

Ahmed MAHMOOD *

CLINOPYROXENES OF THE TESCHENITIC ASSOCIATION FROM THE POLISH CARPATHIANS

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(438.232 Pastwiska k. Cieszyna i Puńców)

A b s t r a c t. A mineralogical study of the chief mineral component i.e. pyroxenes of the teschenitic association is made. The pyroxenes are mostly titan-augites. Besides these a later stage green variety occurs as the chief mafic mineral of the leucocratic rocks. It was identified as ferri-ferrous augite. All these pyroxenes are Si deficient. Al along with a small amount of Ti, in certain cases, compensates this deficiency. The amount of Al + Ti, however, in the case of green ferri-ferrous pyroxene is insufficient and thus Fe^{3+} is supposed to fill the lacking Z sites. The pyroxenes investigated are compared with those from the other petrological provinces.

Clinopyroxenes are the most important mineral group of the teschenitic rock series. These occur in almost all the rock varieties distinguished. Generally the clinopyroxenes are titan-augites but in the products of the later stage of magma crystallization an iron rich variety is the most important mafic. In view of the greatly altered nature of these pyroxenes only three sufficiently fresh specimens could be separated for a detailed mineralogical study.

OCCURRENCE

The pyroxene No. 1 is from a highly melanocratic limburgitic rock occurring in the centre of a sill at Pastwiska near Cieszyn (Teschen). This sill displays a well differentiated sequence. Pyroxene No. 2 is from the margin of the same sill. The host rock in this case is a coarse grained teschenite, with large phenocrysts in titan-augite and lamprobolite in an unclear glassy matrix containing scarce subhedral grains of analcite.

* At present post-graduate student at the Department of Mineralogy and Petrography, Jagellonian University, Cracow (Kraków)

Pyroxene No. 4 occurs in a leucocratic vein in a thick teschenitic sill at Puńców. The rock is a nepheline syenite. Both nepheline and the alkali feldspar are intermixed with unclear glassy mass. Pyroxene constitutes only 7 to 8 per cent of the rock.

OPTICAL AND PHYSICAL PREPRTIES (TABLE 1)

Pyroxene No. 1 forms both small and large grains. These grains are, however, smaller than the accompanying saponitic pseudomorphs of olivine. Pyroxene No. 2 displays equally large grains with those of associated lamproblitic amphibole. The pyroxenes sometimes have large iron ore inclusions. The grains are often cracked. Both pyroxene No. 1 and 2 typically show the colour zoning as a result of unequal distribution of Ti within a single grain. Almost always the outer parts of grains are coloured light purplish brown with a colourless core. In the case of pyroxene No. 2 the coloured parts are more markedly pleochroic. As also observed by Wilkinson (1957), in a classic example of the zoning of this kind, the outlines of the coloured parts are conformable with that of the grain (photo 1 and 2). Under the crossed nicols the colour zoning is manifested in the form of hour-glass structure and in the difference of birefringence, extinction angle and optical axial angle ($2V$). The zoning observed in the present case is of the normal type, whereby $2V$ (core) is greater than $2V$ (margin).

Pyroxene No. 4 is entirely different from the preceding two, both in its mode of occurrence as well as optical characteristics. It forms short prisms. It is greenish yellow and strongly pleochroic. Pleochroism in shades of green agrees with the pleochroic scheme of such kinds of iron rich

Table 1
Physical properties of the teschenitic pyroxenes from the Polish Carpathians

Pyroxene		Sp. gravity	Relief	Pleochroism	N_a	N_y	Z/γ	$2V_y$
No	Locality				(aver- age)	(aver- age)		
1	Pastwiska	3.398	high	in shades of pale purplish brown	1.714	1.744	45° to 50°	45° to 53°
2	Pastwiska	3.400	high	in shades of pale purplish brown	1.726	1.748	50° (ave- rage)	54° to 60°
3	Marklo- wice	3.401	—	greyish violet to greyish yellow	1.721	1.746	50°	51°
4	Puńców	—	medium	α = deep green β = yellow green γ = yellow	1.743	1.766	30°	70°, 71°

Pyroxene No. 3 is taken from Wawryk's study (1935)

pyroxenes (Hess 1949). A yellow tinge may be due to Ti content (Tyler & King 1967).

