Accessory minerals

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Beryl and Be-minerals

Thesis:

1. **Introduction**
2. **Beryl group**
3. **Beryl**
4. **Minerals ofy Be**
5. **Alteration of Be-minerals**

1. Introduction

- **Berylium (Be) is a specific element due to i amphoteric behavior.**

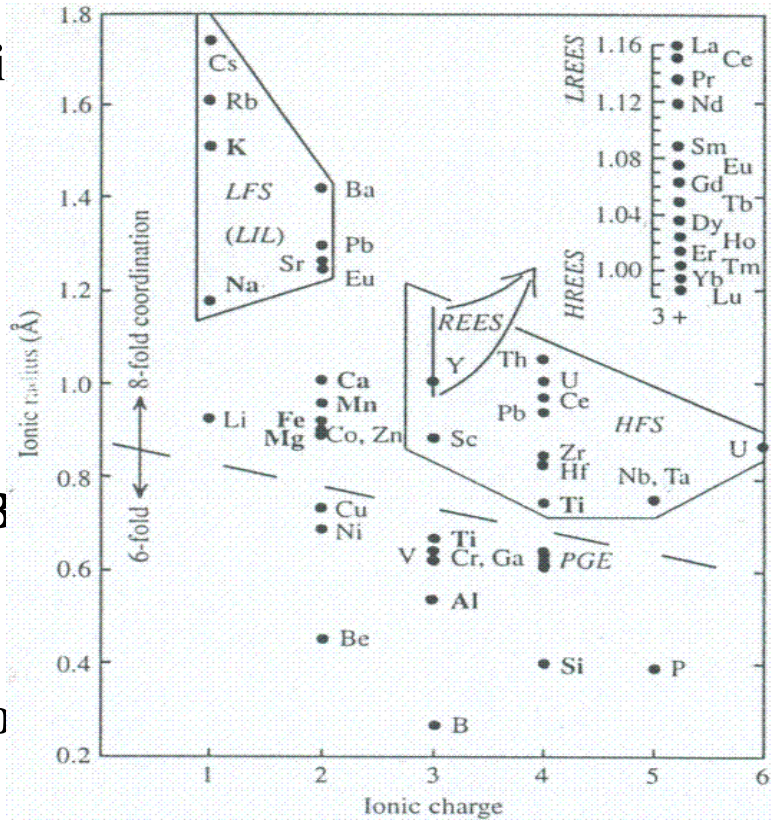
- **Cation radius –**

  ^{IV}Be = 0,27 Å

  ^{VI}Be = 0,45 Å

  and low valency control incorporation of B into tetrahedral sites usually occupied by

  Si, Al or P and Be mostly enter further tetrahedral site T(2) commonly with Al, po Li or B.



1. Introduction

- **Low ability of Be to enter the same structural positions as other elements**
- **Caused high number of Be-bearing minerals 110. Beryllium may be present as classical cation e.g., in bertrandite**

$Be_4[Si_2O_7]\ (OH)_2$,

but it also enters anionic part of alumosilicates

of alkalis (Na) e.g., in epididymite

$Na_2[Be_2Si_6O_{15}]\ .\ H_2O$.

The most common mineral of Be is ber

2. Beryl group

- **Common formula:**

  $CT(2)_3O_2T(1)_6O_{18}$

- **site *C* (channel) = vacancy, Na, Cs, H_2O (He, Ar)**

  I H_2O

  II H_2O

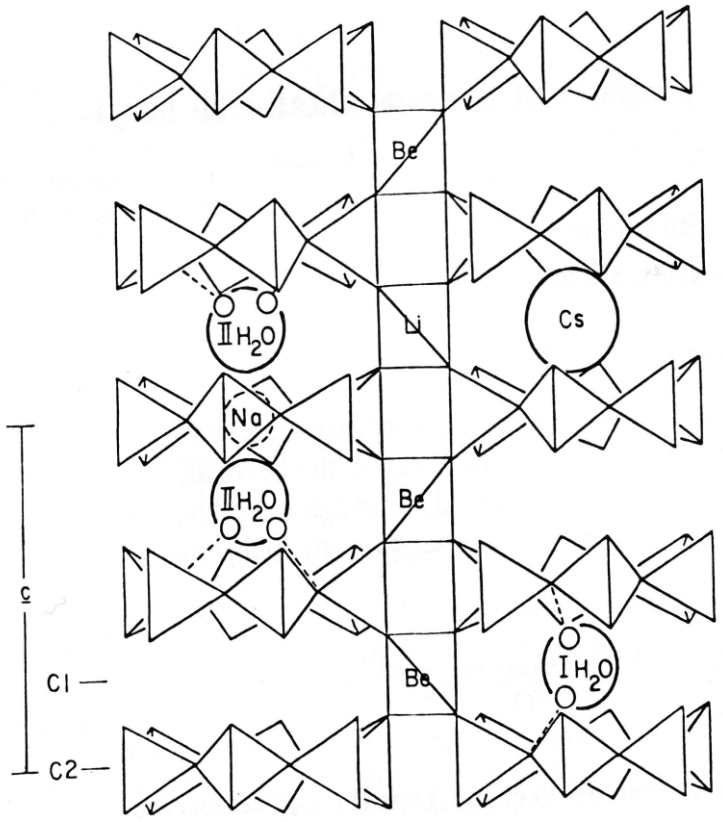
- **site *T(2)* (tetrahedral 2) = Be, Li, Al (vacancy)**
- **Site *O* (oktahedral) =**

  Al, Fe^{3+}, Sc,

  Mg, Fe^{2+}, Cr, V, Mn

- **Site *T(1)* (tetrahedral 1) = Si, Al**

- **Hexagonal**



2. Beryl group

Further formula:

$^{C}(Na,Cs)_{2X-Y+Z}\ ^{C}(H_2O,He,Ar)_{2-(2X-Y+Z)+Na}$

$^{T(2)}(Be_{3-X}Li_{Y\square X-Y})$

$^{O}(Al,Fe,Sc,Cr)^{3+}_{2-Z}\ ^{O}(Fe,Mg,Mn)_{Z}$

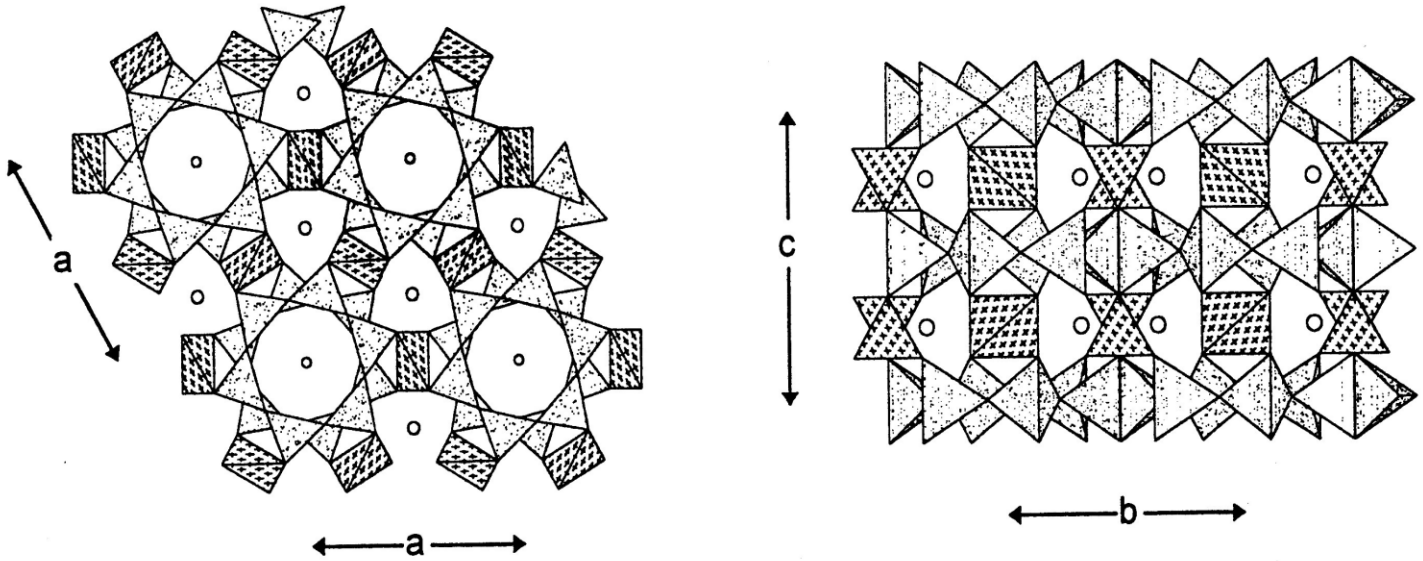
$^{T(1)}[Si_6O_{18}]$ kde $2 \geq Y, X \geq Y, Z << 2$ a $2 \geq 2X-Y+Z$

