Supplementary Publication

The orthogneisses of the Orlica-Śnieżnik complex (West Sudetes, Poland): geochemical characteristics, the importance of pre-Variscan migmatization and constraints on the cooling history

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Abstract

Geochemical analyses in combination with Rb-Sr (whole rock, phengite, biotite) and U-Pb zircon ages provides important constraints on the magmatic, metamorphic and structural evolution of the Śnieżnik and Gierałtów gneisses from the Orlica-Śnieżnik complex (West Sudetes). These two gneisses have been considered to represent distinct petrogenetic units, however their major and trace element compositions as well as their Sr-Nd isotope characteristics show no systematic differences that are indicative for different protoliths. This striking similarity leads to the conclusion that the petrographic variability is caused by superimposed modifications during deformation and migmatization. Most εNd_{500} values are in the range between -3.3 and -5.7 and suggest derivation of the protoliths from pre-existing continental crust. Two-stage T_{DM} model ages mostly fall in the range between 1.4 and 1.6 Ga and closely correspond to other orthogneiss occurrences in the Bohemian Massif. The Rb-Sr whole rock system is disturbed on a regional scale, to variable degrees, resulting in dates (*c.* 450 Ma and *c.* 395 Ma), considerably younger than the time of magmatic crystallization (*c.* 500 Ma). Secondary ionization mass spectrometry (SIMS) U-Pb analyses provide two groups of $^{206}Pb/^{238}Pb$ ages (364–341 Ma and 527–472 Ma), which largely correlate with previously established ages for protolith formation and Variscan high temperature metamorphism. No geochronological evidence for pre-Variscan (“Caledonian”) events was found. For phengite and biotite, the Rb-Sr system yields ages of *c.* 340 to 320 Ma which provides further constraints on the regional cooling history.

Key words: Orlica-Śnieżnik complex, West Sudetes, orthogneisses, migmatization, Rb–Sr dating, U–Pb dating