Pyroxene No. 1 is free from any kind of amphibolitization. It only shows very thin rims of fresh grassy green iron rich pyroxene. Pyroxene No. 2 is rimmed by coarse envelopes of lamproblitic amphibole. Pyroxene No. 4 owing to its extremely iron rich nature alters to limonite. Very infrequently there is partial alteration to biotite as well.

CHEMISTRY AND X-RAY DATA

Three genetically important pyroxenes chosen for chemical analysis were first subjected to preliminary magnetic separation. Further concentration was performed by means of heavy liquids. The separation of the felsics from mafics was achieved using bromoform. The pyroxene No. 1 was separated from the accompanying biotite in the mercuric potassium iodide liquid (sp. gr. 3.18). Pyroxene No. 2 and pyroxenes of similar occurrence, widespread in this petrological province, always presented the difficulty of their separation from the associated brown hornblende and alkali amphibole. In the present case the associated amphibole was lamproblomite. Their separation was achieved by the use of methylene iodide. In the cases of pyroxene No. 4 both Thoulet liquid ($HgI + KI + + aq.$) and methylene iodide was used. In this way nearly pure pyroxene samples, free from biotite and limonitic matter, was obtained. A 100% purity is, however, not claimed, particularly where the Ti-augites had a thin rim of green iron rich pyroxene.

Table 2
Chemical composition, in weight per cent, of the teschenitic pyroxenes from the Polish Carpathians

	No. 1	No. 2	No. 3	No. 4
SiO_2	42.70	40.90	44.71	35.67
TiO_2	2.56	2.58	2.92	2.59
Al_2O_3	6.83	8.60	7.85	5.93
Fe_2O_3	6.76	5.63	4.46	13.87
FeO	2.49	3.50	4.23	13.00
MnO	0.054	0.112	0.10	0.56
MgO	11.92	11.95	11.74	5.26
CaO	25.50	24.81	22.37	19.70
Na_2O	0.18	0.22	0.90	1.30
K_2O	0.27	0.26	0.09	0.26
Loss on ignition	0.796	1.19	0.35 (H_2O)	1.44
Total	100.06	99.75	99.72	99.58

Analyses Nos. 1, 2 and 4 by the author.

Analysis No. 3 by Wawryk (1935).

(The numbers of analyses correspond to the numbers of the pyroxenes).

Table 3

Formulae of clinopyroxenes on basis of six oxygen atoms

		Pyroxene No. 1	Pyroxene No. 2	Pyroxene No. 3	Pyroxene No. 4
Z	Si	1.630	1.584	1.690	1.490
	Ti	0.063	0.026	—	0.080
	Al	0.307	0.390	0.310	0.292
	Fe ³⁺	—	—	—	0.138
	Al	—	—	0.040	—
Y	Ti	0.012	0.051	0.083	—
	Fe ³⁺	0.197	0.162	0.127	0.295
	Fe ²⁺	0.080	0.114	0.134	0.456
	Mn	0.000 —	0.002	0.003	0.001
	Mg	0.678	0.686	0.661	0.325
X	Ca	1.045	1.028	0.906	0.883
	Na	0.013	0.007	0.066	0.105
	K	0.013	0.002	0.004	0.001
Z	=	2.00	2.00	2.00	2.00
X + Y	=	2.03	2.05	2.02	2.06
Atomic %	Mg	34.0	34.4	36.1	15.5
	Fe	13.8	14.0	14.4	42.5
	Ca	52.2	51.6	49.5	42.0
Atomic percentages at Z of the elements accompanying Si					
Al	15.3	19.5	15.5	14.6	
Ti	2.1	1.3	—	4.0	
Fe ³⁺	—	—	—	6.9	

$\text{Al}_2\text{O}_3 + \text{TiO}_2$, MgO , CaO and the total iron were determined by complexometric titrations. TiO_2 alone and MnO were determined colorimetrically. Alkalies were determined using flame photometry. Table 2 presents the results of chemical analysis in wt. percentages, and Table 3 number of ions calculated on the basis of six oxygen atoms.