Typical substitutions

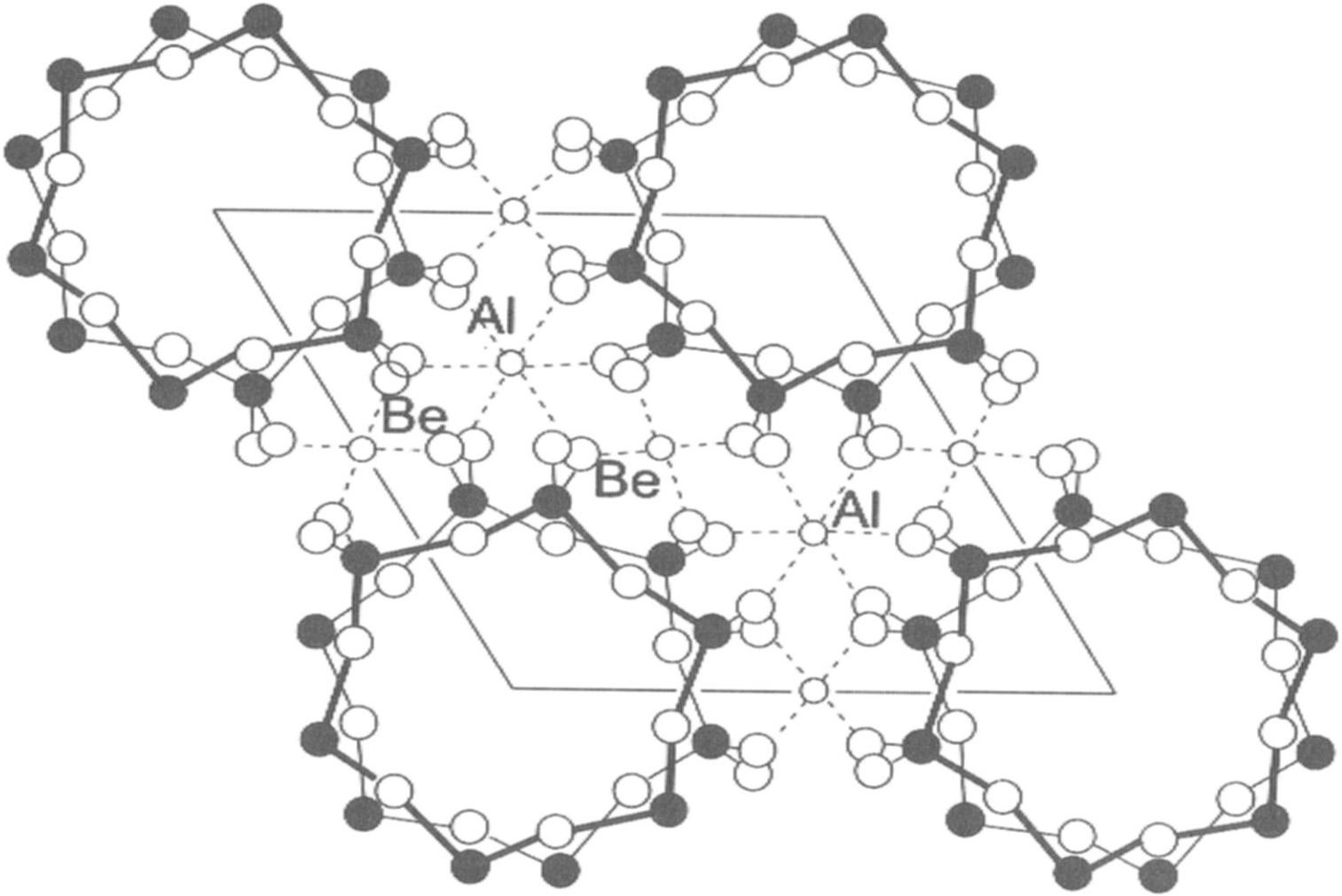
Al = Sc or Fe^{3+}

$^{CH}\square\ ^{O}R3+ = {}^{CH}R+\ {}^{O}R2+$

where $^{CH}R+$ =Na, Cs; $^{O}R3+$ = Al, Sc, Fe3+; $^{O}R2+$ = Mg, Fe2+



2. Beryl group



2. Beryl group

- **Table 1. Review of beryl group minerals**

Mineral	idealized formula	typ locality	described
Beryl	$Be_3Al_2Si_6O_{18}$	neznámá	old
Bazzite	$Be_3Sc_2Si_6O_{18}$	Baveno, Alpy	1915
Stoppaniite	$Be_3Fe^{3+}{}_2Si_6O_{18}$	Capranica, Řím	1998
Pezzottaite	$CsBe_2LiAl_2Si_6O_{18}$	Madagascar	2003
Indialite	$Al_3Mg_2Si_5AlO_{18}$	Bihar, Indie	1954

Because indialite does not contain Be, it is not discussed futhermore.

2. Beryl group

All these beryl group minerals are very rare

Bazzit $Be_3Sc_2Si_6O_{18}$

Ve srovnání s berylem jde o velmi vzácný minerál známý jen z několika málo desítek lokalit na celém světě. Bazzit má většinou jasně modrou barvu, poněkud nižší tvrdost a vyšší hustotu, ale jinak je velmi podobný berylu. Tmavě modré beryly jsou bez detailnějšího studia neodlišitelné. Bazzit se vyskytuje výhradně v pegmatitech vzácných zemin, kde často krystaluje v dutinách. Nejznámější lokalitou je Baveno v Itálii, vyskytuje se také v Königshainu u Görlitz, Německo poblíž našich hranic.

Stoppanit $Be_3Fe^{3+}{}_2Si_6O_{18}$

Dosud je znám pouze z jediné lokality v alkalických vulkanických horninách v oblasti Latium poblíž Říma, jde tedy o extrémně vzácný minerál. Jeho vznik vyžaduje vysoce oxidační prostředí a vysokou aktivitu Be a Fe vedle nízké aktivity Al.

Pezzottait $CsBe_2LiAl_2Si_6O_{18}$

Zcela nově popsaný minerál ze skupiny berylu nazvaný podle mineraloga Přírodovědného muzea v Miláně Federica Pezzotty, který tento minerál objevil. Vyskytuje se na několika lokalitách komplexních pegmatitů na Madagaskaru, kde tvoří růžové tabulkovité krystaly až několik cm velké v dutinách pegmatitů, kde bývá doprovázen albitem. Už se stal velmi atraktivním minerálem pro sběratele.

