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# POTASSIUM-BEARING VOLCANIC ROCKS FROM THE NORTHERN MARGIN OF THE KRZESZOWICE TROUGH

Abstract. Petrographic investigations have been carried out on potassium-rich volcanic rocks from six occurrences in the vicinity of Krzeszowice near Cracow (S Poland, Fig. 1). It has been found that in one case (Szklarka near the trout farm) they represent minetta-like semi-lamprophyre, while in the others — igneous-metasomatic K-feldspar-quartz rocks, called up to now 'kalified rocks', 'potassium trachytes', or 'potassium rhyolites'. Their features confirm, in the authors' opinion, the earlier conclusions (Rozen 1909; Piekarska, Gaweł 1952; Słaby 1987, 1990) that a potassium metasomatosis (adularization-type) decided on potassium-bearingness of the rocks in question. As a result, volcanic rocks with an originally differentiated systematic position have been altered into the rocks being now high-K rhyolites (Fig. 4).

*Key-words*: Palaeozoic volcanic rocks, adularization, minetta-like semi-lamprophyre, S Poland.

## INTRODUCTION

Among the Palaeozoic volcanic rocks from the vicinity of Krzeszowice, occurring both north and south of the Krzeszowice trough, the potassium-rich ones are remarkable. They have been the object of interest for many years, and their genesis has been widely contested (Rozen 1909; Bolewski 1938, 1939; Piekarska, Gaweł 1952; Tokarski 1953; Słaby 1987, 1990, and others). The potassium-bearing rocks from the vicinity of Krzeszowice, determined up to now as 'kalified rocks', 'potassium trachytes' or 'potassium rhyolites', were described from Miękinia (Rozen 1909; Bolewski 1939; Słaby 1990), Siedlec (Bolewski 1938, 1939; Lewowicki 1959), Dubie (Harańczyk 1982), and Zalas (Słaby 1987; Harańczyk 1989).

Three new occurrences of potassium-rich rocks have been reported by the present authors from the Szklarka valley, north of the Krzeszowice trough. These are: two already known outcrops of volcanic rocks, described by Kozłowski (1955) as 'Szklarka near the trout farm' and 'Szklarka near the former border', and the

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third — in the profile of a shallow borehole, drilled in Szklary near the artesian spring (Fig. 1). These three rocks were studied using mineralogical and petrographical methods, and similar supplementary investigations were carried out on the already described potassium-bearing rocks from Miękinia, Siedlec, and Dubie (*op. cit.*). Their results bring about new essential data for the discussion on the genesis of potassium-bearing rocks from this region.

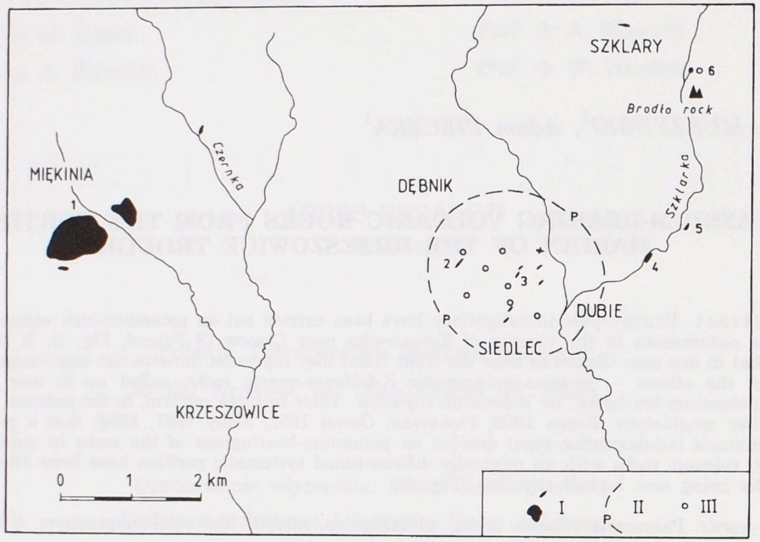


Fig. 1. Occurrences of igneous rocks within the N margin of the Krzeszowice trough between Miękinia and Szklary, with the localization of studied potassium-bearing rocks
1 — Miękinia (N wall of the porphyry quarry, III level), 2 — Siedlec (old mine dump), 3 — Dubie (SW wall of the dolostone quarry), 4 — Szklarka (outcrop near the trout farm), 5 — Szklarka (outcrop near the former border), 6 — Szklary (shallow borehole near the artesian spring); I — igneous rocks cropping out and present in shallow mine workings, II — general extent of the Dębnik porphyry laccolith, III — boreholes with the occurrences of igneous rocks

Miękinia — the top part

The enrichment with potassium of the top part (up to 1 m) of Miękinia porphyries was noted first by Rozen (1909), the rock was studied next by Bolewski (1939) and Słaby (1990), and its genesis discussed by Piekarska and Gaweł (1952). The current authors sampled the topmost, 60-cm thick part of the porphyries, exposed in the N wall of the Miękinia quarry at the III level. Additional samples were taken from the major part of the intrusion, that studied previously by Rozen (1909), Bolewski (1939) and Słaby (1990), for comparative investigations.

The hand-specimen features of the topmost rock correspond well to those cited by Bolewski (1939), and the results of laboratory investigations confirm and supplement those of the earlier ones. It is a rock with the porphyritic texture, in places glomero-porphyritic, with the microcrystalline development of the groundmass and the massive, either random or fluidal structure. The phenocrysts are represented by pseudomorphs after feldspars, biotite and pseudomorphs after this mineral, pseudomorphs after amphiboles, pseudomorphs after pyroxenes previously not reported* (Phot. 1—3), quartz, apatite, and ore minerals (Table 1). The groundmass is built of quartz and feldspars, exclusively potassium ones as confirmed by X-ray analyses (Fig. 2), and subordinate or accessory clay minerals, pseudomorphs after biotite and less frequently after pyroxenes, iron and titanium oxides, apatite and zircon.



Pseudomorphs after feldspars dominate among the phenocrysts and reach sizes up to 12 mm. Originally, the feldspars must have been represented exclusively by plagioclases, developed as automorphic and hipautomorphic tablets and their glomerophyric intergrowths, but now they are built of a clay substance and, subordinately, carbonate minerals. Additionally, particularly in smaller (0.1—0.15 mm) pseudomorphs, an unhomogeneous secondary K-feldspar of the adularia type was observed. Its features are the same as reported by Słaby (1990). Primary inclusions of biotite, apatite and opaque ore minerals have been noted in the pseudomorphs after feldspars.

The biotite of the phenocrysts has been preserved to a various degree: from grains with a weak opacitization to those totally altered. The unchanged biotite has the pleochroism in colours: $\alpha$ — pale yellow, $\beta = \gamma$ — brown-olive. Its crystals, with sizes up to 3 mm, are automorphic, often with a six-sided habit, but show the signs of igneous corrosion. Totally altered pseudomorphs after biotite cannot be distinguished from pseudomorphs after amphiboles, similar in size, habit and mineral composition. This similarity is caused by the fact that the biotite itself, mostly — if not totally, is a secondary mineral, formed from earlier amphiboles. The pseudomorphs after biotite and amphibole are built of clay minerals and an opacite-like substance. The flakes of biotite and their pseudomorphs contain sometimes inclusions of apatite and opaque ore minerals.

Pseudomorphs after pyroxenes reach 0.25 mm in size. They are built of a clay substance and subordinate powdery iron and, possibly, titanium compounds.

The phenocrysts of quartz are strongly corroded, up to 0.8 mm big, and of various shapes. This mineral shows the uniform light extinction.

Apatite forms auto- and hipautomorphic prisms with a maximum length 0.2 mm and elongation from 1 : 3 to 1 : 11.

Intratelluric, basic segregates were observed sporadically. Their sizes correspond to those of the phenocrysts (3.5 mm), and they are built of biotite, opaque ore minerals, clay pseudomorphs after amphiboles (its few relicts show the features of common hornblende) and after subordinate plagioclases; additionally apatite and secondary quartz were found.