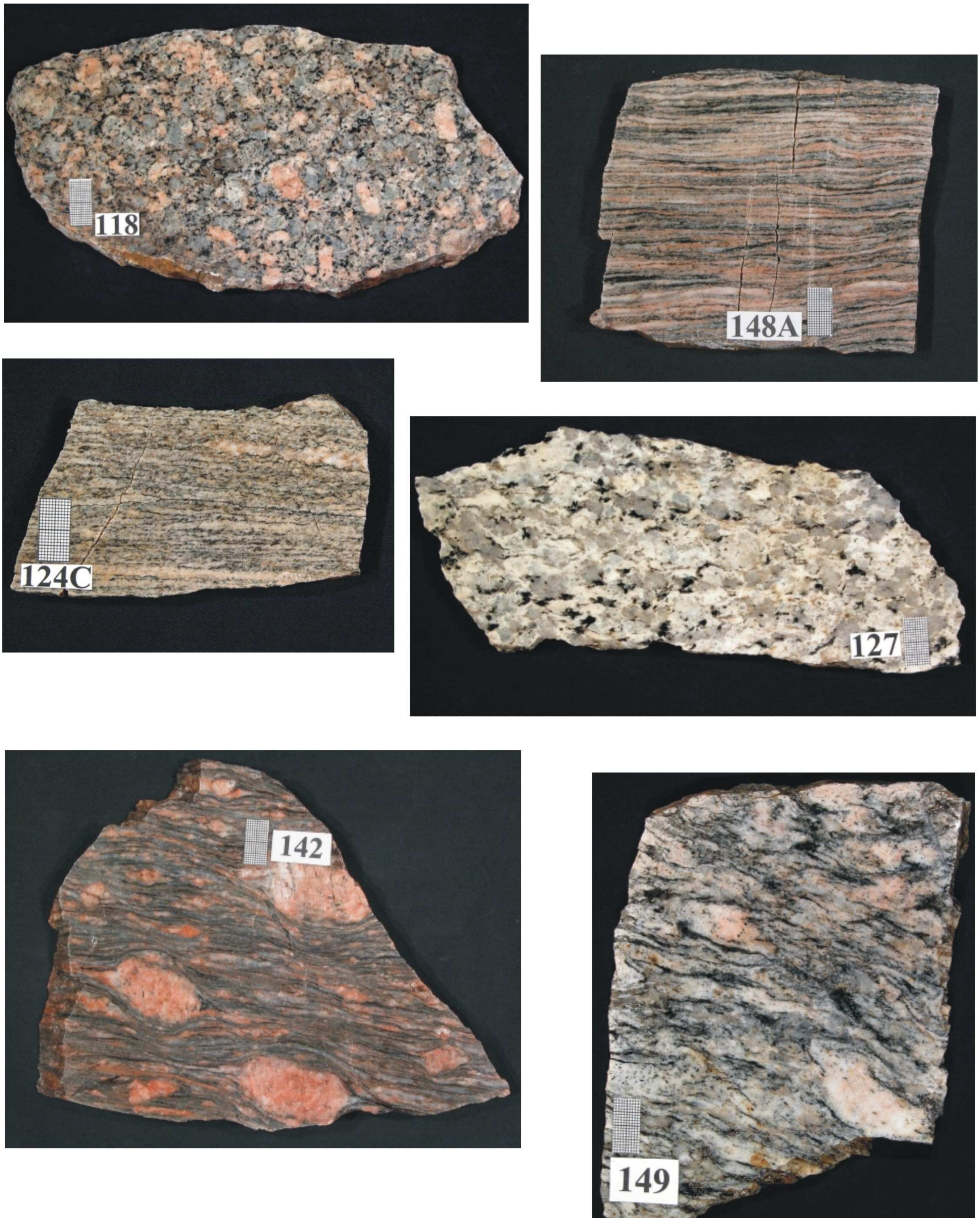

Fig. 1. Photographs of representative handspecimens of Śnieżnik gneisses.

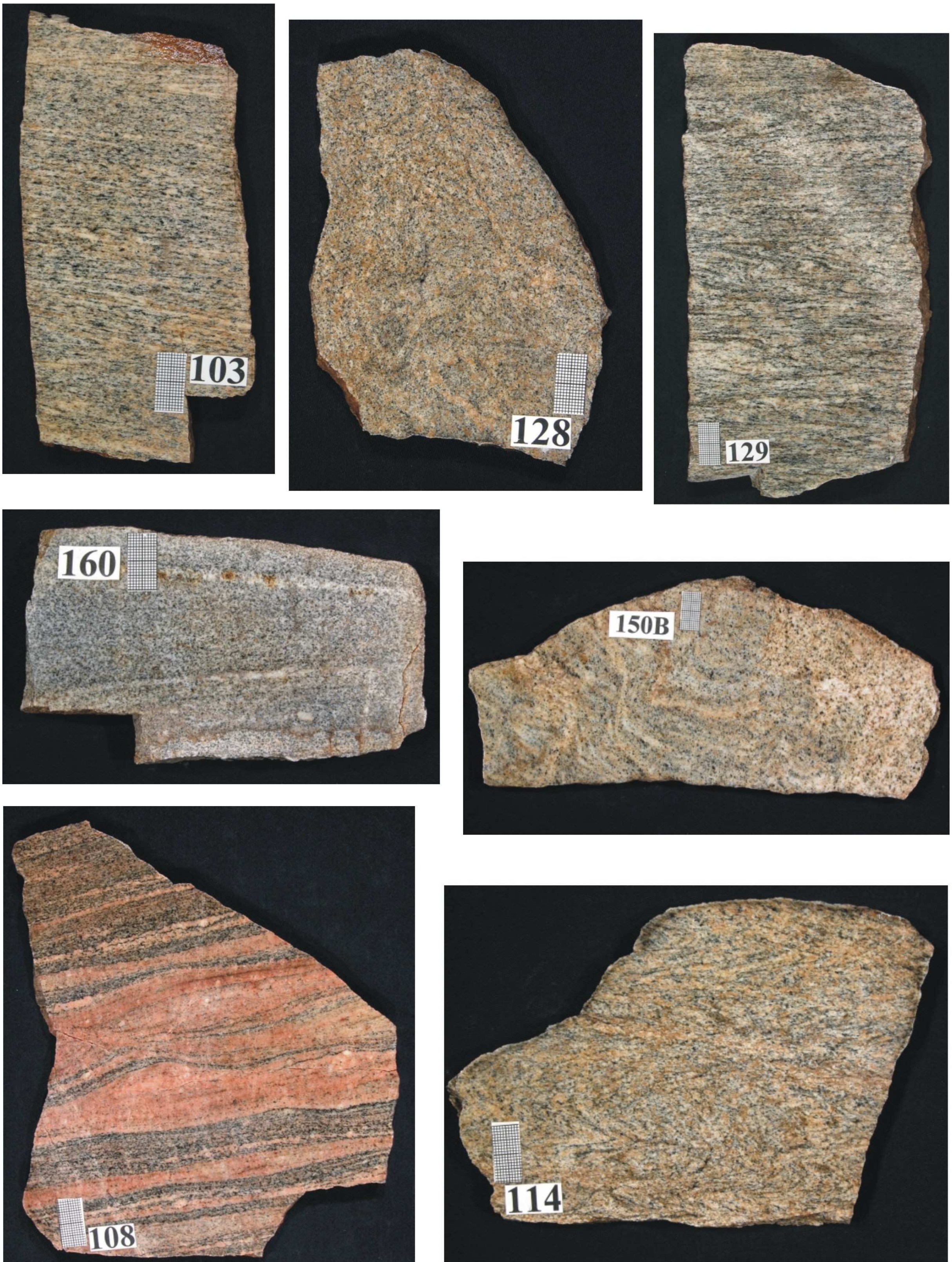

Fig. 2. Photographs of representative handspecimens of Gierałtów gneisses.

