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Potassium feldspars in the Smrekovec volcaniclastic rocks - a byproduct of the reaction from laumontite to analcime

Kalijevi glinenci v vulkanoklastičnih kamninah s Smrekovca kot stranski produkt reakcije nadomeščanja laumontita po analcimu

Polona KRALJ
Geološki zavod Slovenije, Dimičeva 14, 1000 Ljubljana

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Ključne besede: reakcije zeolitov, laumontit, analcim, Slovenija

Abstract

Smrekovec volcaniclastic rocks are characterised by several zeolite reactions among which the replacements of laumontite by analcime are the most outstanding. Analcime formed by the reaction from laumontite contains from 2,1-2,3 % of calcium and 0,5 % of potassium which occupie the Na-sites. Potassium, released by the decomposition of laumontite was partially incorporated in the analcime lattice, but the majority is concentrated in tiny exsolutions of potassium feldspars.

Kratka vsebina

Vulkanoklastične kamnine s Smrekovca označuje niz reakcij med zeoliti, med katerimi so najbolj pomembna nadomeščanja laumontita po analcimu. Analcim, ki je nastal z reakcijo iz laumontita, vsebuje 2,1-2,3 % kalcija in 0,5 % kalija, ki v kristalni strukturi analcima nadomeščata natrij. Sproščeni kalij se je lahko le delno vgradil v kristalno strukturo analcima, povečini pa je skoncentriran v drobnih izločkih kalijevega glinenca.

Introduction

Smrekovec Mountains, located in Northeastern Slovenia (fig. 1) are characterised by a widespread occurrence of coherent volcanic rocks and volcaniclastic deposits. Volcanic complex encompasses an area of approx. 15 sq. km and includes three major mountain peaks, Komen, Krnes and Smrekovec. Volcanic activity which started in Upper Oligocene in the marine environment (K r a l j , 1996), produced lavas, high-level intrusive bodies, autoclastic deposits, pyroclastic deposits and syn-eruptive resedimented volcaniclastic deposits of basic andesitic, acid andesitic, dacitic and finally, rhyodacitic composition.

Particularly coarser volcaniclastic rocks, located in the vicinity of high-level intrusive bodies, are extensively altered. The main authigenic minerals are laumontite, albite, chlorite or interlayered chlorite/smectite and quartz; analcime, heulandite and clinoptilolite may be locally abundant. Subordinately, prehnite, pumpellyite, yugawaralite, thomsonite, sphene and epidote may also occur. The formation of authigenic minerals is related to hydrothermal activity which accompanied and followed volcanic activity (K r a l j , 1997).

Potassium feldspars locally replace pyrogenetic plagioclases, or together with quartz and albite, volcanic glass, too. They also occur with analcime (plate 1- fig. 1,2) in volcaniclastic rocks that underwent at least two stages of hydrothermal alteration - the first, characterised by the formation of laumontite, and the second, by the formation of analcime. This contribution deals with recognition of potassium feldspars which are temporally and geochemically related to the replacements of laumontite by analcime.