Pyroxenes of the present petrologic province, like those from other provinces of similar nature, are under-saturated in Si which is partly replaced by Al. Except for the case of pyroxene 3 (anal. Wawryk 1935), the other three pyroxenes do not have sufficient Al to fill the two Z sites per formula unit. In case of pyroxenes Nos. 1 and 2 part of Ti is probably also situated at Z site. In the case of pyroxene No. 4 the amount of $\text{Si} + \text{Al} + \text{Ti}$ is insufficient to satisfy the numerical requirements of the Z group. In this case a part of Fe^{3+} has also been considered to occupy tetrahedral positions.

In the case of pyroxenes under consideration the amount of Ti is nearly constant. This may also arise the possibility that only a part of

Ti in all the three cases occupies tetrahedral Z sites and some Ti remains in octahedral coordination. Very few pyroxenes which have been analysed show Fe^{3+} in the tetrahedral position. According to Kuno (1955), partial replacement of Si^{4+} by Fe^{3+} appears to be characteristic of sub-calcic and ferro-augites. Where a small portion of Fe^{3+} enters the tetrahedral position in the pyroxenes, the temperature of the crystallization for such pyroxenes is lower than of the normal ones. The temperature of the magma now lies above this point and, therefore, only sub-calcic or ferro-augites can be formed as stable phases ($\text{Mg} : \text{Fe}$ is more than 40 : 60).

There is a gap in total iron content between pyroxenes Nos. 1, 2, 3 and pyroxene No. 4. No intermediate pyroxene was found to occur. Fe^{3+} preponderates over Fe^{2+} , as is the case with most of the pyroxenes of the basic alkaline rocks (Deer, Howie, Zussman 1962). $\text{FeO}/\text{Fe}_2\text{O}_3$ ratio, however, increases from the sample No. 1 to 4.

MgO remains constant in the first three pyroxenes but in the case of pyroxene No. 4 it is greatly reduced due to replacement by FeO .

CaO , like in pyroxenes of other rocks of alkaline associations, shows comparatively feeble changes with the proceeding fractionation. Although in pyroxene No. 4 its amount is markedly reduced yet the overall course of differentiation does not deviate very much from the Di-Hd join, due to large scale replacement of Ca by alkalies.

Total alkalies, and Na_2O in particular, increase from pyroxene No. 1 to No. 4. With an increase in Fe^{3+} the content of acmite molecule in pyroxene (No.4) rises.

In Table 4 the results of the X-ray analyses are given. These are compared with those of a typical diopside and a Ti-augite, taken from Zwaan's study (1954). The present X-ray diffraction patterns were ob-

Table 4
X-ray powder patterns of the teschenitic pyroxenes

Pyroxene No. 1		Pyroxene No. 2		Pyroxene No. 3		Diopside, Zillertal, Tyrol, Austria (No. 13)*		Ti-augite, Babutzim, Czechoslovakia*	
d (Å)	I	d (Å)	I	d (Å)	I	d (Å)	I	d (Å)	I
3.25	s	3.27	vs	3.25	ms	3.23	m	3.24	mw
2.99	vvs	3.12	ms	2.54	ms	2.99	vs	2.999	vs
2.56	s	2.96	s	2.18	m	2.957	mw	2.957	sm
2.16	ms	2.55	ms	1.73	ms	2.896	sm	2.901	mw
2.05	m	2.16	ms	1.63	s	2.562	sm	2.510	m
1.748	m	1.741	m	1.53	ms	2.514	vs	2.148	vw
1.620	s					2.157	w	1.746	mw
						1.754	mw	1.624	w
						1.624	s	1.614	vw

* after Zwaan (1954)

tained using CuK_α radiation which, however, due to Fe content in the samples gives raise to rather high background. The scanning speed was 2°/min.