The quartz of the groundmass is either xenomorphic or developed as auto- or hipautomorphic crystals with habits typical of the high-temperature variety. Their sizes do not exceed 0.1 mm. Potassium feldspars, with the features of adularia, build in the groundmass pseudomorphs after fine laths of primary feldspars, and are partly substituted by clay minerals.

X-ray analyses (Fig. 2) indicate without any doubt that the feldspars in the rock in question are represented only by a potassium variety with the low degree of structural ordering (Fig. 3). The total content of these minerals is lower than that of quartz, and they are mostly confined to the groundmass as indicated by previous optical observations. It has also been found that the clay minerals are represented by kaolinite and, subordinately, Na-montmorillonite.

The chemical composition of the topmost rock of the Miękinia intrusion (Rozen 1909; Bolewski 1939; Table 2) corresponds to high-K rhyolites, while that of the major part of the intrusion — mostly with dacites, also high-K but with the markedly lower amount of potassium (Fig. 4).

Rozen (1909) treated the enrichment with potassium of the topmost part of the Miękinia porphyries as the effect of a specific weathering alteration — so-called kalification. Bolewski (1939) considered the rock as a separate intrusion and described it as potassium trachyte. The results of Słaby (1990), due to more precise laboratory techniques which were unavailable to her predecessors, seem to support without any doubt Rozen's opinion. She showed that the high potassium content of this rock has been caused by a secondary process — adularization, and this content does not stem from a primary magma composition. The same

* Those pseudomorphs (Phot. 4) have also been found in the lower, major part of the Miękinia intrusion (Table 1), where they have not been reported so far.

TABLE 1

Results of point counting of the potassium-bearing volcanic rocks and — comparatively — the porphyries and hornblende rocks from the northern margin of the Krzeszowice trough (wt.%)

| Components | | Potassium-bearing rocks: K-feldspar-quartz rocks | | | | | Potassium-bearing rocks: Semi-lamprofire | Porphyries | | Hornblende rocks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Miękinia — the top of the flow (average of 2) | Siedlec (average of 3) | Dubie — the marginal part of a complex dike (average of 2) | Szklarka — near a former boarder | Szklary — near the artesian spring | Szklarka — near a trout farm (average of 2) | Miękinia — the major part of the flow (average of 6) | Dębnik — laccolith (average of 5*) | Vicinity of Dubie (average of 4)** |
| Phenocrysts | quartz | 0.3 | — | — | 3.5 | 0.2 | 0.1 | 0.2 | 3.1 | — |
| | pseudomorphs after feldspars | 10.4$^{r}$ | 1.4 | 14.3 | 19.5 | 19.5$^{r}$ | — | — | — | — |
| | plagioclase | — | — | — | — | — | — | 14.4 | 26.1$^{p}$ | 17.4 |
| | biotite | 0.8$^{p}$ | 0.5$^{p}$ | } 5.6$^{po(br)}$ | 1.7$^{p}$ | 4.0 | 7.3$^{p}$ | 1.1$^{p}$ | 2.6 | <0.1 |
| | amfiboles and pseudomorphs after its | 1.2$^{po}$ | — | | 0.1$^{po}$ | 0.3$^{po}$ | — | 0.6$^{po}$ | 1.1$^{p}$ | 3.9 |
| | pseudomorphs after pyroxenes | 0.5 | — | — | — | — | 3.8(?) | 0.5 | — | <0.1 |
| | apatite | 0.1 | — | + | 0.1 | 0.2 | 0.5 | + | + | 0.1 |
| | ore minerals | 0.5 | 0.1 | 1.1 | 0.3 | 0.2 | 0.2 | 0.9 | 0.3 | 1.5 |
| Intratelluric basic cummulates | | 1.5$^{p}$ | — | 0.8$^{p}$ | — | — | — | + | — | 0.6 |
| Groundmass$^{s}$ | | 84.7 | 98.0 | 78.2 | 74.8 | 75.6 | 88.1 | 82.3 | 66.8 | 76.4$^{a}$ |
| Total | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

\+ — the component occurs in the amount <0.1%, a — including microaggregates of quartz or crystoballite, br — biotite occurs only as relicts in pseudomorphs, p — the component partly altered, po — the component occurs only as pseudomorphoses, r — relicts of secondary K-feldspars sometimes present, s — together with secondary components.

* Calculated from the data of Muszyński, Pieczka (1994); ** calculated from the data of Muszyński, Pieczka (1992).

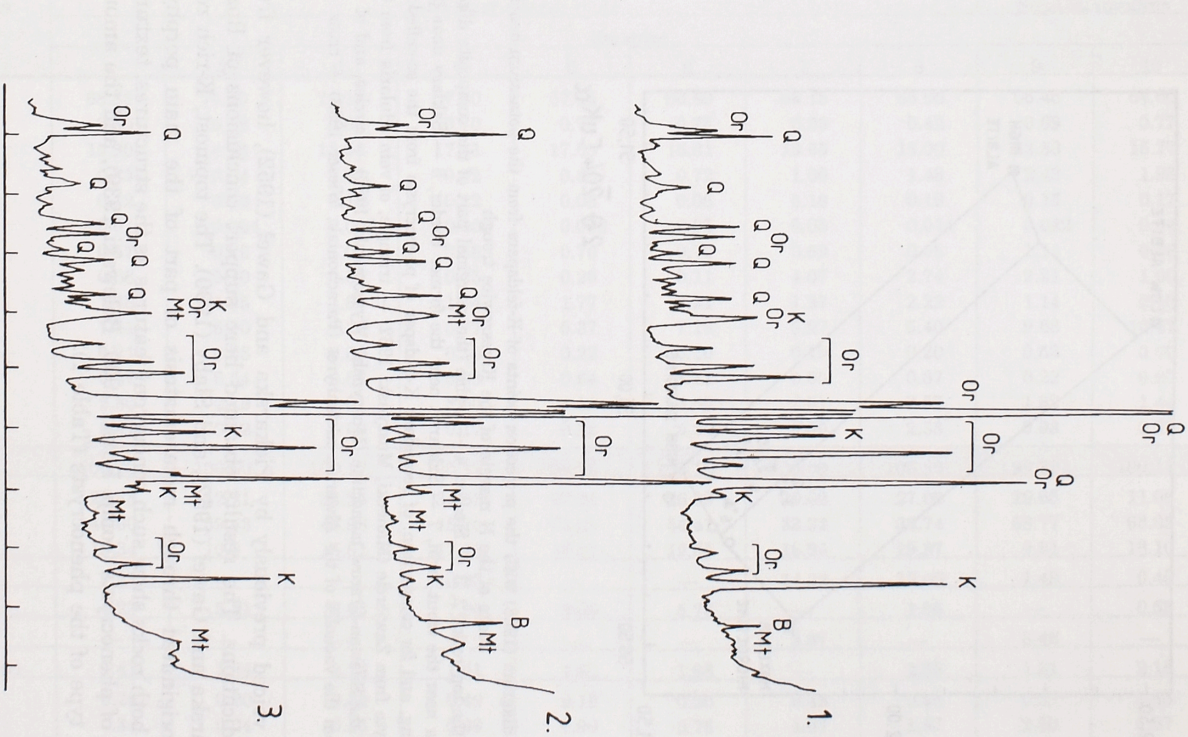


Fig. 2. X-ray diffraction patterns of the potassium-bearing rocks (K-feldspar-quartz ones) from Miękinia (1), Siedlec (2), and Dubie (3)
B — biotite, K — kaolinite, Mt — montmorillonite, Or — K-feldspar, Q — quartz

