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RADIOMETRIC DATING OF THE TERTIARY VOLCANICS IN LOWER SILESIA, POLAND. III. K-Ar AND PALAEOMAGNETIC DATA FROM EARLY MIOCENE BASALTIC ROCKS NEAR JAWOR, FORE-SUDETIC BLOCK

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Abstract: The K-Ar dating of Tertiary basaltic rocks near Jawor, Lower Silesia (Poland), included the sites at Winna Góra (plug) and at Męcinka (lava flow, and vent/dyke), well exposed in working quarries. According to new geochemical data, these rocks, classified so-far as trachyandesites, have been reclassified as basanite and olivine basalt. Early Miocene (Aquitanian) K-Ar ages, have been obtained from the basanite lava flow at Męcinka (21.05±0.85 Ma), and from the basanite plug at Winna Góra (21.62±0.93 Ma, and 21.96±1.36 Ma, respectively). An olivine basalt vent/dyke which cuts the lava flow at Męcinka yielded a younger (Burdigalian) K-Ar age (18.66±0.82 Ma). New palaeomagnetic analysis confirmed the results of previous studies that these rocks were magnetized during a reversed regime of geomagnetic field. The basanite (plug and lava) K-Ar dates spread over reversed parts of the magnetozones C6A and C6B. A significantly younger K-Ar date from olivine basalt intrusion might be correlated either with the C5D or the C5E magnetozones.

Key words: K-Ar dating, basaltic rocks (basanite, olivine basalt), palaeomagnetism, Early Miocene (Aquitanian, Burdigalian), Lower Silesia, Poland

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INTRODUCTION

The present paper is a further contribution to a geochronological study of the Tertiary basaltic rocks in Lower Silesia, Poland. It includes the results of K-Ar dating of a volcanic plug at Winna Góra (Winnica), and of a lava flow cut by a younger vent/dyke at Męcinka, in the vicinity of Jawor. These volcanics belong to the eastern branch of the Bohemo-Silesian volcanic belt, part of the Central European Tertiary volcanic province (Fig. 1). They are located in the Fore-Sudetic Block which was downthrown along the Marginal Sudetic Fault with respect to the Sudetic Mts Block (Fig. 2).

This is a result of bilateral co-operation initiated by the Polish Academy of Sciences (Institute of Geological Sciences, Cracow Research Branch) and the Hungarian Academy of Sciences (Institute of Nuclear Research, Debrecen), which began in 1998 aiming at K-Ar dating of the Polish Tertiary volcanics.

Originally, the research project included K-Ar dating of the Miocene (Sarmatian/Serravallian) andesitic intrusions of the Pieniny Mts, Polish West Carpathians (Birkenmajer & Pécskay, 1999, 2000). Since 2000, it has been extended towards a systematic K-Ar age determination of the Tertiary

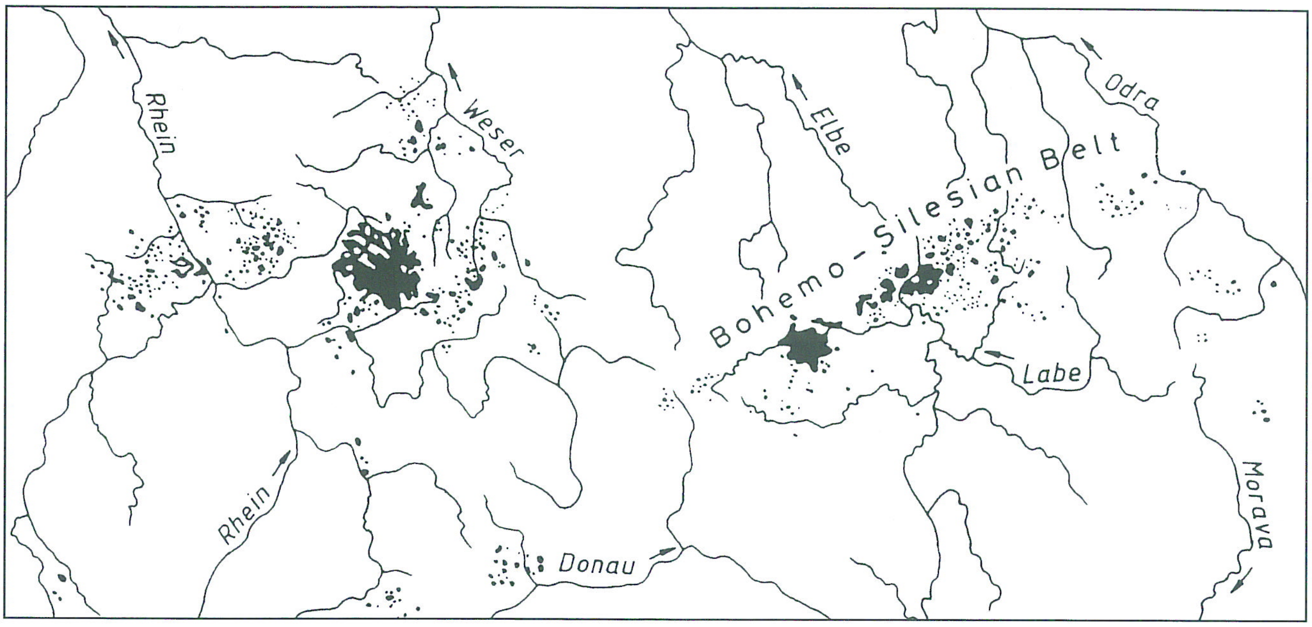


Fig. 1. Basaltic volcanics of the Bohemo-Silesian Belt in Central European Tertiary volcanic province (simplified from Kopecký, 1966)

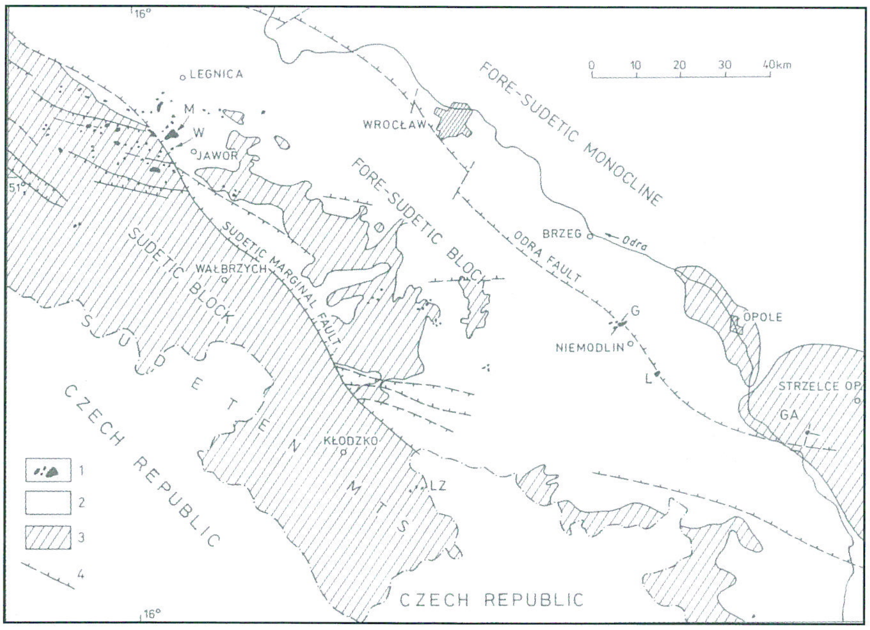


Fig. 2. Location of basaltic sampling sites near Jawor (BP-30-33), in simplified geological map of Lower Silesia, Poland. *1* – Tertiary basaltic rocks; *2* – Cenozoic sedimentary cover; *3* – pre-Cenozoic rocks; *4* – major Tertiary faults; G – Gracze; GA – Góra św. Anny; L – Ligota Tułowicka; LZ – Lądek Zdrój; M – Męcinka; W – Winna Góra (= Winnica)

basaltic rocks in Lower Silesia. The following occurrences of basaltic rocks have so far been elaborated: (I) The Late Oligocene basaltic plugs and lavas of the Opole area, Sudetic Foreland (Birkenmajer & Pécskay, 2002); and (II) The Neogene basanite plug (Messinian/Zanclean) and lava flows (Zanclean) of the Lądek Zdrój area, Sudetes Mountains (Birkenmajer *et al.*, 2002).

