GEOKEMIJA SEDIMENTNIH KAMNIN

Magmatske in metamorfne kamnine na Zemljinem površju niso obstojne zaradi atmosferskih pogojev:

- Nižji tlak (p)
- Nižja temperatura (T)
- Prisotnost
  - O_2
  - CO_2
  - H_2O

- **PREPEREVANJE**

  zajema procese, ki spreminjajo kemijske in fizikalne lastnosti kamnine na ali blizu Zemljinega površja. Kamnine med preperevanjem razpadejo na mestu ali med premikanjem.

- **EROZIJA**

  je fizično odstranjevane preperelih in/ali nepreperelih delcev kamnine.

- **TRANSPORT (PRENOS)**

  je premikanje erodiranih delcev s silo rek, valov, ledenikov ali vetra

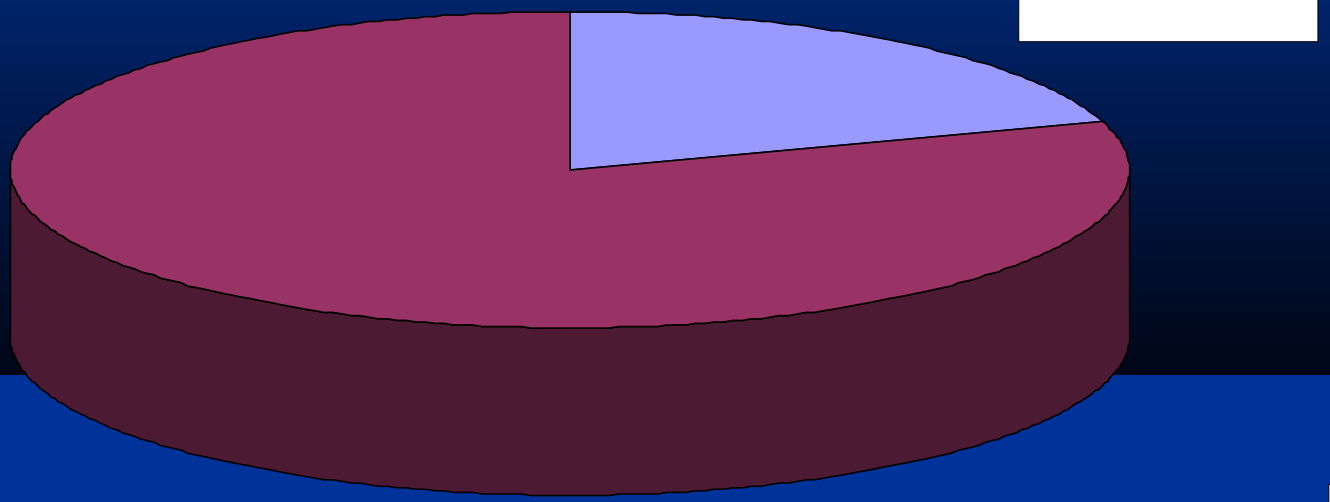
- **SEDIMENTACIJA**

  je odlaganje delcev ali obarjanje iz vodne raztopine, kompakcija in litifikacija

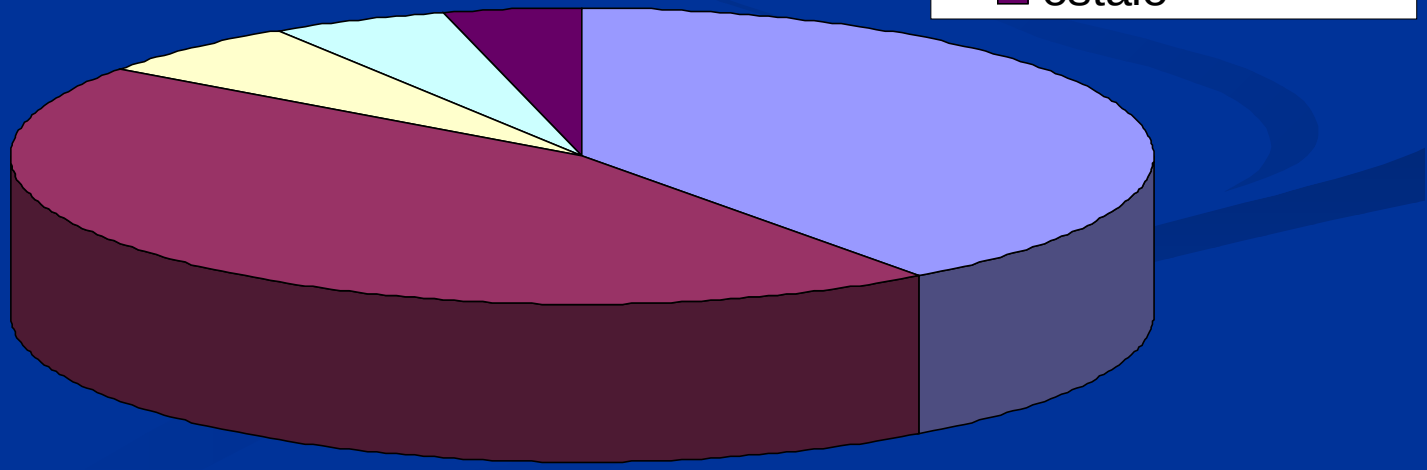
Čas potreben za preperevanje 1 mm kamnine v kaolinit

Kamnina	Podnebje	Čas (leta)
Felsična	Tropsko polpuščavsko	65 – 200
	Tropsko vlažno	20 – 70
	Zmerno vlažno	41 – 250
	Hladno vlažno	35
Metamorfna	Zmerno vlažno	33
Mafična	Zmerno vlažno	68
	Tropsko vlažno	40
Ultramafična	Tropsko vlažno	21 - 35