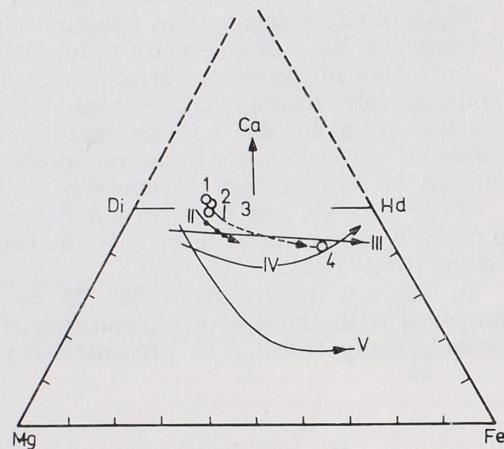
The results of the analyses are close to those of the Di-Hd pyroxenes.

CRYSTALLIZATION

The substitution of Mg by Fe is distinctly marked, especially in No. 4. Subordinately substitution $\text{Ca}(\text{Fe}^{2+}, \text{Mg}) \rightarrow \text{NaFe}^{3+}$ can also be observed. Both of these phenomena are accompanied by an unsystematic replacement of Si by Al. The plot visualizing the crystallization trends of pyroxenes investigated (Fig. 1) show a coarse sub-parallel to Di-Hd join.

Fig. 1. Crystallization trend of monoclinic pyroxenes

I — clinopyroxenes of the teschenitic association from the Polish Carpathians (○ analyses 1—4, Table 2), II — Black Jack Sill, Australia (Wilkinson 1957), III — Japanese alkaline basaltic series (Aoki 1964), IV — Skærgaard intrusion (Brown 1957), V — Japanese tholeitic series (Kuno 1955)



For comparison sake the plots for other pyroxenes are also included. The trends of pyroxenes Nos. 1—4 and those of the Black Jack Sill (Wilkinson 1957) are perfectly parallel, difference is seen only in a slightly more Si-saturated nature of the pyroxenes of the Black Jack Sill, when compared with that of the present ones. Pyroxene No. 4 corresponds to the mineral of the Black Jack Sill whose chemical composition was determined by optical methods. The crystallization trend of the pyroxenes of the Polish Carpathians lies closer to the Di-Hd join. This crystallization trend conforms to the one for the alkaline rock series, in the present case exemplified by the crystallization trend of the alkaline rocks of Japan. On the other hand it differs from that of the tholeitic rock series in not showing a downward sag away from the Di-Hd line.

In Fig. 2, Si and Al_z relation is shown. It is difficult to construct a $\text{Si} \rightarrow \text{Al}$ substitution trend for all the four pyroxenes. Their projection points lie in the zone of feldspathoidal alkaline rocks, which are mentioned by LeBas (1962) as per-alkaline rocks. Ramberg (1952) and later

LeBas (1962) suggested that with increasing Fe/Mg ratio and provided $(\text{Fe}^{\text{total}} + \text{Mn}) / (\text{Fe}^{\text{total}} + \text{Mn}) + (\text{Ca} + \text{alk.}) + \text{Mg}$ is 18 or less (in atomic per cent), Al_z increases. Such a relation in the present case, where Fe/Mg ratio in the Ti-augite group increases very feebly, may not be reliable, despite varying amounts of Al, recorded in the present case. However, pyroxenes Nos. 1 and 2, which are definitely (as supported by the field evidence, too) two end members of a sill differentiated from the core to the margin, show a marked increase in Al_z as compared with a feeble rise in Fe/Mg ratio from the one to the other. Early crystallizing pyroxenes, in fact, show very little change in their Fe, Mg-contents with the proceeding fractionation. Pyroxene No. 4, therefore, forms a magmatic product detached from the rest of the sequence. The leucocratic rocks in the present petrologic province (as already observed by Smulikowski, 1929) form veins between the melanocratic rocks. These, therefore, formed from squeezed out, late stage, liquids crystallizing at low temperatures under hydrous conditions. At these low temperatures only a limited amount of Al could be incorporated in the pyroxene structure whereas the magma was extremely undersaturated in SiO_2 . This facilitated the substitution of Si^{4+} by Fe^{3+} along with Al^{3+} ions.

