GEOLOGIA CROATICA	45	63 - 68	10 Fig.	2 Tab.	ZAGREB 1992

UDC 552.08:548:549.655(497.17) Scientific paper

Crystallographic Determination of Titanite from Smilevski Dol in Selečka Mountain, Macedonia

Vladimir **ZEBEC** and Biserka **RADANOVIĆ-GUŽVICA**

Key words: titanite, morphology, crystal forms, Smilevski Dol

On 30 crystals of titanite, goniometrically measured, the appearance of faces of 25 forms was determined. Crystallographic elements were calculated and morphology and paragenesis of minerals were described. The shape of the crystals was represented by ten parallel perspective figures. Two types of crystals were separated.

Ključne riječi: titanit, morfologija, kristalne forme, Smilevski Dol

Na 30 goniometrijski mjerenih kristala titanita određeno je prisustvo ploha 25 formi. Izračunati su kristalografski elementi te opisana morfologija i parageneza. Izgled kristala prikazan je u 10 paralelno perspektivnih slika. Izdvojena su dva tipa kristala.

1. INTRODUCTION

Numerous pegmatitic and pegmatite-hydrothermal veins were found in the granites and gneisses of Selečka Mountain. Some of them often contain well-formed crystals. One such vein was found about 2.5 kms south--west from the village Dunje on the southern side of the hillock Gorni Kamen (elevation 636) nearby the spring Šohlehov Kladenec in Smilevski Dol. This vein contains hydrothermally deposited well-formed crystals of albite, epidote, titanite, amphiboles with somewhat less of quartz, muscovite, heulandite and stilbite, pyrite, apatite, microcline and chlorite. Lj. BARIĆ (1958) gave the short description of some minerals from this locality. Crystals of albite (RAFFAELLI, 1961), epidote (ZEBEC, 1984) and stilbite and heulandite (TIBLJAŠ et al., 1987) have been in detail elaborated up today. On one of specially yellow and clear crystal of titanite BARIĆ (1958) determined the following forms: {100}, {110}, {021}, {111}, {$\bar{1}$12}, {$\bar{1}$11}, {212} and {$\bar{1}\bar{3}$2}.

2. EXPERIMENTAL PROCEDURE

The investigated material was chosen after the review of all collected crystals by stereomicroscope. The crystals chosen for the quality of their faces could be a solid basis for the precise determination of the crystallographic constants which were estimated by goniometric measurements. Goniometric measurements were performed on the two-circular reflecting goniometer (model A by Goldschmidt). Measurements were performed at a polar setting of both sides of a crystal, if it was possible. The obtained data were middling and if conditions of the observations allowed, were used for determination of the crystallographic elements. The remaining data were used for identification of the measured faces.

3. MATERIAL

The material was predominantly collected by prof. Lj. Barić in 1952., whereas a certain part was collected and ceded by M. Galeski and Z. Gruevski.

The elaborated material is being kept in the collection of Mineralogic-petrographic Department of Croatian Museum of Natural History in Zagreb, inventory numbers:

600:ZAG;5781:MP1,
600:ZAG;5782:MP1,
600:ZAG;7711:MP1
600:ZAG;7712:MP1.

4. THE RESULTS OF GONIOMETRIC MEASUREMENTS

30 crystals of titanite, size from 2 to 8 mms, were chosen for goniometric measurements. The orientation by Descloizeaux was taken. Determination of the faces was performed by gnomon projection. The faces of 25 forms were determined on the measured crystals of the titanite. A review of form combinations on single crystals is shown in Table 1.

The faces of the forms {410}, {364} and {564} were not determined up to now, in the reference which was disposable to as (Mineraly III/I, 1972). The results with the optimal conditions of measurements are shown in Table 2.

5. CALCULATION OF CRYSTALLOGRAPHIC ELEMENTS

The elements of gnomon projection were calculated from the best values obtained by measurements (Table 2) as suggested by GOLDSCHMIDT (1934):

