Calcite	Some silica in solution
Olivine	$(\text{Fe, Mg})_2\text{SiO}_4$	Hematite Limonite Silica	Iron and magnesium in solution Some silica in solution

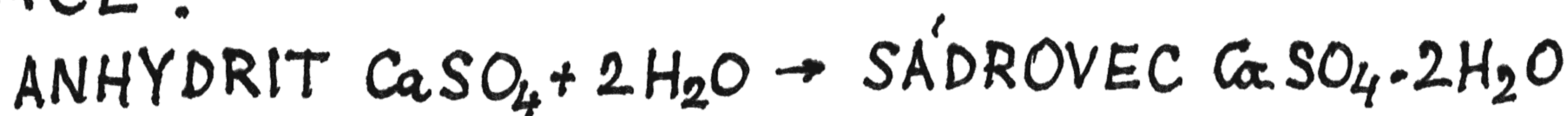
# 1. OXIDACE :



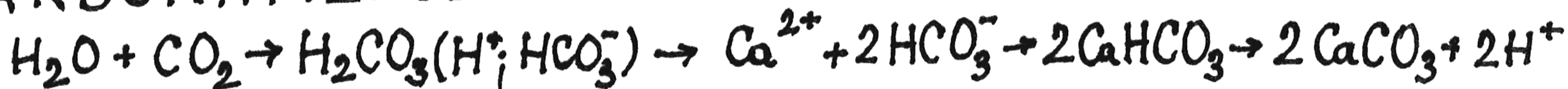
# 2. ROZPOUŠTĚNÍ: VE VODĚ:

- a) HALIT NaCl - vysoká rozpustnost - 263g/l
- b) SÁDROVEC - slabá rozpust.  $CaSO_4 \cdot 2H_2O \rightarrow Ca^{2+} + SO_4^{2-} + H_2O$  - 1,9g/l
- c) VÁPENEC -  $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$  - do roztoku
- d) KŘEMEN -  $SiO_2 + H_2O \rightarrow (H^+, OH^-) \rightarrow H_4SiO_4$  - do roztoku (kys.)

# 3. HYDRATACE :

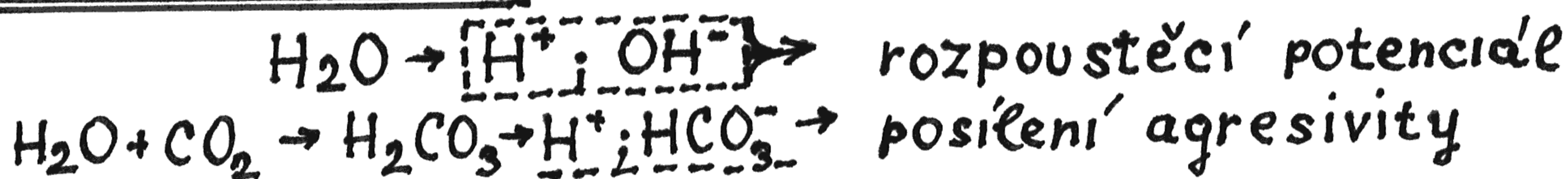


# 4. KARBONATIZACE:

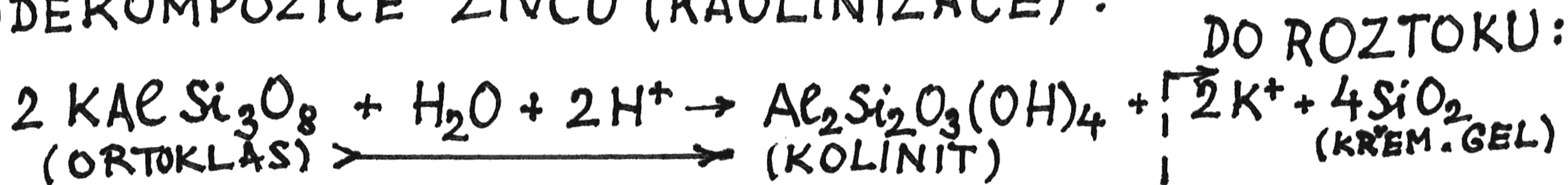


# 5. HYDROLYZA

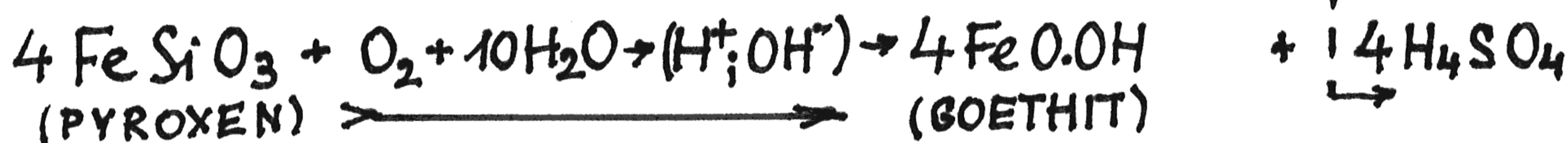
# DEKOMPOZICE SILIKÁTŮ!