3. Beryl

Beryl $Be_3Al_2Si_6O_{18}$

Beryl, Otov

Beryl, Maršíkov

3. Beryl

Písek

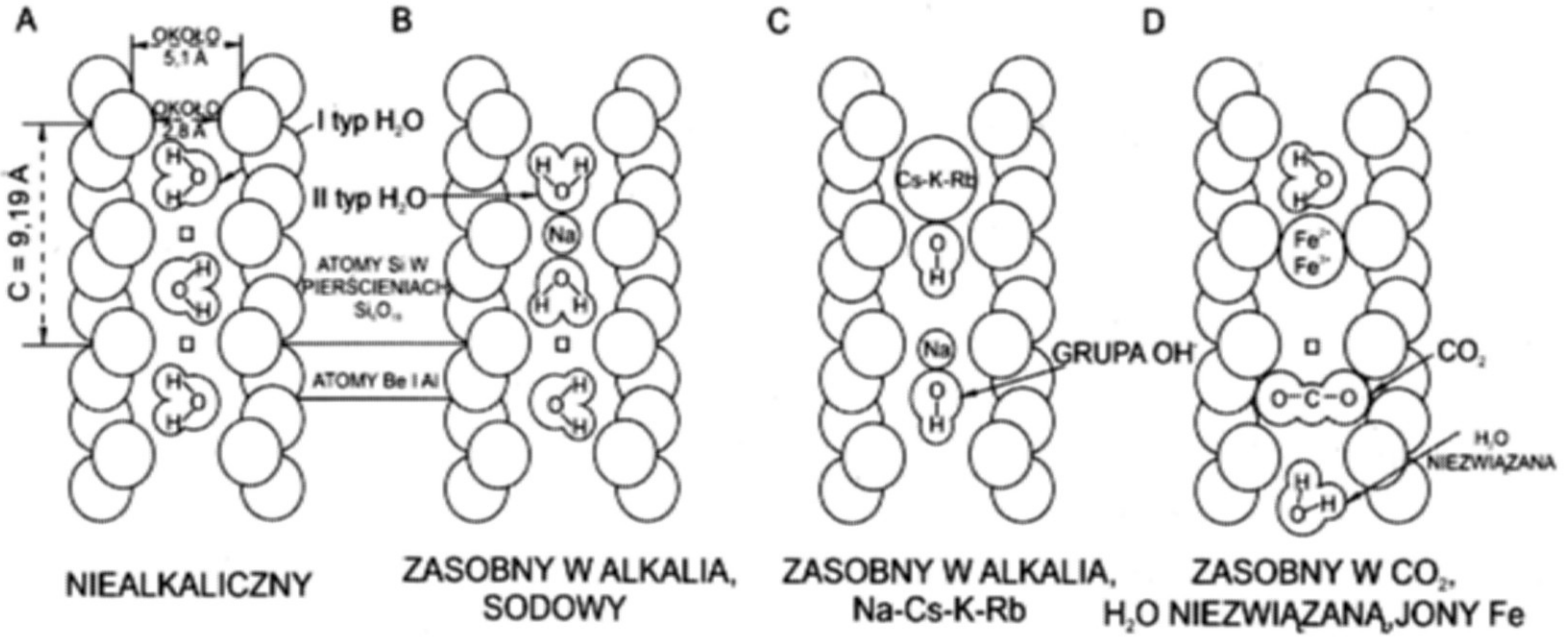
3. Beryl

Beryl $Be_3Al_2Si_6O_{18}$

CH-site vacancy, Na, Cs, H_2O (He, Ar), CO_2 and Fe, and H_2O in 2 (3?) distinct positions.

I H_2O

II H_2O



3. Beryl

- **Propreties**
- **Greenish, yellowish, t = 7, h = 2,65 , simoůlar to quartz in thin section but commonly altered**
- **Varieties:**

  emerald– green (Cr,V)

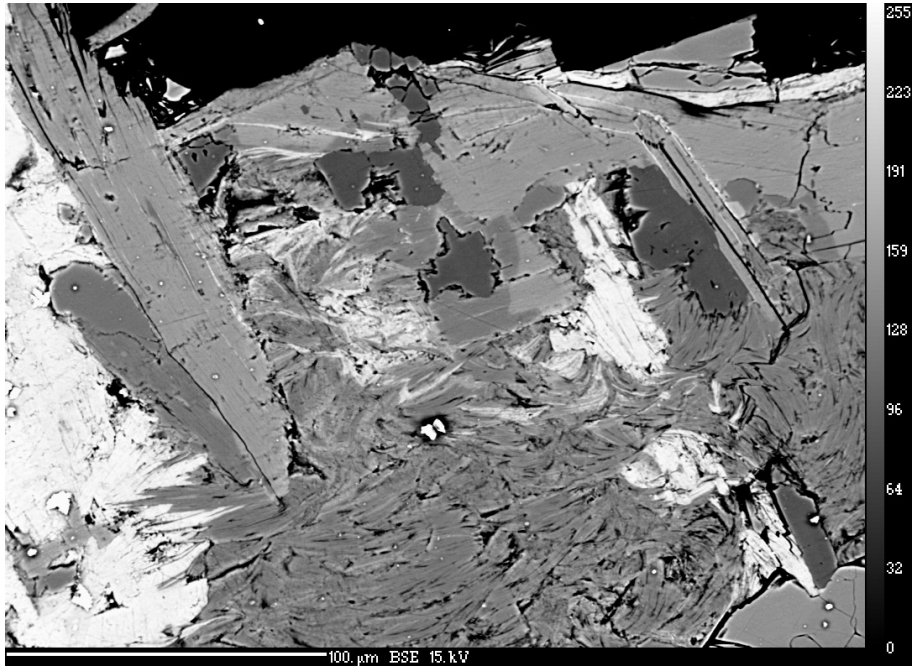
  aqvamaríne - bluish

  heliodor – yellow

  morganite – pink (Cs)
- **Miscibility between beryl and cordierite $Al_3(Mg,Fe)_2AlSi_5O_{18}$ – up to 1,94 wt.% BeO, in cordierite Beryl may contain up to 7 % FeO_{tot}. 4 % MgO.**
- **2 substitutions to enter Be into cordierite**

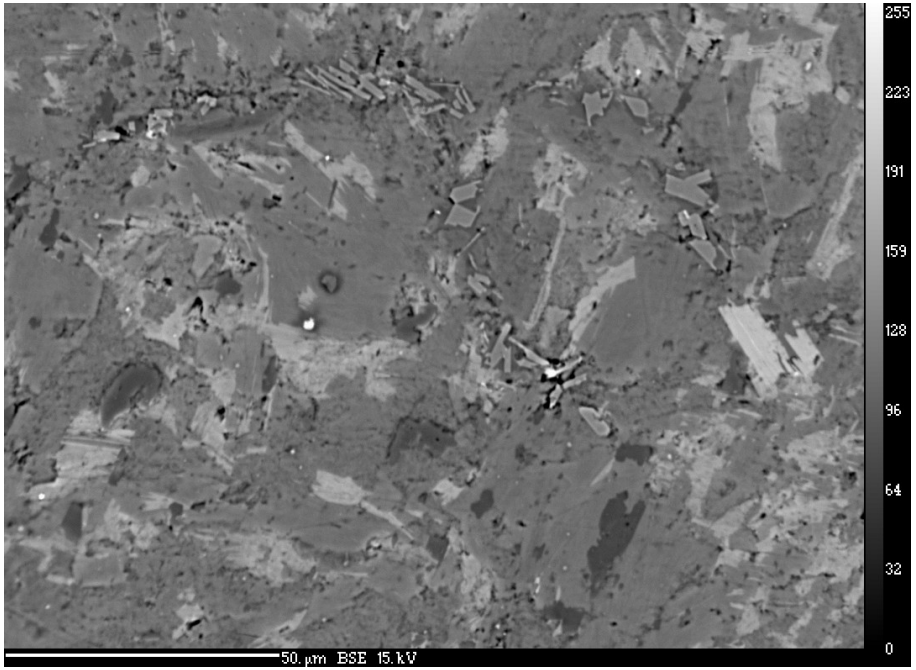
  $^{CH}Na^{T}Be\ ^{CH}\square\ O^{T}Al_{-1}$ a $BeSiAl_{-2}$.