$x_o' = 0{,}570260$
$p_o' = 1{,}303487$
$q_o' = 0{,}854633$

Then, the polar elements were calculated from elements

Mineralogic-petrographic Department of Croatian Museum of Natural History, Demetrova 1, 41000 Zagreb, Croatia
Mineraloško-petrografski odjel Hrvatskog prirodoslovnog muzeja Demetrova 1, 41000 Zagreb, Hrvatska

simbol of form (simbol forme)	crystal num. (kristal br.)																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
001	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
010				+			+																							
100	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
410					+																									
310	+		+	+	+	+	+	+		+	+		+					+	+						+	+	+	+		
520		+						+				+					+													
110	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+		+	+	+
130		+																												
021		+	+	+	+		+	+	+	+	+			+			+	+	+		+	+		+		+			+
101	+	+	+						+						+															+
102	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+		+		+	+	+	+
111	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
113		+																												
114													+	+	+											+	+	+		
112		+	+	+	+	+	+	+	+	+	+	+				+	+	+	+	+	+	+	+	+		+		+	+	+
111	+	+	+	+	+	+	+	+	+	+	+	+					+	+	+	+	+	+	+	+	+	+		+	+	+
221																	+					+		+						
212	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+		+	+		+	+		+	+	+	+	+	+	+
131							+																							
122						+																								
364		+																												
564							+																							
132		+	+		+		+	+	+		+						+	+				+	+	+		+		+		
312							+																							
354					+																									
fig. (sl.)				6	9				7			8	1		2			5									3	4	10	

Table 1. Titanite, Smilevski Dol, review of combination of the forms on single crystals
Tablica 1. Titanit, Smilevski ol, pregled kombinacija formi na pojedinim kristalima

simbol of form (simbol forme)	number of observation (broj opažanja)	variation (kolebanja)		mean value (srednja vrijednost)		calculated value (izračunata vrijednost)	
		φ	ρ	φ	ρ	φ	ρ
001	13	89°48'- 90°20'	29°37'- 30°03'	89°59'36''	29°46'17''	90°00'	29°41'40''
110	7	56°41'- 56°58'	90°00'	56°50'37''	90°00'	56°44'57''	90°00'
310	5	77°19'- 77°57'	90°00'	77°36'26''	90°00'	77°40'19''	90°00'
102	14	89°56'- 90°05'	50°27'- 50°46'	90°00'12''	50°41'27''	90°00'	50°42'21''
111	11	65°25'- 65°36'	63°59'- 64°15'	65°34'09''	64°05'33''	65°28'59''	64°06'02''
$\bar{1}11$	7	319°11'-319°37'	48°22'- 48°29'	319°23'00''	48°31'05''	319°22'12''	48°23'36''
$\bar{1}12$	9	348°56'-349°35'	23°24'- 23°37'	349°16'42''	23°31'24''	349°12'06''	23°30'33''

Table 2. Titanite, Smilevski Dol, review of the best value.

Tablica 2. Titanit, Smilevski Dol, pregled najboljih vrijednosti.

of gnomon projection:

$x_0 = 0{,}4954$
$p_0 = 1{,}1323$
$q_0 = 0{,}7424$
$\mu_0 = 60^0\ 18{,}5'$

Linear elements of the titanite from Smilevski Dol, calculated from polar elements, were:

a:b:c = 0,7548 : 1 : 0,8546 β= 119° 41,5'

The obtained result corresponds well with the data found in literature:

a:b:c = 0,7547 : 1 : 0,8540 β= 119° 43'

(GOLDSCHMIDT, 1897).

6. MORPHOLOGY OF CRYSTALS

Titanite and epidote form the best shaped crystals of the vein association, and this was the reason why quantitative crystallometric determination was done. Crystals are of different size, from 1 to 40 mms, and are predominantly elongated in direction of zone made by the faces of form {111} , that is, in direction [$\bar{1}$01] . An exception was a crystal which was shortened in this direction (Fig. 10). Roughly, speaking, two types of crystals can be separated : one with well-formed faces of prism of general position {114}, and strongly well--formed faces of form {001} and the other without the faces of form {114}, with slightly outstanded faces of form {001}. Among measured crystals predominant are those from the second group (4/5 of measured crystals). Faces of the forms {102} i {212} give specific habitus to crystals. The faces of the forms {001}, {100} and {111} were noticed on all crystals. The faces of the forms {310}, {110}, {021} , {102}, {112}, {$\bar{1}$11}, {212} and {$\bar{1}$32} were very frequent.The faces of the forms {010}, {520}, {101}, {114} and {$\bar{2}$21} were rarely observed. The faces of forms {410}, {130}, {113}, {131}, {122}, {364}, {564}, {$\bar{3}$12} and {$\bar{3}$54} were observed on only one crystal. The quality of the faces, even of the faces of the same form on the same crystal was usually different. This was, particularly evident on different crystals. Some crystals were partially subjected to dissolution. Together with shiny faces the faces corroded by dissolution were also found, especially in their central parts. The best example was the face of the form {100} which could range in quality from shiny and ideal smooth to striated and even hieroglyphically coroded ones. The curving of described elongation zone in the plane of symmetry was noticed on bigger crystals. A free part of one crystal was curved for about 20° toward [100] (600:ZAG;5781:MP1). So, in the attempt to better show the morphology of titanite crystals from Smilevski Dol, besides appart from the Table 1, which shows the presence of the combination of faces of particular forms, parallel perspective figures of first (Figs. 1-4) and second type of characteristic crystals (Figs. 5-10) were constructed.