## a) DEKOMPOZICE ŽIVCŮ (KAOLINIZACE) :

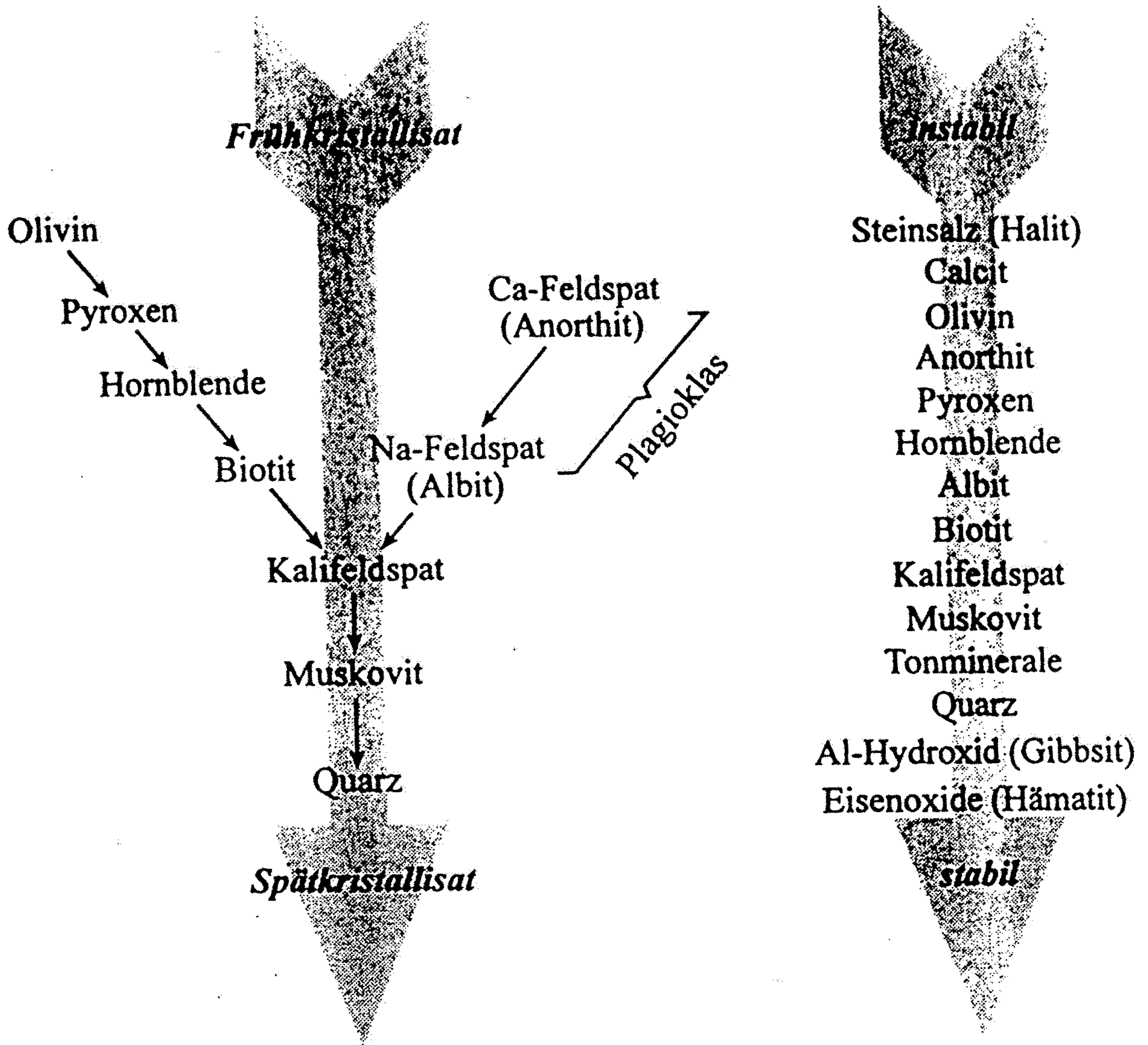


## b) DEKOMPOZICE PYROXENŮ:



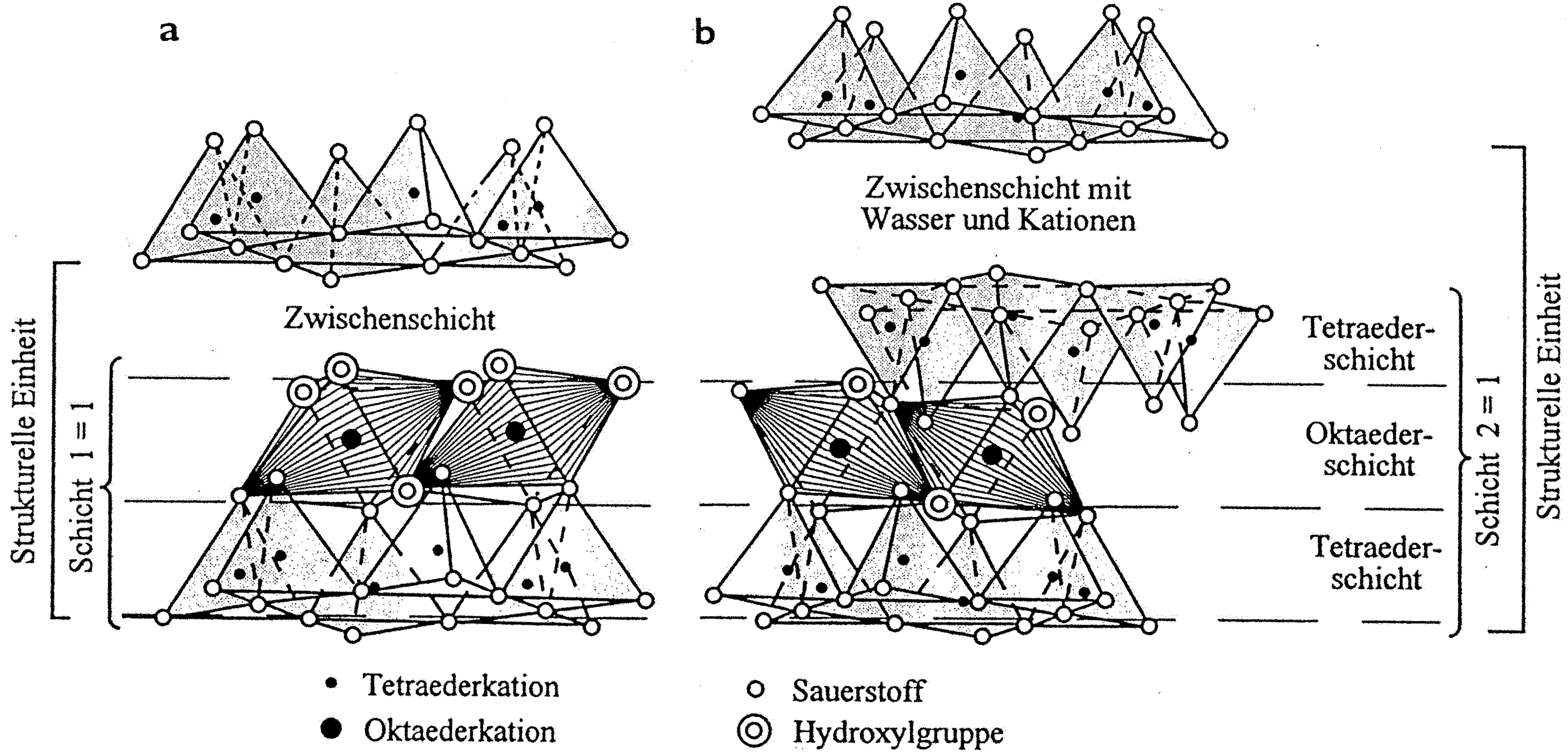
## Bowen'sche Reaktionsreihe der Silikate