3. Beryl

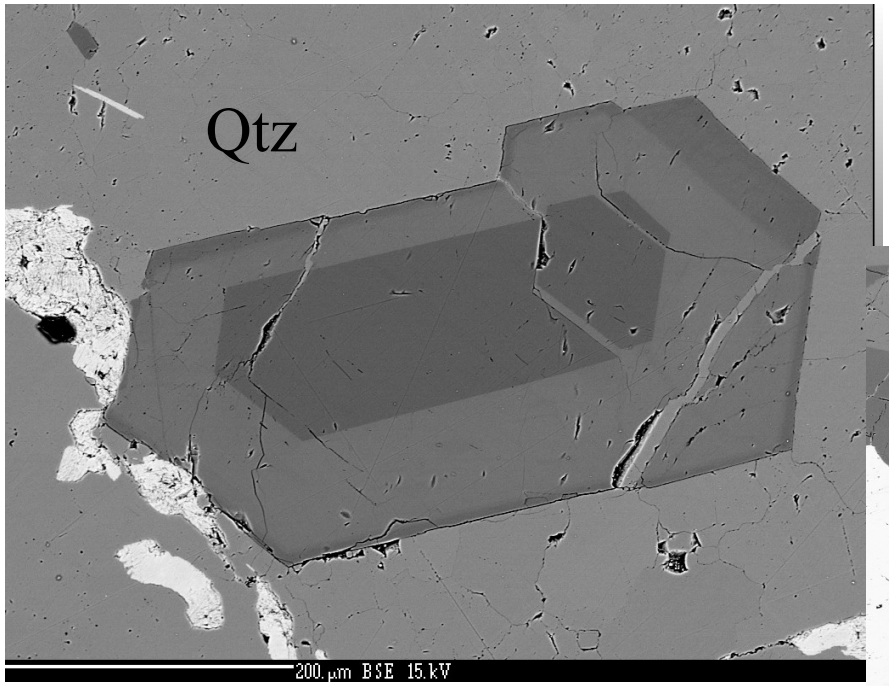


Beryl (dark) in fine-grained chlorite and muscovite

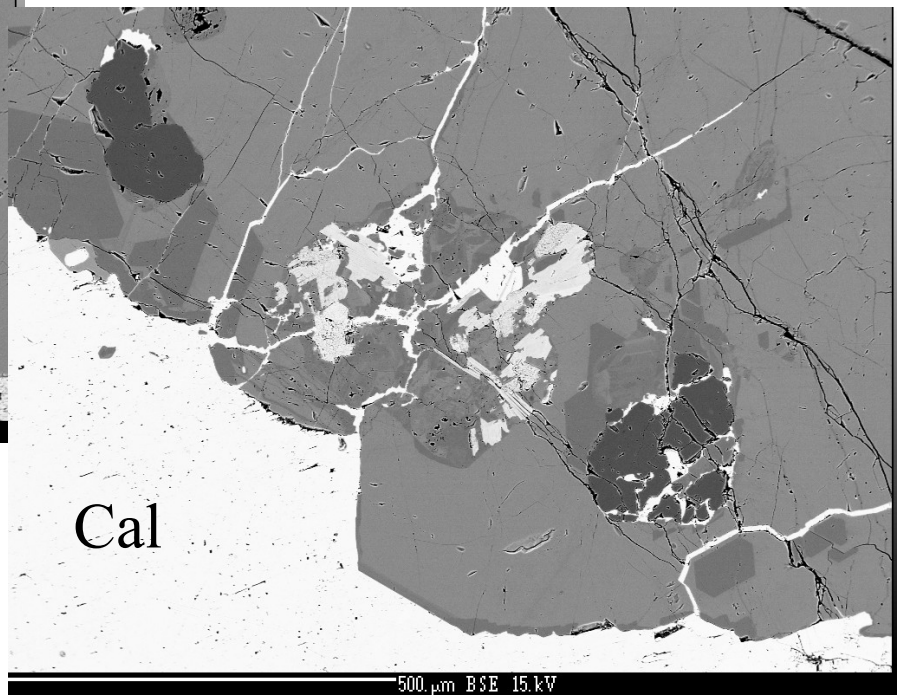
Metamorphic beryl



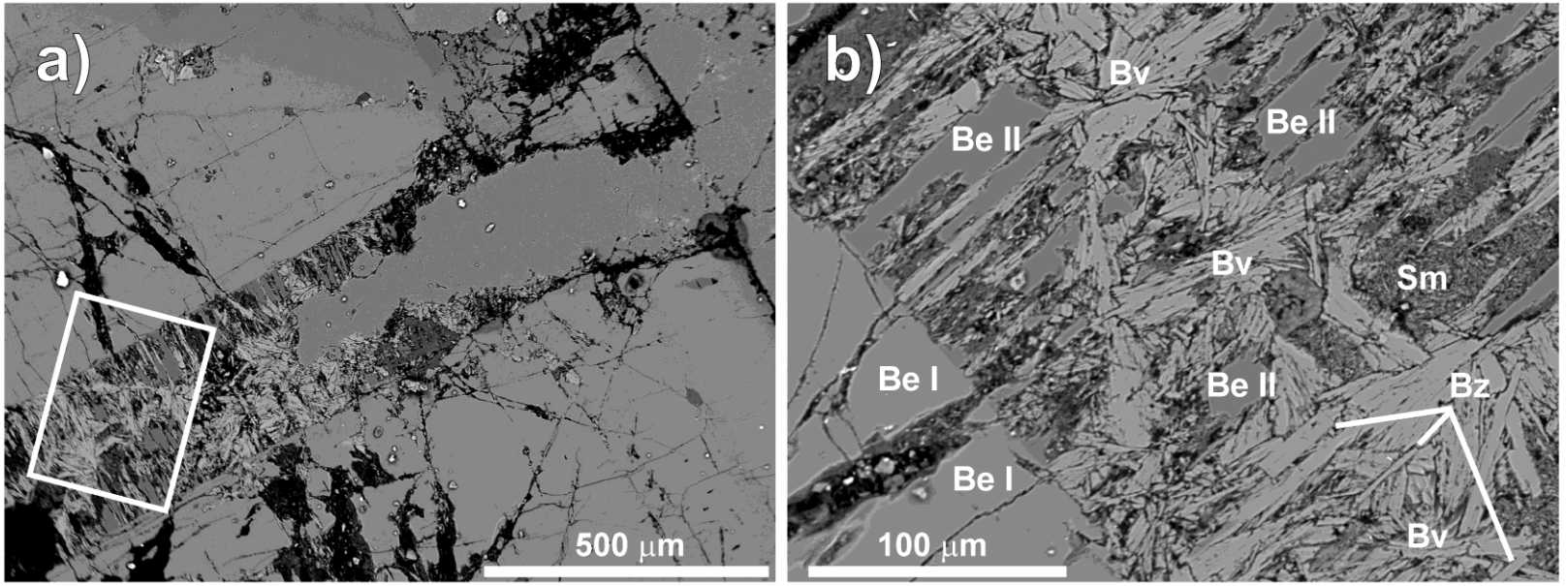
3. Beryl



Zoned beryl from Skal u Rýmařova