It is interesting that in whole material, in neither of the cases the twins of titanite were registered.

7. PARAGENESIS

The beginning of crystallization of titanite, in our case, began after the crystallization of muscovite, pyrite, older and main parts of plagioclases, amphiboles and older epidote. The youngest minerals (albite, apatite, part of amphiboles, epidote and chlorites) were crystallized together with titanite. Microcline and zeolites were younger of titanite.

Titanite appears abundantly, predominantly with amphibole, which, by its optical characteristics, can be determined as hornblende.

The interacting relation between the two noticed types of crystals of titanite could not have been determined.

For the other titanic minerals, very rarely, tiny crystals of rutile could have been found.

On some crystals of titanite, chlorite inclusion were found abundantly.

8. CONCLUSION

Well-formed crystals of titanite from Smilevski Dol near Dunje in Selečka Mountain originated from hydrothermal veins of alpic type with the following paragenesis: muscovite, albite, pyrite, hornblende, epidote, apatite, chlorite, microcline, heulandite and stilbite. On the examined crystals a presence of the faces of 25 forms were determined (Table 1). These crystalographic elements were determined:

a:b:c = 0,7548 : 1 : 0,8546 β=119° 41,5'.

Two types of titanite crystals were separated. The first type is shown in Figures 1-4, and the second one in Figures 5-10. Their interacting relation was not determined.