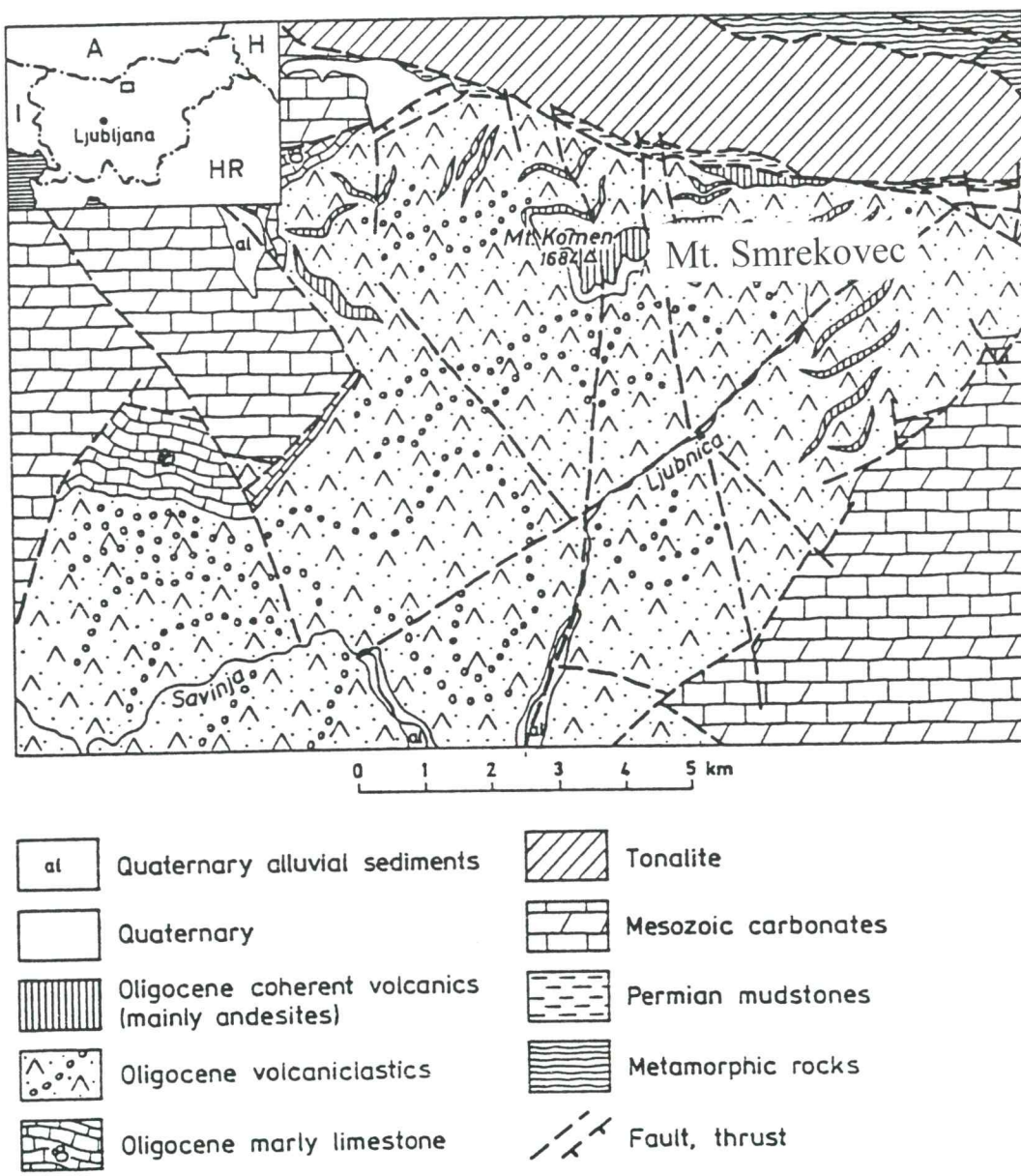


Figure 1. Simplified geological map of the Smrekovec volcanic complex (after Mioč, 1983)
Slika 1. Poenostavljena geološka karta Smrekovškega vulkanskega kompleksa (po Mioču, 1983)