## Stabilität der Minerale gegen Verwitterung

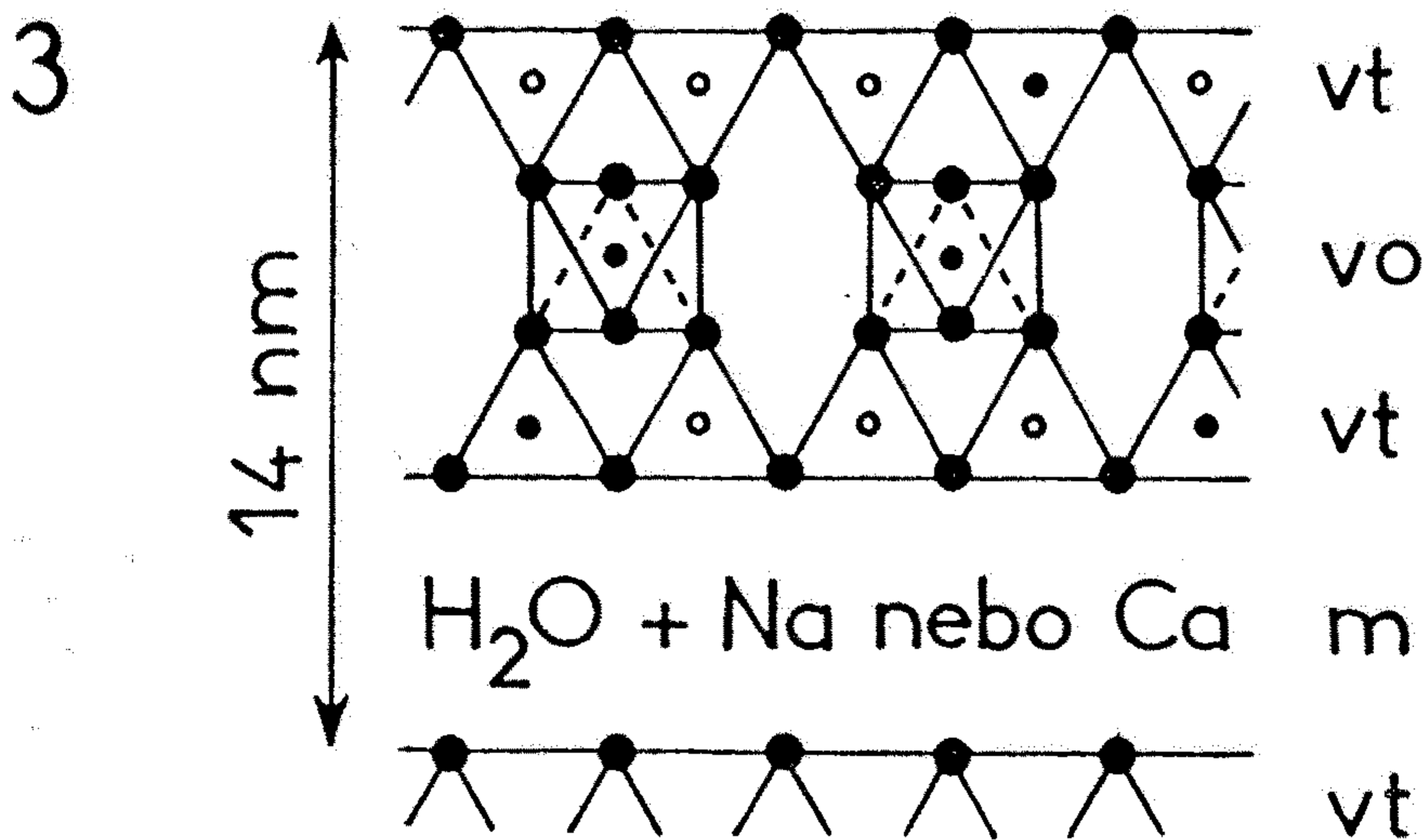
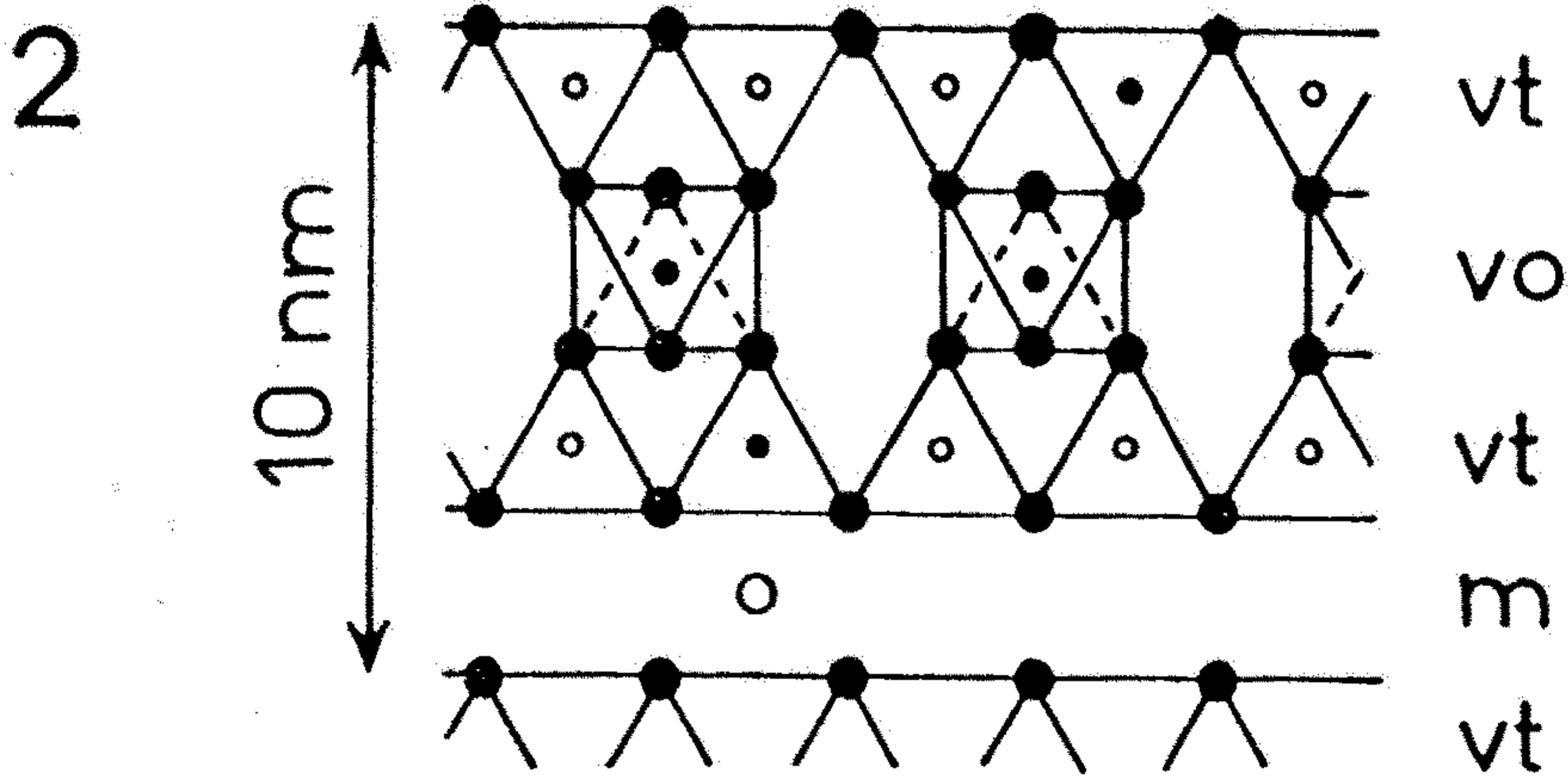
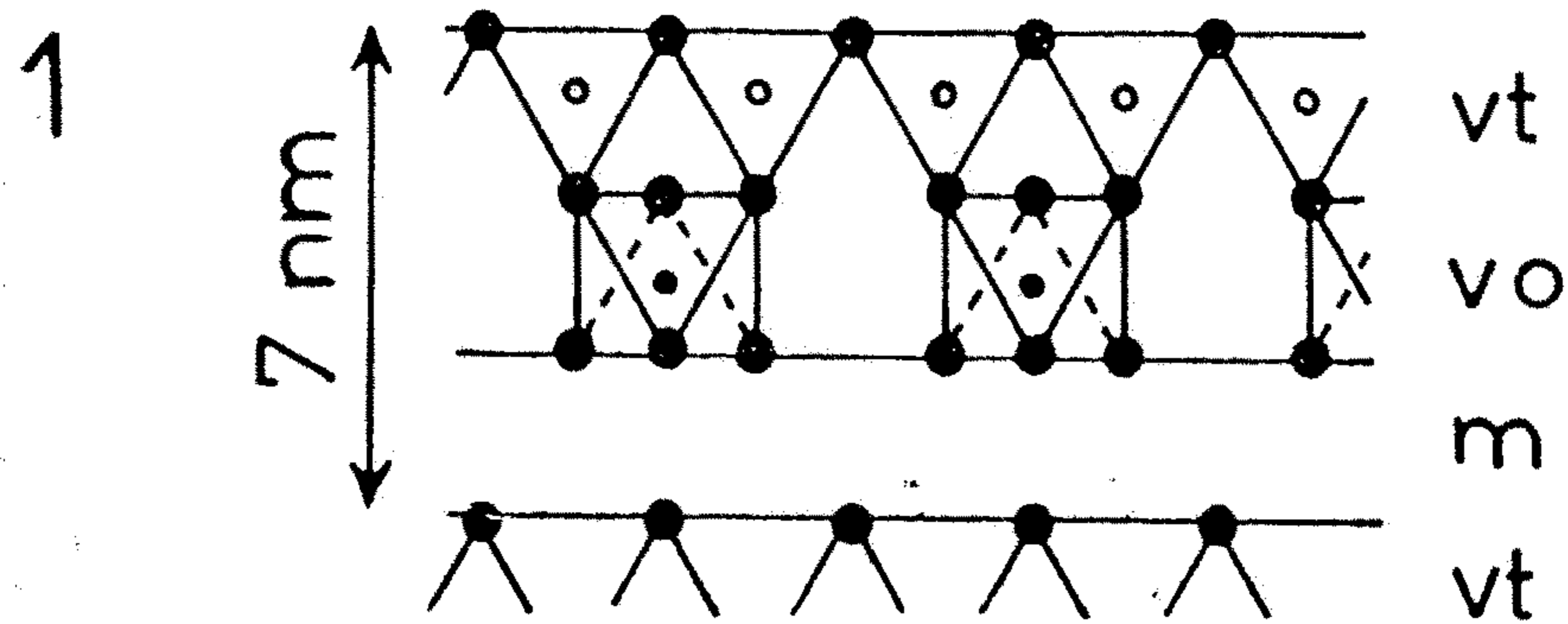


**Abb. 3.9**

Die dargestellte Abfolge der Widerstandsfähigkeit der silikatischen Minerale gegen die hydrolytische Verwitterung entspricht der umgekehrten Reihenfolge, in der sie aus einer silikatischen Schmelze nach der **BOWENSCHEN REAKTIONSEREHE** der Silikate auskristallisieren würden (Abschn. 12.1). Die Frühkristallisate sind demnach unter Verwitterungsbedingungen weniger stabil als die Spätkristallisate. Die Widerstandsfähigkeit von Quarz wird noch übertroffen von den Aluminiumhydroxiden und Eisenoxiden. Calcit und Steinsalz sind instabiler als z.B. Olivin.