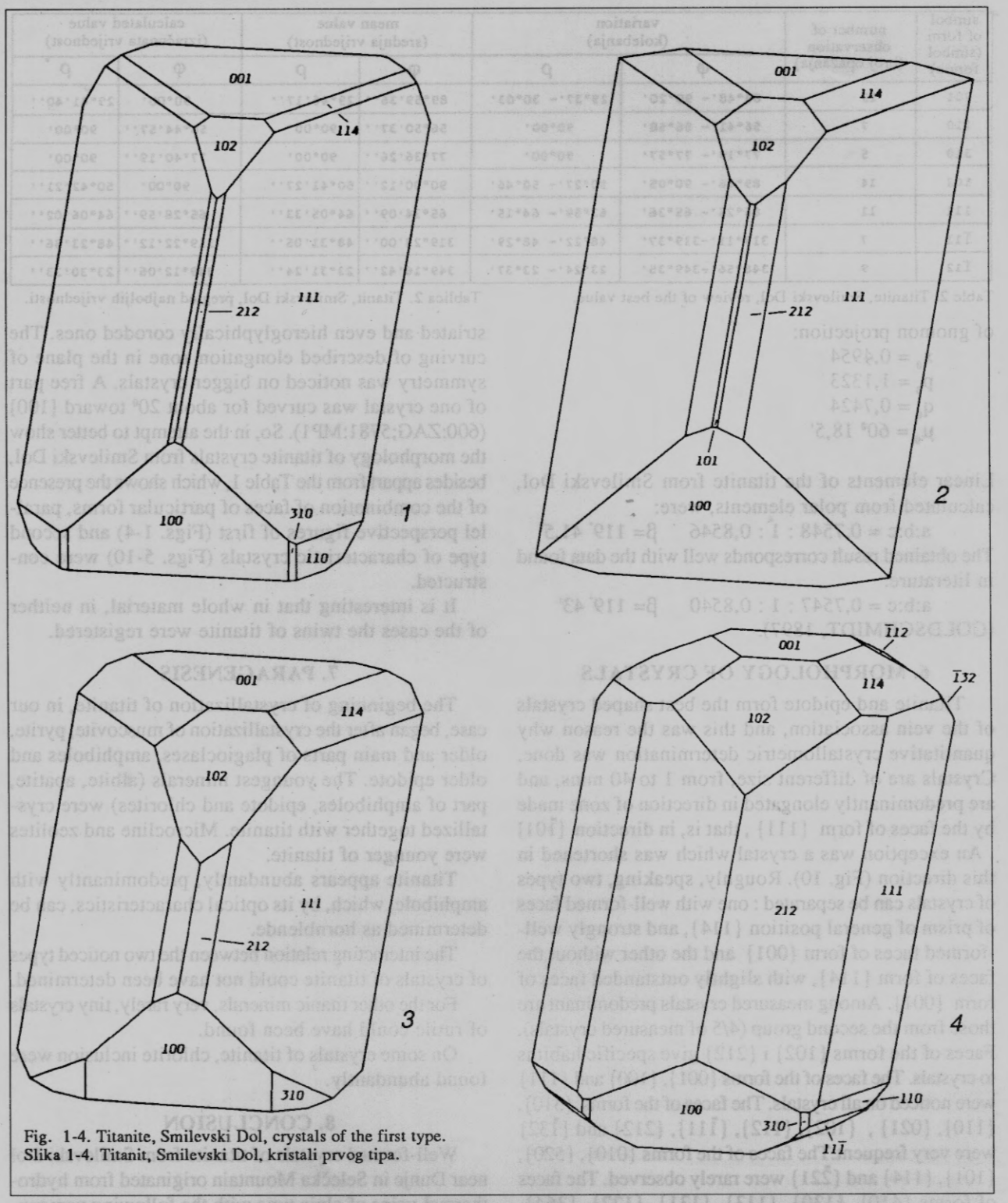

Fig. 1-4. Titanite, Smilevski Dol, crystals of the first type.
Slika 1-4. Titanit, Smilevski Dol, kristali prvog tipa.

9. REFERENCES

BARIĆ, Lj. (1958): Mineralienfundort in Smilevski Dol bei Dunje in Mazedonien.- Bull. Sci. Cons. Acad. Yougosl.4/1, 1, Zagreb.

GOLDSCHMIDT, V. (1897): Krystalographische Winkeltabellen.- Verlag von Julius Springer, 344 p., Berlin.

GOLDSCHMIDT, V. (1934): Kursus der Kristallometrie. - Verlag von gebruder Borntraeger, Berlin.

Mineraly,Tom III, vyp., I. - Akademija nauk SSSR, "Nauka",1972, Moskva.

RAFFAELLI, P. (1961): Albite from Smilevski Dol in Selečka Mountain, Macedonia. - Geološki vjesnik, 14, 133-142, Zagreb.

TIBLJAŠ, D., ZEBEC, V. & BERMANEC, V. (1987): Zeolite occurrence in the vein mineral paragenesis near Dunje, Macedonia.- Geološki vjesnik, 40, 81-87, Zagreb.

ZEBEC, V. (1984): Epidot von Smilevski Dol bei Dunje im Selečka-Gebirge (Mazedonien).- Geologica Macedonica, 1/1, 63-122, Štip.