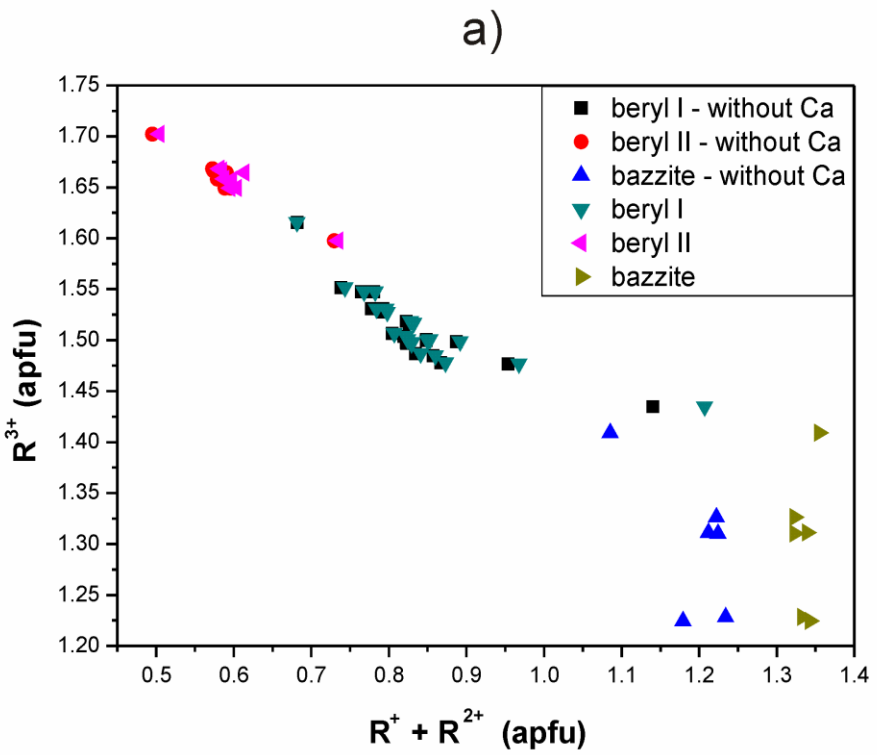


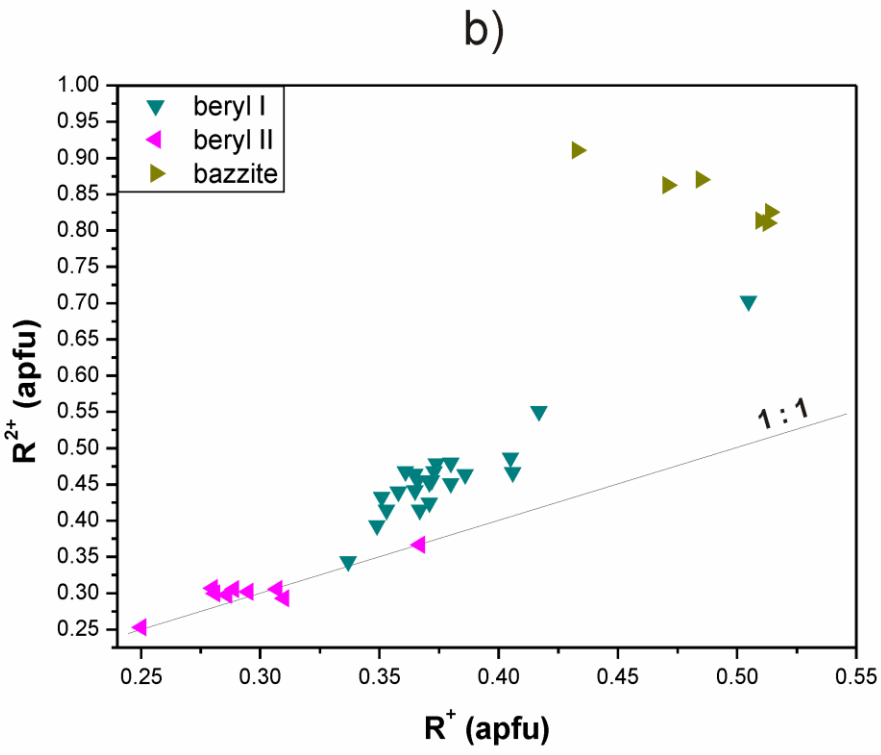
3. Beryl



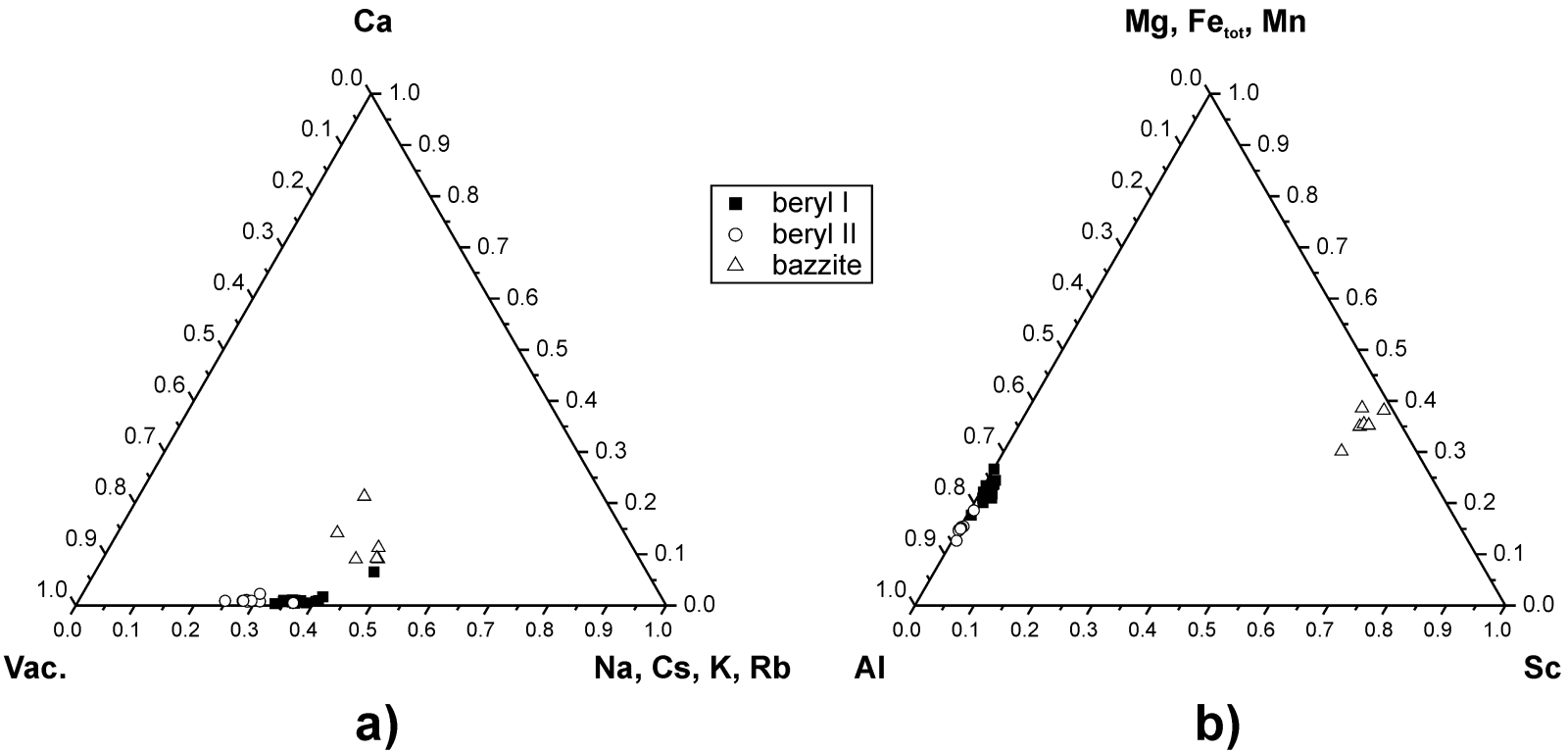
Beryl and products of its breakdown beryl II and bazzite from Kožichovice (Novák and |Filip in print)