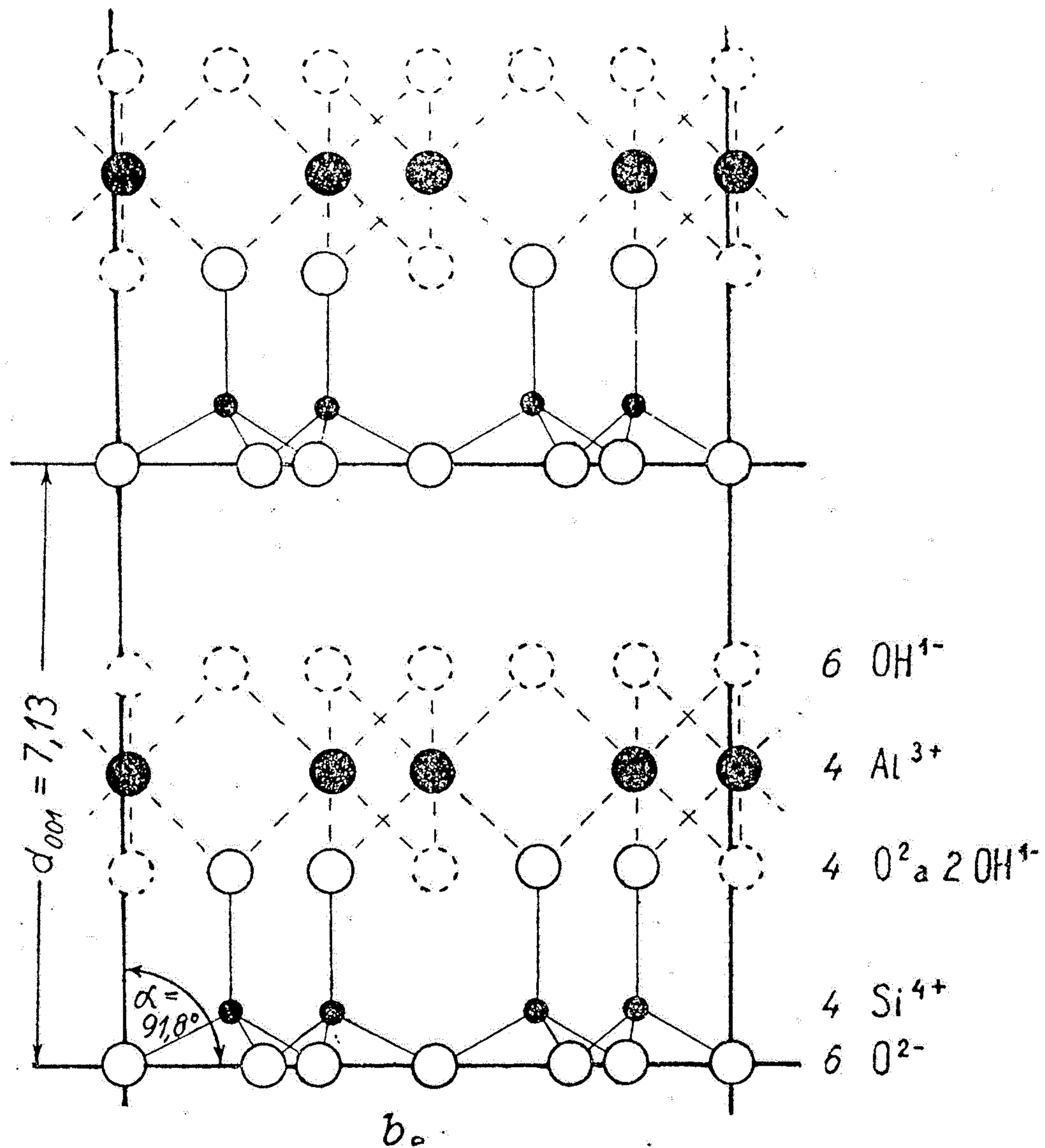


Dreidimensionale Skizze der Kristallstruktur des Zweischicht-Tonminerals Kaolinit (**a**) und des Dreischicht-Tonminerals Smektit (**b**) (verändert nach CHAMLEY, 1989).

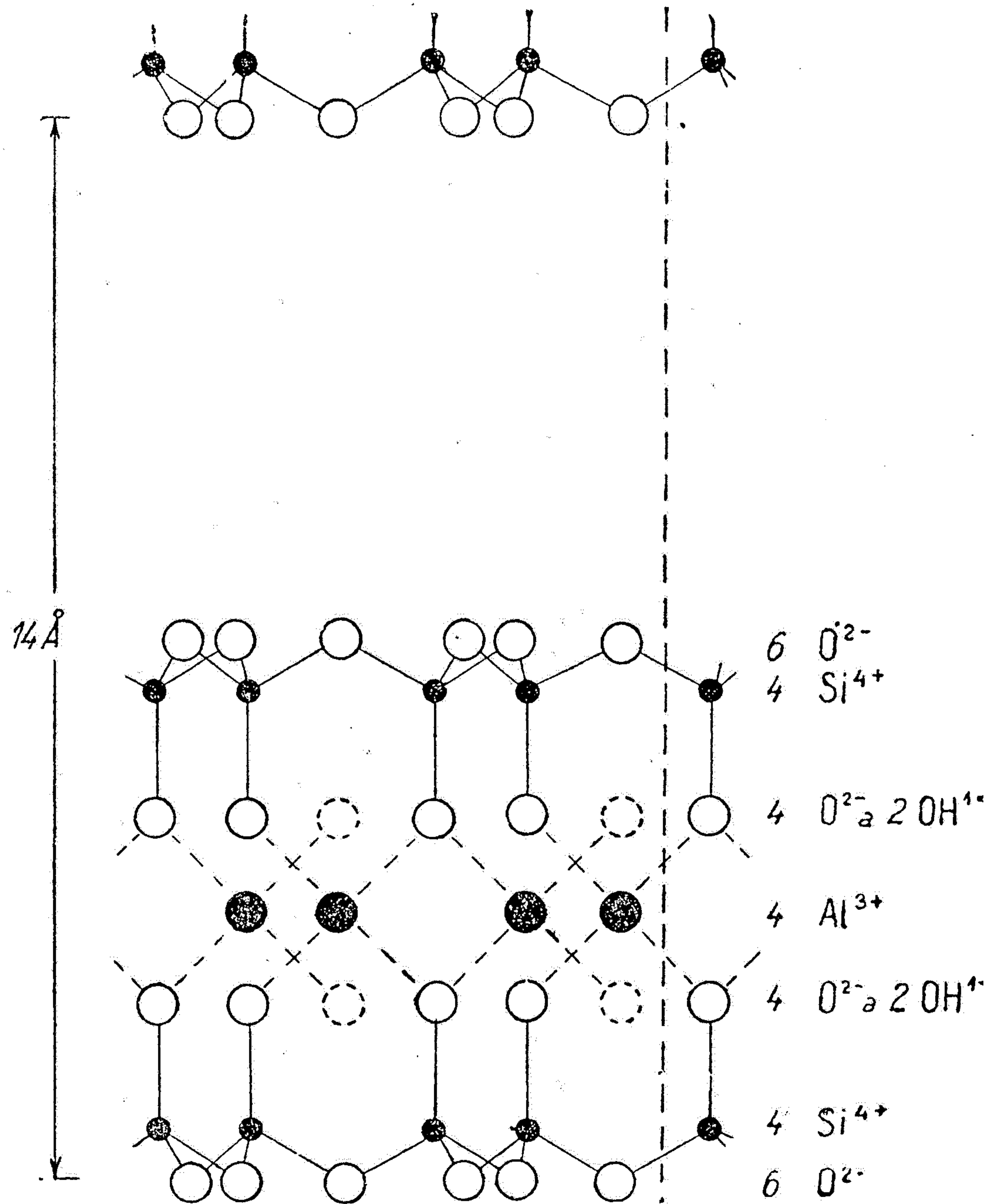


● O    ◦ Si    • Al    ◦ K

Obr. 86. Struktura jílových minerálů  
 1 – kaolinit, 2 – illit, 3 – montmorillonit; vt –  
 vrstvička tetraedrů kyslíku s atomem křemíku  
 uprostřed, vo – vrstvička oktaedrů kyslíku  
 s atomem hliníku uprostřed, m – mezivrstevní  
 prostor (u montmorillonitu do něho snadno  
 vniká voda, což vyvolává bobtnání)



Obr. 4. Schematické znázornění struktury kaolinitu (podle G. W. Brindleye, 1951).



Obr. 8. Schematické znázornění struktury montmorillonitu (U. Hofmann, K. Endell, D. Wilm, 1933).