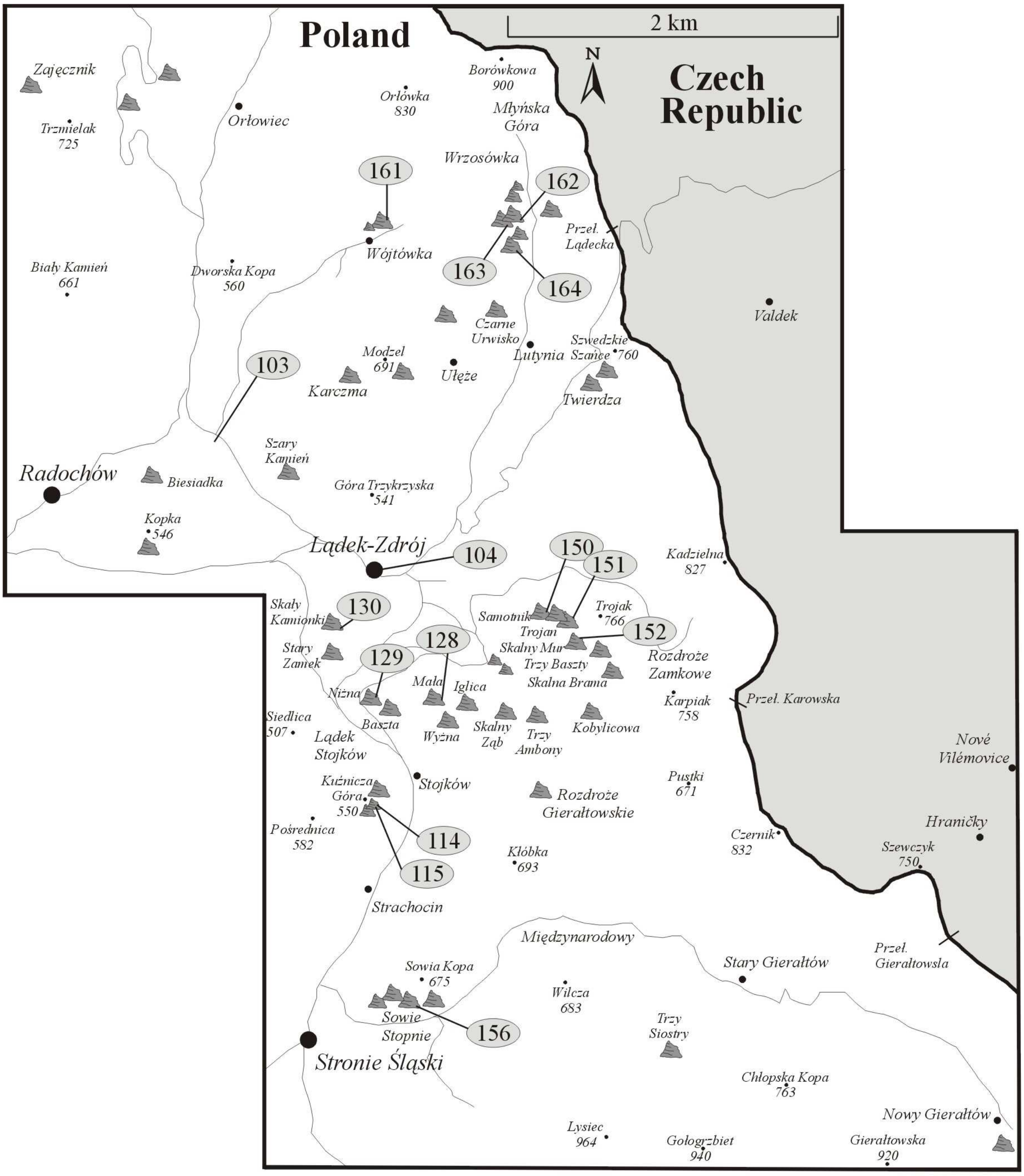

Fig. 3. Sample location map A. Lines indicate roads and foot paths.