The new palaeomagnetic sampling programme initiated in 2001 (Birkenmajer *et al.*, 2002) involves the Polish Geological Institute in Warsaw. It is aimed at supplementing and revising palaeomagnetic data published earlier (e.g., Birkenmajer & Nairn, 1969; Birkenmajer *et al.*, 1970, 1977; Kruczyk *et al.*, 1977, and references therein).

GEOLOGICAL SETTING

In the area of Jawor, there are numerous exposures of the Tertiary basaltic rocks, mainly plugs and lava flows (see Berg, 1930; Wojno *et al.*, 1951; Jerzmański, 1956, 1961, 1965; Birkenmajer, 1967; Birkenmajer & Nairn, 1969; Birkenmajer *et al.*, 1970). The rocks dealt with in the pres-

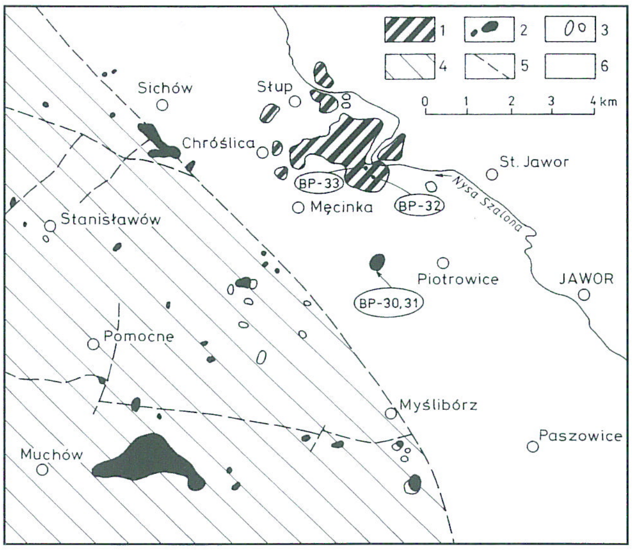


Fig. 3 K-Ar sampling sites in basaltic rocks at Winna Góra (Winnica, BP-30, 31) and Męcinka (BP-32, 33) near Jawor, Lower Silesia (simplified geological sketch from Birkenmajer *et al.*, 1970, fig. 3). *1* – lava flows; *2* – volcanic plugs; *3* – tuff and tuff agglomerate; *4* – Lower Palaeozoic rocks of the Góry Kaczawskie Mts; *5* – faults; *6* – Quaternary cover

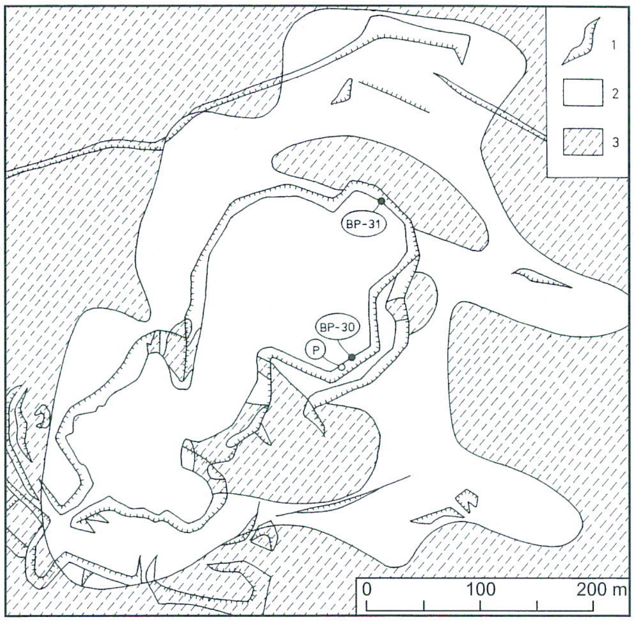


Fig. 4. Winna Góra (= Winnica), working quarry (after Zagożdżon, 2001, simplified), showing location of the K-Ar dated (BP-30, 31) and palaeomagnetic (P) samples

ent paper are well exposed in large working quarries at Winna Góra (= Winnica) and Męcinka, both situated in the Fore-Sudetic Block, immediately north-east of the Marginal Sudetic Fault (Figs 2, 3). Their importance for the history of Tertiary vulcanictity in Lower Silesia lies in the fact that they were the first basaltic rocks ever dated by radiometric techniques (at Early Oligocene – Urry, 1936) and, according to borehole data, the lavas were underlain and overlain by Oligocene sediments (Jerzmański, 1956, 1961, 1965).

SAMPLING DATA

Winna Góra (BP-30, 31)

Geology. This is a volcanic plug associated with lava flows, well exposed in a large working quarry (= Winnica, site 3: Birkenmajer & Nairn, 1969; Birkenmajer *et al.*, 1970; Zagożdżon, 2001) – Fig. 4. The plug, some 300 m across, is situated some 1.5 km NE of the Marginal Sudetic Fault (see Jerzmański, 1956, 1961, 1965; Birkenmajer, 1967). The rock shows vertical or steeply inclined thermal jointing in form of irregular columns 0.1–0.5 m across. Some parts of the plug are reddened, possibly as an effect of post-intrusion weathering.

Sampling. Samples BP-30 and BP-31 were collected from the eastern and the north-eastern parts of the quarry, respectively. Samples for palaeomagnetic investigations were collected in the eastern part of the quarry (see Fig. 4).

Petrology and geochemistry. The rock was originally determined as trachyandesite (Jerzmański, 1956, 1961, 1965), later – as alkali basalt-hawaiite (Kozłowska-Koch, 1965). New petrologic investigations show that this nearly black rock exhibits porphyritic structure, containing groundmass composed chiefly of very fine-grained plagioclase with very distinct albitic twins, moreover of partly chloritized augite and relatively abundant opaque minerals. Interstitial spaces are often filled with brownish-green glass. Olivine is the most common phenocryst; usually, it is cut by irregular network of very fine cracks filled with a green secondary mineral of serpentine group (Fig. 5A, B). Augite phenocrysts are either strongly chloritized or (in sample BP-31) fresh; in the latter case they are sometimes twinned. Both types of phenocrysts are less than 1 mm in size. Aggregates of xenomorphic quartz grains may also be found. Deuteric alteration of the rock is very well marked by red iddingsite rims around most of olivine phenocrysts.

Based on mineral and chemical composition of the studied rocks (Tab. 1), and using the IUGS standard of systematics of igneous rocks (Le Bas & Streckeisen, 1991), we classify them as basanites close to alkali basalts (Figs 6, 7). In our opinion, there is no ground to classify them either as trachyandesite (*sensu* Jerzmański, 1956, 1961, 1965) or hawaiite (*sensu* Kozłowska-Koch, 1987).

The above classification based upon mayor elements has not been confirmed by that based on trace elements (cf. Winchester & Floyd, 1977), in which our basanite samples (BP-30-33) plot as alkaline basalts (Fig. 8). However, contents and proportions of Nb, Y and Zr, which are very indicative immobile elements, are typical for alkaline within-plate basaltoids (Figs 9–11).

Męcinka (BP-32, 33)

Geology. A lava flow, some twenty or so metres thick, classified as trachyandesite by Jerzmański (1956, 1961, 1965; see also Birkenmajer & Nairn, 1969; Birkenmajer *et al.*, 1970: Męcinka E and W, sites 1 and 2, respectively), is well exposed in large working quarry about 0.5 km wide (Fig. 12). The flow exhibits thick thermal columnar jointing well recognizable in the north-eastern and northern parts of