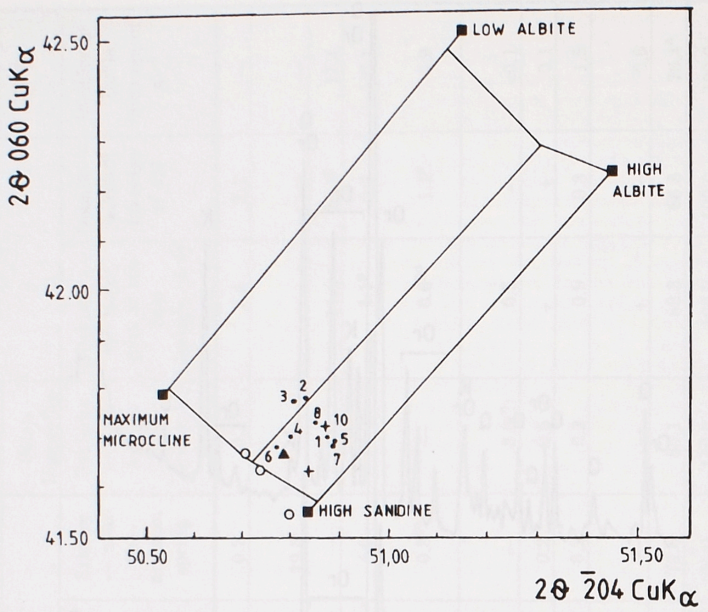


Fig. 3. Wright's diagram (1968) with the projection points of K-feldspars from the potassium-bearing rocks of the N margin of the Krzeszowice trough
1 — Miękinia (the top rock), 2, 3 — Siedlec, 4 — Dubie (the marginal part of the composite dike), 5, 6 — Szklarka near the trout farm, 7 — Szklarka near the former border, 8 — Szklary near the artesian spring, and for comparison: of secondary K-feldspar of phenocrysts from the so-called potassium trachyte from Zawiercie (Manecki, Muszyński 1982) — triangle, of vein adularia from the basement of the Silesian-Cracow monocline (Muszyński, Wyszomirski 1986) — circles, and of adularia from the vacuoles of the Alwernia melaphyres (Parachoniak, Wieser 1992) — cross

opinion was voiced previously by Piekarska and Gaweł (1952), however from geological indications. The results obtained here support conclusions of Rozen (1909), Piekarska and Gaweł (1952), and Słaby (1990). The topmost, K-rich rock must have originated through metasomatosis of part of the main porphyry intrusion, as both rocks show such concurrent features as the structures, textures, development of phenocrysts (comp. Rozen 1909; Bolewski 1939), and the amount and primary type of the phenocrysts (Table 1).

### Siedlec

The potassium-bearing rock, which was mined in Siedlec in 1935—1939 and then shortly after the war, makes a dike with an average thickness of 8 m within Devonian limestones. It was analysed under the microscope and chemically by Bolewski (1938, 1939). Its technological parameters were



TABLE 2

Chemical and normative (CIPW) compositions of the potassium-bearing volcanic rocks from the northen margin of the Krzeszowice through (wt.%)

| Components | K-feldspar-quartz rocks | | | | | | | | Semi-lamprofires | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Samples | | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| $SiO_2$ | 68.85 | 74.10 | 72.10 | 67.60 | 67.15 | 66.60 | 66.15 | 65.90 | 66.45 | 64.60 |
| $TiO_2$ | 0.50 | 0.12 | 0.53 | 0.70 | 0.75 | 0.75 | 0.33 | 0.42 | 0.69 | 0.77 |
| $Al_2O_3$ | 15.90 | 14.15 | 13.58 | 17.31 | 17.65 | 16.81 | 13.65 | 15.00 | 12.88 | 15.77 |
| $Fe_2O_3$ | 0.33 | 0.04 | 0.53 | 0.92 | 0.86 | 0.72 | 1.00 | 1.48 | 2.43 | 1.93 |
| FeO | 0.12 | 0.09 | 0.13 | 0.22 | 0.08 | 0.08 | 0.18 | 0.19 | 0.15 | 0.17 |
| MnO | 0.01 | 0.004 | 0.007 | 0.002 | 0.003 | 0.01 | 0.03 | 0.014 | 0.022 | 0.04 |
| MgO | 0.57 | 0.72 | 1.07 | 0.58 | 0.70 | 0.76 | 0.69 | 0.98 | 1.14 | 0.86 |
| CaO | 0.66 | 0.10 | 0.09 | 0.35 | 0.26 | 0.11 | 4.07 | 2.74 | 2.21 | 1.00 |
| $Na_2O$ | 1.75 | 1.25 | 1.80 | 1.94 | 1.77 | 2.21 | 1.87 | 2.22 | 1.14 | 2.10 |
| $K_2O$ | 7.61 | 6.50 | 7.26 | 5.77 | 5.37 | 7.19 | 5.27 | 5.40 | 9.68 | 10.47 |
| $P_2O_5$ | 0.21 | 0.08 | 0.09 | 0.13 | 0.22 | 0.10 | 0.19 | 0.20 | 0.53 | 0.70 |
| $H_2O$ (–) | 0.42 | 0.54 | 0.88 | 0.83 | 0.64 | 1.11 | 0.65 | 0.87 | 0.22 | 0.27 |
| $H_2O$ (+) | 2.86 | 2.19 | 2.01 | 3.60 | 4.18 | 3.40 | 2.51 | 2.57 | 1.32 | 1.44 |
| LOI | 0.41 | 0.12 | 0.09 | 0.17 | 0.12 | 0.30 | 3.50 | 2.38 | 0.93 | 0.29 |
| Total | 100.20 | 100.00 | 100.17 | 100.12 | 99.75 | 100.15 | 100.09 | 100.36 | 99.79 | 100.11 |
| Quartz (Q) | 28.88 | 42.21 | 33.24 | 34.53 | 37.31 | 26.39 | 29.02 | 27.02 | 19.65 | 11.06 |
| Ortoclase (or) | 46.60 | 39.43 | 43.96 | 35.70 | 33.21 | 44.41 | 33.32 | 33.74 | 58.77 | 63.05 |
| Albite (ab) | 15.34 | 10.8 | 15.61 | 17.19 | 15.67 | 19.55 | 16.94 | 19.87 | 9.91 | 18.10 |
| Anorthite (an) | 1.97 | — | — | 0.93 | — | — | 14.22 | 13.00 | 1.48 | 0.40 |
| Corundum (C) | 4.23 | 5.31 | 3.00 | 7.90 | 9.68 | 5.78 | — | 1.06 | — | 0.55 |
| Diopside (di) | — | — | — | — | — | — | 3.97 | — | 3.46 | — |
| Hypersthene (hy) | 1.47 | 1.84 | 2.73 | 1.51 | 1.82 | 1.98 | — | 2.58 | 1.31 | 2.18 |
| Ilmenite (il) | 0.28 | 0.20 | 0.30 | 0.49 | 0.19 | 0.20 | 0.48 | 0.46 | 0.37 | 0.45 |
| Hematite (hm) | 0.34 | 0.04 | 0.55 | 0.96 | 0.90 | 0.76 | 1.07 | 1.57 | 2.50 | 1.97 |
| Apatite (ap) | 0.52 | 0.20 | 0.22 | 0.32 | 0.54 | 0.25 | 0.48 | 0.50 | 1.29 | 1.69 |
| Rutile (ru) | 0.37 | 0.02 | 0.39 | 0.47 | 0.68 | 0.68 | — | 0.20 | — | 0.55 |
| Titanite (tn) | — | — | — | — | — | — | 0.25 | — | 1.26 | — |
| Wollastonite (wo) | — | — | — | — | — | — | 0.25 | — | — | — |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Localization of samples: 1 — Miękinia (the upper part of flow), 2, 3 — Siedlec (mine dump), 4, 5, 6 — Dubie (marginal part of a complex dike in the SW wall of the dolomite quarry), 7 — Szklarka (outcrop near a former border), 8 — Szklary — (a shallow borehole near an artesian spring), 9, 10 — Szklarka (outcrop near a trout farm).