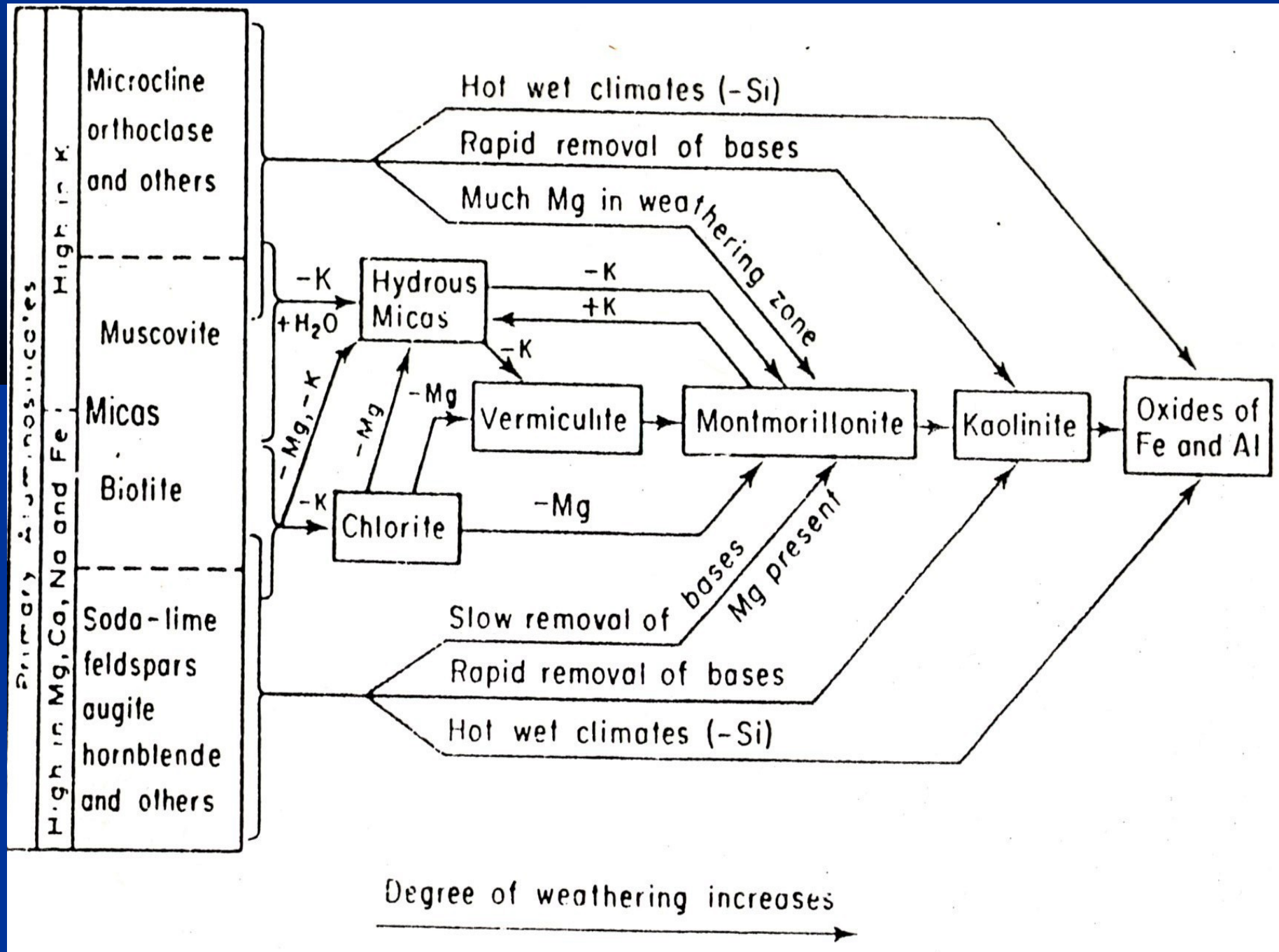
MAGMATSKE IN METAMORFNE KAMNINE



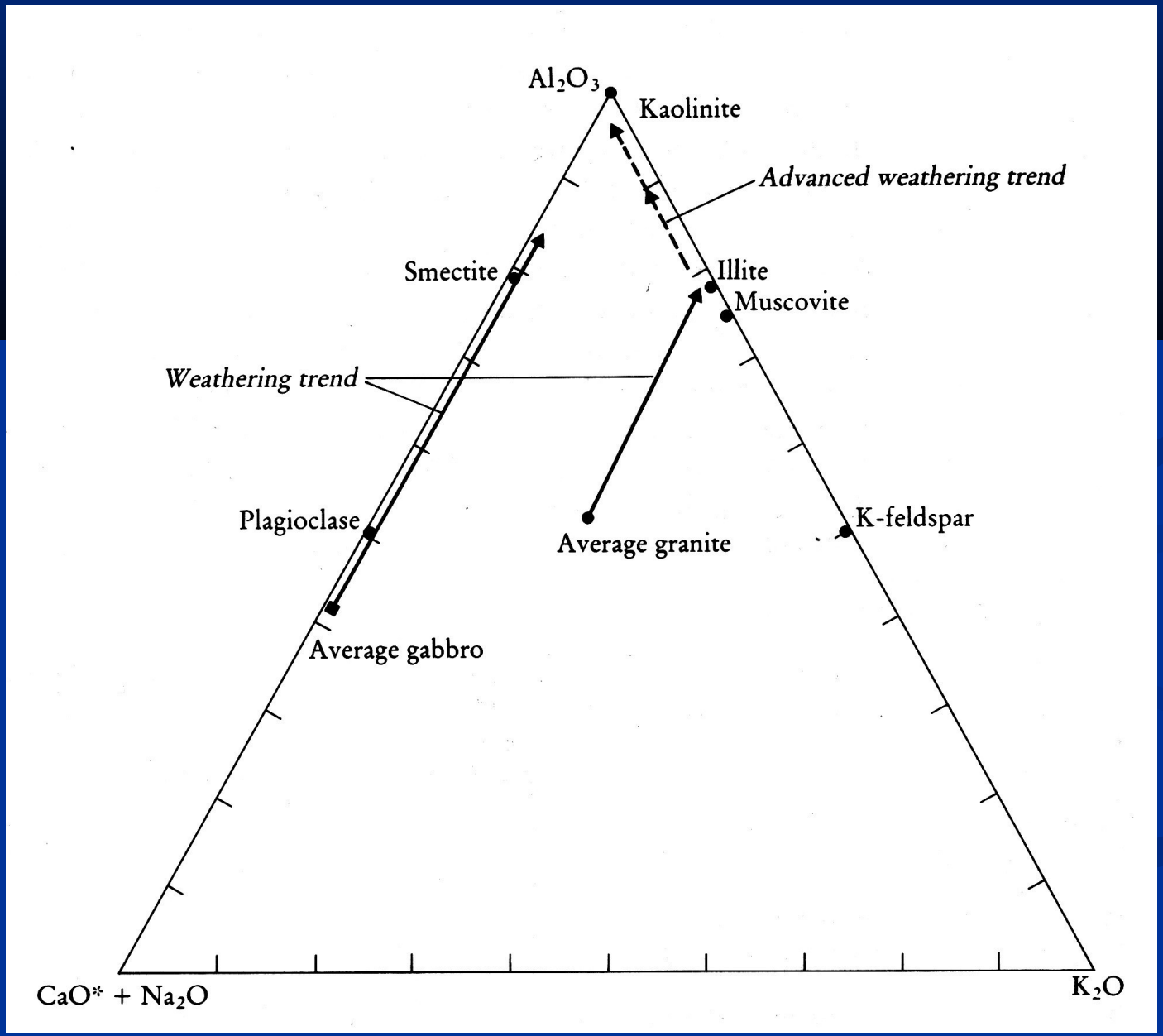
SEDIMENTNE KAMNINE



Primarni mineral	Glavni sekundarni mineral	Drugi (večinoma topni) produkti
Glinenec	Glineni mineral (illit, kaolinit)	Na^+, Ca^{2+}, K^+, SiO_2
Feromagnezijski minerali (pirokseni, amfiboli, biotit)	Glineni mineral (klorit, montmorillonit)	Na^+, Ca^{2+}, K^+, SiO_2, Fe oksidi
Muskovit	Glineni mineral (illit)	K^+, SiO_2
Kremen	Kremenova zrna	
Kalcit		Ca^{2+}, HCO_3^-


Primary aluminosilicates
High in K
High in Mg, Ca, Na and Fe
Microcline
orthoclase
and others
Muscovite
Micas
Biotite
Soda-lime
feldspars
augite
hornblende
and others
Hot wet climates (-Si)
Rapid removal of bases
Much Mg in weathering zone
-K
+H2O
Hydrous
Micas
-K
+K
-K
-Mg, -K
-Mg
-Mg
Vermiculite
Montmorillonite
Kaolinite
Oxides of
Fe and Al
-K
Chlorite
-Mg
Slow removal of bases
Mg present
Rapid removal of bases
Hot wet climates (-Si)
Degree of weathering increases