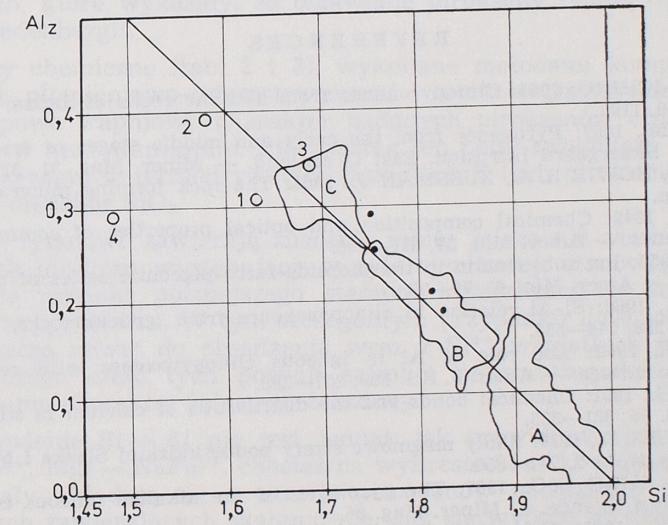


Fig. 2. Relation between the atomic proportions of Si and Al_z in the clinopyroxenes from the three different rock groups. Approximate concentration areas of projection points

A — clinopyroxenes from the tholeitic rocks, B — clinopyroxenes from the feldspathoid-free alkaline rocks, C — clinopyroxenes from the feldspathoid-bearing rocks. ○ clinopyroxenes of the teschenitic association from the Polish Carpathians. ● clinopyroxenes of the Black Jack Sill, Australia (Wilkinson 1957). Atomic proportions are calculated on the basis of six oxygen atoms. (Kushiro 1960)

Pyroxene No. 4, though its projection point lies in the ferrosalite range, shows chemical properties slightly in between those of ferrosalite and aegirine-augite. Somewhat high octahedral Fe^{3+} content of this pyroxene may indicate charge balancing for the trivalent ions accompanying Si in the tetrahedral position.

Ti remains surprisingly constant and does not show a correlation with Al. The lack of its influence on Al_z in case of these pyroxenes seems to be in agreement with Kushiro's (1960) findings.

The pyroxenes of the teschenitic association of the Polish Carpathians are, therefore, products of a magma undersaturated in SiO_2 . The amount of other elements, substituting Si, are subordinated to the state of saturation in SiO_2 of the particular magma fraction, and, in a lesser degree, to the temperature of crystallization.

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Ahmed MAHMOOD

PIROKSENY SKAŁ SERII CIESZYNITOWEJ POLSKICH KARPAT

Streszczenie

Niniejsze studium mineralogiczne poświęcone jest piroksenom jednokształtnym, stanowiącym jeden z najważniejszych składników skał serii cieszyńskiej polskich Karpat. Autor szczegółowo zbadał trzy wybrane okazy świeżych i z genetycznego punktu widzenia ważnych piroksenów. Najpospolitszą odmianą w tych skałach są augity tytanowe, z których zbadano dwa. Trzeci okaz reprezentuje zieloną odmianę augitu, zasobną w żelazo, wyseparowaną z leukokratycznego sjenitu zawierającego nefelin i analcy. Skałami macierzystymi pozostałych piroksenów były odpowiednio limburgit i cieszyńc. Ponadto w rozwązaniach uwzględniono dane o augicie tytanowym zawarte w pracy Wawryka (1935).

