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ALBITE FROM SMILEVSKI DOL IN SELEČKA MOUNTAIN, MACEDONIA

With 6 tables and 3 text-figures

The granites of Selečka Mountain in the later stages of their development were submitted to a sodium metasomatism accompanied by vein and fissure crystallizations. Hydrothermal veins containing fine crystals may be found in the border part of the granite massif and in the adjacent gneisses and schists. Such a vein with fine crystals of *quartz, albite, amphibole, epidote, sphene, zeolite* and occasionally *pyrite* and *apatite* occurs in the small valley Smilevski Dol near the village of Dunje, about 15 km. south-east of Prilep in Macedonia.

A preliminary survey of some minerals from this locality was made by Lj. Barić (1957). On a yellow sphene crystal he found developed the following forms: (100), (110), (021), (111), $(\bar{1}12)$, $(\bar{1}11)$, (212), and $(\bar{1}32)$; on a perfectly transparent thick tabular (0001) apatite crystal: (0001), $(10\bar{1}0)$, $(11\bar{2}0)$, $(10\bar{1}2)$, $(10\bar{1}1)$, $(20\bar{2}1)$, $(40\bar{4}1)$, $(11\bar{2}1)$, $(21\bar{3}1)$, and $(31\bar{4}1)$; on a columnar quartz crystal the forms: $(10\bar{1}1)$, $(01\bar{1}1)$, $(11\bar{2}1)$, $(51\bar{6}1)$ and $(10\bar{1}0)$; on an epidote crystal elongated parallel to the b-axis the forms: (001), (010), (100), (210), (110), (012), (011), $(\bar{1}02)$, $(\bar{1}01)$, (111), $(\bar{1}11)$ and $(\bar{2}21)$. Our investigation deals with the albite crystals, their crystallography, physical properties and chemical composition.

1. CRYSTALLOGRAPHY

Albite crystals are prismatic [001] Fig. 1, occasionally short prismatic or thick tabular parallel to (001) Fig. 2, and usually have a few milimeters in size, but crystals of about one inch or so are not unusual. The bigger ones are milky white, coated often by a film of minute zeolite crystals, showing a simple combination of forms. The small ones are colourless, transparent, richer in forms and more suitable for measurements.

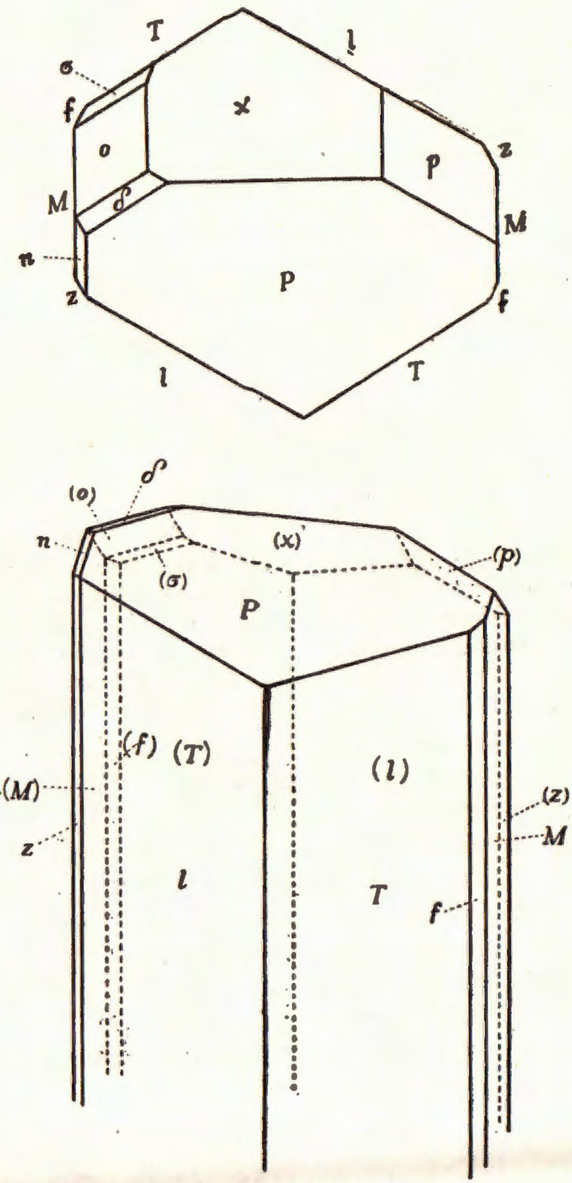

Fig. 1. Prismatic habit of albite crystals from Smilevski Dol.
Kristal albita prizmatskog habitusa iz Smilevskog Dola.