Sprememba kemizma med preperevanjem



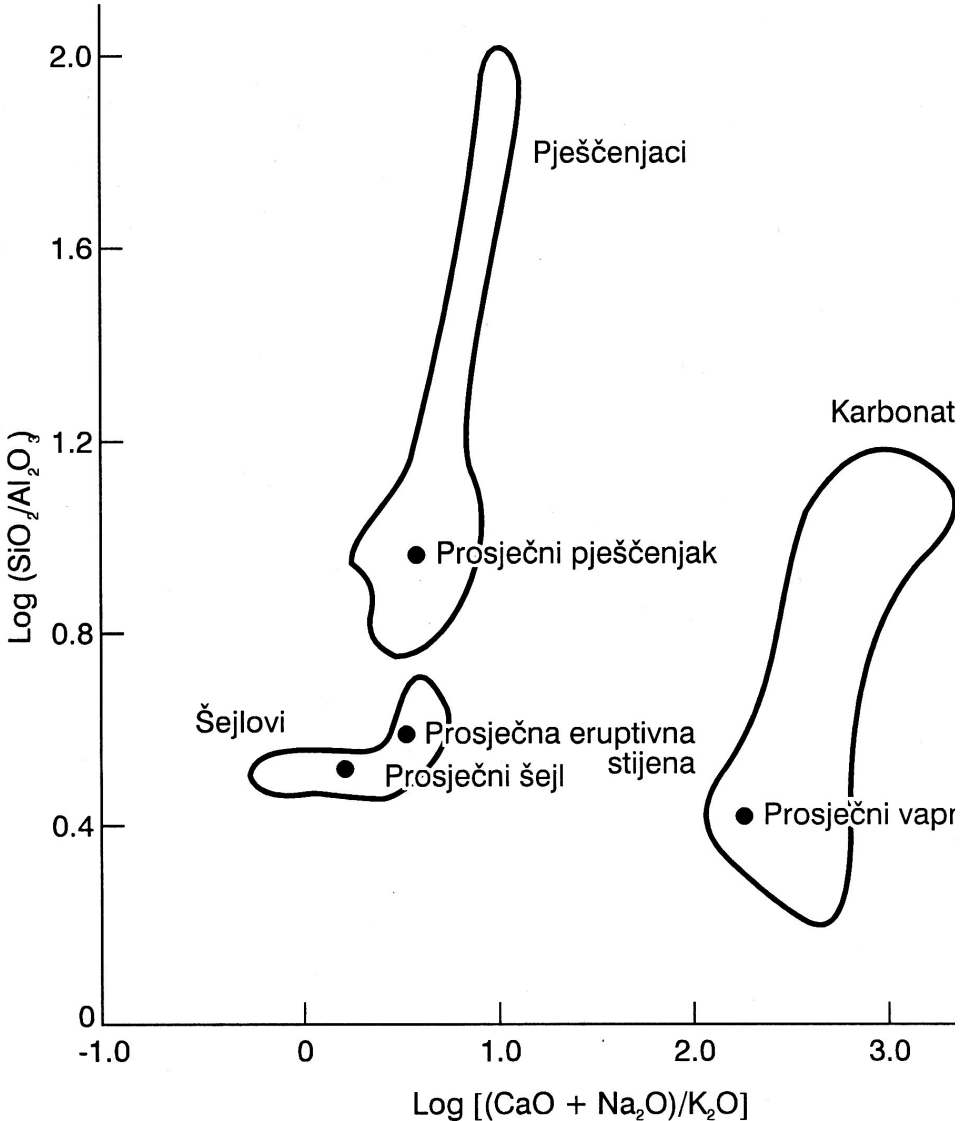
Kemijska sestava sedimentnih kamnin

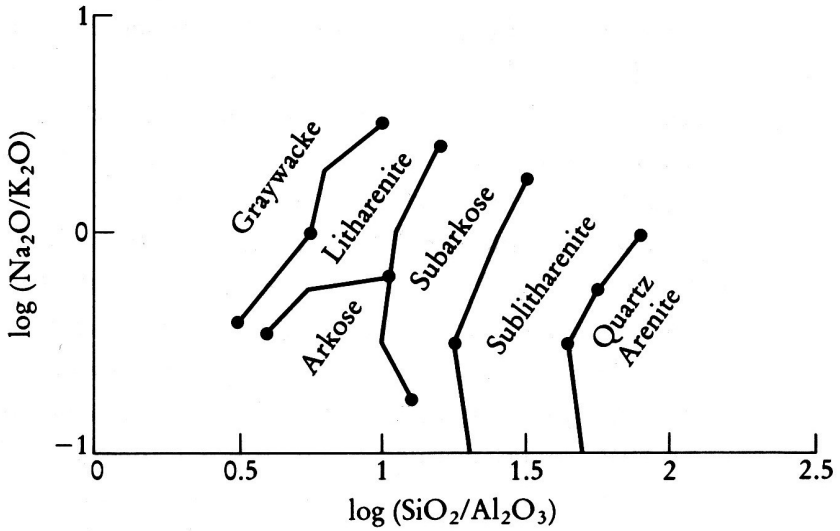
	PEŠČENJAK	GLINAVEC	APNENEC	DOLOMIT
SiO_2	72,21	56,29	0,29	3,24
TiO_2	0,22	0,64		
Al_2O_3	10,69	19,22	0,26	0,17
Fe_2O_3	0,80	4,39	0,11	0,17
FeO	0,72			0,06
MnO	0,22		0,01	
MgO	1,47	1,65	0,70	20,84
CaO	3,85	0,09	55,53	29,58
Na_2O	2,30	0,19	0,07	
K_2O	3,32	10,85	0,02	
P_2O_5	0,10	2,04	0,05	
CO_2	2,66		43,42	45,54

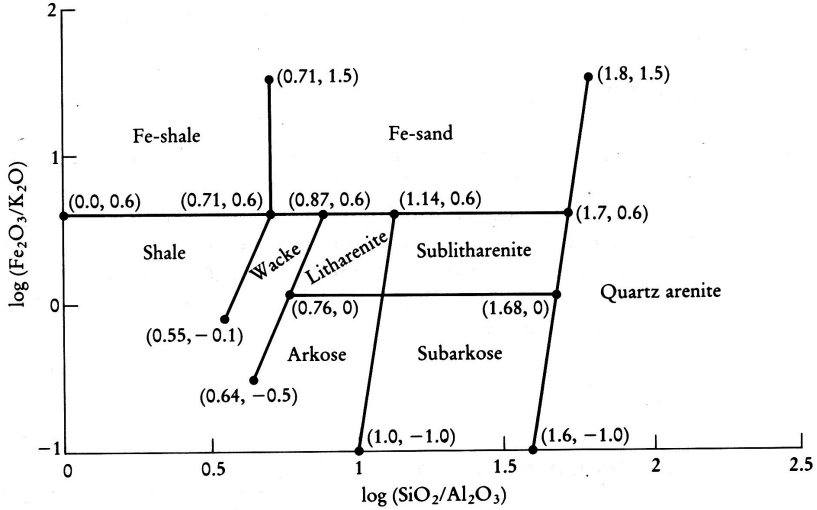
Kemijska sestava sedimentnih kamnin

	PEŠČENJAK	GLINAVEC	APNENEC
As	0,43 - 3,0	4,4 - 9,2	0,17 - 2,0
Ba	38 - 170	220 - 510	5,6 - 160
B	18 - 36	43 - 110	29 - 31
Cr	2 - 39	62 - 130	2,7 - 29
Co	1,6 - 7,4	4,8 - 13	1,3 - 7,1
Cu	1,2 - 8,4	13 - 130	0,84 - 12
La	6 - 36	29 - 67	24
Ni	1,2 - 18	21 - 110	2,3 - 16
Pb	5 - 17	11 - 24	4 - 18
Sc	2,1 - 7,2	8,2 - 18	6,1 - 9
Se	0,09 - 0,11	0,46 - 0,64	0,16 - 0,31
Sr	13 - 99	90 - 200	100 - 990
V	5,3 - 38	74 - 400	3,9 -40