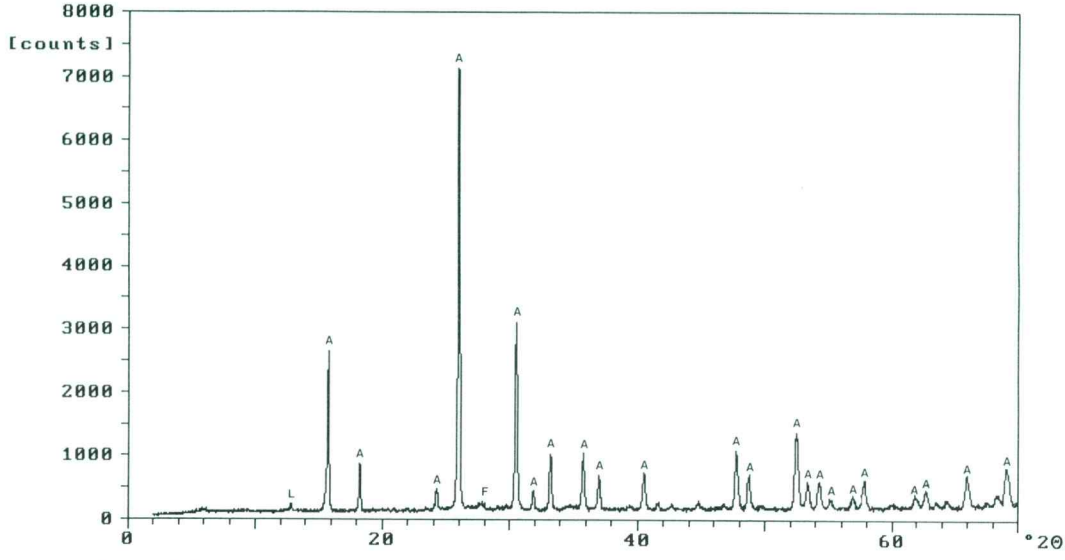


Figure 2. X-ray diffraction pattern of analcime, separated from an analcime-rich rock
Slika 2. Difraktogram analcima, izdvojenega iz kamnine, ki je bogata z analcimom

Potassium feldspars in analcime which replaces laumontite

Some rocks may contain up to 60 % of analcime, the rest are interlayered smectite/chlorite (50/50) filosilicates and small amounts of plagioclases, which are completely albitised. Quartz occurs in very small amounts, most commonly under 5 % of the bulk rock. Analcime, separated from

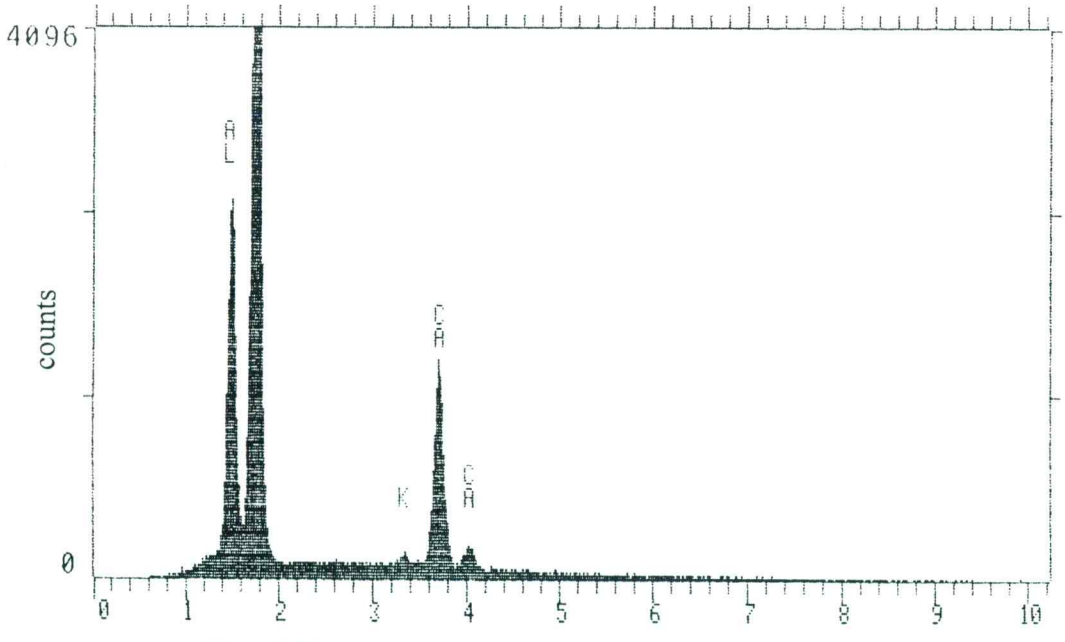


Figure 3. Energy dispersive x-ray spectrum (EDX) of laumontite
Slika 3. Energijsko disperzijski spekter rentgenskih žarkov (EDX) laumontita

Table 1. Analcime: chemical composition, formulae on the basis of 96 oxygens and lattice constants in Å
Tabela 1. Analcimi: kemična sestava, formule na osnovi 96 kisikov in mrežne konstante v Å