For goniometer measurements 11 best-developed small crystals were selected. Seven of them were single crystals and 4 albite twins. The measurements were carried out on a two-circle goniometer, and the fol-

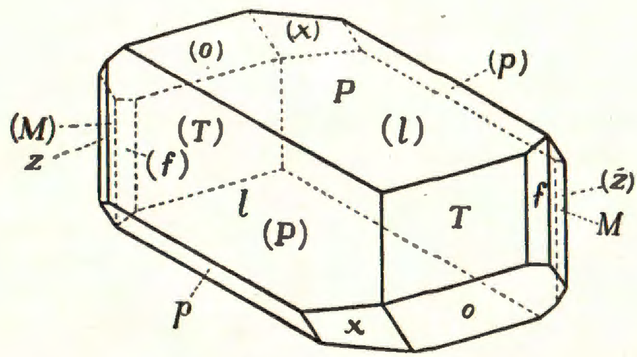

Fig. 2. Thick tabular (001) habit of albite crystals from Smilevski Dol.
Kristal albita pločastog habitusa iz Smilevskog Dola.

lowing 14 forms were found: P(001), M(0$\bar{1}$0), f(130), T(110), l(1$\bar{1}$0), z(1$\bar{3}$0), n(0$\bar{2}$1), x($\bar{1}$01), r($\bar{4}$03), γ($\bar{1}$12), p($\bar{1}$11), δ($\bar{1}\bar{1}$2), o($\bar{1}\bar{1}$1), and σ($\bar{4}$43). Table 1. shows the combinations of forms.

Table 1.

No. Br.	Forms observed Opažane forme														
1.	P	M	f	T	l	z	n	x	r	·	p	δ	o	·	
2.	P	M	f	T	l	z	n	x	·	·	p	δ	o	σ	Fig. 2
3.	P	M	f	T	l	z	n	x	·	·	·	δ	o	σ	
4.	P	M	f	T	l	z	n	x	r	γ	p	·	o	σ	
5.	P	M	f	T	l	z	·	x	·	·	p	δ	o	·	
6.	P	M	f	T	l	z	n	x	r	γ	p	·	o	·	
7.	P	M	f	T	l	z	n	x	·	·	p	δ	o	σ	Fig. 1
8.	P	M	·	T	l	z	n	·	·	·	·	δ	·	·	
9.	P	·	·	T	l	z	·	x	·	·	·	δ	·	·	
10.	P	M	f	T	l	z	n	x	·	·	·	δ	o	σ	
11.	P	M	·	T	l	z	·	x	·	γ	p	·	·	·	

The best-developed and ever-present forms were (001), (110), (1$\bar{1}$0) and ($\bar{1}$01). The habit of the crystals was determined by their shape. The form (1$\bar{3}$0) was also always present as a very narrow face with a rather good signal. Other forms were less frequent: $(\bar{1}11)$ and $(\bar{1}\bar{1}1)$ always as well-developed faces, $(\bar{1}12)$ and $(\bar{1}\bar{1}2)$ as very narrow faces bevelling the edges $(001):(\bar{1}11)$ and $(001):(\bar{1}\bar{1}1)$ respectively. On crystal No. 8 only, $(\bar{1}12)$ was well developed together with (001) and $(0\bar{2}1)$. Otherwise $(0\bar{2}1)$ was in most cases present as a narrow face. Forms $(\bar{4}03)$ and $(\bar{4}\bar{4}3)$ were found only occasionally.

All the faces of zone [001] were striated parallel to the zone axis, and this was very halpful in orienting the crystals. Owing to the striation, uneven faces and other imperfections, it was not possible to calculate the crystallographic elements from the goniometer measurements. In table 2 the average values of the observed angles φ and ϱ are listed. In the two last columns the corresponding values taken from Dreyer and Goldschmidt (1907) are quoted for comparison.