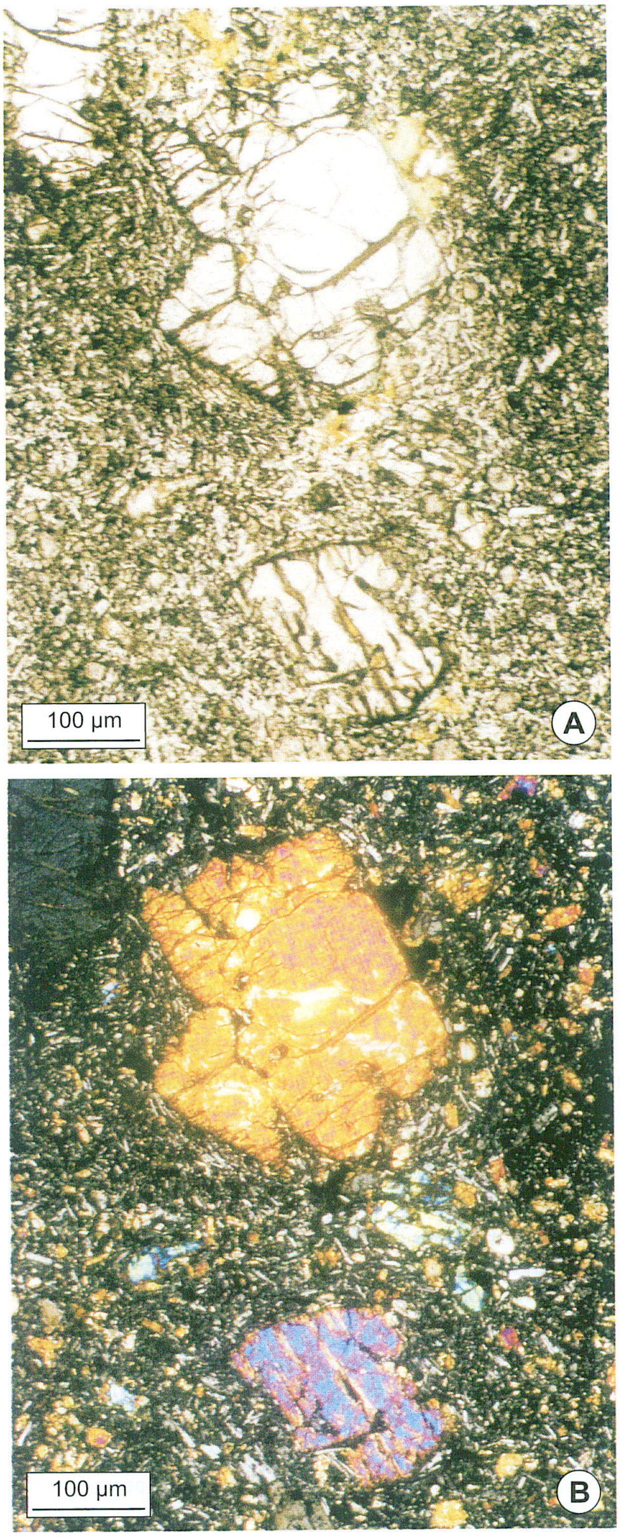


Fig. 5. Photomicrograph of cracks in olivine phenocryst filled with serpentine-group minerals. Basanite plug at Winna Góra, site 31: **A** – one nicol; **B** – crossed nicols

Table 1

Chemical composition of basaltic rocks from the vicinity of Jawor, Lower Silesia. Analysed at the Chemistry Laboratory of the Polish Geological Institute, Warsaw (Project No 6.20.1719.00.0)

	BP-30	**BP-31**	**BP-32**	**BP-33**
%				
SiO_2	44.79	43.84	44.20	47.15
TiO_2	2.57	2.48	2.47	2.29
Al_2O_3	15.80	15.42	15.07	14.56
Fe_2O_3	11.65	11.58	12.25	11.29
MnO	0.19	0.18	0.19	0.17
MgO	9.34	10.21	10.09	9.38
CaO	9.33	9.75	10.06	9.15
Na_2O	3.99	3.54	3.57	2.89
K_2O	0.73	0.62	0.99	0.82
P_2O_5	0.59	0.55	0.54	0.40
SO_3	0.01	0.01	0.01	0.01
Cl	0.04	0.06	0.09	0.01
F	0.06	0.01	0.06	0.02
LOI	0.67	1.47	0.18	1.62
SUM	99.75	99.73	99.74	99.73
ppm				
As	3	3	3	3
Ba	440	327	190	388
Bi	3	3	3	3
Ce	73	59	40	45
Co	57	45	25	42
Cr	261	312	288	355
Cu	45	36	35	26
Ga	20	19	18	19
Hf	8	5	5	7
La	35	35	18	25
Mo	2	2	2	2
Nb	54	51	43	34
Ni	125	137	141	107
Pb	3	6	3	3
Rb	36	28	29	27
Sr	602	565	500	472
Ta	4	4	3	3
Th	6	6	5	7
U	3.7	2.9	2.8	4.2
V	194	182	143	178
W	5	5	5	5
Y	34	35	30	30
Zn	114	103	110	103
Zr	292	252	223	203
Ti/Y	453.1	424.8	493.6	457.6
Zr/TiO_2	0.011	0.010	0.009	0.009
Zr/Y	8.59	7.20	7.43	6.77
Nb/Y	1.59	1.46	1.43	1.13

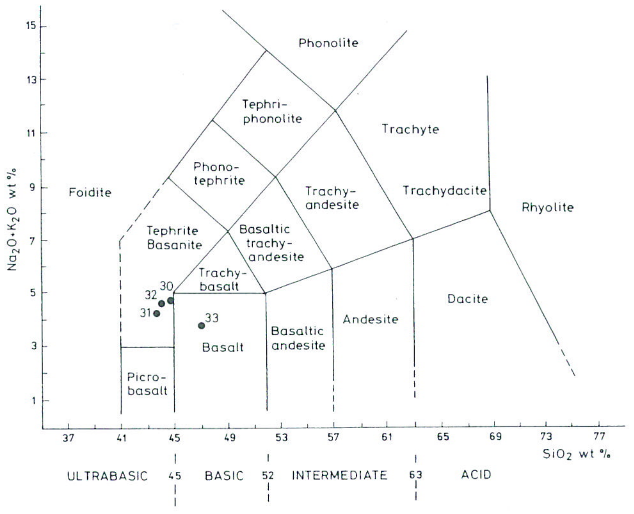


Fig. 6. Plot of basaltic rock samples BP-30-33 in the TAS classification diagramme

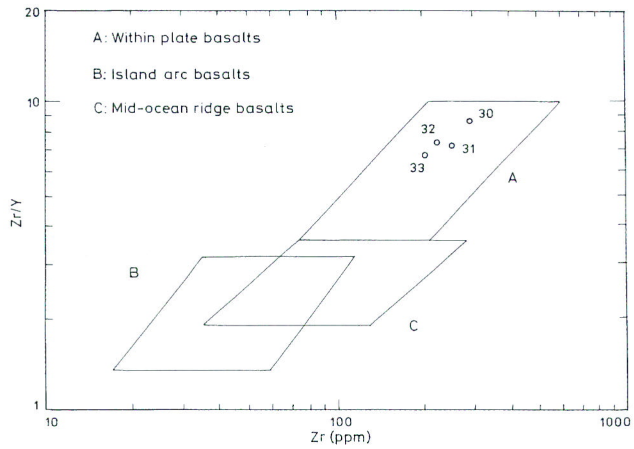


Fig. 9. Plot of basaltic rocks (samples BP-30-33) in the classification diagramme of Pearce and Norry (1979)

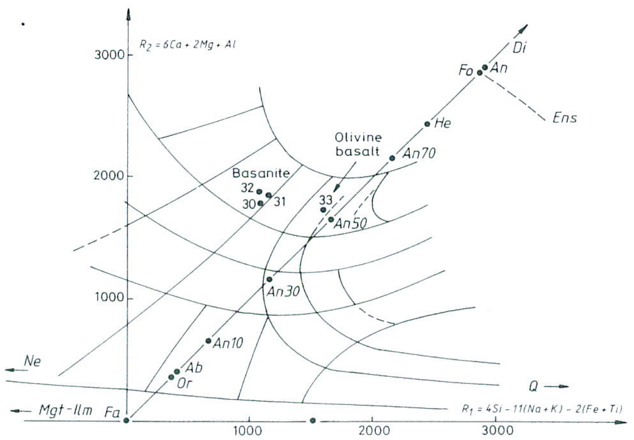


Fig. 7. Plot of basaltic rock samples BP-30-33 in the R_1-R_2 classification diagramme of de la Roche *et al.* (1980)