Pirokseny wydzielono ze skał za pomocą separatora magnetycznego oraz cieczy ciężkich (jodku metylenu i cieczy Thculeta).

W tabelach 1 i 4 przedstawiono wyniki badań mikroskopowych i rentgenowskich, które wykazały, że omawiane pirokseny należą do szeregu diopsyd-hedenbergit.

Analizy chemiczne (tab. 2 i 3), wykonane metodami kompleksometrycznymi, płomieniowo-fotometrycznymi i fotokolorimetrycznymi, wykazały typowo wapniowy charakter badanych piroksenów oraz wysoką zawartość w nich aluminium. Pierwiastek ten pełni zasadniczo rolę podstawnika krzemu w tetraedrycznych pozycjach Z tych piroksenów, które wykazują niedobór SiO_2 .

Augity tytanowe zawierają znacznie mniej żelaza niż zasobny w ten pierwiastek piroksen występujący w żyłce sjenitowej, stanowiącej przypuszczalnie produkt późniejszego stadium krystalizacji w środowisku o niższej temperaturze. W tym szczególnym przypadku ilość jonów Al^{3+} nie wystarcza nawet do obsadzenia wraz z Si^{4+} wszystkich pozycji Z, wskutek czego część tych pozycji zajmuje najprawdopodobniej Fe^{3+} , a piroksen ma charakter żelazowo-żelazawy.

Podstawienie $\text{Si} \rightarrow \text{Al}$ nie jest jednak tak prawidłowe jak $\text{Mg} \rightarrow \text{Fe}$ lub $\text{Ca}(\text{Fe}^{2+}, \text{Mg}) \rightarrow \text{NaFe}^{3+}$, chociaż na wykresie $\text{Si} : \text{Al}_z$ wszystkie badane minerały układają się w strefie piroksenów pochodzących ze skał alkalicznych zawierających skaleniowce. Jak się wydaje, w danym przypadku Ti nie jest czynnikiem kontrolującym Al_z .

Jest rzeczą charakterystyczną, że omawiane pirokseny nie wykazują podstawienia wapnia przez alkalia na większą skalę. Dlatego linia przebiegu ich krystalizacji jest niemal równoległa do linii łączącej punkty projekcyjne Di i Hd. Jednak przy wyższej zawartości Na i Fe^{3+} w piroksenie żelazowo-żelazowym może on zawierać domieszkę drobiny akmitowej.

Na ogół omawiane pirokseny wykazują skład odpowiadający ich środowisku magmowemu. Ich główną cechą jest niedobór Si i związane

z tym zjawisko wchodzenia w pozycje tetraedryczne Z takich jonów trój- i czterowartościowych, jak: Al, Fe i Ti. Stopień tego podstawienia zależy od nasycenia krzemionką danej frakcji magmy oraz od temperatury jej krystalizacji.

OBJAŚNIENIA FIGUR

Fig. 1. Przebieg krystalizacji piroksenów jednoskośnych
I — pirokseny jednoskośne z serii cieszyńskiej polskich Karpat (○ analizy 1–4,
tab. 2), II — Black Jack Sill, Australia (Wilkinson 1957), III — seria alkalicznych ba-
zaltów Japonii (Aoki 1964), IV — intruzja Skaergaard (Brown 1957), V — seria toleito-
wala Japonii (Kuno 1955)

Fig. 2. Zależność między ilością atomów Si oraz Al w piroksenach jednoskośnych
z trzech różnych typów skał
A — pirokseny jednoskośne ze skał toleitowych, B — pirokseny jednoskośne z bez-
skaleniowcowych skał alkalicznych, C — pirokseny jednoskośne ze skał skaleniowco-
wych. ○ pirokseny jednoskośne z serii cieszyńskiej polskich Karpat • — pirokseny
z Black Jack Sill, Australia (Wilkinson 1957). Ilość atomów wyliczono w stosunku do
6 atomów tlenu. (Kushiro 1960)