3. Beryl

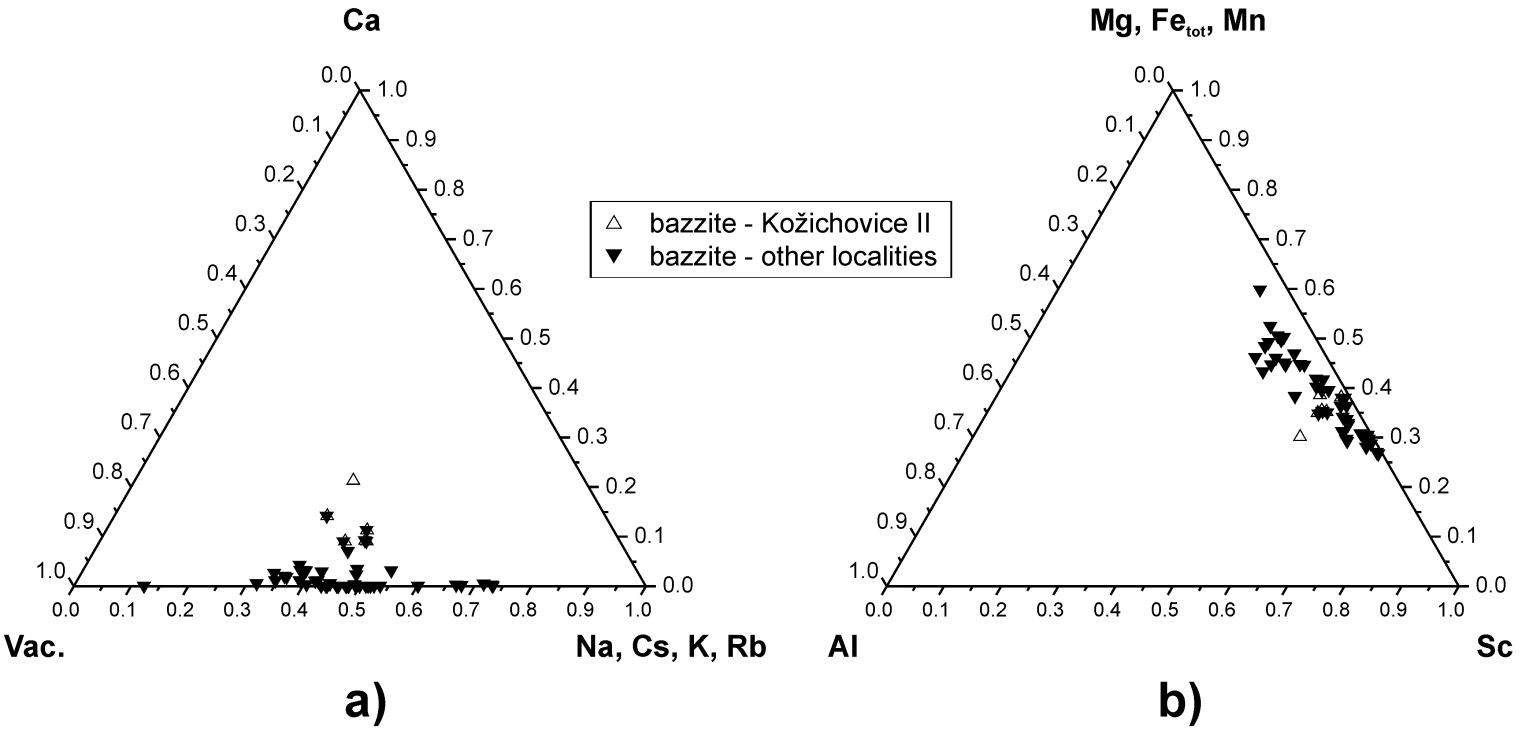

a)
beryl I - without Ca
beryl II - without Ca
bazzite - without Ca
beryl I
beryl II
bazzite
R3+ (apfu)
R+ + R2+ (apfu)


b)
beryl I
beryl II
bazzite
1 : 1
R2+ (apfu)
R+ (apfu)

3. Beryl



3. Beryl



Composition of bazzitu

3. Beryl

- **Occurrences of beryl**

  Beryl is the most abundant mineral of Be the main source of Be is bertrandite in tuffs.

- **Beryl occurs in different geological environments**
- **1. granitické pegmatity -**
- **2. greisens and associated high-T hydrothermal quartz veins**
- **3. metamorphic rocks commonly with high contents of Fe, Cr, Mg, Sc.**

4. Minerals of Be - a

- **Oxidy**

Chryzoberyl	**$BeAl_2O_4$**	**rombický**

- **Fosfáty**

Beryllonit	**$NaBe(PO_4)$**	**rombický**
Hurlbutit	**$CaBe_2(PO4)_2$**	**monoklinický**
Herderit	**$CaBe\ PO_4\ (F,OH)$**	**monoklinický**

- **Boráty**

Hambergit	**$Be_2\ [BO_3]\ (OH,F)$**	**rombický**

- **Silikáty**

Fenakit	**$Be_2\ SiO_4$**	**trigonální**
Euklas	**$BeAl\ SiO_4\ (OH)$**	**rombický**
Bertrandit	**$Be_4[Si_2O_7]\ (OH)_2$**	**rombický**
Bavenit	**$Ca_4\ [Be_2Al_2Si_9O_{27}]\ (OH)$**	**rombický**
Bityit	**$CaLiAl_2AlBeSi_2O_{10}\ (OH)_2$**	**monoklinický**

4. Minerals of Be - b

- **Silicates**

Milarite	**A2B2C[T(2)3T(1)12O30] H2O**	**hexagonální**
A = K, Na, Y, REE, Ca		
B = Ca, Y, Na, vakance		
T(2) = Be, Al		
T(1) = Si		
Gadolinite group	**X2Y [Be2Si2O10]**	**monoklinický**
X = Y, Ce, Yb, Ca		
Y = Fe3+, Y, vakance		
O = OH		
Helvite group	**A4[Be3Si3O12] S**	**kubický**
A = Mn (helvin), Fe (danalit), Zn (genthelvin)		

4. Minerals of Be - c

- **Silicates from alkaline rocks**

  Epididymite Na2[Be2Si6O15] . H2O rombický

  Čkalovite Na2BeSi2O6 rombický

  Melifane CaNaBeSi2O6F tetragonální

4. Minerals of Be

- **Geological environment with Be-minerals**

- **1. Magmatic**

  1.1. granitic pegmatites and granites LCT (beryl, chryzoberyl, boráty, fosfáty) and NYF (beryl, fenakit, gadolinit, bazzit)

  1.2. alkaline pegmatites (čkalovit, melifan, epididymit)

  1.3. volcanic rocks (beryl, stoppannit)

  1.4. ryolite tuffs (bertrandit)
- **2. Hydrothermal and metasomatic**

  2.1. greisens (beryl, euklas)

  2.2. skarns (helvin, danalit)
- **3. Metamorphic**

  3.1. mica schists, gneisses, metabazites (beryl, fenakit, chryzoberyl)

  3.2. Alpine paragenezis (milarit, euklas)
- **4. Late hydrothermal products (sekundary) alteration of primary minerals (bertrandit, bavenit, milarit).**

5. Alteration of Be-minerals

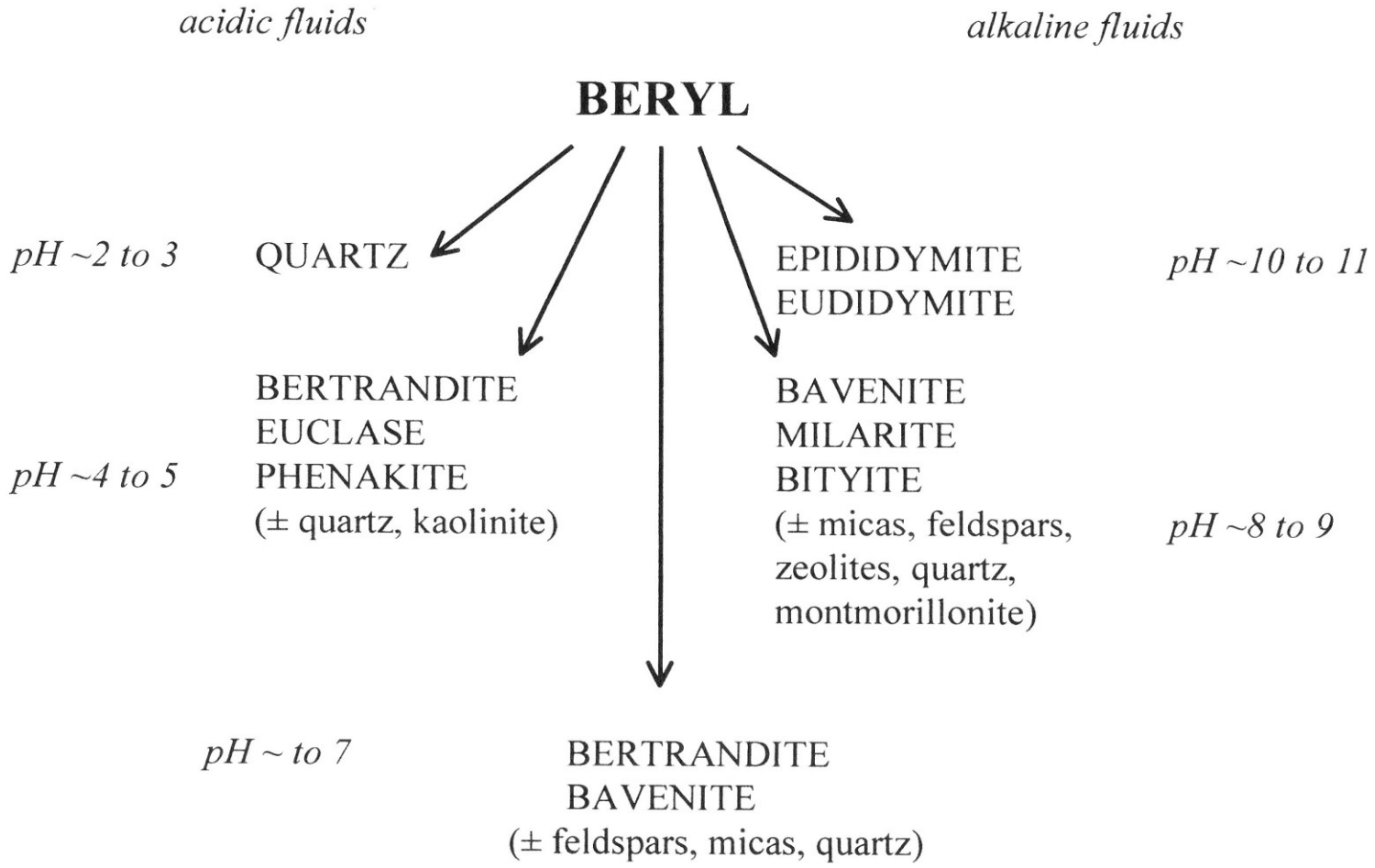


Figure 5. The most common silicate products of alteration of beryl in granitic pegmatites, generated by acidic (left side) and alkaline (right side) solutions. Modified after Černý (1970).