Zn	5,2 - 31	55 - 82	6,3 - 24
Zr	22 - 170	95 - 230	6,5 - 42

Klasifikacija – glavne prvine







KEMIJSKE REAKCIJE MED PREPEREVANJEM

- Oksidacija
- Hidroliza silikatov
- Raztapljanje karbonatov

OKSIDACIJA

- **Silikati, karbonati**
  - $2Fe_2SiO_4 + O_2 + 4H_2O \Leftrightarrow 2Fe_2O_3 + H_4SiO_4$

    fayalit hematit
  - $4FeCO3 + O_2 + 4H_2O \Leftrightarrow 2Fe_2O_3 + H_2CO_3$

    siderit hematit
- **Sulfidi**
  - $PbS + 2O_2 \Leftrightarrow PbSO_4$
  - $ZnS + 2O_2 \Leftrightarrow Zn^{2+} + SO_4^{2-}$

Raztapljanje karbonatov

$CO_2 + H_2O \Leftrightarrow H_2CO_3$

$CaCO_3 + H_2CO_3 \Leftrightarrow Ca^{2+} + 2HCO^{3-}$

Kalcit

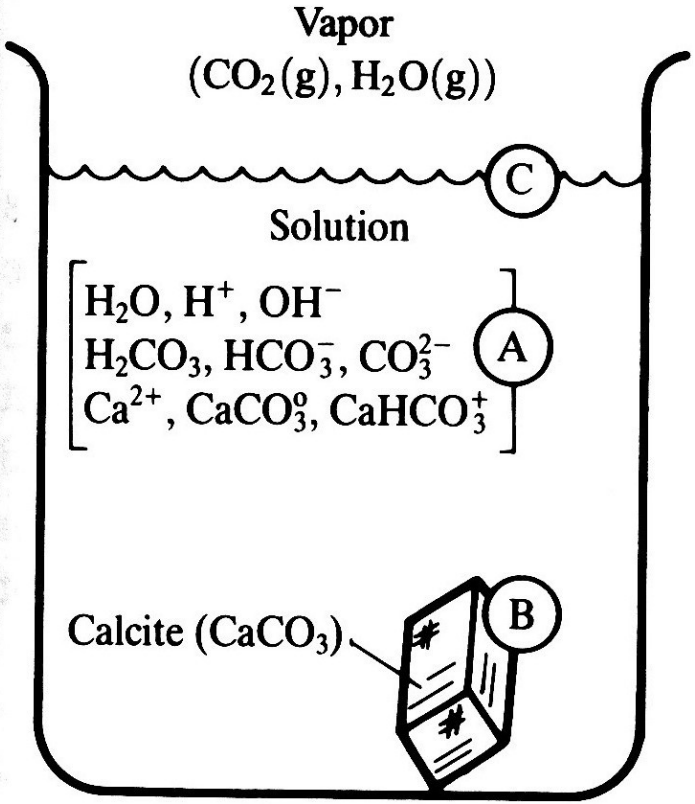


FIGURE 3-1
Conditions for heterogeneous equilibrium between calcite and a solution of carbonic acid, and between solution and carbon dioxide in the gas. The principal ions present in the solution are indicated. Examples of heterogeneous equilibria would be:

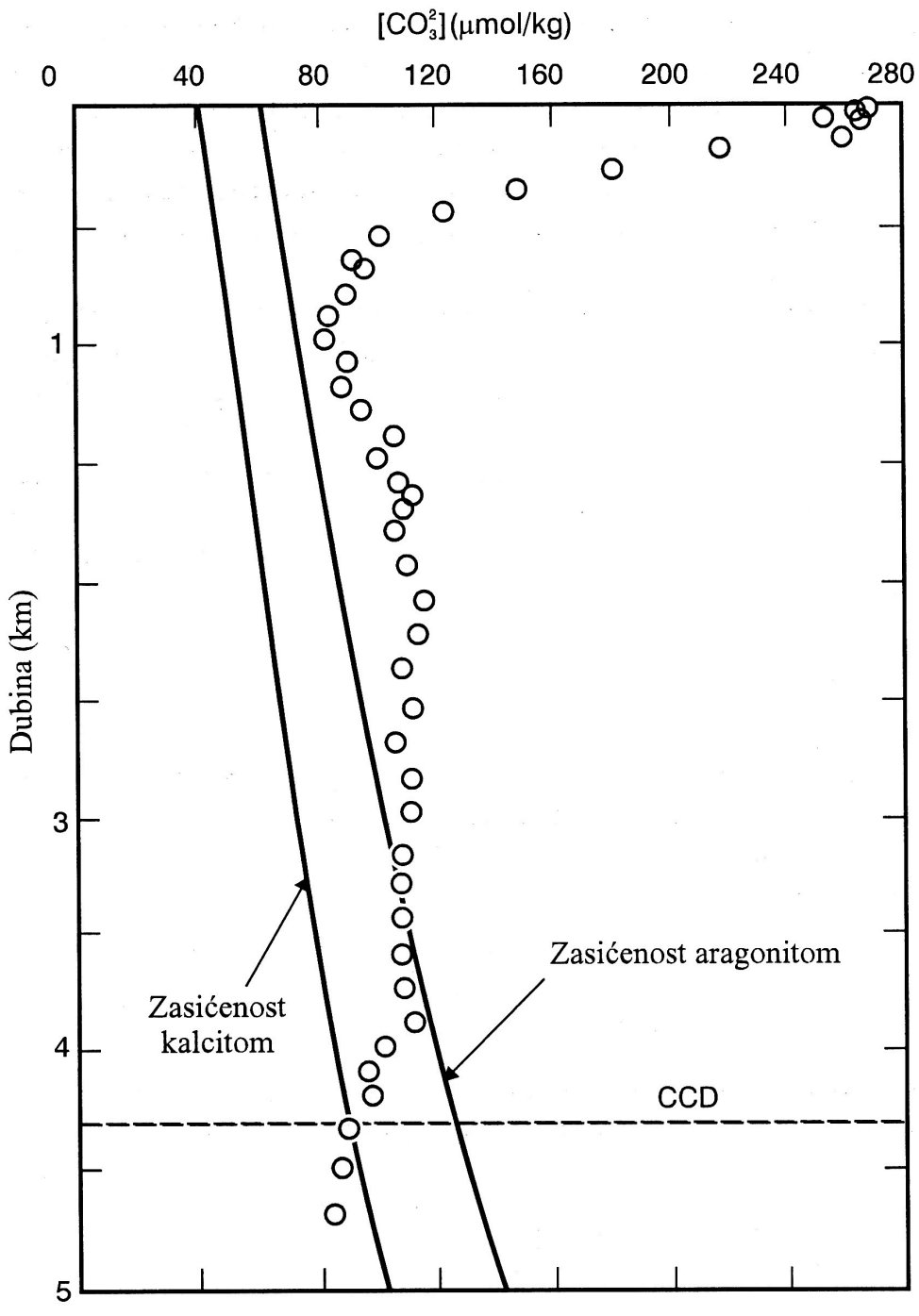
$$CaCO_3(\text{calcite}) \rightleftharpoons Ca^{2+} + CO_3^{2-},$$
$$CaCO_3(\text{calcite}) + H^+ \rightleftharpoons Ca^{2+} + HCO_3^-,$$
$$H_2O(l) + CO_2(g) \rightleftharpoons H_2CO_3(aq),$$

and examples of homogeneous equilibria would be:

$$CaCO_3(aq) \rightleftharpoons Ca^{2+} + CO_3^{2-},$$
$$CaHCO_3^+ \rightleftharpoons Ca^{2+} + HCO_3^-.$$

Na topnost vplivajo:

- **Temperatura**
  - **Z višanjem T topnost kalcita v čisti vodi pada (obratno kot pri večini kamninotvornih mineralov)**
  - **Razlog je tudi v tem, da z višanjem T pada tudi topnost CO_2 v vodi**
  - **V oceanih se karbonat v globini v hladni vodi raztapla, v topli površinski obarja**
- **Tlak**
  - **Zvišanje p povzroči zvišanje topnosti kalcita (globina oceana)**
  - **Poglavitni razlog vpliva p blizu površja je količina raztopljenega CO_2**
- **Organska aktivnost**
  - **Vgrajevanje $CaCO_3$ (ar) v lupine organizmov**
  - **Fotosinteza zelenih rastlin (alge)– indirekten vzrok precipitacije**
- **Razpad organske snovi**
  - **Nastanek CO_2 poviša topnost karbonata**


[CO$_3^2$] (μmol/kg)
0
40
80
120
160
200
240
280
1
3
4
5
Dubina (km)
Zasićenost kalcitom
Zasićenost aragonitom
CCD