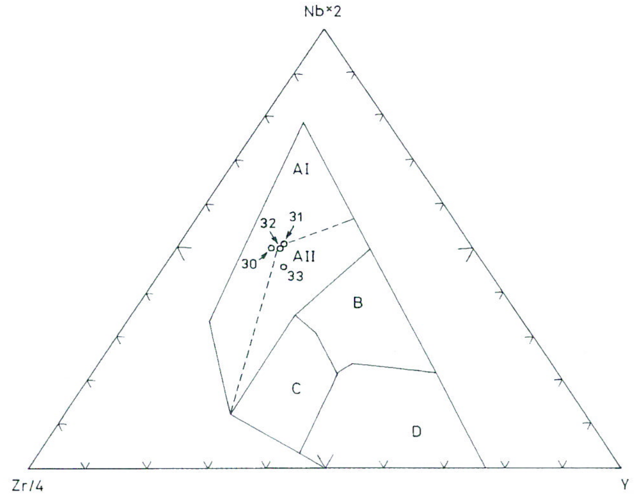


Fig. 10. Plot of basaltic rocks (samples BP-30-33) in the Zr-Nb-Y discrimination diagramme of Meschede (1986). AI – within-plate alkaline basalts; AII – within-plate alkaline basalts and within-plate tholeiites; B – E-type MORB; C – within-plate tholeiites and volcanic-arc basalts; D – N-MORB and volcanic-arc basalts

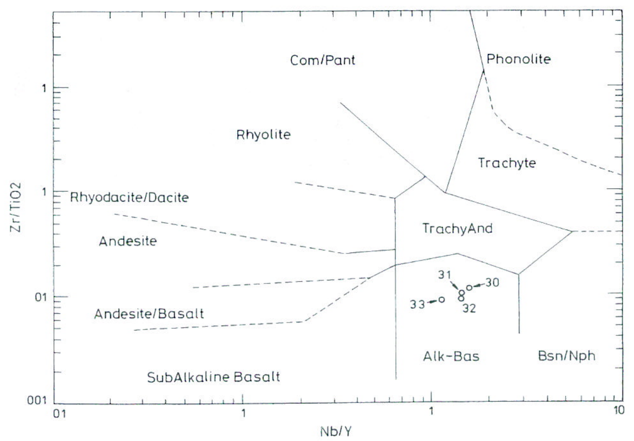


Fig. 8. Plot of basaltic rocks (samples BP-30-33) in the classification diagramme of Winchester and Floyd (1977)

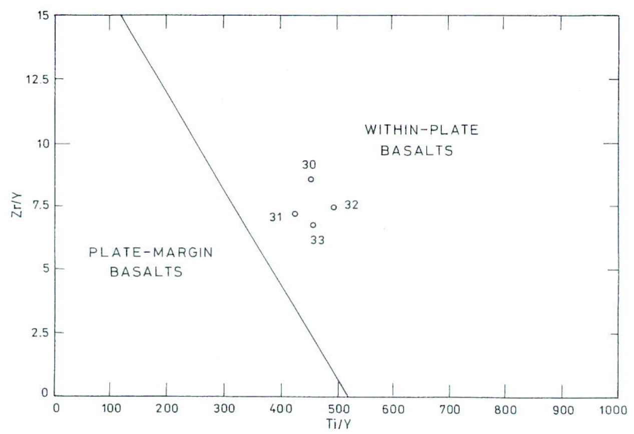


Fig. 11. Plot of basaltic rocks (samples BP-30-33) in the classification diagramme of Pearce and Galle (1977)

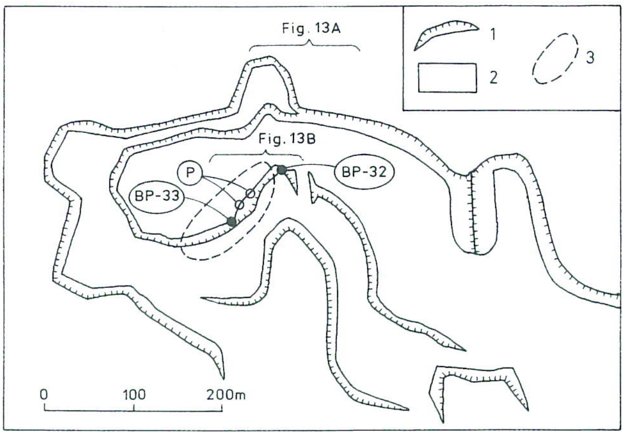


Fig. 12. Męcinka, working quarry (after Zagożdżon, 2001, simplified), showing location of the K-Ar dated (BP-32, 33) and palaeomagnetic (P) samples

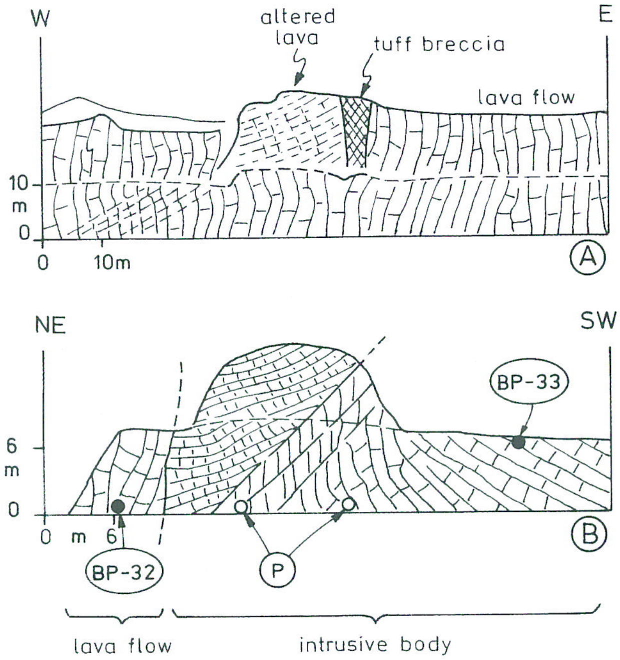


Fig. 13. Męcinka: geological sketches of exposures in working quarry, showing location of the K-Ar dated (BP-32, 33) and palaeomagnetic (P) samples. **A** – northern part of the quarry; **B** – central part of the quarry

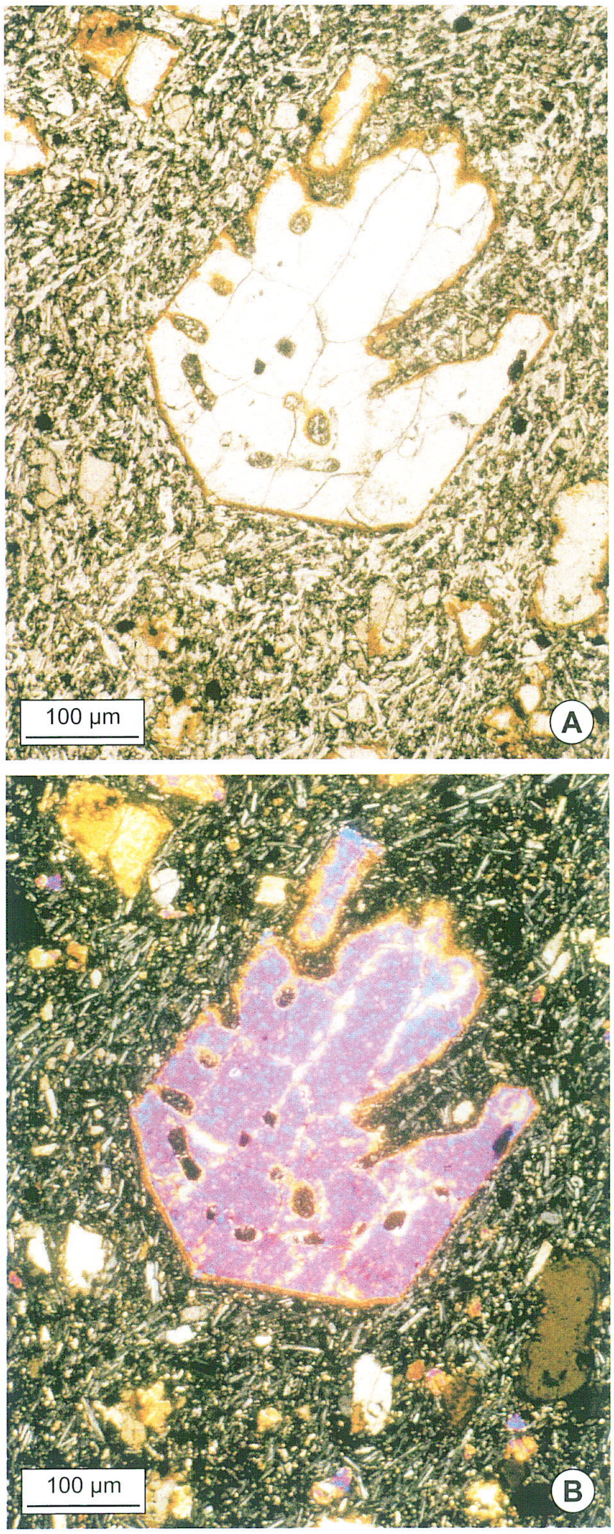


Fig. 14. Photomicrograph of corroded olivine phenocryst with iddingsite rim. Basanite lava at Męcinka, site BP-32: **A** – one nicol; **B** – crossed nicols

the quarry (Fig. 13A, B). Pink volcanic breccia, apparently forming a vertical vent cutting the lava flow (Fig. 13A), occurs in the northern part of the quarry.