Sample Element (wt.%)	N34 1/4L	34/31 2L	34/60L
SiO_2	54,0	53,9	54,1
Al_2O_3	23,1	21,9	21,9
Fe_2O_3	0,6	0,6	0,6
MgO	0,5	0,4	0,4
CaO	2,1	2,3	2,2
Na_2O	9,9	10,0	10,5
K_2O	0,5	0,5	0,5
H_2O^-	0,2	0,5	0,2
H_2O^+	8,7	9,3	9,1
Sum.	99,9	99,4	99,5
Si	31,86	32,28	32,33
Al	16,06	15,46	15,45
Fe	0,26	0,27	0,26
Mg	0,65	0,36	0,32
Ca	1,29	1,47	1,31
Na	11,32	11,61	12,61
K	0,38	0,38	0,39
H_2O	17,0	18,3	17,9
E%	4,7	0,5	0,6
Si/Al	1,98	2,08	2,09
$Si+Al+Fe^{3+}$	48,12	48,1	48,3
Na+K+2Ca	14,28	14,93	15,17
D	2,582	2,579	2,584
a	13,7195	13,7143	13,7231
b	13,7195	13,7143	13,7231
c	13,7195	13,7143	13,7231
$\gamma=\beta=\alpha$	90,000	90,000	90,000

Plate 1, Tabla 1

Fig. 1. Analcime and potassium feldspar (Kf) replacing laumontite, PPL, magnification 53x
Sl. 1. Analcim in kalijev glinenec (Kf), ki nadomeščata laumontit. Presevna polarizirana svetloba, povečava 53x

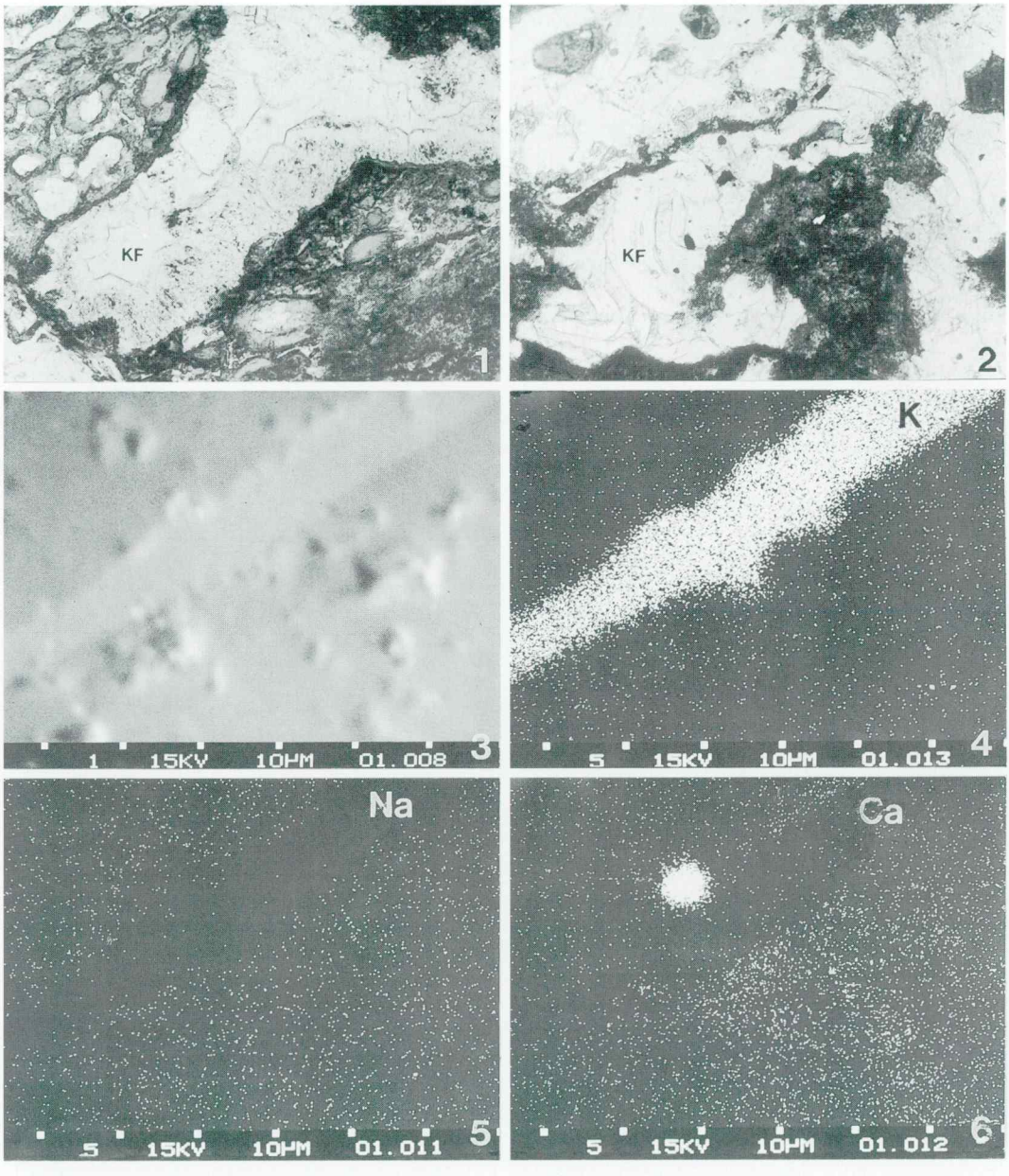
Fig. 2. Analcime and potassium feldspar (Kf) replacing laumontite, PPL, magnification 53x
Sl. 2. Analcim in kalijev glinenec (Kf), ki nadomeščata laumontit. Presevna polarizirana svetloba, povečava 53x