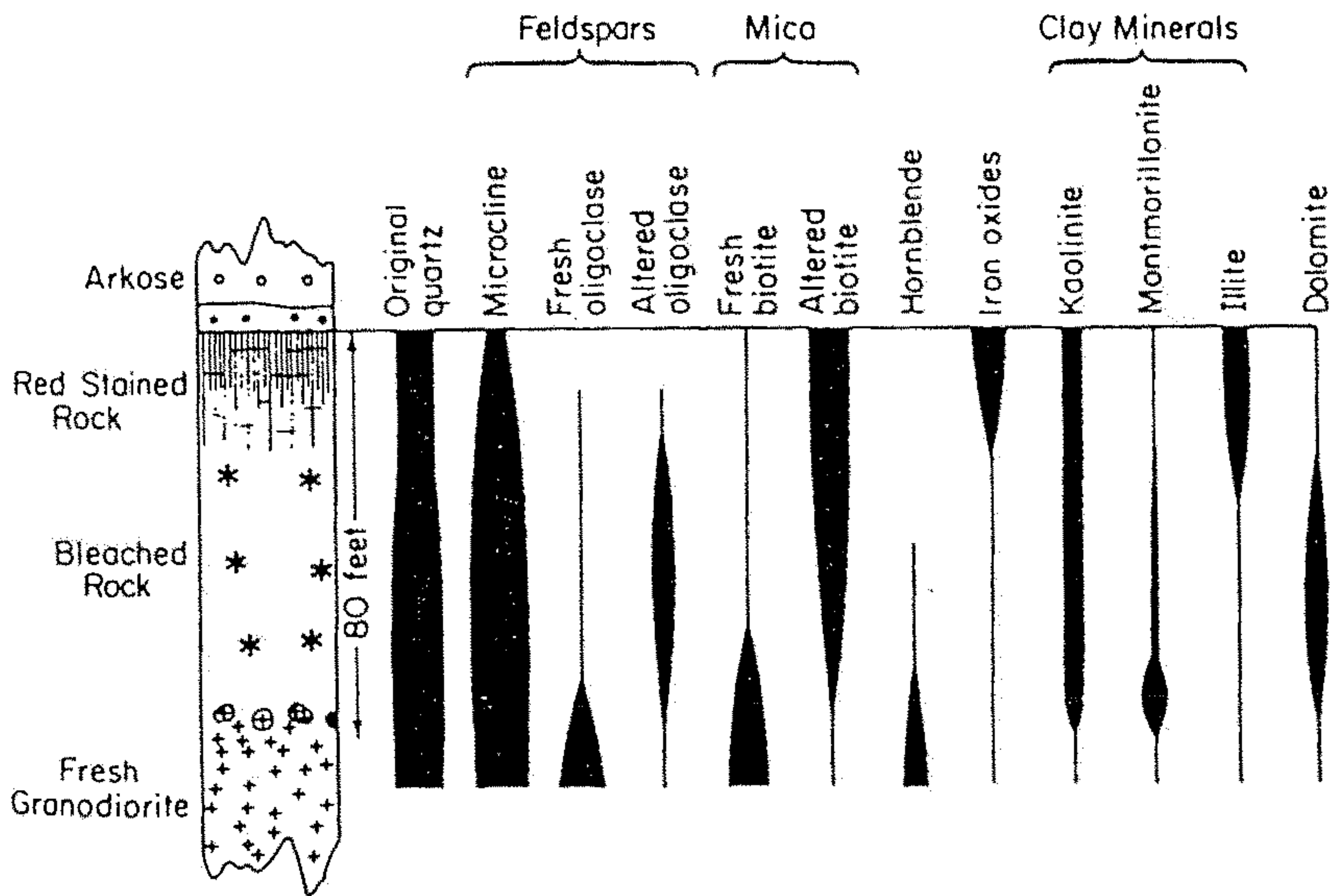


Figure 8.3. Weathering profile from a Mississippian soil developed on granodiorite near Boulder, Colorado. Relative abundance of minerals within the ancient soil profile is indicated by the width of the line. (Source: Adapted from E. E. Wahlstrom, Pre-Fountain and Recent weathering on Flagstaff Mountain near Boulder, Colorado, *Geological Society of America Bulletin*, vol. 59, 1948.)



Figure 8.4. Spheroidal weathering of relatively impermeable, homogeneous rocks such as granite results from weathering concentrated along fracture planes, such as in this granite from the Sandia Mountains of New Mexico. (Source: Photograph by Mark Johnsson.)

Figure 8.5. Mineral transformations with the progressive weathering of basalt. (Source: Adapted from D. Carroll and J. C. Hathaway, *Mineralogy of selected soils from Guam*, U.S. Geological Survey Professional Paper 403-F, 1963, 51 pp.)