Table 2.

No. Br.	Miller	Angles measured Mjereni kutovi		No. of observations Br. opažanja	Dreyer & Goldschmidt values Vrijednosti po Dreyeru i Goldschmidtu	
		φ	ϱ		φ	ϱ
1.	(001)	81° 47′	26° 51′	16	81° 59′	26° 51′
2.	(010)	0° 00′	90° 00′	21	0° 00′	90° 00′
3.	(130)	30° 31′	90° 00′	13	30° 24′	90° 00′
4.	(110)	60° 34′	90° 00′	23	60° 38′	90° 00′
5.	$(1\bar{1}0)$	120° 06′	90° 00′	23	120° 04′	90° 00′
6.	$(1\bar{3}0)$	150° 03′	90° 00′	18	149° 50′	90° 00′
7.	$(0\bar{2}1)$	154° 38′	49° 18′	9	154° 30	49° 21′
8.	$(\bar{1}01)$	$\overline{80^{\circ}}\ 47'$	26° 11′	13	$\overline{80^{\circ}}\ 44'$	26° 00′
9.	$(\bar{4}03)$	$\overline{84^{\circ}}\ 30'$	39° 05′	3	$\overline{84^{\circ}}\ 16'$	39° 06′
10.	$(\bar{1}12)$	1° 20′	19° 31′	3	1° 36′	19° 33′
11.	$(\bar{1}11)$	$\overline{36^{\circ}}\ 48'$	38° 03′	8	$\overline{36^{\circ}}\ 58'$	38° 40′
12.	$(\bar{1}\bar{1}2)$	176° 45′	11° 40′	6	177° 14′	11° 39′
13.	$(\bar{1}\bar{1}1)$	$\overline{134^{\circ}}\ 54'$	34° 23′	11	$\overline{135^{\circ}}\ 03'$	34° 16′
14.	$(\bar{4}\bar{4}3)$	$\overline{129^{\circ}}\ 39'$	46° 28′	4	$\overline{129^{\circ}}\ 29'$	46° 21′

Only albite twins were found on the material investigated. It was possible to detect even under an ordinary hand-lens re-entrant angles and broad twin lamellae on (001) and $(\bar{1}01)$. In thin sections twin lamellae were also often observed. On the universal stage they were in all cases identified as being twinned according to the albite law.

2. OPTICAL-CRYSTALLOGRAPHIC RELATIONSHIP

The optic orientation was studied in thin sections. The material was previously identified on the goniometer. The angle coordinates of the normals to cleavage cracks, the composition planes and the traces of the terminal faces towards the axes (Z, Y, X) of the indicatrix were determined by the standard universal stage procedure. The stereographic