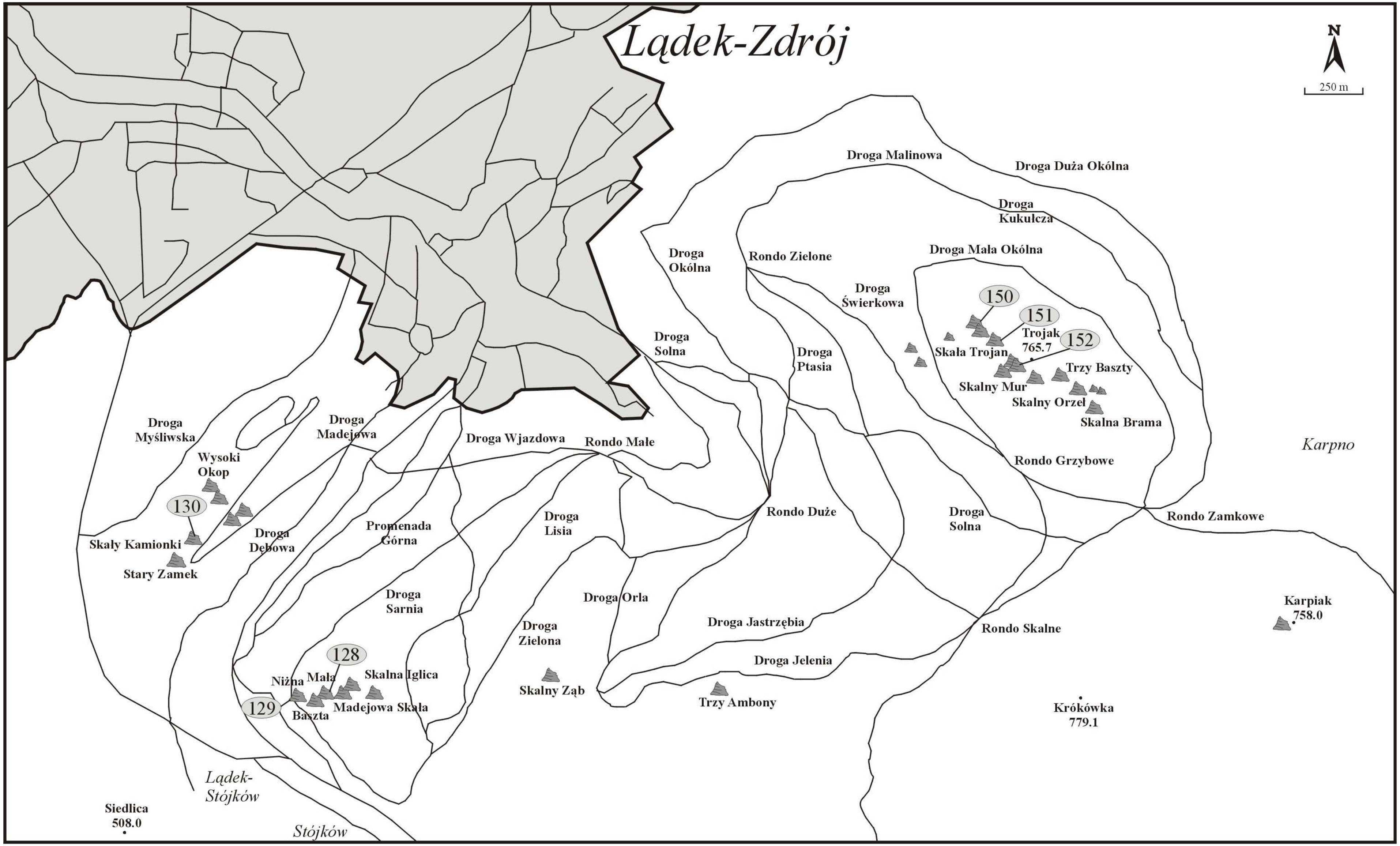

Fig. 4. Sample location map of the surroundings of Lądek-Zdrój. Lines indicate roads and foot paths.

Fig. 5. Sample location map B. Lines indicate roads and foot paths.