HIDROLIZA

- $H^+ \Leftrightarrow Ca^{2+}, Na^+, K^+$
- $H_2S, HF \Leftarrow$ vulkanski izbruhi, rudniške vode
- $H_2CO_3 \Leftarrow$ atmosfera, tla

$$2KAlSi_3O_8 + 2H^+ + 2HCO^{3-} + H_2O \Leftrightarrow Al_2Si_2O_5(OH)_4 + 2H^+ + 2HCO^{3-} + 4SiO_2$$

Glinenec — Glineni mineral — Kremen

$$Mg_2SiO_4 + 4H_2O \Leftrightarrow 2Mg^{2+} + 4OH^- + H_4SiO_4$$

Forsterit

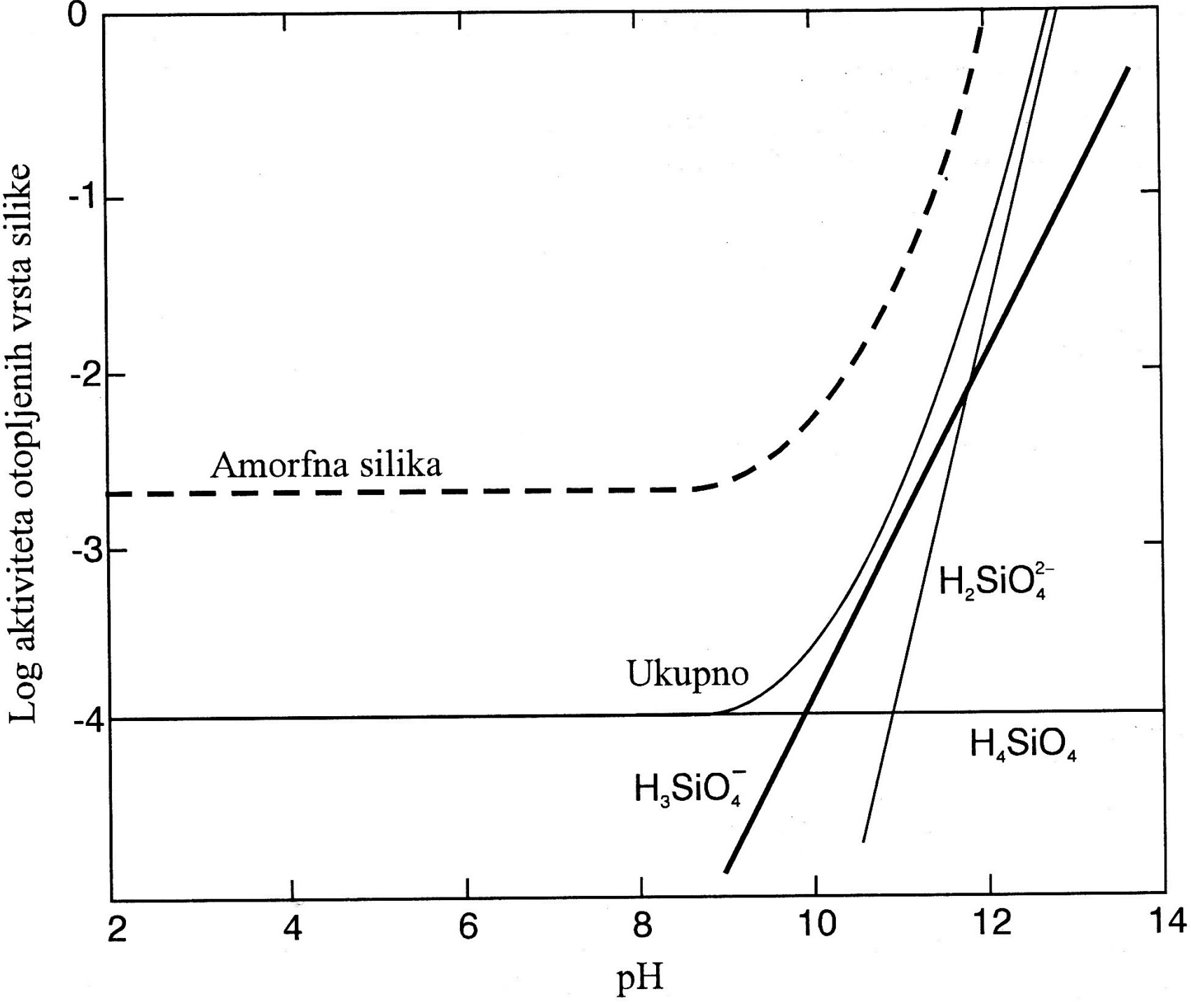
Sistem $SiO_2 - H_2O$

- $SiO_2 + 2H_2O \Leftrightarrow H_4SiO_4$ $\quad K_q = 10^{-4}$

  $K_{amf} = 2 \cdot 10^{-3}$

- Šibka kislina H_4SiO_4 pri pH>9 disociira v dveh stopnjah:
  - $H_4SiO_4 \Leftrightarrow H^+ + H_3SiO_4^-$ $\quad K_1 = 1{,}26 \cdot 10^{-10}$
  - $H_3SiO_4^- \Leftrightarrow H^+ + H_2SiO_4^{2-}$ $\quad K_2 = 5{,}01 \cdot 10^{-11}$
- Koncentracija vseh oblik SiO2 je:
- $\sum Si = mol_{H_4SiO_4} + mol_{H_3SiO_4^-} + mol_{H_2SiO_4^{2-}}$

$$\sum Si = mol_{H_4SiO_4}\left[1 + \frac{K_1}{H^+} + \frac{K_1 K_2}{H^+}\right]$$


Log aktiviteta otopljenih vrsta silike
0
-1
-2
-3
-4
Amorfna silika
Ukupno
$H_2SiO_4^{2-}$
H_4SiO_4
$H_3SiO_4^-$
2
4
6
8
10
12
14
pH

Sistem $K_2O - Al_2O_3 - H_2O$

- $KAlSi_3O_8 + H^+ + 4{,}5H_2O \Leftrightarrow 0{,}5\ Al_2Si_2O_5 + K^+ + 2H_4SiO_4$

  K-glinenec Kaolinit

- $KAlSi_3O_8 + H^+ + 2H_2O \Leftrightarrow 0{,}5\ Al_2Si_4O_{10}(OH)_2 + K^+ + 2H_4SiO_4$