5. Alteration of Be-minerals

System BASH (beryl, chryzoberyl, fenakit, euklas, bertrandit)

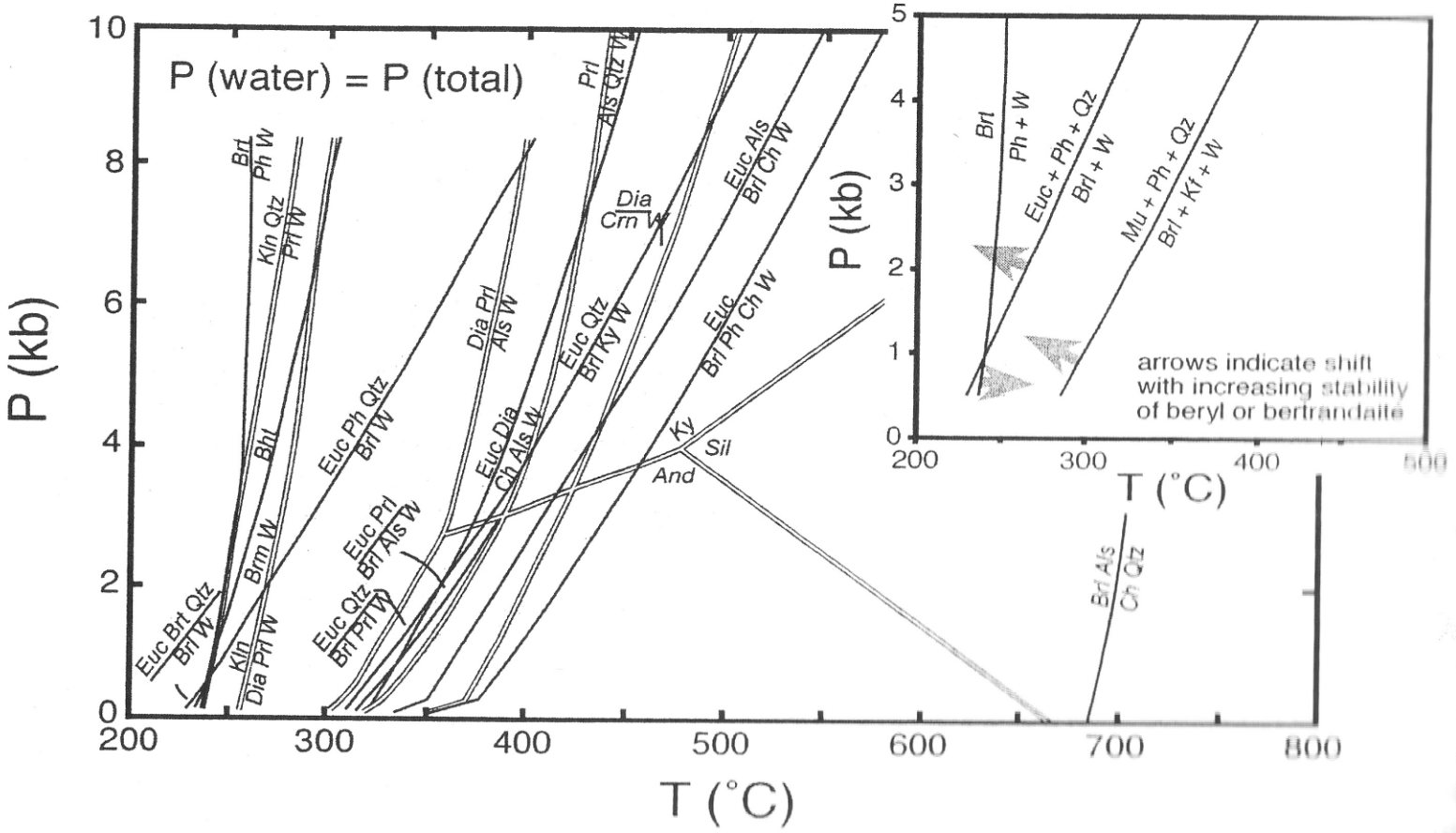
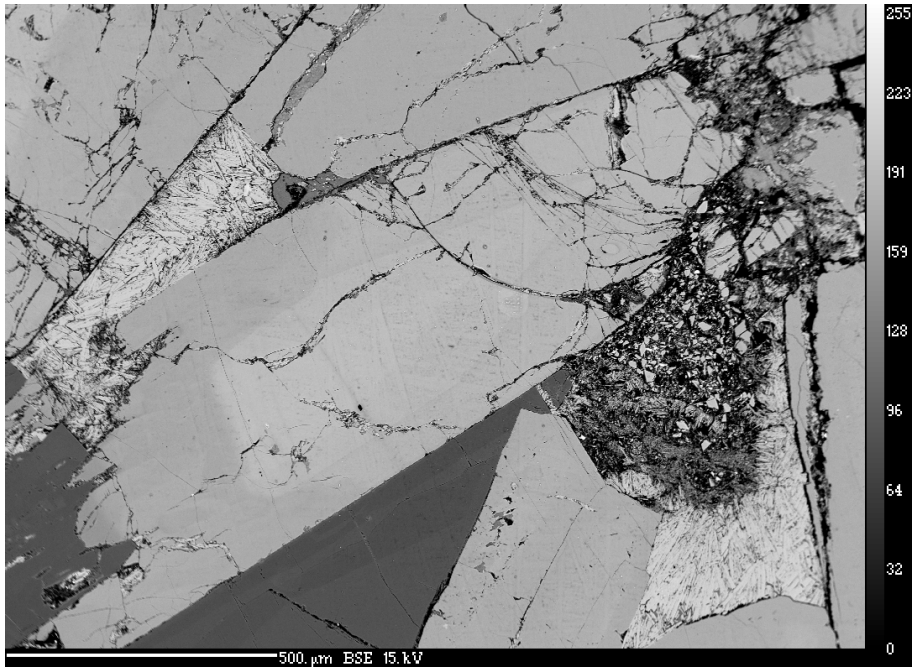


Figure 10. Pressure-temperature projection of phase relationships in the BeO-Al_2O_3-SiO_2-H_2O (BASH) system. Redrawn from Barton (1986). Limiting reactions for bertrandite and beryl both can depend on solid solution effects, F for OH in bertrandite, and multiple components in beryl (inset).