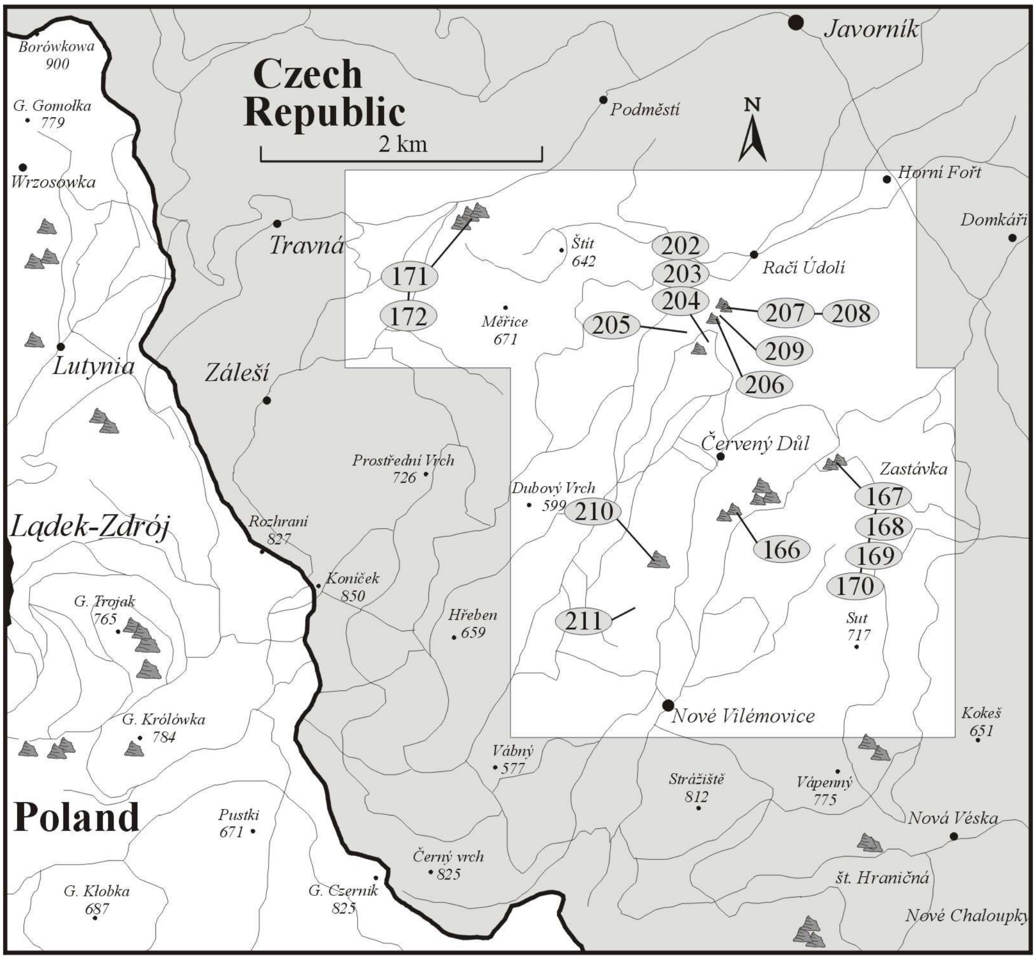

Fig. 6. Sample location map C. Lines indicate roads and foot paths.