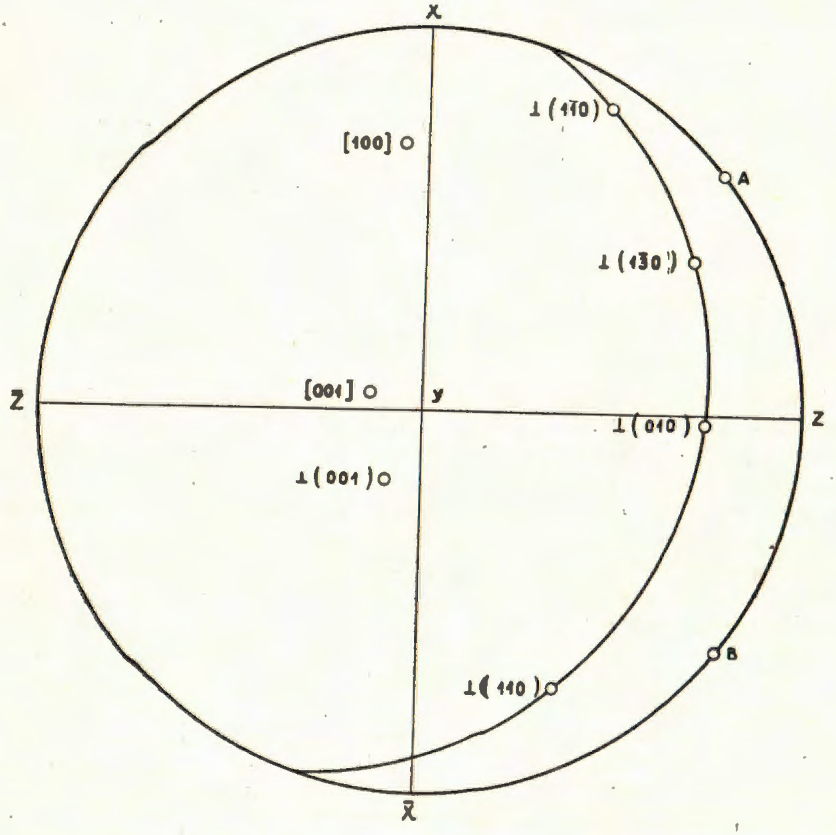

Fig. 3. Stereographic projection of the crystallographic elements on the optic axial plane.

Stereografska projekcija kristalografskih elemenata na ravninu optičkih osi.

projection of the crystallographic elements is represented in Fig. 3, and the mean values of the observed angles are set down in table 3. The same table shows the angle values adjusted by the method of the least squares.

Table 3.

	Angle coordinates Kutne koordinate			No. of obser-vations Br. opa-žanja	Adjusted values Izravnane vrijednosti		
	Z	Y	X		Z	Y	X
(001)	$\overline{78}^{1}/_{2}{}^{0}$	$23^{2}/_{3}{}^{0}$	$\overline{70}^{0}$	8	$\overline{78}^{0}$ 29′ 28″	23^{0} 39′ 00″	$\overline{69}^{0}$ 51′ 12″
(010)	$16^{1}/_{2}{}^{0}$	$73^{1}/_{2}{}^{0}$	$\overline{89}^{0}$	11	16^{0} 20′ 24″	73^{0} 20′ 24″	$\overline{88}^{0}$ 59′ 23″
(110)	64^{0}	$77^{1}/_{2}{}^{0}$	$\overline{29}^{1}/_{2}{}^{0}$	6	63^{0} 59′ 14″	77^{0} 29′ 35″	$\overline{29}^{0}$ 21′ 37″
$(1\bar{1}0)$	$58^{2}/_{3}{}^{0}$	86^{0}	$31^{2}/_{3}{}^{0}$	8	58^{0} 39′ 28″	85^{0} 59′ 55″	31^{0} 39′ 27″
$(1\bar{3}0)$	31^{0}	$78^{1}/_{2}{}^{0}$	$61^{1}/_{2}{}^{0}$	4	31^{0} 04′ 01″	78^{0} 31′ 46″	61^{0} 33′ 49″
[100]	$\overline{85}^{2}/_{3}{}^{0}$	70^{0}	$20^{1}/_{2}{}^{0}$	10	$\overline{85}^{0}$ 40′ 01″	70^{0} 00′ 06″	20^{0} 30′ 06″
[001]	$\overline{74}^{1}/_{2}{}^{0}$	$16^{3}/_{4}{}^{0}$	$84^{1}/_{2}{}^{0}$	10	$\overline{74}^{0}$ 17′ 14″	16^{0} 42′ 03″	84^{0} 28′ 59″

3. DETERMINATION OF BIREFRINGENCE AND OPTIC AXIAL ANGLE

The maximal birefringence $(\gamma - \alpha)$ was determined on cleavage fragments parallel to (001), and the partial birefringence $(\beta - \alpha)$ on fragments parallel to (010). The thickness of the fragments was determined with a screw-micrometer eye-piece, and the retardations with a Berek-compensator. The optic symmetry planes were oriented on the universal stage, the angle of inclination (ϑ) read from the stereogram. As a light source a sodium-vapor lamp was used.

The maximum birefringence was obtained on 4 fragments, and the results are quoted in table 4.

Table 4.