  K-glinenec Pirofilit

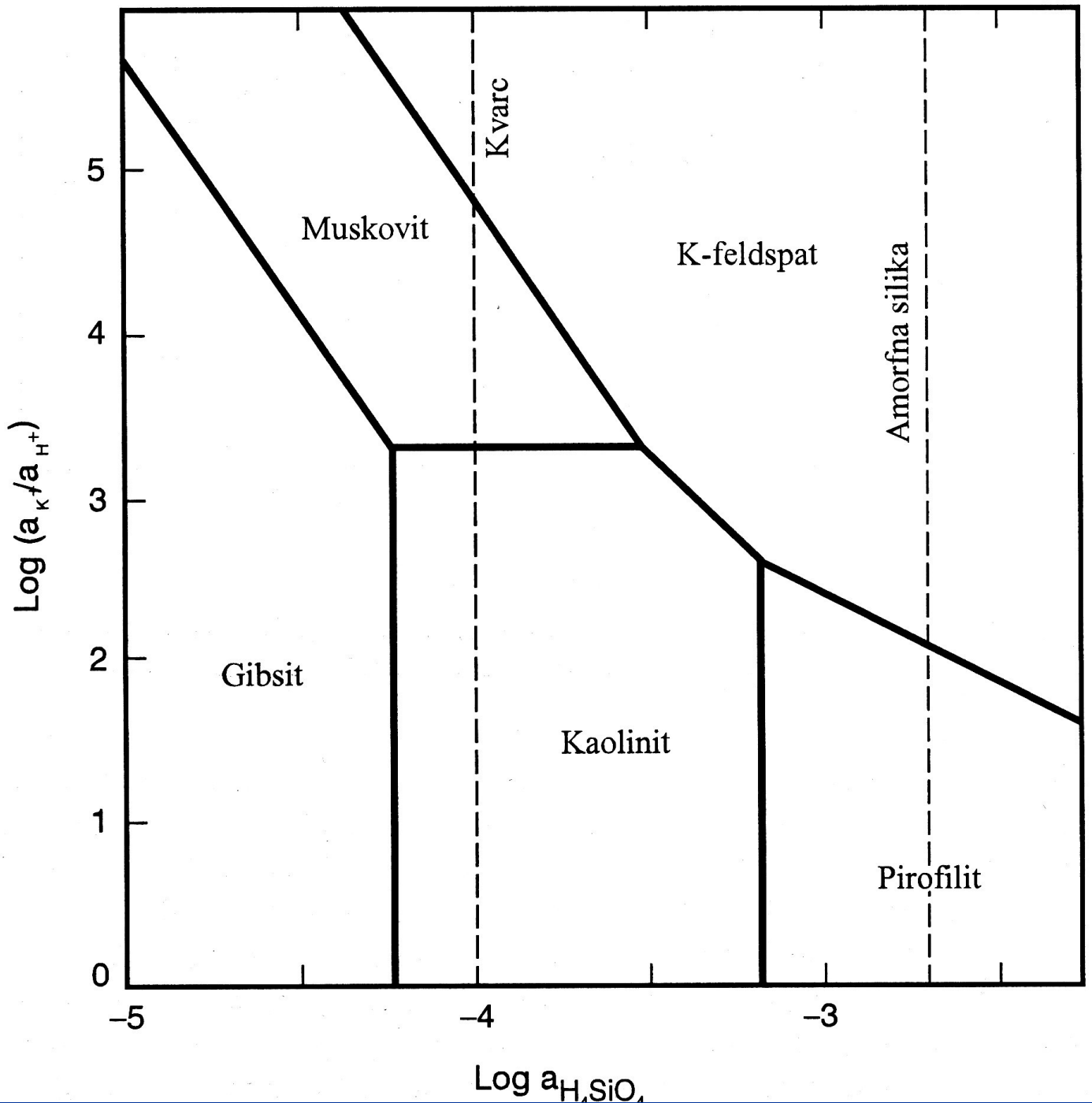
- $KAlSi_3O_8 + 2/3H^+ + 4H_2O \Leftrightarrow 1/3\ KAl_3Si_3O_{10}(OH)_2 + 2/3K^+ + 2H_4SiO_4$

  K-glinenec Muskovit

- $KAlSi_3O_8 + H^+ + 1{,}5H_2O \Leftrightarrow 1{,}5\ Al_2Si_2O_5(OH)_4 + K^+$

  K-glinenec Kaolinit

- $0{,}5\ Al_2Si_4O_{10}(OH)_2 + 2{,}5H_2O \Leftrightarrow 1{,}5\ Al_2Si_2O_5(OH)_4 + 2H_4SiO_4$


Kvarc
Muskovit
K-feldspat
Amorfna silika
Gibsit
Kaolinit
Pirofilit
5
4
3
2
1
0
–5
–4
–3
Log (a_{K^+}/a_{H^+})
Log $a_{H_4SiO_4}$

Eh – pH diagrami

- pH
  - $H_2O \Leftrightarrow H^+ + OH^-$
  - $K = m_{H+}\ m_{OH-}/m_{H2O} = m_{H+}\ m_{OH-} = 10^{-14}$
  - $pH = -\log m_{H+}$
- Eh
  - $E^0 = \Delta G/nF$
  - $Eh = E^0 + \frac{0,059}{n}\log K$

$H_2O \Leftrightarrow 2H^+ + ½\ O_2 + 2e^-$ $\quad E^0 = 1{,}23V$

$Eh = E^0 + 0{,}059/n \log K$

$Eh = 1{,}23 + 0{,}03 \log a^{0,5}_{O_2}\ a^2_{H^+}$

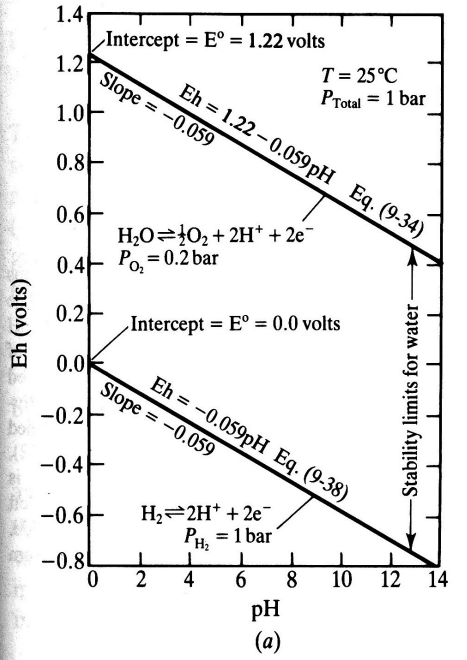
Ker je kisika približno 1/5 atmosfere, za njegovo koncentracijo privzamemo 0,2 atm