Ахмед МАХМУД

ПИРОКСЕНЫ ГОРНЫХ ПОРОД ТЕШЕНИТОВОЙ СЕРИИ ПОЛЬСКИХ КАРПАТ

Резюме

В работе представлена минералогическая характеристика моноклинных пироксенов, являющихся одним из основных компонентов пород тешенитовой серии Польских Карпат. Автором были детально изучены три образца свежих и генетических важных пироксенов. Два из них, выделенные соответственно из лимбургита и тешенита, принадлежат к самой распространенной разновидности — титанистому авгиту, а третий, выделенный из лейкократового сиенита с нефелином и анальцимом, является зеленой, богатой железом разновидностью. Кроме того, в работе учтены результаты химического и минералогического исследования титанистого авгита из силезских тешенитов, выполненного Ваврыком (Wawryk 1935).

Жимические анализы, выполненные автором методами комплексометрии, пламенной фотометрии и фотоколориметрии, показали, что эти минералы относятся к кальциевым пироксенам, содержащим повышенное количество алюминия, который, в основном, замещает кремний в тетраэдрах пироксенов, недосыщенных этим элементом.

Титанистые авгиты содержат намного меньше железа чем вышеуказанная разновидность из сиенитовой жилы, являющаяся, вероятно, продуктом поздней стадии кристаллизации, протекающей при более низкой температуре. В этих специфических условиях количество ионов кремния и алюминия было недостаточно даже для заполнения всех тетраэдри-

ческих положений. Поэтому часть из них была занята ионами трехвалентного железа, вследствие чего образовался пироксен железистого типа (ферроавгит). Однако замещение $\text{Si} \rightarrow \text{Al}$ не настолько закономерно как $\text{Mg} \rightarrow \text{Fe}^{2+}$ или Ca/Fe^{2+} , $\text{Mg}/\text{NaFe}^{3+}$, хотя на диаграмме $\text{Si}:\text{Al}_z$ все рассмотренные пироксены расположены в зоне этих минералов из щелочных пород, содержащих фельдшпатоиды. Повидимому, в данном случае титан является фактором контролирующим Al_z .

Следует отметить, что в пироксенах из пород тешенитовой серии не наблюдается значительного замещения щелочными элементами. Поэтому путь их кристаллизационной эволюции почти параллелен линии, соединяющей проекционные точки Di и Hd . Однако, необходимо сказать, что железистый пироксен, более богатый натрием и трехвалентным железом, содержит примесь акмитовой молекулы.

В общем состав изученных пироксенов соответствует магматической среде их образования. Наиболее характерным признаком этих минералов является недостаток кремнезема и связанное с этим присутствие в тетраэдрических позициях таких трех- или даже четырехвалентных ионов как ионы алюминия, железа и титания. Степень такого замещения зависит от насыщения кремнекислотой данной фракции магмы и от температуры её кристаллизации.

ОБЪЯСНЕНИЯ К ФИГУРАМ

Фиг. 1. Пути кристаллизации пироксенов

I — тешенитовая серия Польских Карпат (о анализы 1–4, табл. 2), II — силь Блек Джек (Wilkinson 1957), III — японская серия щелочных базальтов (Aoki 1964), IV — скаргаардская интрузия (Brown 1957), V — японская толейитовая серия (Kuno 1955)