In central part of the quarry, a small feeder vent or dyke which exhibits thin columns and fan-wise platy jointing cuts the lava flow (Fig. 13B).

Palaeobotanic dating. Palaeobotanic dating of freshwater sediments found below (in boreholes) and above the lava flow, suggested a "Middle or Lower Oligocene" age of the deposits (Jerzmański, 1956, 1961, 1965).

Previous radiometric dating. Radiometric age determination of the lava flow by the helium method yielded two apparently Early Oligocene dates: 34±2 Ma and 29±2 Ma (Urry, 1936). This result, now of historical value only, has not been supported by the K-Ar dating (15.5±2.5 Ma), which indicated a Middle Miocene age of the lava (Kruczyk *et al.*, 1977: sample C; K = 0.83±0.03 wt %).

Sampling. Sample BP-32 was taken from columnar lava flow in the north/central part of the quarry at lower exploitation level; sample BP-33 – from platy-jointed basaltic rock which forms a vent/dyke structure cutting the lava at upper exploitation level (see Figs 12, 13).

Petrology and geochemistry. The basaltic rocks exposed at Męcinka quarry have previously been classified as trachyandesite (Jerzmański, 1956, 1961, 1965). Our petrologic and chemical investigations (see Tab. 1 and Figs 6, 7), show that – according to the IUGS systematics of igneous rocks (Le Bas & Streckeisen, 1991) – we deal here with two different rock types: the basanite (lava flow) and the olivine basalt (vent/dyke).

In its lower part (sample BP-32), the basanite lava flow consists of very fine-grained, dark-grey to almost black rock, showing very well marked flow structure. Its groundmass exhibits the presence of fine plagioclase (labradorite An_{55-60}) laths and equally fine pyroxene, both minerals being fresh without any signs of deuteric changes. Abundant opaque minerals, mainly iron-oxides, are dispersed within the groundmass. Olivine, maximum 1 mm in size, is the only phenocryst; its crystals are surrounded by red iddingsite rims (Fig. 14A, B). A light-grey variety of the basanite exposed close to the breccia in the northern part of the quarry (see Fig. 13A) exhibits fine-grained groundmass consisting of relatively fresh plagioclase and pyroxene, with red iddingsite pseudomorphs after olivine phenocrysts.

The dark-grey basaltic intrusive rock (vent/dyke – BP-33), exposed at upper exploitation level (see Figs 13A, B), is fine-grained. Its groundmass, consisting of plagioclase laths (An_{58-60}) and pyroxene (augite) grains, exhibits a very distinct flow structure. Black iron-oxide grains are dispersed within groundmass. Olivine, which is the only phenocryst (<1 mm in size), is cut by irregular network of microcracks filled with serpentinite minerals and iron-oxide trails (Fig. 15A, B). Locally, aggregates of fine augite crystals occur.

Remark. According to geochemical classification of Winchester and Floyd (1977), based upon immobile trace elements (see Fig. 8), both samples from the Męcinka quarry (BP-32, 33) should be classified as alkaline basalts. This is not confirmed, however, by the classification based upon mayor elements (see Figs 5, 6). Contents of immobile elements and their relative ratios in basaltic rocks are very useful criteria for determining tectonic regime of their emplacement. Fig. 9 shows that both studied basaltic samples represent typical within-plate alkaline basaltoids.

K-Ar ANALYTICAL PROCEDURE AND RESULTS

Two fresh rock samples (about 2 kg in weight) were collected from each site investigated (see Figs 4, 12, 13). Care was taken to avoid rocks with xenoliths. The samples were crushed and sieved. The sieved fraction 250 to 100 μm was further used. Whole rock samples, approximately 500 mg in weight, were further used for Ar analysis. A split of the crushed rock was selected and finely ground for potassium determination. Conventional experimental techniques were used for both the K and Ar analysis (for more information on details of the procedures – see Birkenmajer & Pécskay, 2002; for calibration of the instruments and the methods applied – see Balogh, 1985).

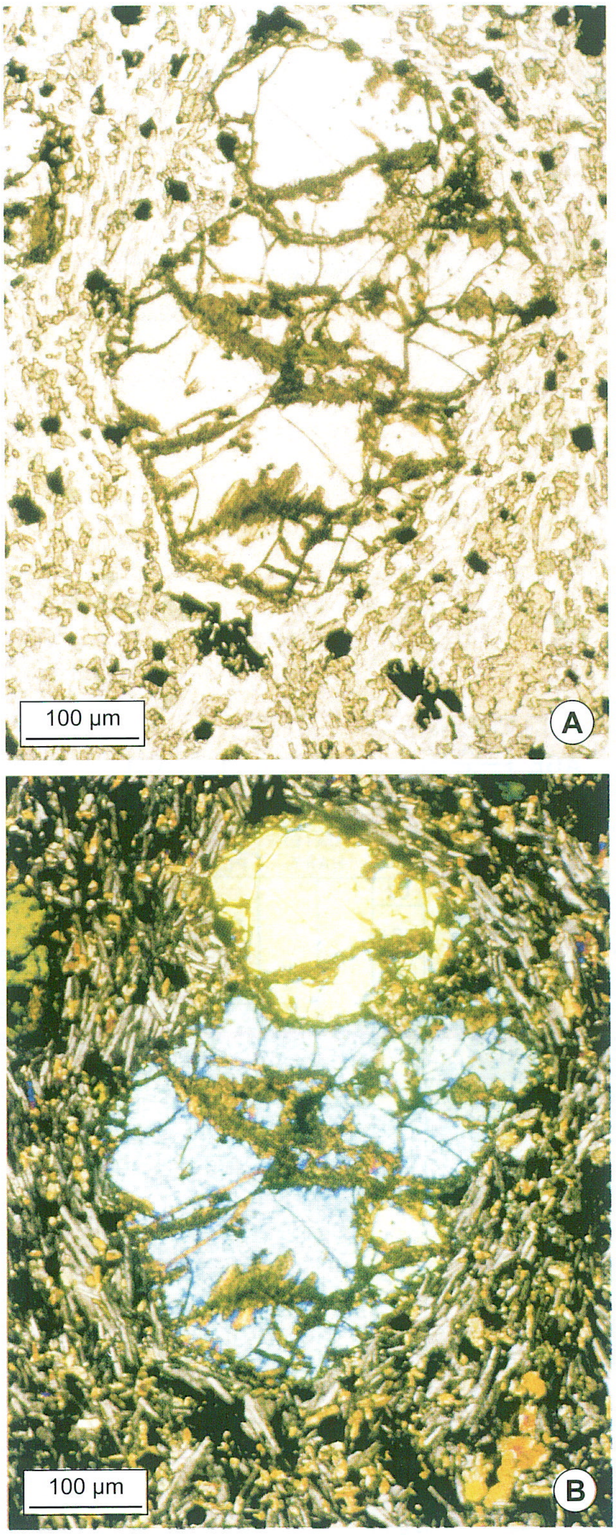


Fig. 15. Photomicrograph of cracks in olivine phenocryst filled with serpentine-group minerals. Olivine basalt intrusion at Męcinka, site BP-33: **A** – one nicol; **B** – crossed nicols

The K-Ar ages were calculated using the decay constants as proposed by Steiger and Jäger (1977). All analytical errors represent one standard deviation (68% analytical