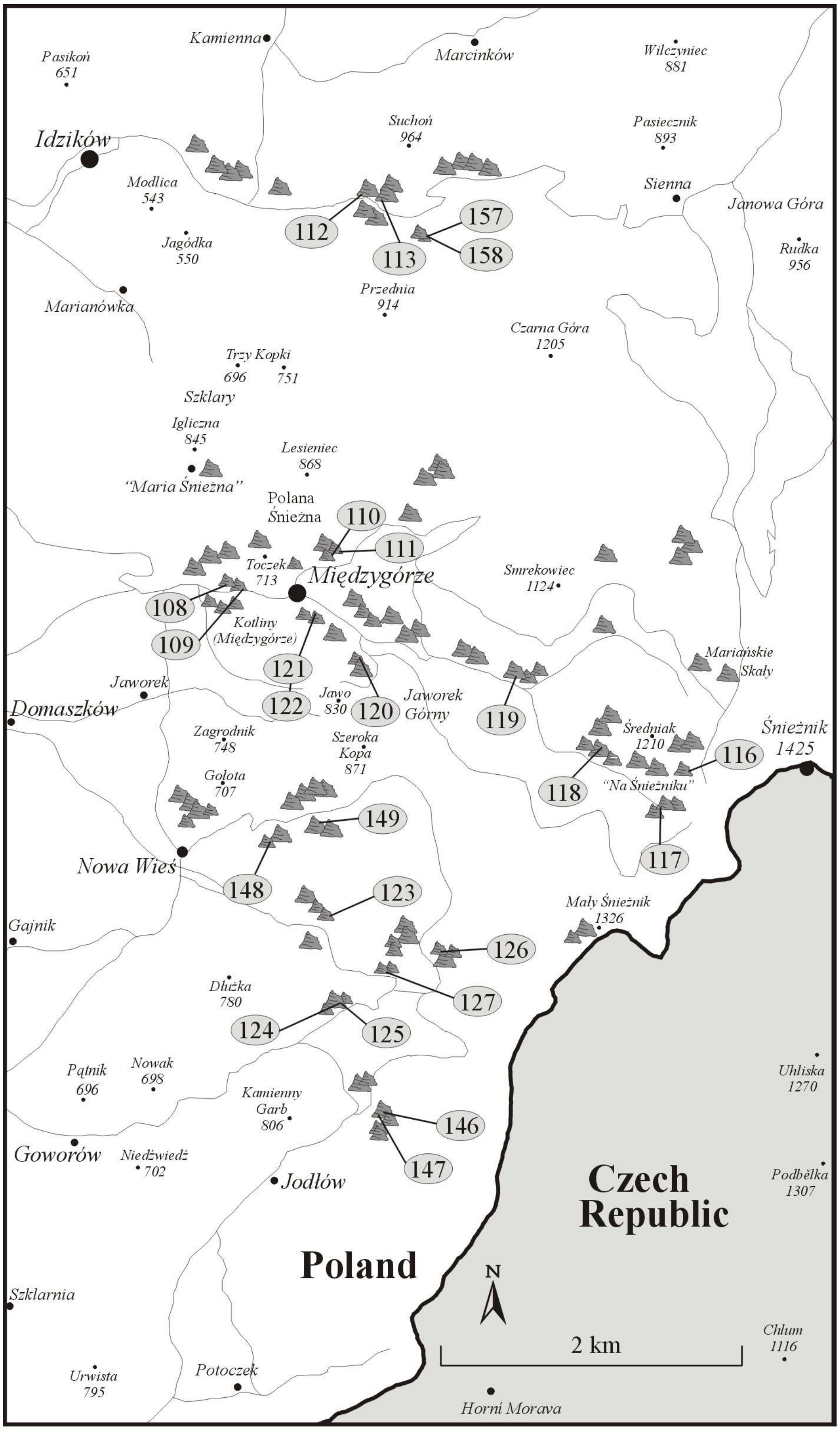

Fig. 7. Sample location map D. Lines indicate roads and foot paths.

Fig. 8. Sample location map E. Lines indicate roads and foot paths.