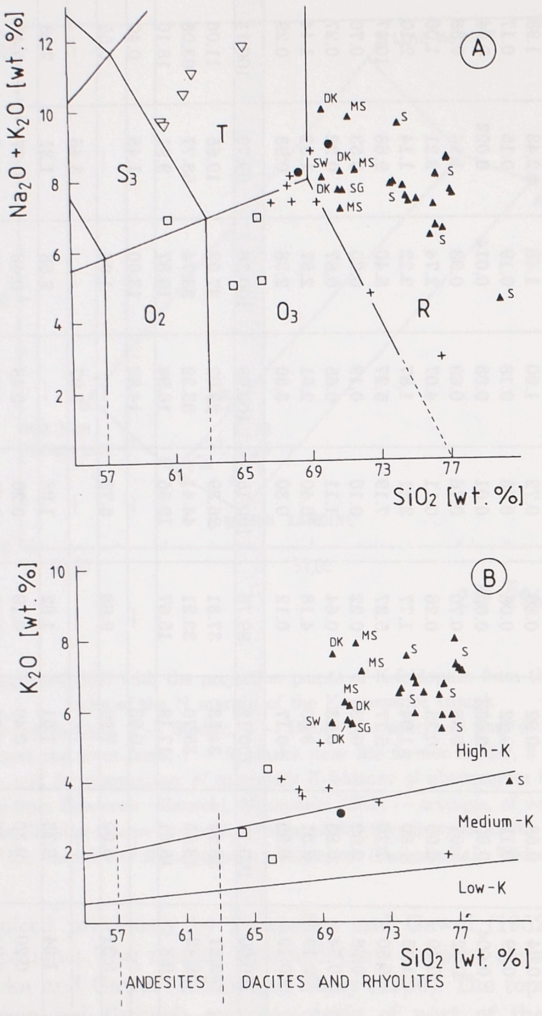


Fig. 4. Diagrams: fundamental TAS (A) and additional (B) of the chemical classification of volcanic rocks (Le Maitre et al. 1989) with the projection points of the studied K-feldspar-quartz rocks (solid triangles)

DK — Dubie quarry, MS — Miękinia, the top rock, S — Siedlec, SG — Szklarka near the former border, SW — Szklary near the artesian spring, and, for comparison, of other acid and intermediate volcanic rocks from the N margin of the Krzeszowice trough: porphyry of the main Miękinia flow — crosses, porphyry of the Dębnik laccolith — solid circles, hornblende rocks of the Dubie area — squares, Filipowice tuffs — inverted triangles; (from analyses contained in: Table 2, Katalog 1959, 1961; Harańczyk 1980; Parachoniak, Wieser 1985; Muszyński, Pieczka 1992, 1994, unpublished materials of the Faculty of Geology, Geophysics and Environmental Protection)

The fields in the TAS diagram: $O_2$ — andesites, $O_3$ — dacites, R — rhyolites, $S_3$ — trachyandesites, T — trachytes/trachyandesites



provided by Lewowicki (1959), and a short contribution included in Parachoniak and Wieser (1985). Current investigations have allowed to verify and supplement some data of Bolewski (1938, 1939). Samples were collected from an old dump, and they correspond to the darker rock variety distinguished by Bolewski (1938). The rock is characterized by the fluidal structure and porphyritic texture, primarily with a few phenocrysts (Table 1). The phenocrysts are represented by pseudomorphs after feldspars, biotite, and — in traces — opaque ore minerals.

The pseudomorphs after feldspars, probably after plagioclase, reach the size 3 mm. They were developed as individual, idiomorphic tablets or — subordinately — their glomerophyric intergrowths. At the moment they are substituted by an unhomogeneous clay substance; rarely they contain the primary inclusions of zircon and relicts of secondary K-feldspars with microscopical features of adularia (Phot. 5).

The phenocrysts of biotite are either fresh or more or less altered (opacitization). Its flakes, with sizes up to 1.5 mm, are sometimes intergrown with muscovite, and seldom contain inclusions of zircon. The unchanged biotite has the pleochroism in colours: $\alpha$ — light brown-olive, light greenish yellow, $\beta = \gamma$ — dark brown-olive, brown-olive.

The groundmass is built mostly of two components: K-feldspar and quartz, and the latter prevails. Small flakes of more or less altered biotite are subordinate, opaque or translucent ore minerals are rare, and zircon occurs in traces. The feldspar of the groundmass is micro- or cryptocrystalline, and forms pseudomorphs after the laths of primary feldspars, usually 0.03—0.05 mm long. This feldspar has been partly substituted by clay minerals. The quartz in question is usually developed as auto- and hipautomorphic crystals with the habits typical of the high-temperature variety of this mineral (Phot. 6), and sizes 0.01—0.07 mm.

Shapeless aggregates of a clay substance and/or post-chalcedony quartz as well as brownish iron oxides may be sometimes observed in the groundmass.

X-ray investigations have revealed that the sole feldspars are of the potassium type, and the clay substance is Na-montmorillonite and kaolinite (Fig. 2). The feldspars show the medium degree of their structural ordering (Fig. 3).

The chemical composition of the potassium-bearing rock from Siedlec (Bolewski 1938, 1939; Lewowicki 1959; Table 2) places the rock in question among rhyolites, almost exclusively high-K, in the diagrams of the chemical classification of volcanic rocks (Fig. 4). This systematic position is markedly different from the other potassium-rich rocks studied here.

The rock from Siedlec was initially determined by Bolewski (1938) as an altered (kalified) porphyry, originally similar to the rock from Miękinia, but later redefined (Bolewski 1939) as a potassium trachyte and recognized as the crystallization product of a potassium-rich, Mediterranean type magma. This research and an earlier one, that of Parachoniak and Wieser (1985), shed new light on the genesis of this rock. Investigations of the latter authors on zircons indicate that the rock crystallized from an over-cooled, viscous magma. Thus, the magma represented probably an acid, alkali-rich residual melt that may be directly linked with the Dębnik laccolith according to earlier suggestions (Parachoniak, Wieser 1985; Muszyński, Pieczka 1994). The crystallization has led to the formation of a microcrystalline, almost aphyritic rock, whose ultimate mineral composition has been shaped by deuteric processes: adularization, montmorillonitization, and kaolinization.

The presence of potassium-bearing rocks among the intrusions that intersect the Devonian strata in the Dubie quarry (intrusions Dubie I and II) and in its immediate vicinity (intrusion Dubie-Zamczysko) was reported by Harańczyk (1982). He identified them as trachytes, but provided a short petrographical characteristic only for the Dubie II intrusion.

The potassium-bearing rocks studied here form fragments of the composite dike some meters thick, almost vertically intersecting the Devonian dolostones in the Dubie quarry (the Dubie I dike of Harańczyk, 1982). These rocks build the upper part of the intrusion, sub-outcropping below the thin cover of Quaternary strata (partly removed by mining development), and the side fragments of the intrusion parallel to its footwall and hangingwall. The central part of the intrusion is represented by hornblende andesites (in the current systematic — potassium trachyandesites) and hornblende dacites (Muszyński, Pieczka 1992). Thin, from single centimetres to some tens of centimetres, strongly argillized veins of potassium-bearing rocks, occurring in the vicinity of the main dike, have also been studied here.

The rocks in question are generally rusty-cream or light ash-grey, massive and medium-compact. They have the porphyritic or glomero-porphyritic texture and the massive, slightly directional structure. The group of phenocrysts includes almost exclusively pseudomorphs, mainly after feldspars and amphiboles (Phot. 7), subordinately after biotite that is seldom preserved as relicts (Table 1). Additionally, there are opaque and translucent in brownish colours ore minerals, and in some sections — apatite. The phenocrysts are accompanied by few extratelluric basic cumulates of similar sizes.