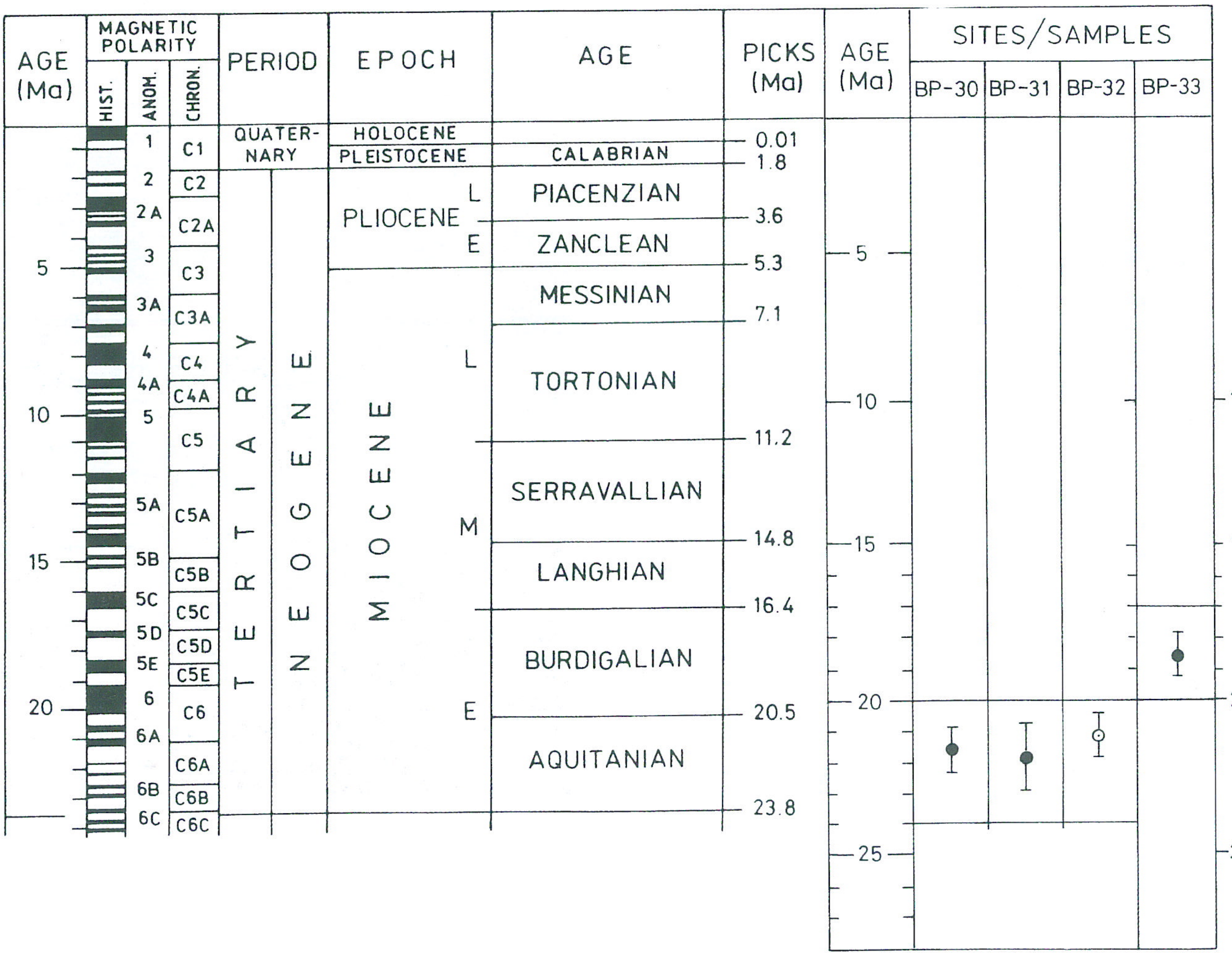
Table 2

Results of K-Ar dating of basaltic rocks from the vicinity of Jawor, Fore-Sudetic Block, Lower Silesia (performed at the Institute of Nuclear Research, Hungarian Academy of Sciences, Debrecen, ATOMKI)

K-Ar No	Sample No	Site	Geology	Dated fraction	K %	^{40}Ar rad cc STP/g	^{40}Ar rad %	K-Ar age Ma
5586	BP-30	Winna Góra, working quarry	basanite plug	w.r.	0.614	5.192×10^{-7}	47.40	21.62 ± 0.93
5587	BP-31			w.r.	0.527	4.527×10^{-7}	24.5	21.96 ± 1.36
5588	BP-32	Męcinka, working quarry	basanite lava flow	w.r.	0.801	6.593×10^{-7}	60.30	21.05 ± 0.85
5589	BP-33		basalt vent or dyke	w.r.	0.657	4.792×10^{-7}	45.10	18.66 ± 0.82

Table 3

K-Ar ages (with analytical error bars) of basanites (BP-30-32) and olivine basalt (BP-33) from the vicinity of Jawor, Fore-Sudetic Block, Lower Silesia (chronostratigraphic and magnetostratigraphic scales from Palmer & Gassman, 1999). Open circle – lava flow; solid circles – plugs and vent/dyke intrusion



confidence level). The results of the K-Ar determination performed at the Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen, are presented in Table 2.

Meaningful analytical ages can be obtained if the following essential conditions are fulfilled:

– $^{40}Ar_{rad}$ has to be zero at the time of formation of the rock;

– $^{40}Ar_{rad}/K$ ratio has been changed by radioactive decay, but not by any other physico-chemical process.

In this case, the K-Ar age can be considered as a "real geological age".

Due to the highly consistent radiometric ages of the basanites investigated (samples BP-30-32 – see Tab. 2), we do not assume the presence of "excess argon", neither we see any evidence for "argon loss". The younger age (18.66±0.82 Ma) of the olivine basalt vent/dyke which cuts the basanite lava, certainly represents a younger volcanic event.

For stratigraphic classification, the Geological Society of America 1999 Geologic Time Scale (Palmer & Geissman, 1999) has been used (Tab. 3).

PALAEOMAGNETISM

Palaeomagnetic studies of the "trachyandesite" lava at Męcinka, and of the plug at Winna Góra (= Winnica), performed several decades ago (Birkenmajer & Nairn, 1969; Birkenmajer *et al.*, 1970; Kruczyk *et al.*, 1977) indicated that the rocks exhibit reverse polarity. Taking into account that these results were presented only in the text-tables, without details of demagnetization and stereographic projections of characteristic demagnetizations, we have decided to re-study these localities.

At Winna Góra, one drill core (WG 1) and two hand samples (WG 2 and WG 3) were taken: WG 1 and WG 2 were collected from the same site (10 cm distance), close to the sample BP-30 (see Fig. 4); WG 3 was collected from the NE part of the quarry, close to the sample BP-31 (see Fig. 4): it looked apparently more fresh than WG 1-2.

At Męcinka, three hand samples (JM 1-3) were collected from the SE wall of the quarry, between samples BP-32 and BP-33, at a distance of 25 m (see Fig. 12). Samples JM 1 and 2 belong to a light-grey variety of basanite, with olivine almost completely transformed into red iddingsite. Sample JM 3 was apparently unaltered.

All palaeomagnetic experiments were carried out in the Palaeomagnetic Laboratory of the Polish Geological Institute, Warsaw (PGI Project No 6.20.1719.00.0), in the magnetically shielded space (low-field cage, Magnetic Measurements, UK) reducing the ambient geomagnetic field by about 95%. From each hand sample, 3–4 cylindrical specimens were obtained. Natural remanent magnetization (NRM) was measured using the JR-5 spinner magnetometer (AGICO, Czech Republic). Alternating field (AF) demagnetization was performed using Molspin device (max. demagnetizing field available 99 mT) and thermal demagnetization – using non-magnetic oven MMTD (Magnetic Measurements, UK). Characteristic remanent magnetization

Table 4

Palaeomagnetic results from the Winna Góra (= Winnica) quarry (sites BP-30, 31)

Sample	Dec/Inc	α_{95}	k	n_o/n
WG 1	190/-54	–	–	1/1
WG 2	197/-51	6.0	236	4/4
WG 1-2 mean	196/-52	4.9	246	5/5
WG 3	145/-54	6.0	421	3/3

Mean (this study): Dec/Inc = 171/-56, N = 2
(after Birkenmajer & Nairn, 1969):
177.2/-53.4, α_{95} = 3.3, n/n_o = 6/6
Dec – declination; Inc – inclination; α_{95}, k – Fisher statistics parameters; n_o – number of specimens demagnetized; n – number of specimens used for calculation of site mean direction

Table 5

Palaeomagnetic results from the Męcinka quarry (sites BP-32, 33).