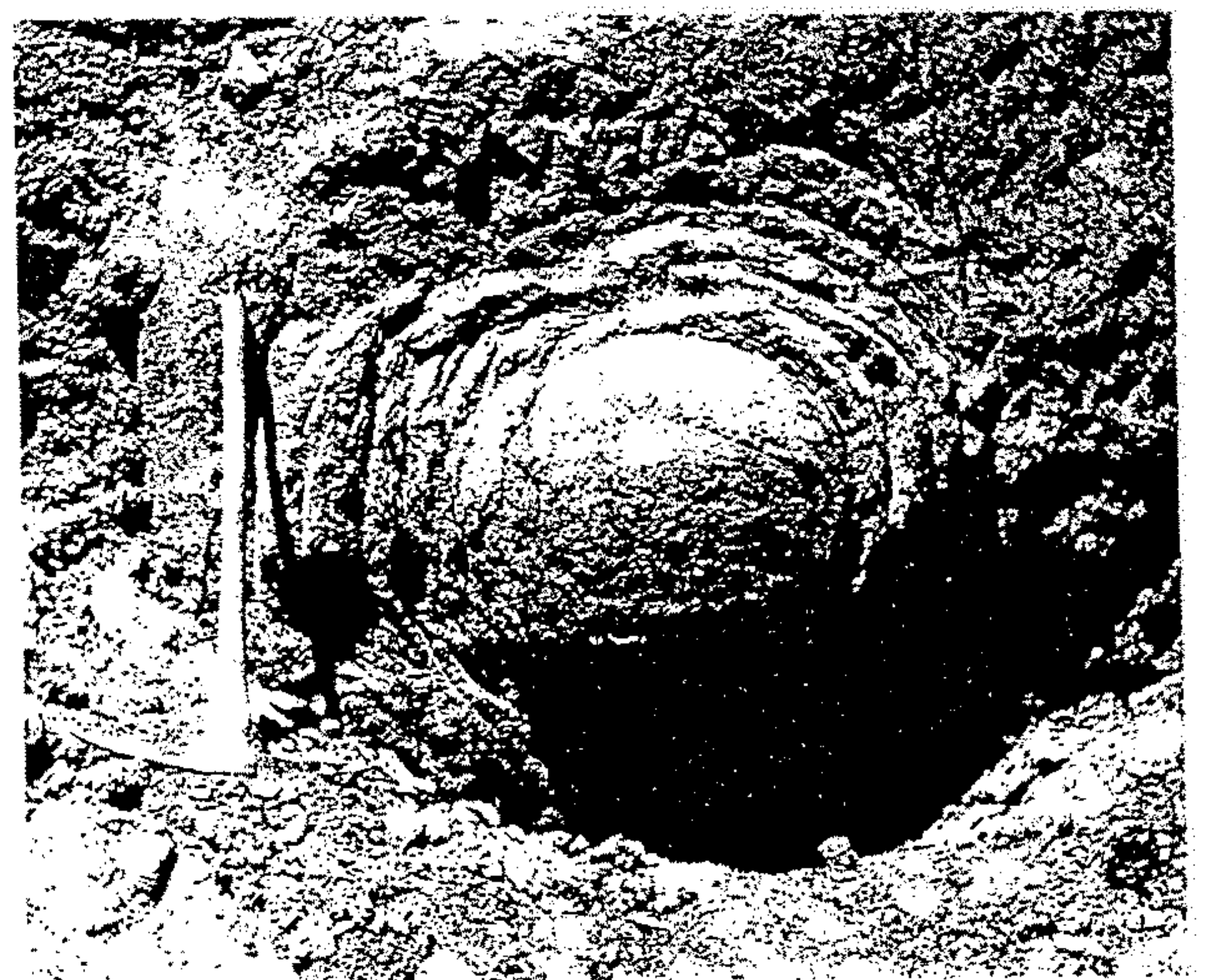
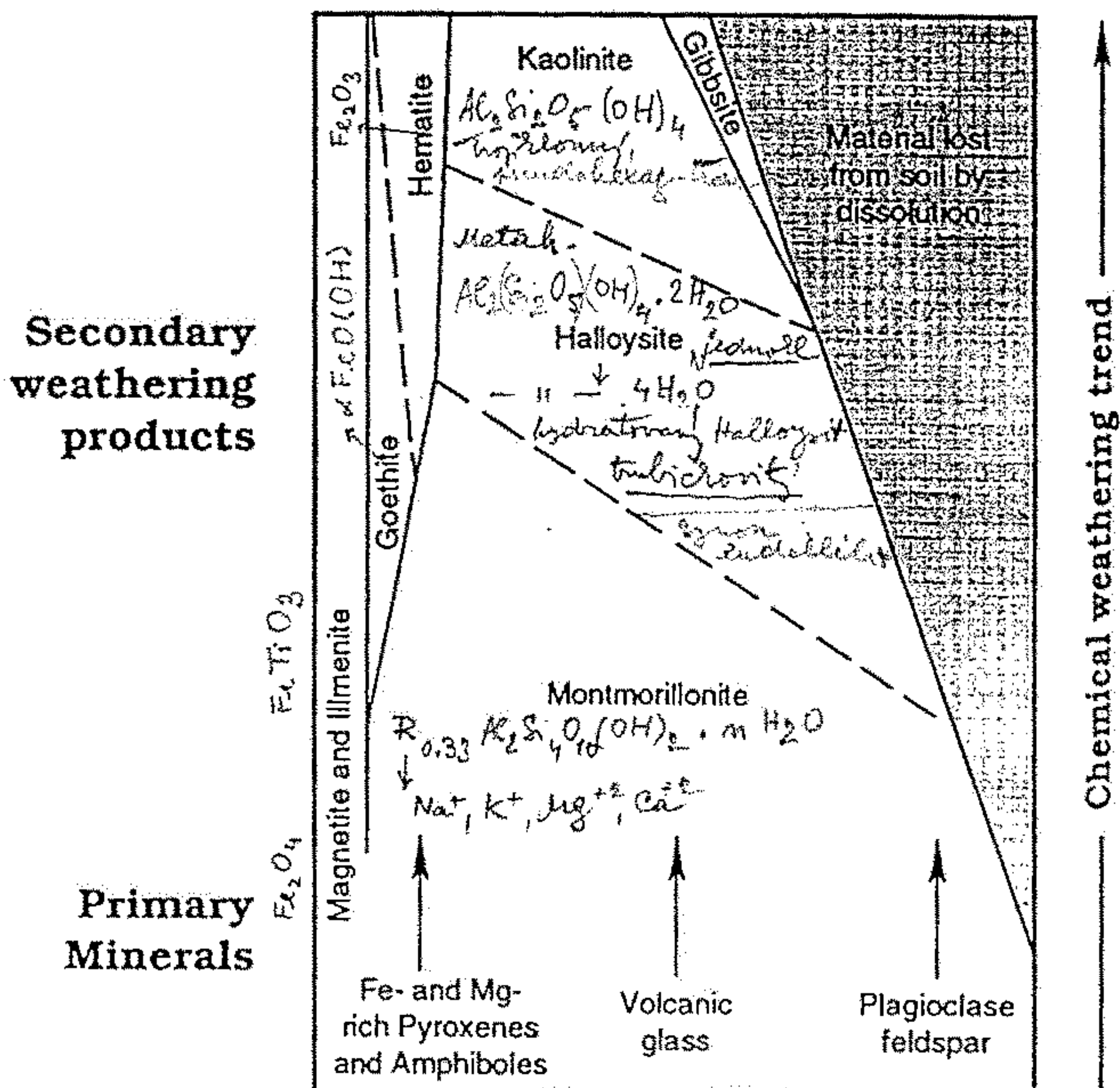
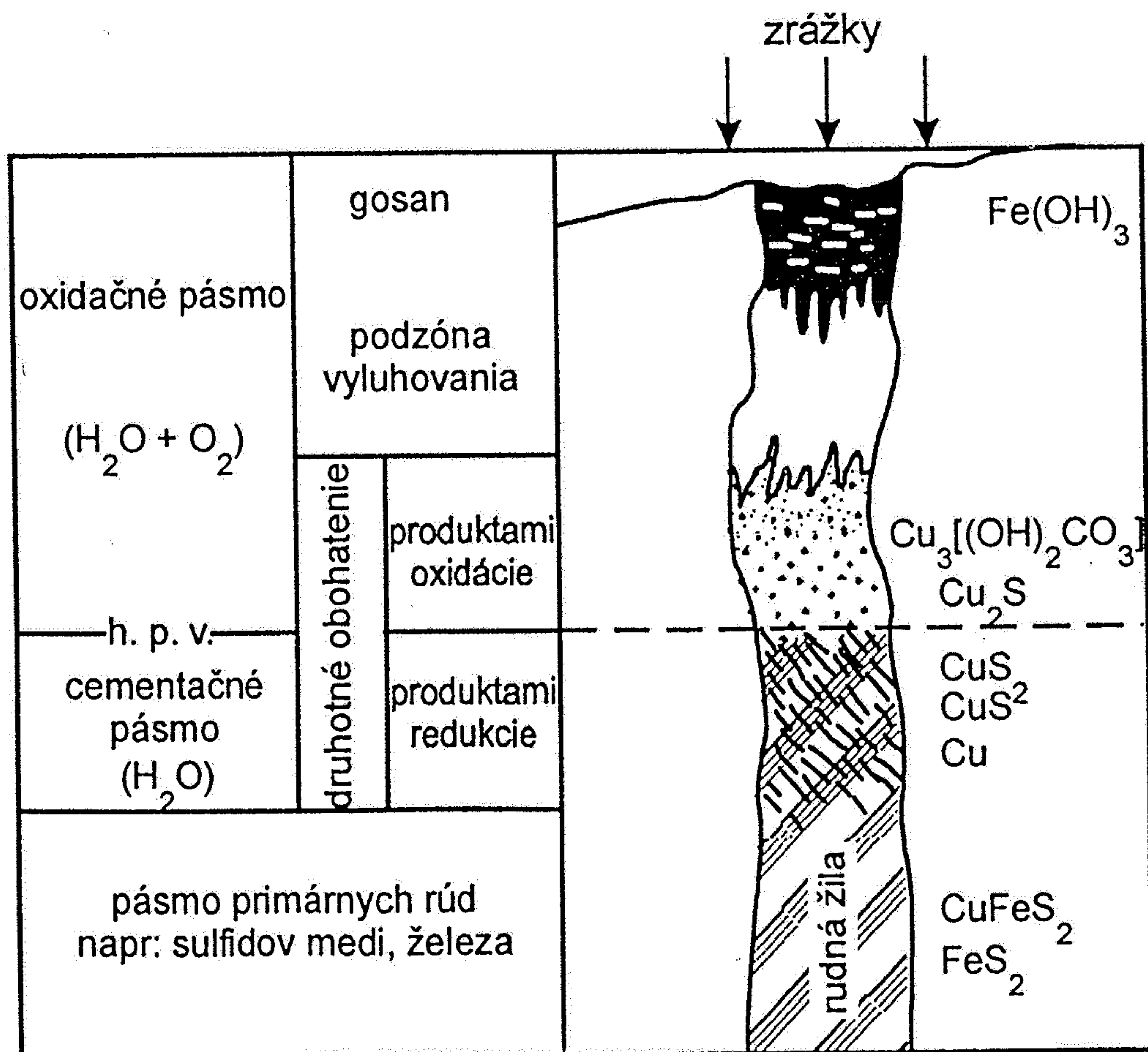
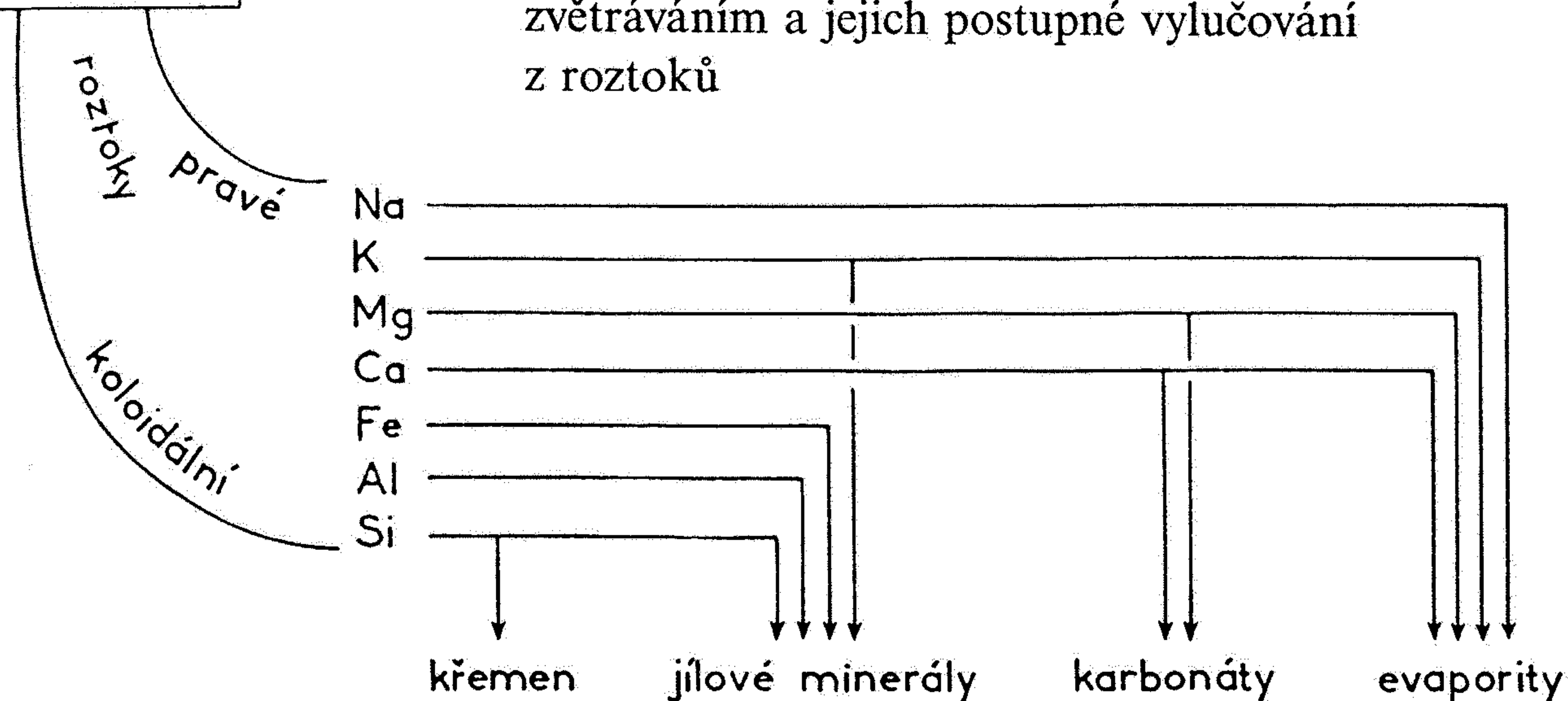