The pseudomorphs after feldspars reach 3.5 mm. Initially, the feldspars were probably only plagioclases, developed as individual tablets or their glomerophyric intergrowths. They have been substituted by an unhomogeneous clay substance and preserved as relicts of secondary potassium feldspars with the features of adularia. The feldspars of this type separated out from the argillized veins of potassium-bearing rocks, situated close to the main intrusion, have the form of fine, acute-angled crystals (Fig. 5). Infrared spectroscopic analyses have shown the medium degree of their structural ordering (Fig. 6). Sodium has not been found in these minerals, at least in amounts detectable by the EDX method (Fig. 5).

The pseudomorphs after hipauto- and automorphic prisms of amphiboles, and rarely after their glomerophyric intergrowths, reach 2 mm. They are built of an unhomogeneous clay substance, opaque opacite-type minerals, and in some fragments of the rock — red-brownish iron compounds.

The pseudomorphs after biotite have the same composition and sizes as those after amphibole. Very seldom the biotite has been preserved as relicts, with the pleochroism from pale brownish to olive-brownish.

The extratelluric basic cumulates have rounded or irregular shapes and sizes up to 1.5 mm. Their primary constituents: mostly biotite and opaque ore minerals, subordinately feldspars, and probably amphiboles, have been considerably altered.

The groundmass is built mostly of two components: dominant quartz and lesser feldspars, only potassium ones as indicated by X-ray analyses (Fig. 2) with the medium degree of structural ordering (Fig. 3). Additionally, there is a clay substance present, and sometimes red-brownish iron compounds. The feldspars form micro- and cryptocrystalline, optically unhomogeneous mass, with some outlines of short (0.05 mm) laths. The quartz is developed as xenomorphic, less often automorphic crystals with the habits of the high-temperature quartz and sizes 0.02—0.05 mm, and also fine (up to 0.01 mm) rounded aggregates and irregular impregnations. In the last two cases the quartz shows sometimes features indicating its recrystallization from chalcedony.

X-ray investigations have revealed that the clay substance observed under a microscope is kaolinite or Na-montmorillonite (Fig. 2).

The chemical composition of those definitely altered rocks (Table 2) places them among rhyolites high-K (Fig. 4). Initially, they must have been rocks similar to the ones occurring at present in the inner part of the vein, i.e. hornblende andesites-trachyandesites-dacites. This conclusion is supported by: the same type of structures



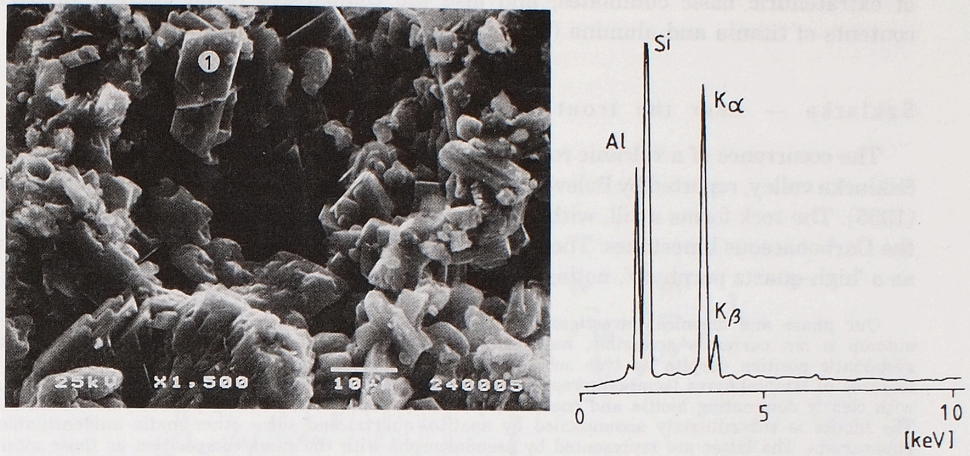


Fig. 5. Fragment of the aggregate of secondary K-feldspars (adularia) building a pseudomorph after a phenocrysts, probably of plagioclase, separated out from the argillized thin vein of the K-feldspar-quartz rock (NW wall of the Dubie quarry), and the point chemical analysis EDX of one of the crystals (1)

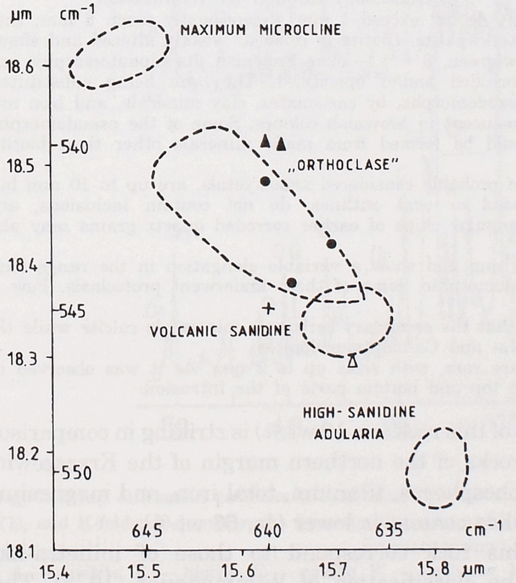


Fig. 6. Černy and Chapman's diagram (1986) with the projection points, obtained from the absorption infrared analyses, of secondary K-feldspars from the argillized thin veins of the K-feldspar-quartz rocks in the Dubie quarry (solid triangles), and for comparison: of the secondary K-feldspar of phenocrysts from the so-called potassium trachyte from Zawiercie (Manecki, Muszyński 1982) — cross, of vein adularia from the basement of the Silesian-Cracow monocline (Muszyński, Wyszomirski 1986) — dots, and of adularia from the vacuoles of the Alwernia melaphyres (Parachoniak, Wieser 1992) — triangle

and textures, the development, amount and kind of primary phenocrysts, the presence of extratelluric basic cumulates, and also the comparable (even slightly higher) contents of titania and alumina (Table 1, 2, and Muszyński, Pieczka 1992).

Szklarka — near the trout farm

The occurrence of a volcanic rock some 200 m north of trout farm buildings in the Szklarka valley, reported by Bolewski (1938), was geologically recognized by Kozłowski (1955). The rock forms a sill, with a thickness ca. 1.8 m, followed over 200 m within the Carbonaceous limestones. The last author determined the rock in hand specimens as a 'high-quartz porphyry', noting however an atypical setting for such an acid rock.

Our phase and chemical investigations, carried out on samples collected from rubble as the outcrop is not currently accessible, have indicated that the rock should be ascribed a different systematic position despite its true acid character. This is because the volcanic has the definite features of lamprophyres (semi-lamprophyres). Its texture is porphyritic (of the lamprophyric type), with clearly dominating biotite and pseudomorphs after this mineral among phenocrysts (Table 1). The biotite is subordinately accompanied by apatite, quartz, and some other mafic unidentifiable phenocrysts. The latter are represented by pseudomorphs with the same composition as those after biotite but of slightly different shapes. Among the phenocrysts there are neither feldspars nor pseudomorphs after them, but those minerals form the main component of a microcrystalline groundmass. They are represented exclusively by K-feldspars (X-ray analyses) with the low to medium degree of structural ordering (Fig. 7, 3). The grains of potassium feldspars do not exceed 0.03 mm, they are xenomorphic or form short, rather irregular tablets. The orientation of feldspars and biotite imparts in places the weakly expressed fluidal texture. Among the feldspars of the groundmass there are subordinate: quartz, biotite, apatite, a clay substance, carbonate minerals, and ore minerals (magnetite, goethite, leucoxene) developed as a ultra- fine dust. In a background there are also impregnations and aggregates of quartz and/or carbonates, of various shapes, differentiated sizes, and sharp or diffused borders. Around some of them, those clearly filling microcaverns, [illegible] potassium feldspar of the adularia type occurs. The properties of all quartz grains in[illegible] that they have been fo[illegible] chalcedony through recrystallization.