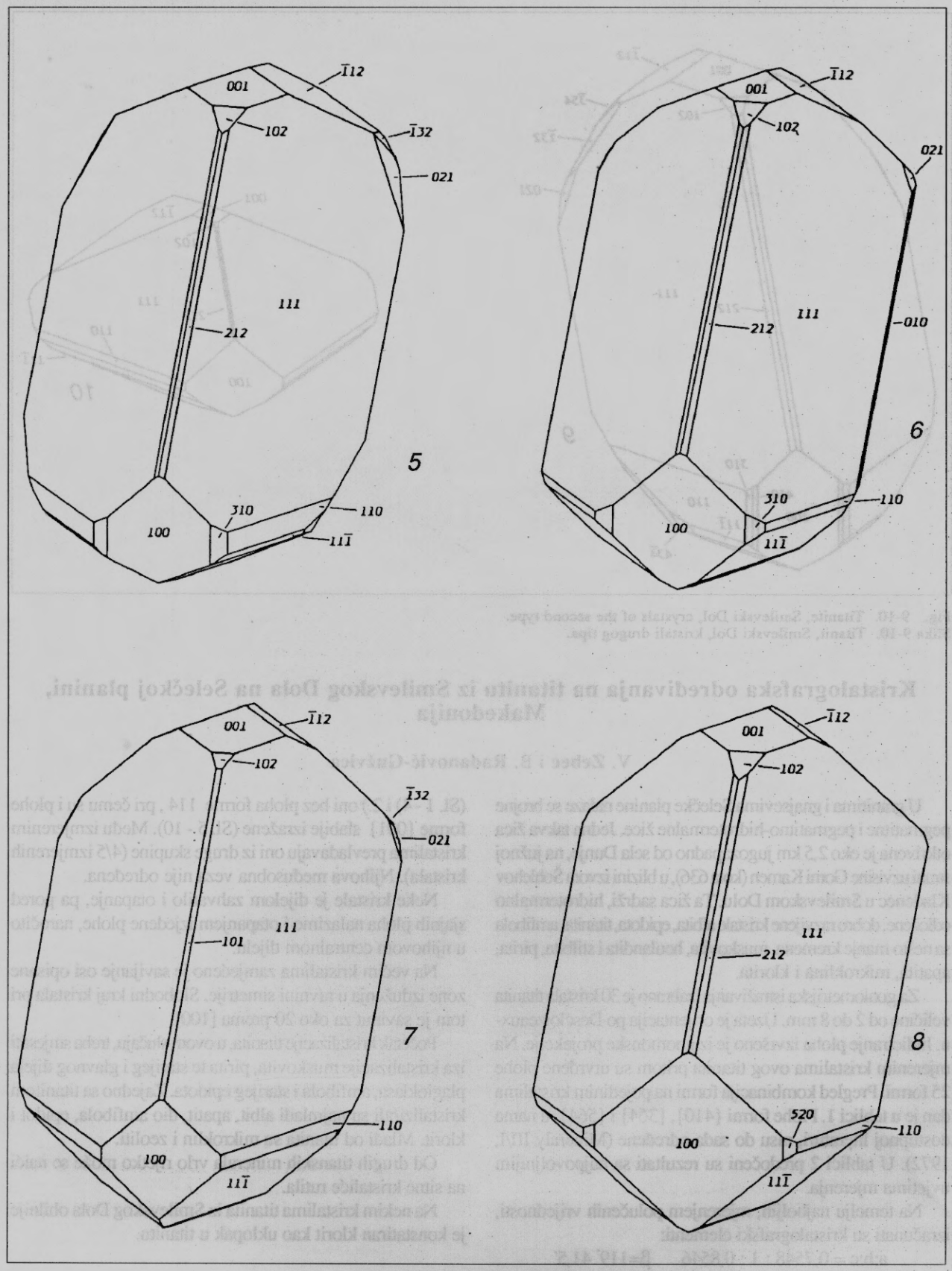

Fig. 5-8. Titanite, Smilevski Dol, crystals of the second type.
Slika 5-8. Titanit, Smilevski Dol, kristali drugog tipa.