Fig. 3. Scanning electron micrograph of analcime and an exsolution of potassium feldspar (lighter area), magnification 1530x
Sl. 3. Posnetek analcima in kalijevega glinenca (svetlejša proga) z vrstičnim elektronskim mikroskopom, povečava 1530x

Fig. 4. Distribution of potassium in the surface area, shown in fig. 3
Sl. 4. Porazdelitev kalija na področju, prikazanem na sliki 3

Fig. 5. Distribution of sodium in the surface area, shown in fig. 3
Sl. 5. Porazdelitev natrija na področju, prikazanem na sliki 3

Fig. 6. Distribution of calcium in the surface area, shown in fig. 3
Sl 6. Porazdelitev kalcija na področju, prikazanem na sliki 3


KF
1
KF
2
1 15KV 10UM 01.008
3
K
5 15KV 10UM 01.013
4
Na
5 15KV 10UM 01.011
5
Ca
5 15KV 10UM 01.012
6

these rocks is commonly pure, although some samples contain traces of laumontite and alkali feldspars (fig.2).

Chemical composition of analcime (table 1) indicates low-silica character; calcium ranges from 2,1-2,2 % and potassium amounts to 0,5 % of the bulk rock. Mineralogical studies have shown the separated samples are cubic with the cell dimensions a=b=c= 13,7195 Å.

Energy dispersive x-ray spectra (EDX) of laumontite indicates, that some potassium is incorporated in the mineral lattice (fig.3), most probably occupying the Ca-sites. Potassium (1+) ion, however, seems to be too large to occupy the Na-sites in the analcime structure. Potassium, released during the replacement of laumontite by analcime, was likely incorporated in K-felspar (plate 1 - fig. 1,2). Studies with scanning electron microscope have shown that analcime includes up to some tenths of mm sized exsolutions of potassium feldspars. The feldspars are practically free of sodium, but may contain traces of calcium (plate 1 - fig. 4,5,6).

Geological evidence indicates that the replacements of laumontite by analcime occurred during the emplacement of a high-level intrusive body into unconsolidated pyroclastic sediments. Marine water, entrapped in the sediment was probably the main source of sodium. Intensive heating of pore waters by the magma intrusion caused hydrothermal conditions and crystallisation of analcime and alkali feldspars.

Experimental studies on the laumontite to analcime transformation, performed on Smrekovec volcaniclastic by Barth-Wirsching et al. (1994) indicate that analcime can develop in either closed system with concentrated sodium solutions, such as marine water, at low temperatures (≥ 100 °C), or in an open system with dilute sodium solutions, such as hydrothermal solutions or heated surface waters, at elevated temperatures (≥ 200 °C). In the experiments, potassium feldspars crystallised in closed system at the temperatures of 50-150 temperatures 100 °C, and in open system from 150-250 °C.

Conclusions

In the Smrekovec volcaniclastics, potassium feldspars accompanied hydrothermal reactions from laumontite to analcime, which were related to a shallow intrusion of andesitic magma into soft sediments, probably saturated with marine water. The main source of potassium was decomposing laumontite. Potassium seems to be unable to incorporate in the analcime lattice, most probably owing to too large ionic radius. It was incorporated in the lattice of potassium feldspar, which crystallised contemporaneously with analcime, in the form of tiny crystals and irregularly shaped exsolutions.

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