The [illegible] of biotite phenocrysts usually do not exceed 1 mm, exceptionally reach 6 mm; they may contain the inclusions of magnetite and apatite. Biotite is fresh or weakly altered and shows the intensive pleochroism: α — pale yellow-green, β = γ — olive brownish. Its hipautomorphic and automorphic flakes are more or less corroded and/or opacitized. They are being substituted, sometimes up to the formation of total pseudomorphs, by carbonates, clay minerals, and iron and titanium compounds either opaque of translucent in brownish colours. Some of the pseudomorphs, inferring from their different shapes, could be formed from mafic minerals other than biotite, probably pyroxenes.

The quartz phenocrysts, which may be probably considered xenocrystals, are up to 10 mm big. They are strongly corroded, have rounded or oval outlines, do not contain inclusions, and simultaneously extinct light. The partly angular chips of earlier corroded quartz grains may also be observed.

Apatite prisms attain the length of 1 mm and show a variable elongation in the range from 1 : 2 to 1 : 10. They are auto- and hipautomorphic, some of them underwent protoclasis. Few of them contain inclusions.

X-ray investigations (Fig. 7) revealed that the secondary carbonate mineral is calcite while the clay substance kaolinite and smectites (Na- and Ca-montmorillonites).

Xenoliths of surrounding limestones are rare, with sizes up to 2 mm. As it was observed by Kozłowski (1955), they concentrate in the top and bottom parts of the intrusion.

The very high potassium content of this rock (ca. 10 wt.%) is striking in comparison with the other potassium-bearing rocks of the northern margin of the Krzeszowice trough (Table 2). Respectively, its phosphorus, titanium, total iron, and magnesium contents are also high, while the silica content is lower (ca. 66 wt.%).

The mentioned features of this rock correspond to those of minetta-like semi-lamprophyre, according to the classification of Wimmenauer (1973). This



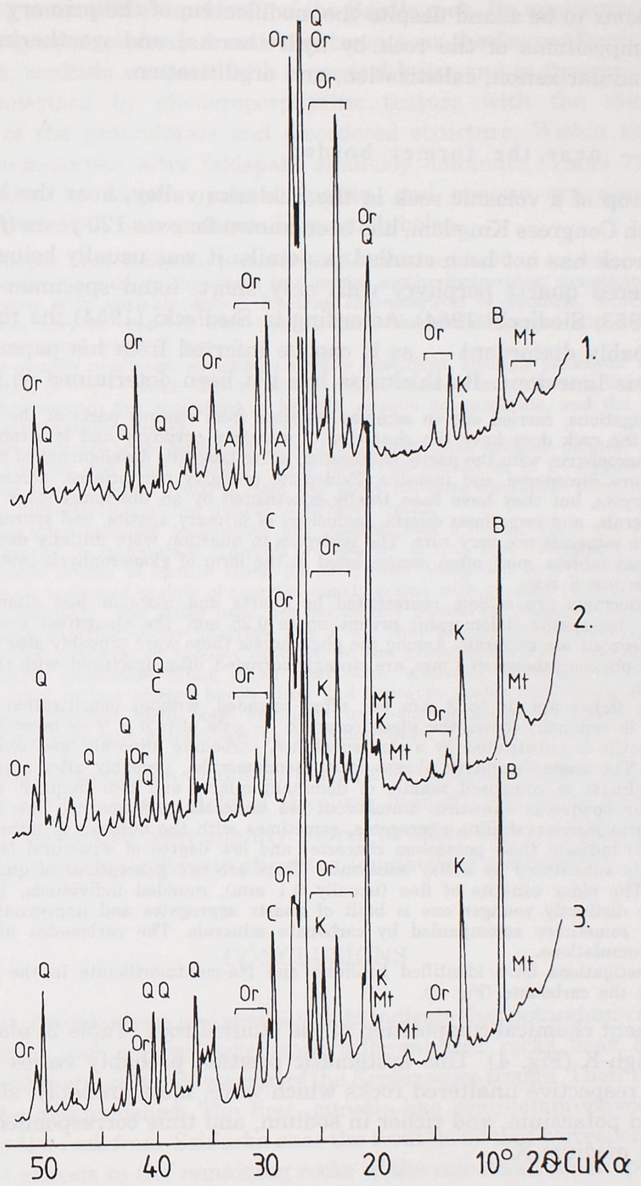


Fig. 7. X-ray diffraction patterns of semi-lamprophyre from the Szklarka valley near the trout farm (1), and K-feldspar-quartz rocks from the Szklarka valley near the former border (2) and near the artesian spring (3)

A — apatite, B — biotite, C — calcite, K — kaolinite, Mt — montmorillonite, Or — K-feldspar, Q — quartz diagnosis seems to be sound despite the modification of the primary mineral and chemical compositions of the rock by hydrothermal and weathering processes: silification, adularization, calcitization, and argilitization.

### Szklarka — near the former border

The outcrop of a volcanic rock in the Szklarka valley, near the border of the former Polish Congress Kingdom, has been known for over 120 years (*fide* Zaręczny 1953). The rock has not been studied in details: it was usually being determined as a weathered quartz porphyry with only short, hand specimen descriptions (Zaręczny 1953; Siedlecki 1954). According to Siedlecki (1954) the rock occurs as a vein, probably discordant — as it can be inferred from his paper, within the Carboniferous limestone. Its thickness has not been determined so far.

Our investigations, carried out on samples collected from various parts of the intrusion, have revealed that the rock does have the character of a quartz porphyry and is strongly altered. Its texture is glomerophyric, with the partly obliterated, micro-poikilitic development of the groundmass, and its structure disordered and massive. Feldspars, probably plagioclases, dominated (Table 1) among phenocrysts, but they have been totally substituted by an unhomogeneous clay substance, carbonate minerals, and sometimes quartz. Inclusions of primary apatite, and sporadically of zircon and opaque ore minerals are very rare. The feldspars in question were initially developed as more or less elongated tablets, most often accumulated in the form of glomerophyric intergrowths. Their maximum sizes are 6 mm.

Other phenocrysts are seldom represented by quartz and more or less altered biotite, and sporadically — by apatite (idiomorphic prisms up to 0.25 mm, the elongation from 1 : 2 to 1 : 8) (Phot. 8), and opaque ore minerals. Among the phenocrysts there were probably also few amphiboles.

The quartz phenocrysts reach 4 mm, are strongly corroded, often fractured, with the simultaneous light extinction.

The biotite flakes are up to 3 mm big, often corroded, without opacitization. The unaltered biotite, which is common, shows the pleochroism: α — pale olive,β = γ — brownish olive. When altered, the biotite is substituted by a clay substance, carbonate minerals, and compounds of iron and titanium. The same secondary phases form pseudomorphs, probably after amphiboles.

The groundmass is composed mainly of dominant quartz and less frequent feldspars, being accompanied by opaque or brownish translucent ore minerals, and apatite. The feldspars of the groundmass form microcrystalline aggregates, sometimes with the outlines of laths. X-ray investigations (Fig. 7) indicate their potassium character and low degree of structural ordering (Fig. 3). They are partly substituted by a clay substance. There are two generations of quartz in the rock groundmass. The older consists of fine (usually 0.1 mm), rounded individuals, intergrown with feldspars. The distinctly younger one is built of quartz aggregates and impregnations of various shapes, being sometimes accompanied by carbonate minerals. The carbonates also form locally individual accumulations.

X-ray investigations have identified kaolinite and Na-montmorillonite in the clay substance, and calcite as the carbonate (Fig. 7).

The present chemical composition of the studied rock (Table 2) places it among rhyolites high-K (Fig. 4). This systematic position probably varies a little from that of the respective unaltered rocks which were, most probably, slightly poorer in silica and potassium, and richer in sodium, and thus corresponded to rhyolites (or dacites) medium-K.

### Szklary — the borehole near the artesian spring

The rock, according to information obtained from Mr. A. Górny of the Geological Museum, University of Mining and Metallurgy, who also provided its samples, was found in 1988 in Szklary during drilling a shallow well, situated close to the



artesian spring some 200 m upstream of the Brodło rock. Its appearance is similar to the altered quartz porphyry from the outcrop near the former border. The rock is also altered, medium compact, with a general beige and in fragments light tan colour, characterized by glomeroporphyritic texture with the micropoikilitic development of the groundmass and disordered structure. Within the group of feldspars pseudomorphs after feldspars similarly dominate (Table 1), and they are accompanied by biotite, quartz, apatite, and opaque ore minerals. Few phenocrysts could also be represented by amphiboles.