Figure 5-16 Spheroidal weathering of a boulder of gabbro, Mesa Grande, San Diego County, California. [Photo by W. T. Schaller, U.S. Geological Survey.]

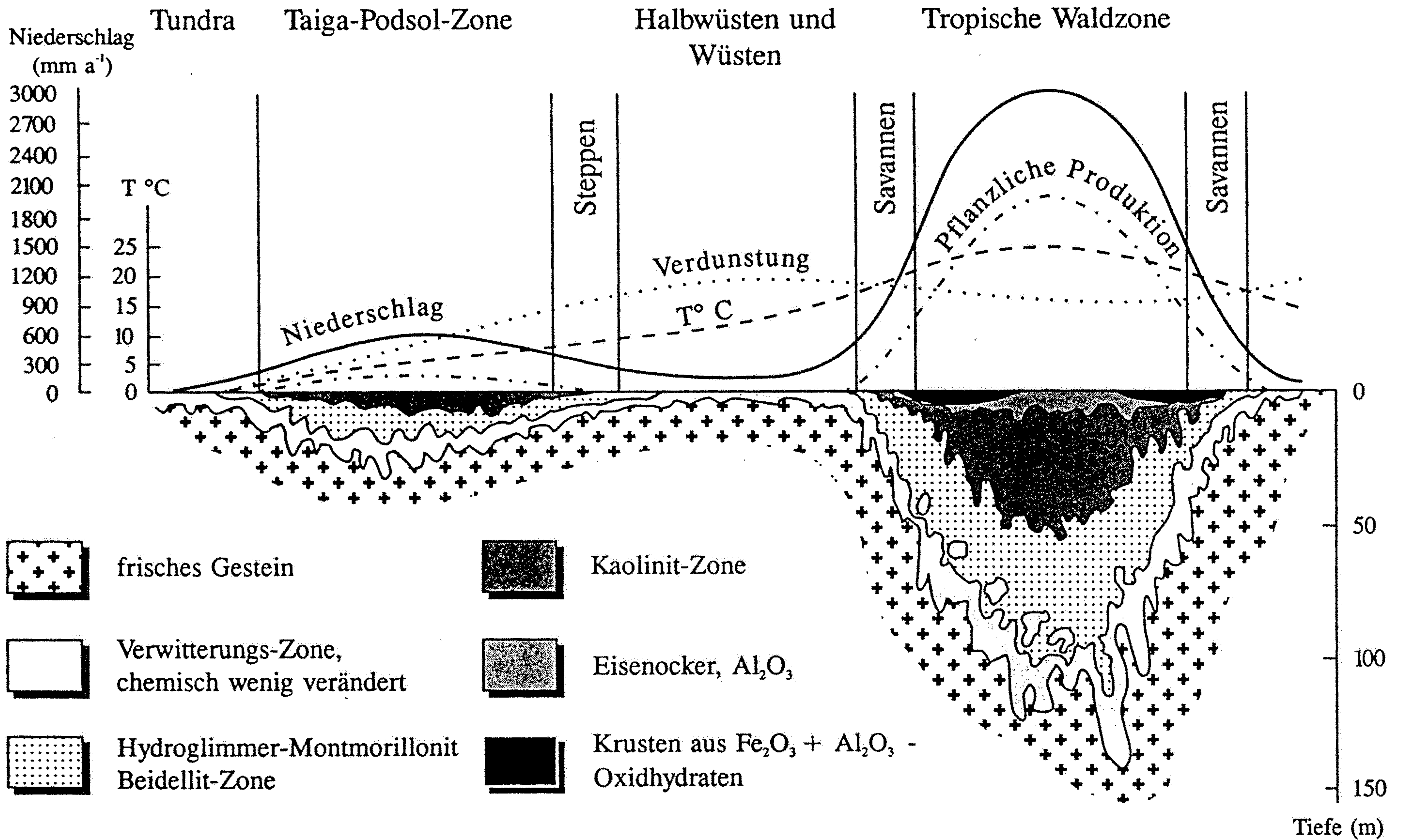
# ZVĚTRÁVÁNÍ

Obr. 262. Hlavní prvky uvolňované chemickým zvětráváním a jejich postupné vylučování z roztoků



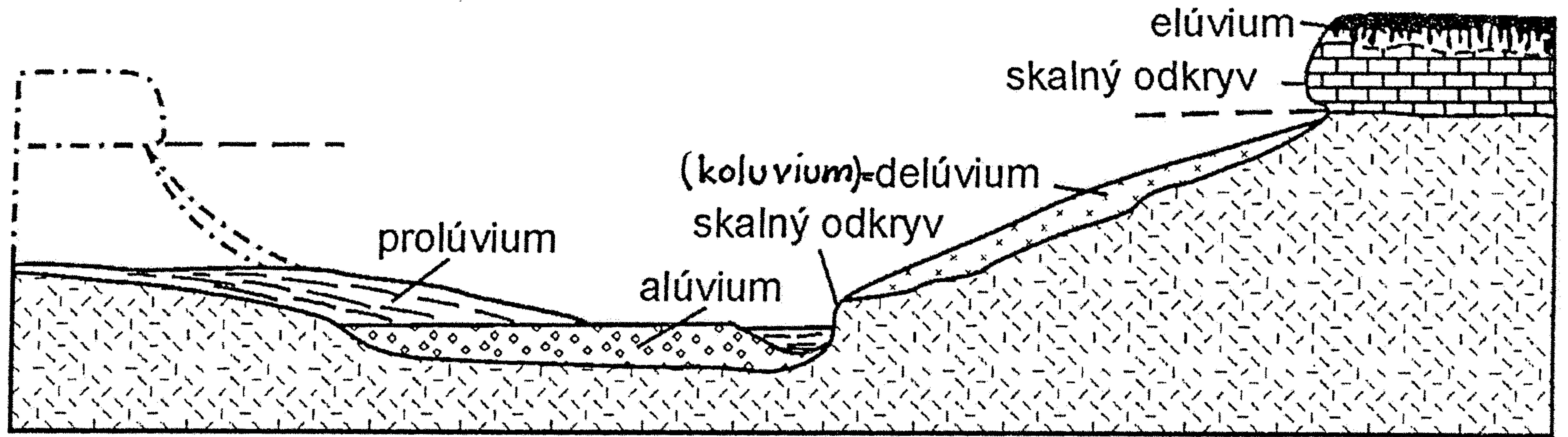
Obr. 11.9. Gosan (železný klobúk) je tvorený z produktov oxidácie primárnych minerálov (sulfidov) Fe v pripovrchových častiach rudných ložísk.  $Fe^{3+}$  je nepohyblivé a vo forme limonitu ostáva na mieste zvetrania. Rozhranie h.p.v. = hladina podzemnej vody. (upravené podľa Petránka 1993)