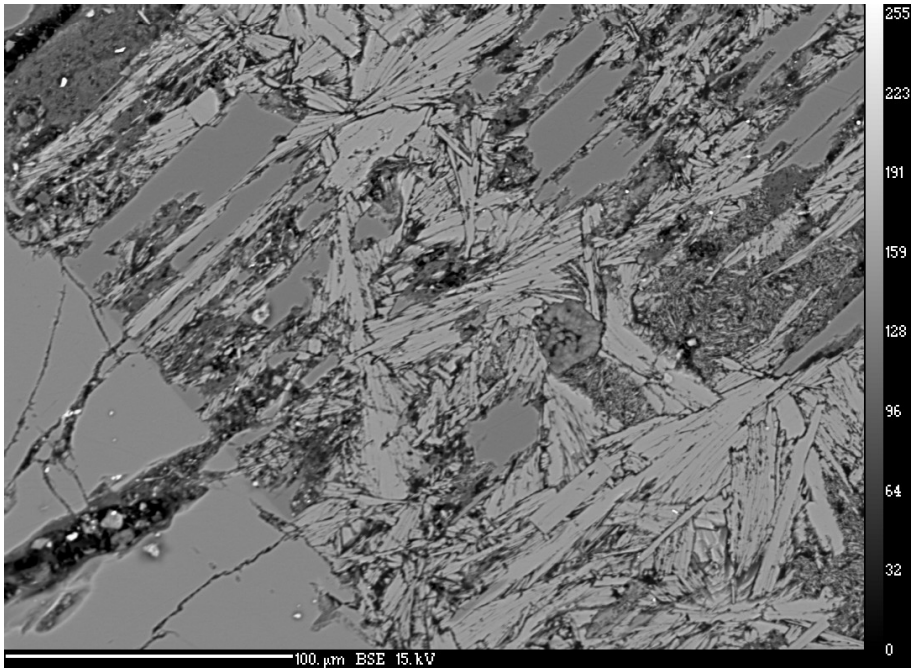
5. Alteration of Be-minerals

Kožichovice



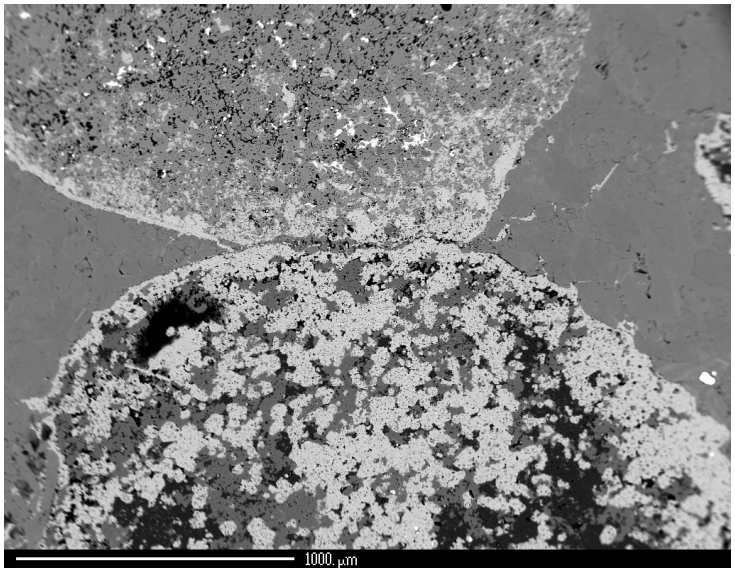
Zoned beryl, bertrandite, bavenite

Beryl, secondary beryl II, bavenite, bazzite



5. Alteration of Be-minerals

Pseudomorphs of herderite after po beryllonite,z Rožná, Borovina



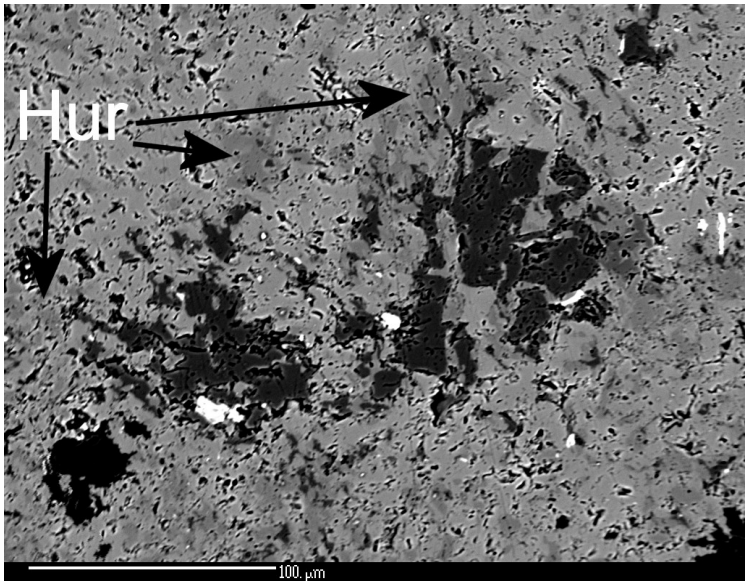
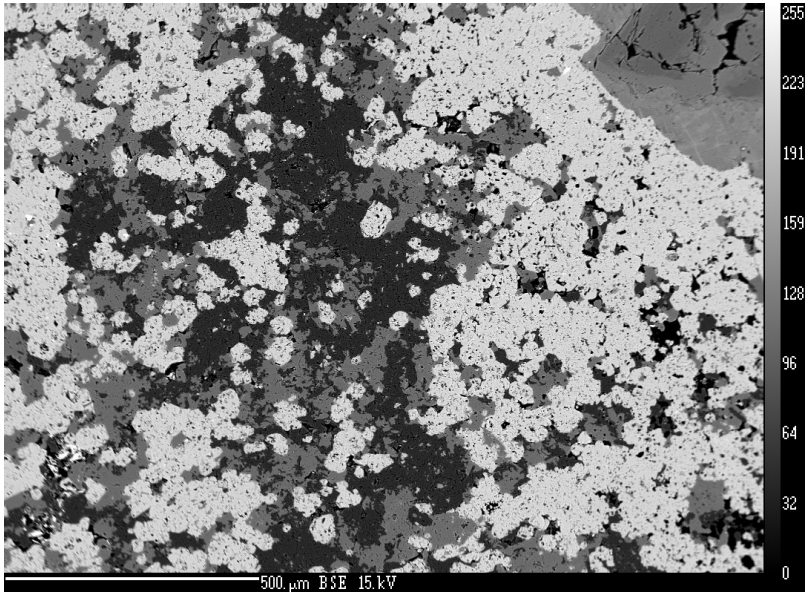


Figure 2. Assemblage I - relics of dark beryllonite are replaced by darker grey hurlbutite and lighter grey hydroxylherderite. Bright white spots are inclusions of unknown phosphates of Ba and Sr. Scale bar length is 0.1 mm.

5. Alteration of Be-minerals



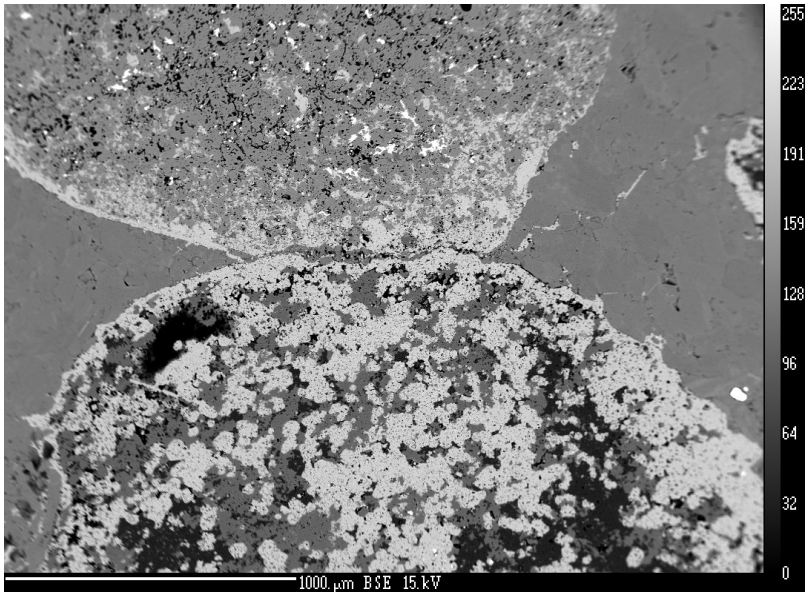


Figure 3. Assemblage II – aggregates of bertrandite (dark) + quartz (grey) + apatite (white) as a replacement product after hydroxylherderite (grey, very similar to quartz). Scale bar length is 0.5 mm.

Sekvence of replacement:

beryllonite ⇒ hurlbutite ⇒ hydroxylherderite ⇒ bertrandite + fluorapatite

6. Conclusions

- Minerals of Be are due to specific behavior of Be very good indicator of their origin in wide PTX-conditions including pH, and activity of some elements (Na, Ca, P).