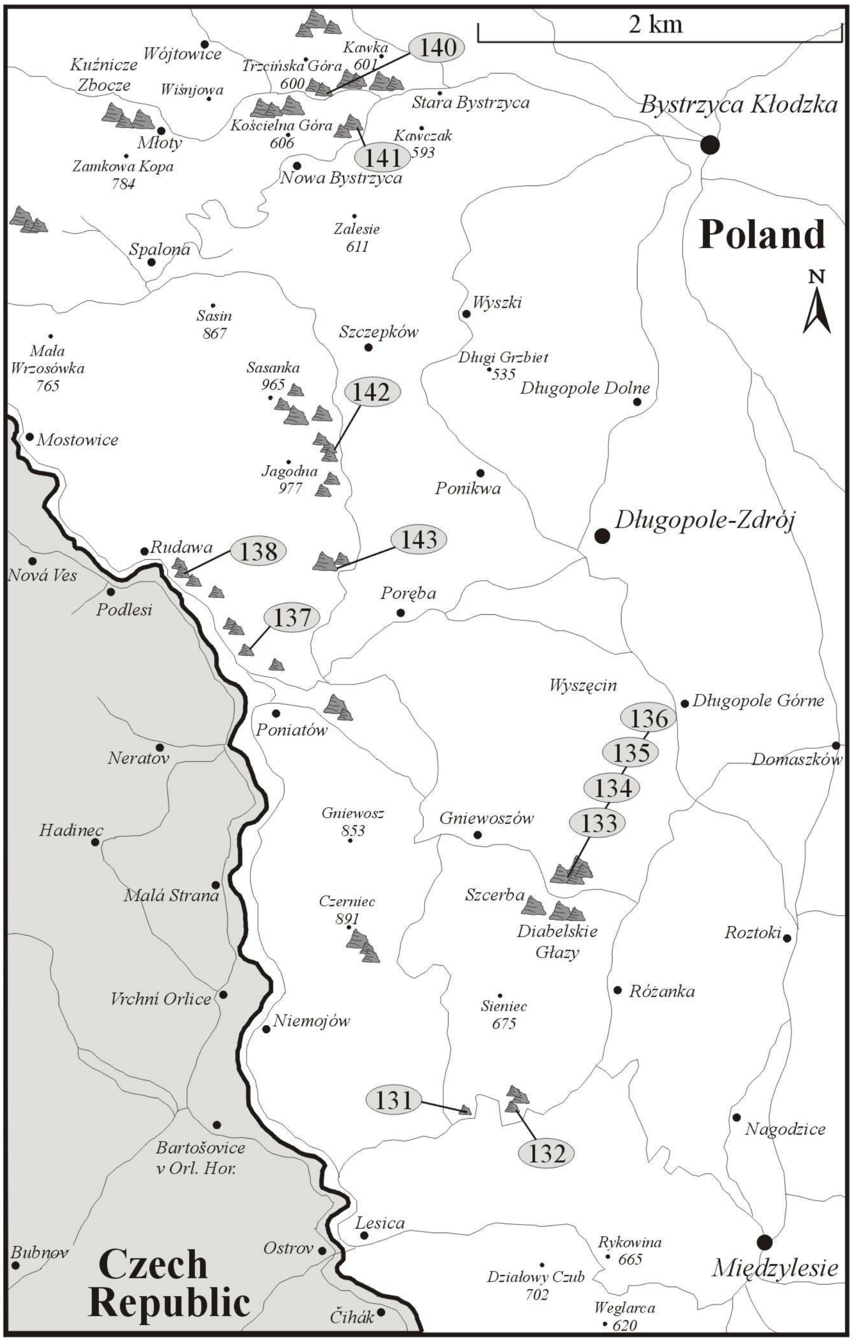

Fig. 9. Sample location map F. Lines indicate roads and foot paths.

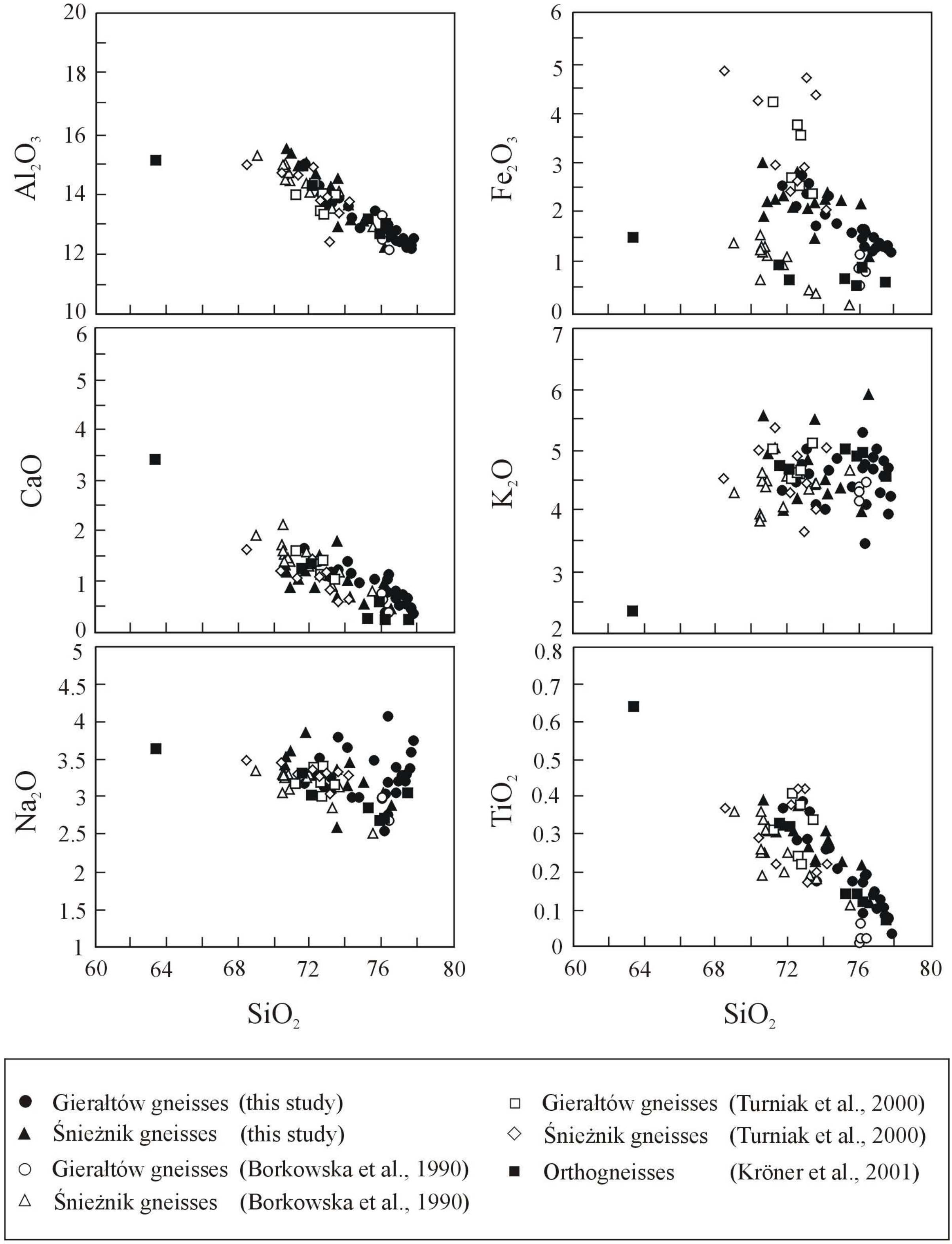

Fig. 10. Major and minor element variations in orthogneisses of the OSC.