No. Br.	Thickness Debljina (mm)	Retardations Razlika u hodu (mμ)	Angle Kut ϑ	$\gamma - \alpha$
1.	0.1920	2135	23°	0.01023
2.	0.1710	1955	25°	0.01036
3.	0.0733	789	23°	0.00991
4.	0.1153	1250	25°	0.00983

The mean value for maximal birefringence calculated from these values is:

$$\gamma - \alpha = 0.0101 \pm 0.0003$$

The partial birefringence ($\beta - \alpha$) was determined on 3 sections cut parallel to (010). The results are quoted in table 5.

Table 5.

No. Br.	Thickness Debljina (mm)	Retardations Razlika u hodu (mμ)	Angle Kut ϑ	$\beta - \alpha$
1.	0.2678	1115	16° 40′	0.00399
2.	0.1789	691	16° 00′	0.00371
3.	0.19615	821	17° 30′	0.00399

The mean value for partial birefringence calculated from these values is:

$$\beta - \alpha = 0.0039 \pm 0.0001$$

The optic axial angle was determined on the same sections parallel to (010). Owing to the thickness of the sections it was possible to observe the interference figures in convergent polarized light and to measure directly the optic angle by turning on the universal stage from one optic axis to the other. The following values were obtained on sections Nos. 1, 2 and 3 (table 5) for the angle 2V: 80° 18′, 79° 58′, and 79° 50′ (these values are corrected for the index of refraction of the glass hemisphere n = 1.554). The aritmetic mean calculated from the cited values is:

$$+ 2V = 80^{\circ}\, 02'$$

With the optic plane in the parallel position it was possible to observe the unsymmetrical dispersion. In this position, the optic axis B for the red spectral region emerged on the right side of the isogyre and for the violet spectral region on the left side. The optic axis A was not dispersed. In the diagonal position the dispersion was not observed for either axis.

4. DETERMINATION OF THE INDICES OF REFRACTION

The indices of refraction were determined on a high polished (010) face trough a Klein refractometer. Using sodium light the indices γ and α were determined by direct observation. The values cited in table 6

Table 6.

λ (mμ)	γ	β	α	$\gamma - \alpha$	$\gamma - \beta$	$\beta - \alpha$	2V
589.3	1.5378	1.5319	1.5280	0.0098	0.0059	0.0039	78° 40′

are the mean values of 10 separate readingns. The index β was calculated by adding the partial birefringence $\beta - \alpha$ to the index α.

The total and partial birefringences and the angle 2V quoted in table 6 are calculated from the indices of refraction. They are in good agreement with the valves directly observed.

5. INCLUSIONS

The albite crystals contained inclusions of minute grains of green epidote and muscovite. On a scaly muscovite fragment extracted from an albite crystal the optic axial angle was determined by direct observation of interference figures in convergent polarized light. The measured optic axial angle was $-2V = 45^1/_2{}^0$. Dispersion was very weak $v < r$.

6. CHEMICAL COMPOSITION

The material for the chemical analysis was carefully selected in order to eliminate as far as possible the inclusions of epidote and muscovite which the albite crystals contained.

The chemical analysis resulted as follows:

Analyst: P. Raffaelli

SiO_2	68.04		
Al_2O_3	19.88		
Fe_2O_3	0.16		
FeO	0.12	Or	5.29%
MgO	0.02	Ab	93,89
CaO	0.17	An	0,82
Na_2O	10.56		
K_2O	0.91		
H_2O+	0.14		
H_2O-	0.03		
	100.03		

The specific gravity was determined with a pycnometer and reduced to the temperature of water, 4^0 C was:

$$D = 2.610 \pm 0.002$$

The albite investigated from Smilevski Dol in Macedonia, as a fissure mineral has a low-temperature optic which is in agreement with data cited in the literature (Azzini 1933, Meen 1933, Adamson 1942, Crump and Ketner 1953).