Фиг. 2. Зависимость между содержаниями кремния и алюминия в тетраэдрических по-

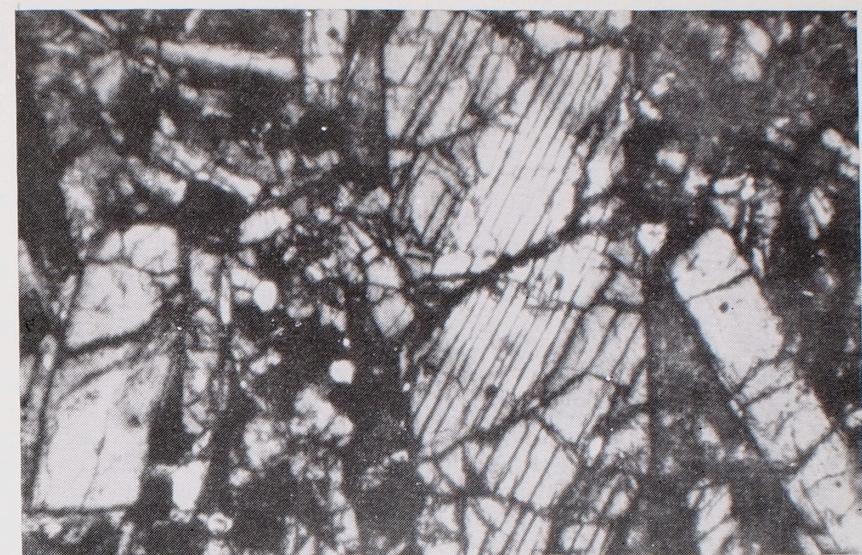
зициях моноклинных пироксенов разных групп горных пород
A — пироксены толейитовой серии, B — пироксены из щелочных пород, не содержащих фельдшпатоидов, G — пироксены из пород, содержащих фельдшпатоиды, ○ моноклинные пироксены тешенитовой серии Польских Карпат, • моноклинные пироксены из силь Блек Джек, Австралия (Wilkinson 1957) Атомные соотношения вычислены в пересчете на 6 О. (Kushiro 1960)

PLATE I (PLANSZA I, ТАБЛИЦА I)

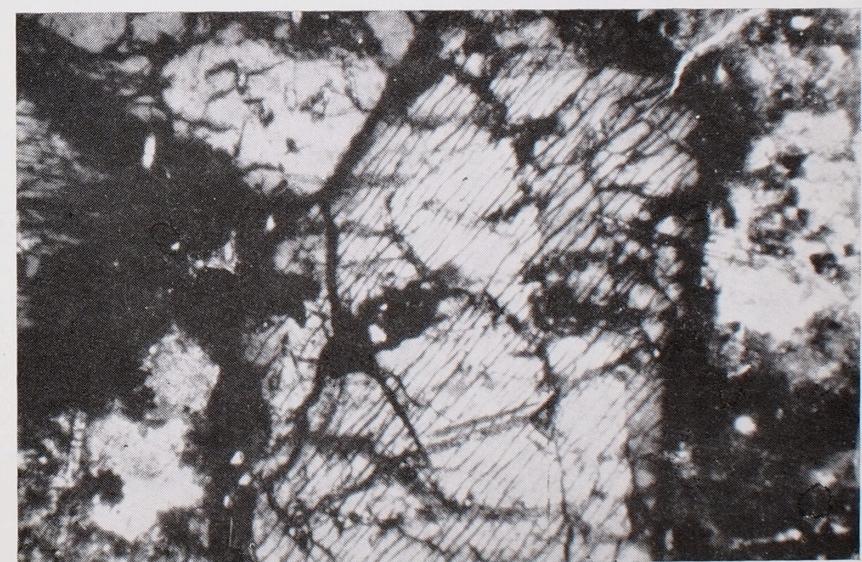
Phot. 1 and 2. ($\times 67$) Hour glass structure in titanoaugites. Outlines of the inner zones are parallel to those of the grains. (Photo nos. correspond to pyroxene nos. in the text). Enlarged 67 \times

Augity tytanowe o strukturze klepsydrowej. Zarysy stref wewnętrznych są równoległe do zarysów ziarn. (Numery fotografii odpowiadają numerom piroksenów w tekście). Pow. 67 \times

Титанистые авгиты со структурой песочных часов. Границы внутренних зон параллельны очертаниям зерн. (Номера фотографий соответствуют номерам пироксенов в тексте). Увелич. 67 \times



Phot. 1



Phot. 2

Ahmed MAHMOOD — Clinopyroxenes of the tešchenitic association from the Polish Carpathians