Sample	Dec/Inc	α_{95}	k	n_o/n
JM 1	186/-52	5.6	187	5/5
JM 2	186/-51	9.7	90	4/4
JM 3	161/-40	9.4	95.3	4/4

Mean (this study): Dec/Inc = 176/-45, α_{95} = 18.3, k = 46, N =3
(after Birkenmajer & Nairn, 1969):
site 1: 154.7/-56.6, α_{95} = 8.1, n/no = 4/4
site 2: 171.2/-53.9, α_{95} = 4.3, n/no = 4/5
(after Kruczyk *et al.*, 1977):
166/-51, α_{95} = 6.3, k = 35, n = 16
For explanations – see Tab. 4

(ChRM) directions were calculated based on the principal component analysis (see Kirschvink, 1980), and using the PALMAG package of Lewandowski *et al.* (1997).

The reversed polarity of ChRM was confirmed in all the studied samples (the Winna Góra and Męcinka samples). However, the demagnetization characteristics were different between the sites. A single-component magnetization was encountered in the samples WG 1 and 2 (Fig. 16A, B), which were fully demagnetized up to 99 mT and 575°C, giving good consistency of results (Tab. 4). In the sample WG 3, a significant low-stability component was present, which has been removed between 0 and 10 mT (Fig. 16C). Afterwards, a second component has appeared which revealed quite high coercivity – ca 10–20% of the NRM intensity; it still persisted after AF demagnetization up to 99 mT (Fig. 16C). Besides, characteristic magnetization of this hand sample differed from those in WG 1-2 by almost 45° in declination (Tab. 4; Fig. 17A). Thermal cleaning gave essentially the same results, however demagnetization path was not very smooth (Fig. 16D): the specimens became unstable after 400–500°C.

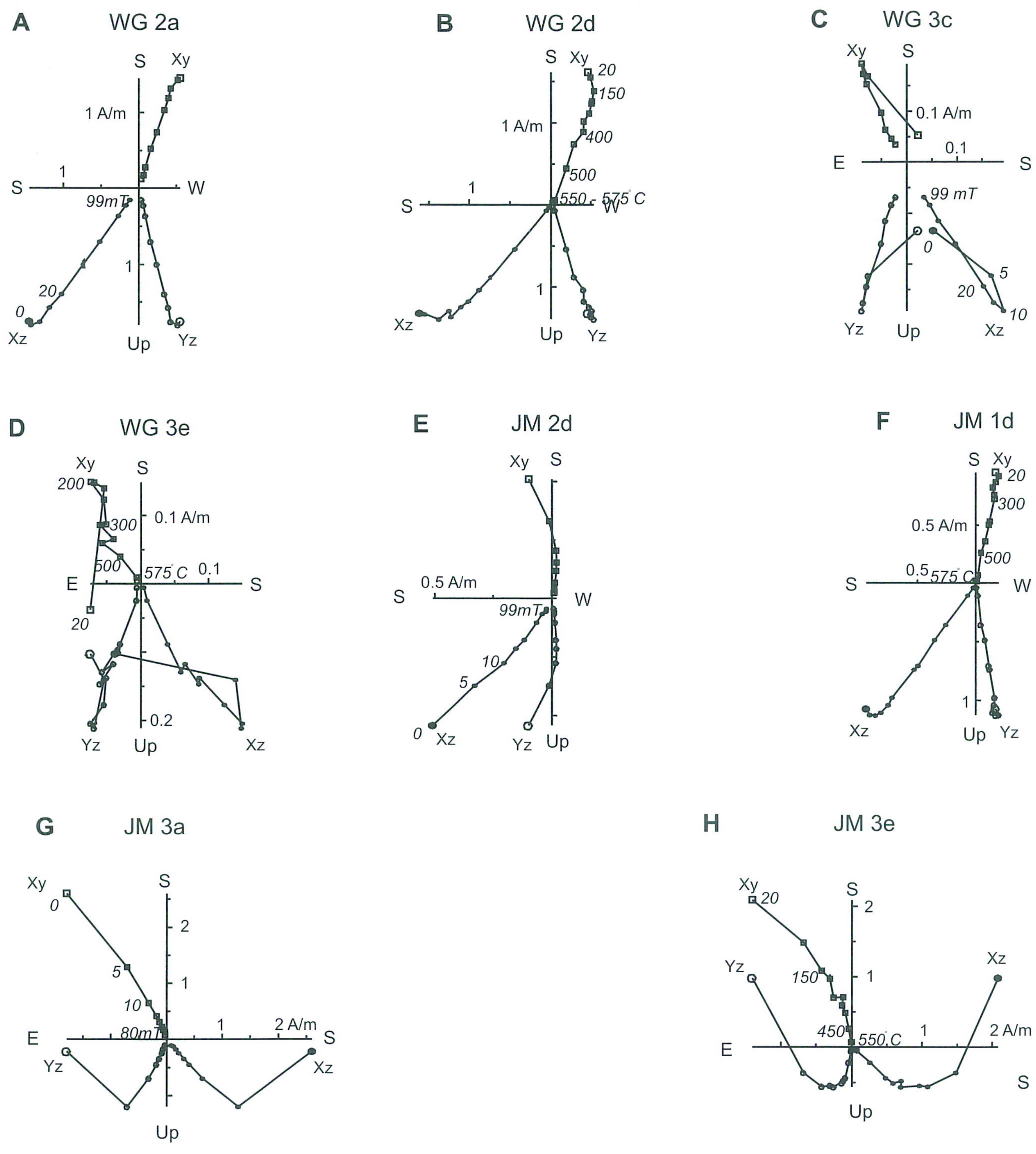


Fig. 16. Orthogonal projections of typical AF and thermal demagnetization paths. **A**, **B** – Winna Góra (basanite plug), site BP-30; **C**, **D** – Winna Góra (basanite plug), site BP-31; **E**, **F** – Męcinka (olivine basalt intrusion between sites BP-32 and 33 – a variety with abundant red iddingsite); **G**, **H** – Męcinka, unaltered olivine basalt

The samples JM 1-2 yielded results quite similar to those of WG 1-2 (Fig. 16E, F; Fig. 17B; Tab. 5); only the low stability component was occasionally better developed. Declination in sample JM 3 is apparently rotated counter-clockwise by ca. 40°, and also inclinations are lower than those of JM 1, 2. Here, again, as in the case of WG 3, the specimens were more stable during AF than during thermal treatment (Fig. 16G, H).

Summary: The pale-coloured basanite samples which displayed a significant alteration of olivine (JM 1, 2, and WG 1, 2) yielded more stable and better N–S-oriented magnetizations, than the dark varieties (JM 3 and WG 3) which revealed the NW–SE-directed declinations and were slightly unstable during thermal demagnetization.

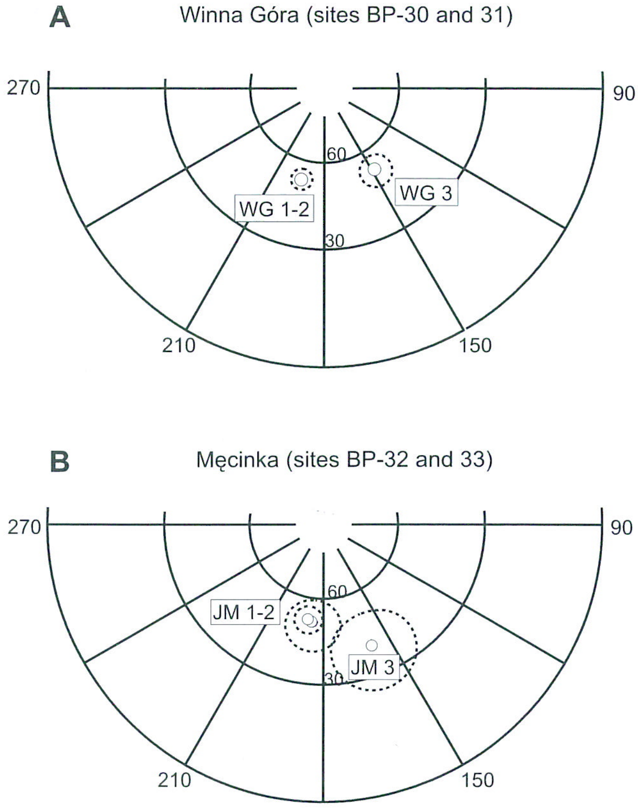


Fig. 17. Stereographic projections of sample-mean directions from the Winnica basanite plug (**A**) and the Męcinka olivine-basalt intrusion (**B**): 95% confidence ovals indicated, upper hemisphere projection