The pseudomorphs after feldspars, probably plagioclases, are built of an unhomogeneous clay substance, carbonate minerals, red-brownish iron oxides and/or hydroxides, sometimes quartz. The relicts of K-feldspar with variable optical features characteristic of adularia, which is probably a secondary phase, may be observed from time to time. The pseudomorphs, which formed mostly glomerophyric aggregates, reach 5 mm.

The biotite is usually unaltered, sometimes slightly opacitized, strongly pleochroic in the colours: α — pale greenish, β = γ — dark olive-green. Its flakes reach 2 mm, form individual grains or intergrowths. They contain few inclusions of apatite, opaque ore minerals, and the exsolutions of secondary iron and titanium oxides.

The quartz phenocrysts with maximum sizes 4 mm have differentiated shapes, resulting both from their initial habits and later corrosion. They occur individually or in 2—3-grain intergrowths. The quartz grains have frequent reaction rims and are sometimes fractured. Their light extinction is simultaneous, characteristic of the quartz of volcanic rocks.

Pseudomorphs after probable amphiboles are smaller than 0.2 mm. They are built of a clay substance and opaque or translucent minerals — possibly of iron and titanium.

The automorphic prisms of apatite reach 0.6 mm, their elongation does not exceed 1 : 5.

The groundmass is formed mainly of rounded quartz grains with average sizes around 0.05 mm, intergrown with feldspars. The latter ones are exclusively potassium feldspars with the medium degree of structural ordering (X-ray analyses, Fig. 7, 3). They are crypto- or microcrystalline, form fine aggregates with irregular or tabular outlines. In the groundmass there are additionally: the quartz of a younger generation filling small interstices, carbonate minerals, an unhomogeneous clay substance, more or less altered biotite, iron and titanium oxides, and accessory apatite.

The carbonate minerals have been identified in X-ray analyses as calcite, and the clay substance — as kaolinite and subordinate Ca-montmorillonite (Fig. 7).

The chemical composition (Table 2) places this rock, similarly as the one 'close to the former border', in the field of rhyolites high-K (Fig. 4). Initially however, the rock must have also been slightly poorer in silica and potassium and richer in sodium, thus corresponding to rhyolites (or dacites) medium-K.

## CONCLUSIONS

The current investigations and previous data indicate that potassium-rich volcanics are the common and, at the same time, differentiated rocks near Krzeszowice, particularly within the northern margin of the Krzeszowice trough. Their two essential groups may be distinguished. The first, minetta-like semi-lamprophyres, is represented only by the rock from 'Szklarka near the trout farm' that corresponds probably in its age and genesis to the remaining rocks of the calc-alkali lamprophyres of the Cracow-Silesia region (Heflik et al. 1992). In comparison with them, the Szklarka rock is exceptionally rich in silica and potassium and poor in iron (notably $Fe^{2+}$), magnesium and calcium. Such a composition results both from the more leucocratic character of an initial rock and its secondary alterations: silification, adularization, calcitization, and argillitization.

The second group of the potassium-bearing rocks comprises the ones from the other mentioned here occurrences and the rock described previously from Zalas (Słaby 1987; Harańczyk 1989) called in the literature 'kalified rocks', 'potassium trachytes', and 'potassium rhyolites'. The Filipowice tuffs is related to them in its mineral and chemical compositions (Rozen 1909; Kuhl 1936; Tokarski 1953; Bolewski, Manecki 1970; Parachoniak, Wieser 1985). These rocks were given by Muszyński (1995) a general, collective name 'K-feldspar-quartz rocks' and this description has been confirmed here: the results indicate that the rocks are not of a strictly igneous genesis but of a mixed, igneous-metasomatic origin. They have been formed by partial alterations of various volcanics (from andesites to rhyolites), mainly by the hydrothermal metasomatosis close to adularization. Such a genesis is documented the best for the rocks from Miękinia and Dubie, where the potassium-bearing rocks make smaller parts of igneous bodies with different systematic positions (the same textures, structures, as well as the development, amount and initial type of phenocrysts). Potassium feldspars, which decide about the potassium-bearingness of these rocks, are secondary minerals (adularias) without any doubt, and substitute both the primary feldspars of phenocrysts and of the groundmass. The potassium metasomatosis is responsible for the position of the discussed rocks in the diagrams of the chemical classification of volcanic rocks (Le Maitre et al. 1989) in the field of rhyolites, almost exclusively high-K, and in the field of trachytes for the Filipowice tuffs (Fig. 4). It is difficult to determine how these positions deviate from those occupied by respective primary (i.e. unaltered) rocks. Most probably, the closest to the original position is the rock from Siedlec, and the farthest — the one from Dubie.

Potassium-bearing rocks, formed during the hydrothermal metasomatosis (adularization) of various volcanics and their tuffs, are not rare. The adularization is caused by the easy exchange of $Na^+$ and $Ca^{2+}$ into $K^+$ in feldspars, shown experimentally by Manecki (1970) and Fournier (1976). The data on such alterations were provided, among others, by Piekarska and Gaweł (1952), Gaweł (1957), Nowakowski (1959), Giusca (1961), Szèki-Fux (1964, 1975), Kubovics (1965), Mezösi (1968), Munhà et al. (1980), Słaby (1987, 1990).

The vicinity of Krzeszowice, as the fragment of the NE border of the Upper Silesian Coal Basin, is not exceptional considering the occurrences of adularized rocks. The signs of this process were observed in the basement of the whole region in question, both in various igneous rocks and altered sedimentary ones (Muszyński, Wyszomirski 1986; Muszyński 1991). The adularization accompanies both the polymetallic mineralization of these rocks (Cu–Mo porphyries) and the final, barren stage of the evolution of the Palaeozoic magmatism. The latter process is just represented in the studied rocks from the Krzeszowice area.

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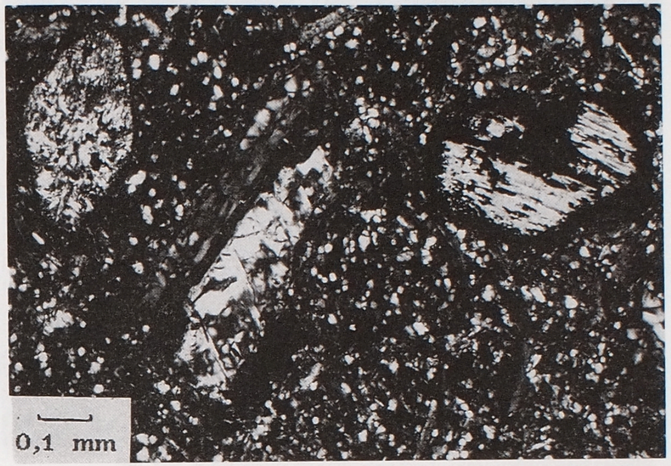
## POTASONOŚNE SKAŁY WULKANICZNE Z PÓŁNOCNEGO OBRZEŻENIA ROWU KRZESZOWICKIEGO (S POLSKA)

Streszczenie

Przeprowadzono badania petrograficzne zasobnych w potas skał wulkanicznych z sześciu wystąpień w okolicy Krzeszowic koło Krakowa (S Polska) (Rys. 1). Stwierdzono, że w jednym przypadku (Szklarka koło pstrągarni) jest to semilamprofir minettopodobny, w pozostałych zaś — magmowo-metasomatyczne skały K-skaleniowo-kwarcowe, które w dotychczasowych pracach były nazywane „skałami skalifikowanymi", „potasowymi trachitami" lub „potasowymi ryolitami". Zdaniem autorów — cechy tych skał potwierdzają wcześniejsze poglądy (Rozen 1909; Piekarska, Gaweł 1952; Słaby 1987, 1990), że o ich potasonośności zadecydowała metasomatoza potasowa typu adularyzacji. Przeobraziła ona skały wulkaniczne, o pierwotnie zróżnicowanej pozycji systematycznej, w utwory odpowiadające obecnie ryolitom wysoko-K (Rys. 4).