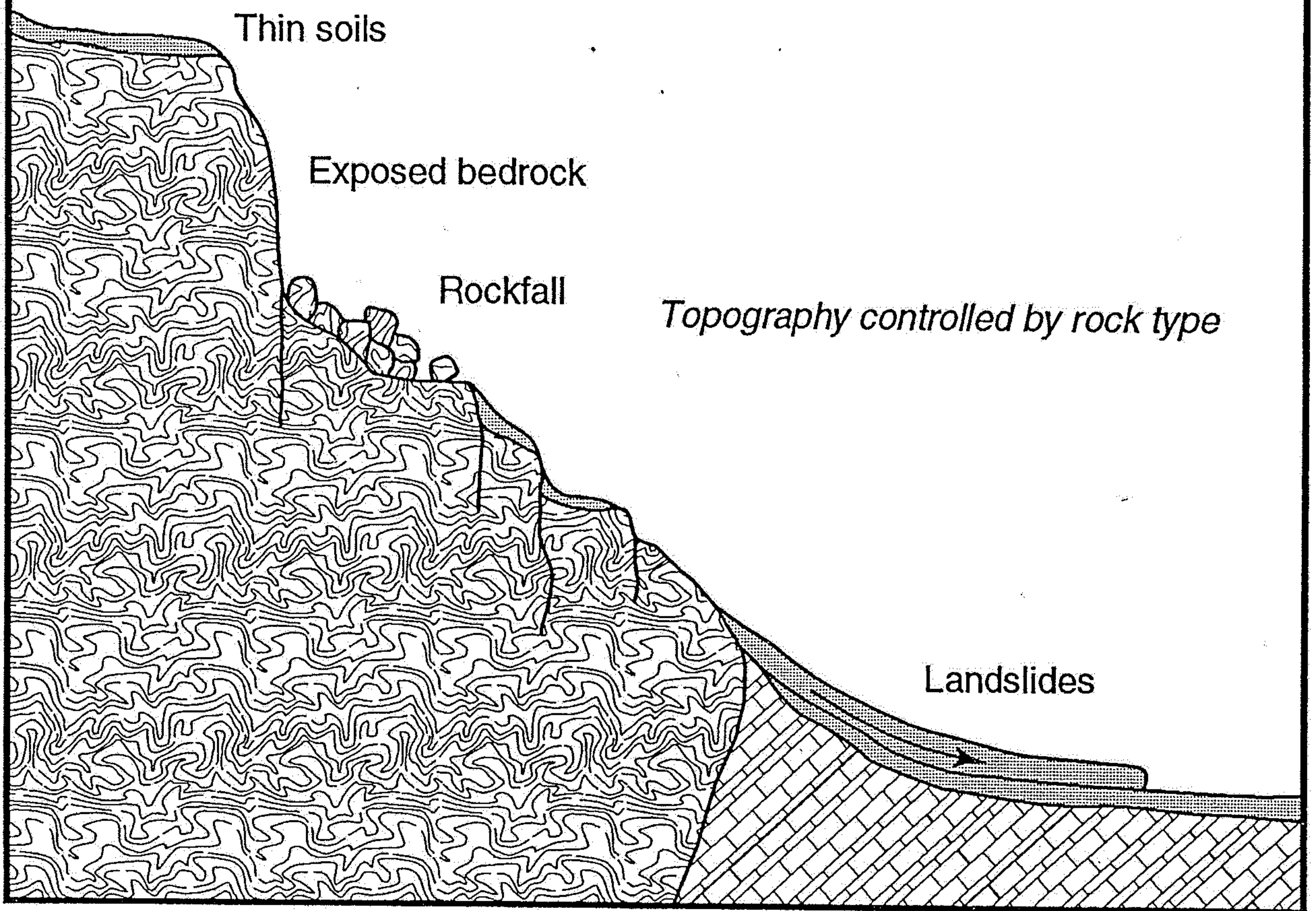
**Abb. 3.8**

Faktoren der Verwitterung und Bodenbildung in einem Profil vom Pol zum Äquator. Bemerkenswert ist die tiefgründige Verwitterung im tropisch-humiden Bereich (verändert nach STRACHOW, 1962).

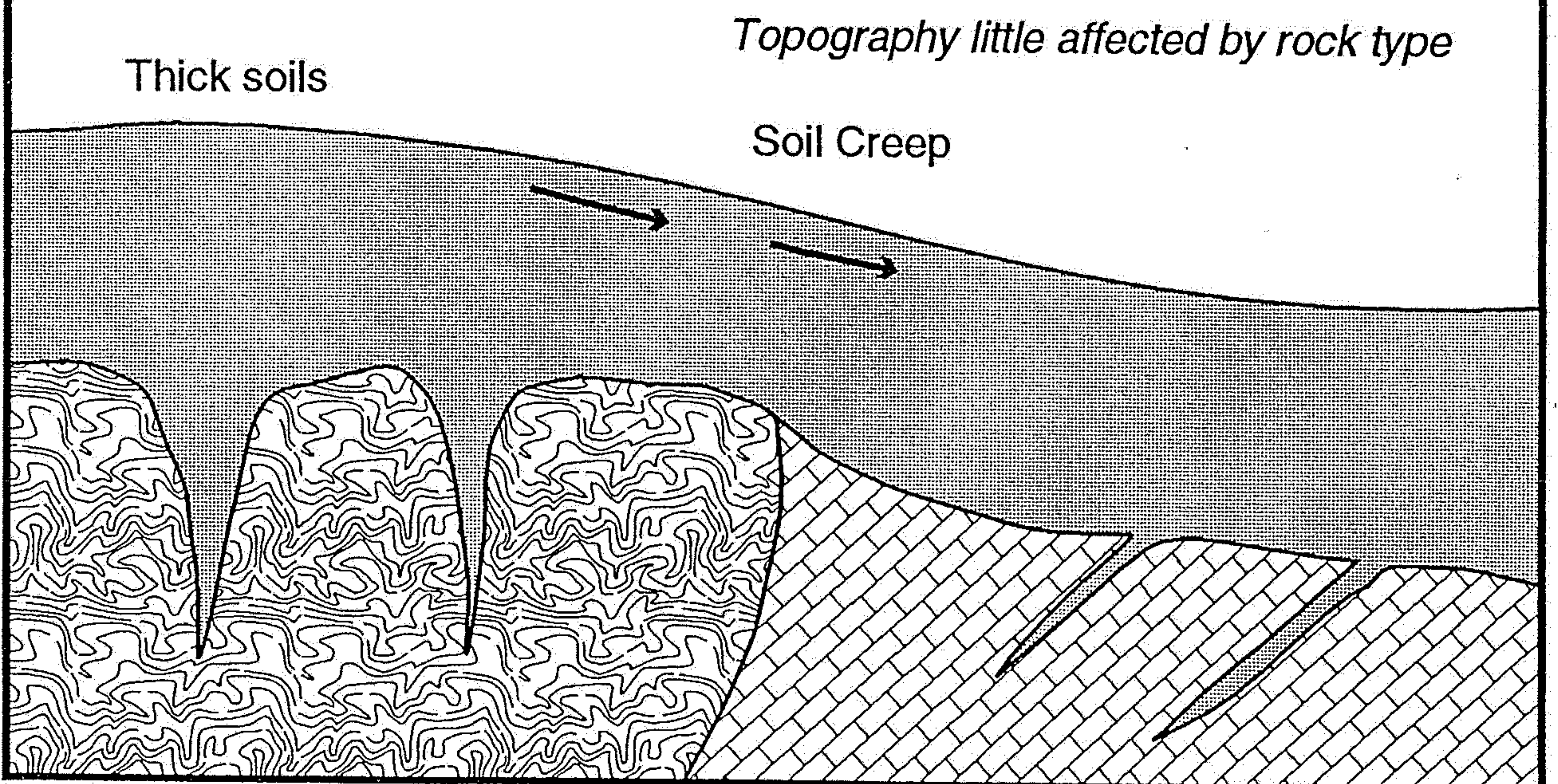


*Obr. 11.6. Pokryvné útvary zahrňujú rôzne druhy zvetranín a mladých sedimentov, ktoré prekrývajú starší podklad. Odkryv je miesto výchozu podkladu na povrch. Alúvium je sediment riečneho údolia. Prolúviá sú akumulácie vodou slabotriedených zvetranín bočných údolí. Do hlavnej doliny vybiehajú v podobe náplavového vejára. Svah za údolím s prolúviom je vyznačený bodkočiarkovane*

### A) Weathering-limited erosion



### B) Transport-limited erosion



**Figure 8.8.** Schematic cross-sectional diagrams exhibiting important characteristics of regions experiencing (A) weathering-limited erosion, and (B) transport-limited erosion. (Source: Adapted from M. J. Johnson and W. A. Nierenber, eds., Chemical weathering controls on sand composition, *Encyclopedia of Earth System Science*, Academic Press, 1992.)