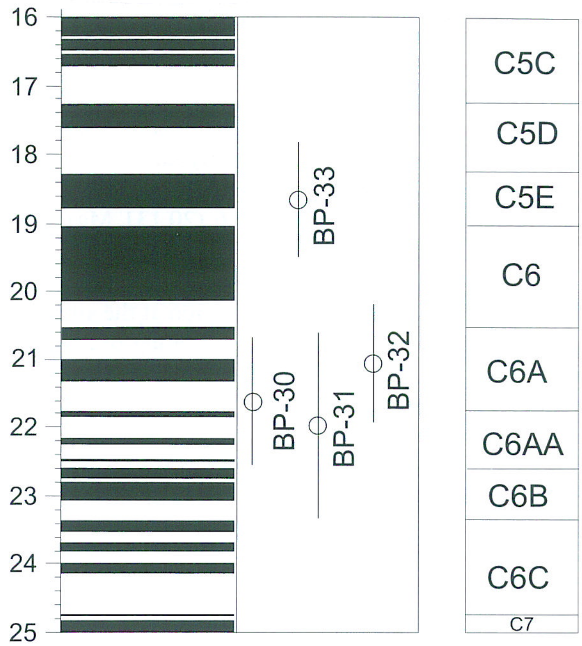


Fig. 18. K-Ar dates of investigated basanites (BP-30-32) and olivine basalt (BP-33) against the geomagnetic polarity time scale of Cande & Kent (1995). Left side – radiometric scale in Ma; right side – magnetozones

DISCUSSION AND CONCLUSIONS

(1) New petrologic and geochemical investigations have shown that the basaltic rocks, so-far classified as trachyandesite by Jerzmański (1956, 1961, 1965), and as hawaiite by Kozłowska-Koch (1987), should be reclassified as basanite (plug at Winna Góra, samples BP-30, 31, and lava flow at Męcinka, sample BP-32). A new olivine basalt site at Męcinka (sample BP-33) is represented by a vent or dyke which cuts, and thus post-dates, the basanite lava flow.

(2) Geochemical classification based upon contents and ratios of immobile trace elements does not confirm the difference between the olivine basalt (BP-33) and the basanites (BP-30-32) studied: all these rocks are alkaline basalts (see Fig. 8). Moreover, discrimination diagrams, based upon contents of Nb, Y and Zr, and the ratios Zr/Y vs. Zr, and Zr/Y vs. Ti/Y (see Figs 9–11), clearly show that these rocks were formed in the same geotectonic environment: both the basanites and the alkaline basalt are typical within-plate basaltoids.

(3) Three out of four K-Ar dates obtained from the basanite bodies in the vicinity of Jawor (BP-30, 31 from the plug, and BP-32 from the lava flow), yielded very consistent geological ages between 21.96±1.36 Ma and 21.05±0.85 Ma. They fall within the Aquitanian (Early Miocene) time span, 23.8–20.5 Ma (see Palmer & Geissman, 1999; and Tab. 3). The Early Miocene (Aquitanian) geological age of the basanite rocks in question is therefore preferred (see Tab. 2) over the previously obtained Middle Miocene one (15.5±2.5 Ma: see Kruczyk *et al.*, 1977).

(4) The present K-Ar dating (see Tab. 2) may give support to the opinion of Birkenmajer *et al.* (1970), that the Winna Góra (= Winnica) basanite plug (K-Ar dates: BP-30 – 21.62±0.93; and BP-31 – 21.96±1.36 Ma) represents a feeder vein for the Męcinka basanite lava flow (K-Ar date, BP-32 – 21.05±0.85 Ma).

(5) A significantly younger K-Ar date from the Męcinka quarry (BP-33), 18.66±0.82 Ma (Burdigalian – see Tabs 2, 3), was obtained from an olivine basalt vent or dyke which cuts the basanite lava flow (see Fig. 9B), the latter dated at 21.05±0.85 (BP-32: Aquitanian).

(6) The Early Miocene basanites and olivine basalt of the Jawor area dealt with in the present paper are much younger than melabasanite lavas and plugs of the Opole area, their mean K-Ar age calculated at 26.5 Ma (Late Oligocene: Chattian, middle part – Birkenmajer & Pécskay, 2002).

(7) Newly performed palaeomagnetic analysis confirmed the results of previous studies (Birkenmajer & Nairn, 1969; Birkenmajer *et al.*, 1970; Kruczyk *et al.*, 1977) that the basaltic rocks of Męcinka and Winnica (= Winna Góra) were magnetized during a reversed regime of geomagnetic field.

(8) When plotted against the Miocene geomagnetic polarity time-scale (see Cande & Kent, 1995; Opdyke & Channell, 1996), the K-Ar ages obtained from the sites BP-30-31-32 spread over reversed parts of the magnetozone C6A and C6B (Fig. 18). Taking into account that the frequency of magnetic reversals during Early Miocene was very high (geomagnetic polarity changed sometimes every 250–300 Ky), it was not possible to correlate the time of extrusion/in-

trusion of our basanites with specific reversed polarity intervals. However, as it is shown in Fig. 18, all the three basanite dates correspond to the period of prevailing reversed polarity regime of the geomagnetic field. Therefore, from palaeomagnetic viewpoint, the most likely time interval of our basanite effusions and intrusion would be between the top of reversed part of magnetozone C6 (20.131 Ma) and the bottom of magnetozone C6B (23.353 Ma).

(9) A significantly younger K-Ar date (18.66±0.82 Ma) obtained from the olivine-basalt intrusion at the site BP-33, might be correlated with reversed parts either of the magnetozone C5D (17.615–18.281 Ma) or the magnetozone C5E (18.781–19.048 Ma) – see Fig. 18.

(10) The site mean palaeomagnetic directions obtained now, and in the previous studies (see Tabs 4, 5), are roughly similar, i.e. slightly rotated to NW–SE from the present-day axial geocentric dipole. There seems to be an apparent correlation between degree of iddingsitization and palaeodeclination. However, as too few samples have been demagnetized to average and eliminate adequately the effect of possible secular variations and alterations, the palaeopoles have not been calculated, and no tectonic interpretation has been undertaken.

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Streszczenie

DATOWANIE RADIOMETRYCZNE TRZECIORZĘDOWYCH WULKANITÓW DOLNEGO ŚLĄSKA. III. DATY K-Ar I WYNIKI BADAŃ PALEOMAGNETYCZNYCH DOLNOMIOCEŃSKICH SKAŁ BAZALTOWYCH OKOLIC JAWORA (BLOK PRZEDSUDECKI)

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Datowaniem radiometrycznym (K-Ar) objęto trzeciorzędowe skały bazaltowe odsłonięte w kamieniołomach Winna Góra (czop wulkaniczny) i Męcinka (potok lawowy i intruzja) w okolicy Jawora na Dolnym Śląsku (blok przedsudecki). Według nowych danych geochemicznych i petrograficznych, wśród skał tych, dotychczas uważanych za trachyandezyty, wyróżniono bazanity i bazalt oliwinowy. Uzyskane daty K-Ar wskazują na wiek dolnomioceński (akwitan) potoku lawowego bazanitu w Męcince (21.05±0.85 Ma) i czopu bazanitowego Winnej Góry (21.62±0.93 Ma i 21.96±1.36 Ma). Intruzja bazaltu oliwinowego w Męcince, która przecina potok lawowy bazanitu, jest nieco młodsza, odpowiadając burdygałowi (18.66±0.82 Ma). Nowe badania paleomagnetyczne potwierdziły uprzednio publikowane dane wskazujące na to, że skały te zostały namagnesowane w epoce odwróconego pola magnetycznego Ziemi. Daty K-Ar z bazanitów (czop i potok lawowy) odpowiadają partiom odwróconego pola magnetycznego magnetozon C6A i C6B. Młodsza data z intruzji bazaltu oliwinowego może być korelowana z magnetozonami C5D lub C5E.