Phot. 1. Pseudomorphs after the phenocrysts of amphibole (upper left corner) and feldspar (center), and a partly opacitized biotite phenocryst (upper right corner). Miękinia — potassium-bearing top rock. Crossed polars


Phot. 2. Pseudomorphs after the phenocrysts of amphiboles. Miękinia — potassium-bearing top rock. Crossed polars

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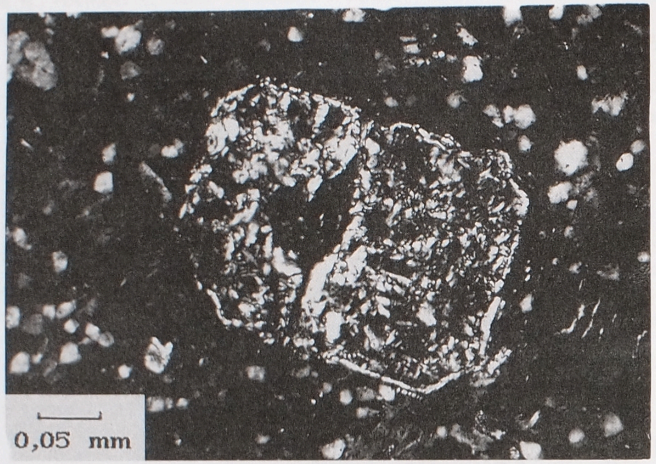
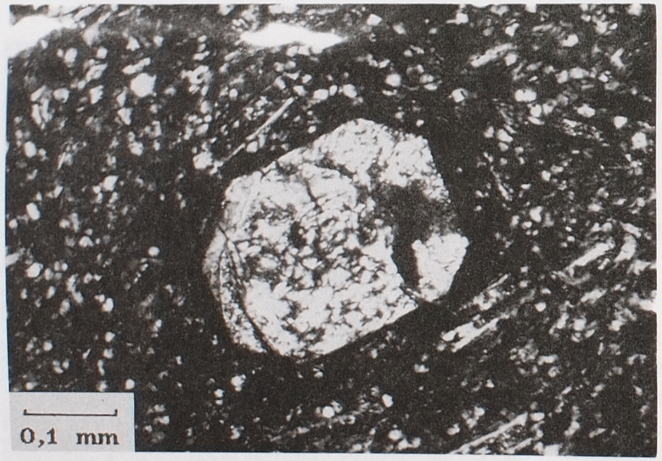



Phot. 3. Pseudomorph after the phenocryst of pyroxene. Miękinia — potassium-bearing top rock. Crossed polars




Phot. 4. Pseudomorph after the phenocryst of pyroxene. Miękinia — main type of the porphyry. Crossed polars

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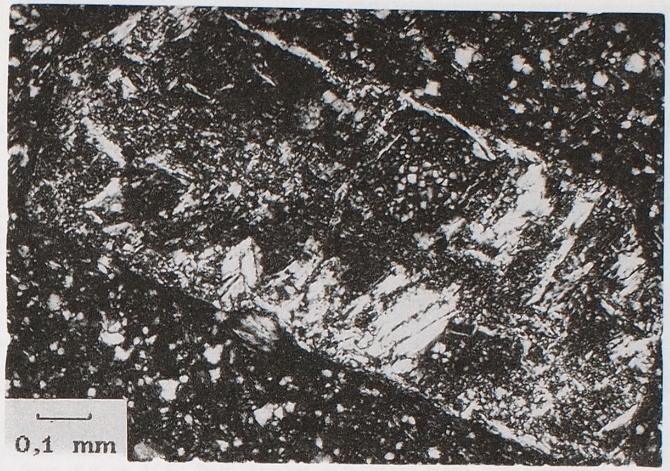
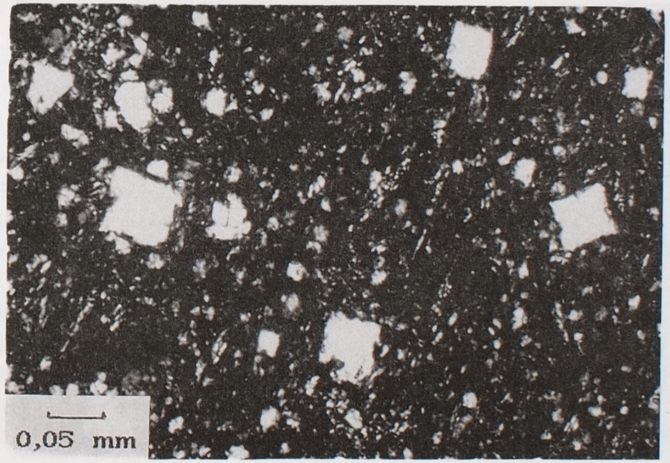
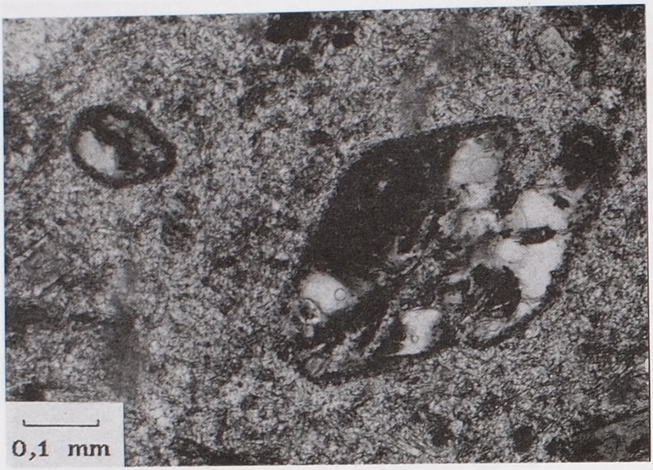



Phot. 5. Clay pseudomorph after a feldspar phenocryst with relicts of the secondary K-feldspar of adularia type (white fragments). Siedlec — potassium-bearing rock. Crossed polars

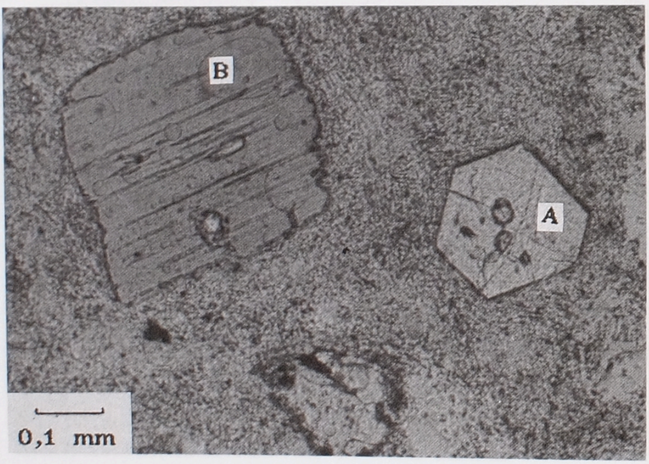



Phot. 6. Automorphic quartz crystals in a groundmass. Siedlec — potassium-bearing rock. Crossed polars

M. MUSZYŃSKI, A. PIECZKA — Potassium-bearing volcanic rocks from the northern margin of the Krzeszowice trough




Phot. 7. Pseudomorphs after the phenocrysts of amphiboles. Dubie — potassium-bearing rock, marginal part of a dike in the SW wall of the quarry. One polar




Phot. 8. Phenocrysts of biotite (B) and apatite (A). Szklarka near the former border — potassium-bearing rock. One polar

M. MUSZYŃSKI, A. PIECZKA — Potassium-bearing volcanic rocks from the northern margin of the Krzeszowice trough