$Eh = 1{,}23 + 0{,}03 \log (0{,}2)^{0,5} + 0{,}059 \log a_{H^+}$

$Eh = 1{,}22 - 0{,}059\ pH$

$H_2 \Leftrightarrow 2H^+ + 2e^-$ $\quad E^0 = 0V$

$Eh = - 0{,}059\ pH$



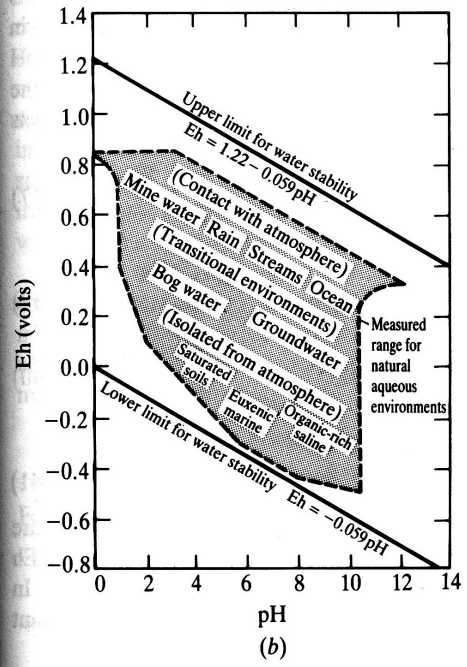


FIGURE 9-1
Framework of Eh–pH diagrams. Diagonal lines in (*a*) define the upper [Eq. (9-34)] and lower [Eq. (9-38)] stability limits for water at 25°C and 1 bar. The shaded area in (*b*) shows the measured limits of Eh and pH in natural environments. (Reprinted by permission from Baas Becking et al., 1960.)

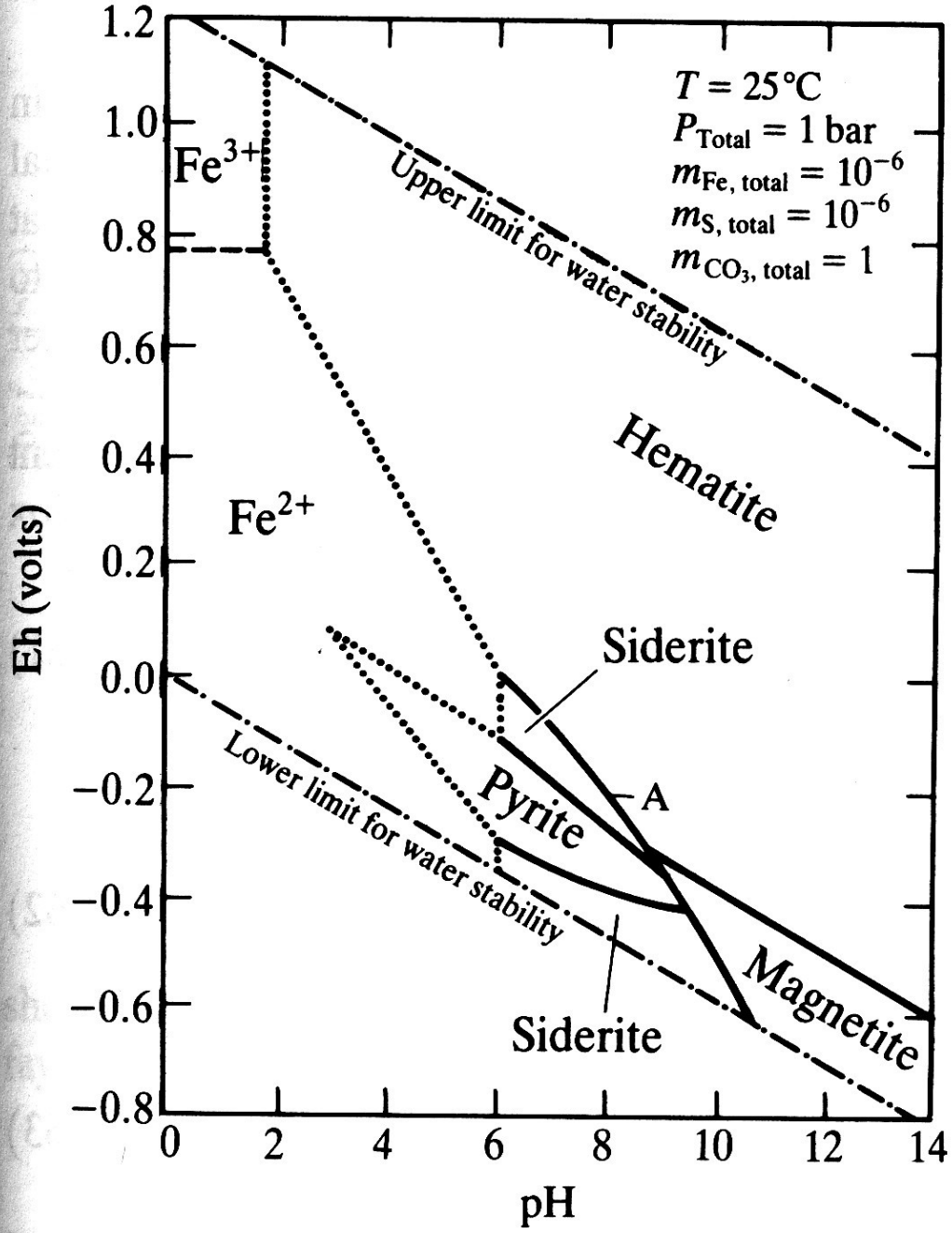


FIGURE 9-5
Eh–pH diagram showing fields of common iron minerals. Total concentration of dissolved carbonate $1m$, of dissolved sulfur $10^{-6}m$. The dotted boundaries on the left side of the diagram represent equilibrium of hematite, siderite, and pyrite with a solution containing $10^{-6}m$ total iron. (Reprinted by permission from Garrels and Christ, 1965.)