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P. RAFFAELLI

ALBIT IZ SMILEVSKOG DOLA U SELEČKOJ PLANINI, MAKEDONIJA

S 6 tabela i 3 figure u tekstu

Hidrotermalne žice koje nalazimo u granitima i gnajsima Selečke planine, sadrže ponekad u pukotinama lijepo razvijene kristale. Jedna takva žica nalazi se u Selečkoj na južnoj strani uzvisine Gorni Kamen u blizini vrela Šohlehov Kladenec u Smilevskom Dolu, oko 2.5 km zračne linije jugozapadno od sela Dunje. Ova žica sadrži lijepe kristale kvarca, albita, amfibola, epidota, titanita, zeolita, a ponekad pirita i apatita. Bogatiji formama i lijepo razvijeni su naročito zeleni kristali epidota (izduženi u smjeru osi b), žuti kristali titanita, albiti, zatim kristali kvarca i apatita. Neke minerale iz ovog nalazišta opisao je ukratko Lj. Barić (1957), a meni je ustupio da detaljno istražim albit. Ugodna mi je dužnost da se i na ovom mjestu zahvalim prof. Lj. Bariću na ustupljenom materijalu, kao i na savjetima i pomoći koju mi je ukazivao za vrijeme rada.

Na 11 najljepših kristala koje sam izabrao za goniometrijska mjerenja, našao sam ove forme: P(001), M(010), f(130), T(110), l($1\bar{1}0$), z($1\bar{3}0$), n($0\bar{2}1$), x($\bar{1}01$), r($\bar{4}03$), γ($\bar{1}12$), p($\bar{1}\bar{1}1$), δ($\bar{1}\bar{1}2$), o($\bar{1}11$) i σ($\bar{4}43$). Kombinacija formi prikazana je u tabeli 1, a srednje vrijednosti izmjerenih kutova φ i ϱ u tabeli 2. U dvije desne kolone tabele 2, navedene su za usporedbu vrijednosti istih kutova uzete iz rada Dreyera i Goldschmidta (1907). Mjerenjem na goniometru, kao i mikroskopskim istraživanjem preparata utvrdio sam, da su albiti iz ovoga nalazišta srasli samo po albitnom zakonu.

Položaj pojedinih kristalografskih elemenata (okomica na pukotine kalavosti, na sraslačke šavove i na terminalne plohe) prema glavnim vibracionim smjerovima Z, Y i X, odredio sam teodolitnomikroskopskim mjerenjima. U tabeli 3 prikazane su srednje vrijednosti izmjerenih koordinata, te iste vrijednosti izravnane metodom najmanjih kvadrata.

Maksimalni dvolom ($\gamma - \alpha$) i parcijalni dvolom ($\beta - \alpha$) odredio sam na kalotinama priređenim paralelno plohama (001) i (010). Debljinu kalotina odredio sam direktno mikrometarokularom na vijak, a razlike u hodu Berekovim kompenzatorom. Podaci pojedinačnih mjerenja prikazani su u tabelima 4 i 5.

Na preparatima priređenim paralelno plohi (010) mogao sam na teodolitnom stolu u konvergentnom svijetlu nagibanjem oko osi A_4 vidjeti obje optičke osi, te tako direktno mjeriti kut optičkih osi, koji korigiran za indeks loma segmenata $n = 1.554$ iznosi:

$$+2V = 80^{\circ}02'$$

U konvergentnom svijetlu je bilo moguće opaziti i disperziju, ali samo u paralelnom položaju ravnine optičkih osi. U tom položaju, optička os B za crveno područje spektra izbijala je na desnu stranu izogire, a za ljubičasto područje spektra na lijevu stranu; oko optičke osi A međutim, nije bilo moguće opaziti disperziju. To odgovara slučaju asimetrijske disperzije.

Indekse loma odredio sam na Kleinovom totalrefraktometru, na jednoj fino poliranoj kalotini smjerom (010). Direktno sam izmjerio vrijednosti za indekse loma γ i α, a ostale vrijednosti navedene u tabeli 6 su izračunate.

Na str. 140 navedene su kemijska analiza i specifična težina istraživanog albita. Materijal za analizu je veoma pažljivo odabran, jer su kristali albita u većini slučajeva sadržavali uklopljene sitne kristale epidota i muskovita. Analiziran je samo najčišći materijal.

Istraživanja albita iz Smilevskog Dola su pokazala da ovaj mineral ima niskotemperaturnu optiku, što se i očekivalo obzirom na to, da se ovdje radi o pukotinskom mineralu. Optika i kemizam su u skladu sa podacima, koji se mogu naći u literaturi (Azzini 1933, Meen 1933, Adamson 1942, Crump i Ketner 1953).

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