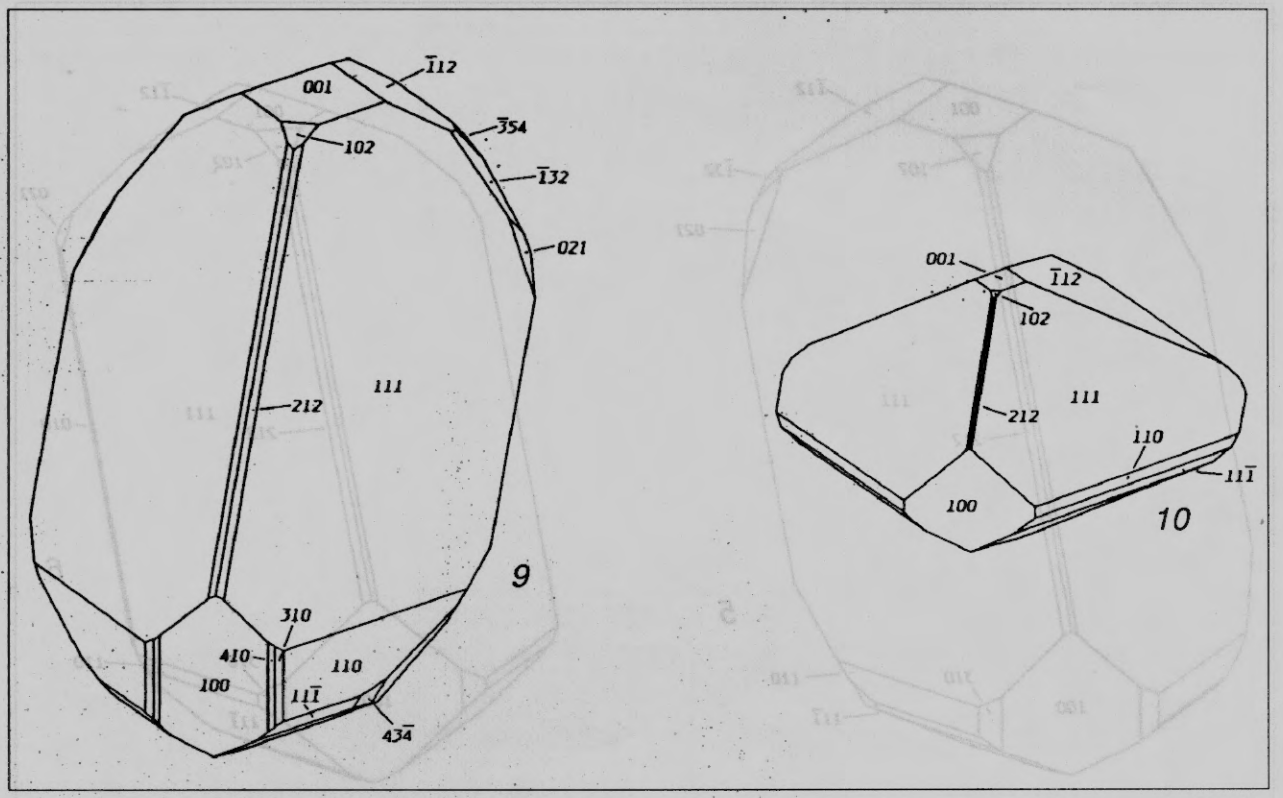

Fig. 9-10. Titanite, Smilevski Dol, crystals of the second type.
Slika 9-10. Titanit, Smilevski Dol, kristali drugog tipa.

Kristalografska određivanja na titanitu iz Smilevskog Dola na Selečkoj planini, Makedonija

V. Zebec i B. Radanović-Gužvica

U granitima i gnajsevima Selečke planine nalaze se brojne pegmatitne i pegmatitno-hidrotermalne žice. Jedna takva žica otkrivena je oko 2,5 km jugozapadno od sela Dunje, na južnoj strani uzvisine Gorni Kamen (kota 636), u blizini izvora Šohlehov Kladenec u Smilevskom Dolu. Ta žica sadrži, hidrotermalno odložene, dobro razvijene kristale albita, epidota, titanita, amfibola sa nešto manje kremena, muskovita, heulandita i stilbita, pirita, apatita, mikroklina i klorita.

Za goniometrijska istraživanja izabrano je 30 kristala titanita veličine od 2 do 8 mm. Uzeta je orijentacija po Descloizeaux-u. Indiciranje ploha izvršeno je iz gnomonske projekcije. Na mjerenim kristalima ovog titanita pritom su utvrđene plohe 25 formi. Pregled kombinacija formi na pojedinim kristalima dan je u tablici 1. Plohe formi {410}, {364} i {564}, u nama dostupnoj literaturi, nisu do sada određene (Mineraly III/I, 1972). U tablici 2 predočeni su rezultati sa najpovoljnijim uvjetima mjerenja.

Na temelju najboljih, mjerenjem polučenih vrijednosti, izračunati su kristalografski elementi:

$$a:b:c = 0{,}7548 : 1 : 0{,}8546 \qquad \beta = 119^{\circ}\,41{,}5'$$

Kristali titanita iz Smilevskog Dola uglavnom su izduženi smjerom zone što ju čine plohe forme {111} tj. smjerom [$\bar{1}$01]. Grubo se mogu izdvojiti dva tipa kristala: 1.) oni sa razvijenim plohama forme {114} i jače razvitim plohama forme {001} (Sl. 1 - 4) i 2.) oni bez ploha forme 114, pri čemu su i plohe forme {001} slabije izražene (Sl. 5 - 10). Među izmjerenim kristalima prevladavaju oni iz druge skupine (4/5 izmjerenih kristala). Njihova međusobna veza nije određena.

Neke kristale je dijelom zahvatilo i otapanje, pa pored sjajnih ploha nalazimo i otapanjem izjedene plohe, naročito u njihovom centralnom dijelu.

Na većim kristalima zamjećeno je savijanje osi opisane zone izduženja u ravnini simetrije. Slobodni kraj kristala pri tom je savinut za oko 20 prema [100].

Početak kristalizacije titanita, u ovom slučaju, treba smjestiti iza kristalizacije muskovita, pirita te starijeg i glavnog dijela plagioklasa, amfibola i starijeg epidota. Zajedno sa titanitom kristalizirali su najmlađi albit, apatit, dio amfibola, epidot i klorit. Mlađi od titanita su mikroklin i zeoliti.

Od drugih titanskih minerala vrlo rijetko može se naići na sitne kristaliće rutila.

Na nekim kristalima titanita iz Smilevskog Dola obilnije je konstatiran klorit kao uklopak u titanitu.

Manuscript received March, 31. 1992.
Revised manuscript accepted June, 23. 1992.