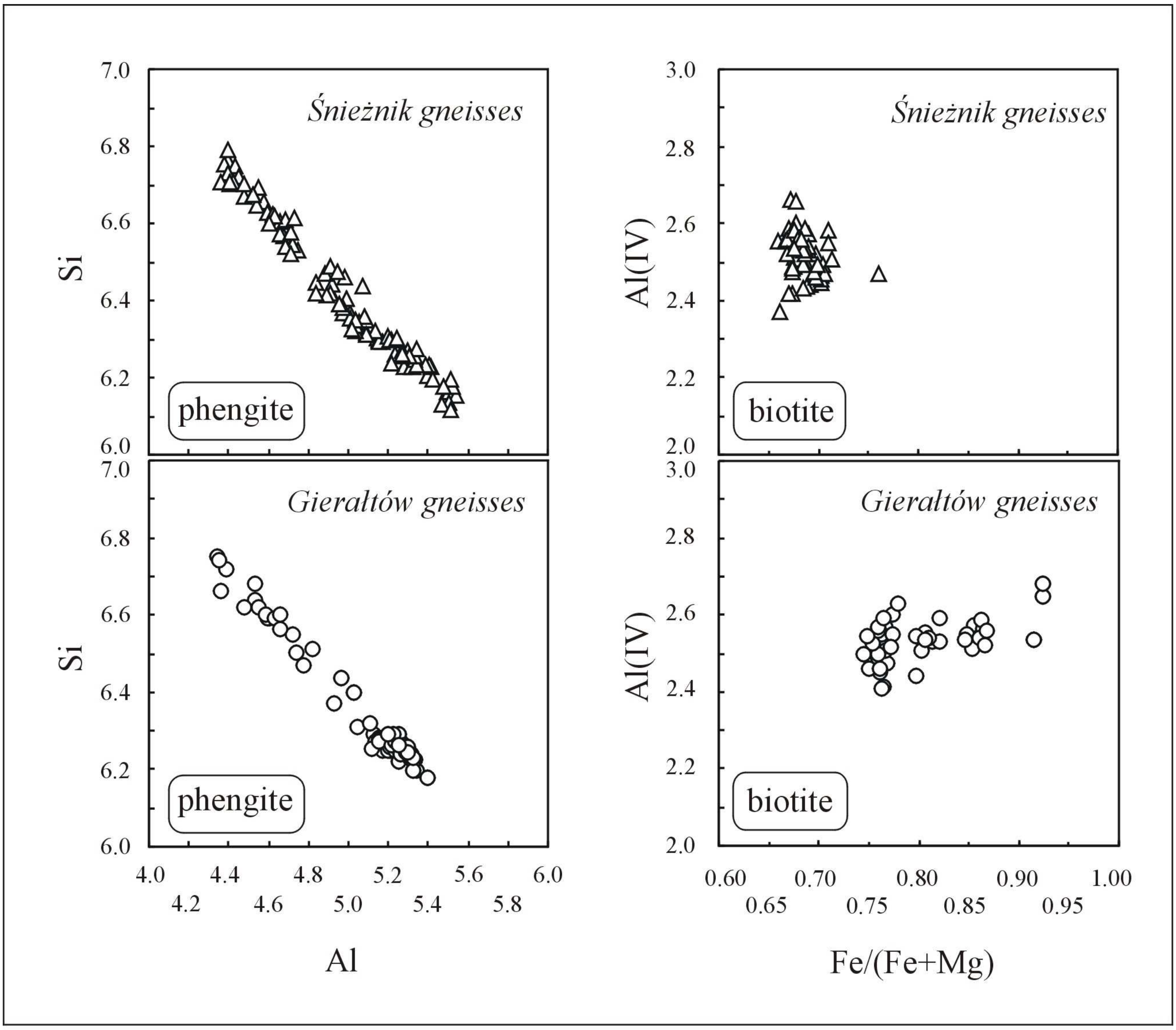

Fig. 11. Phengite and biotite compositions of Śnieżnik and Gierałtów gneisses.

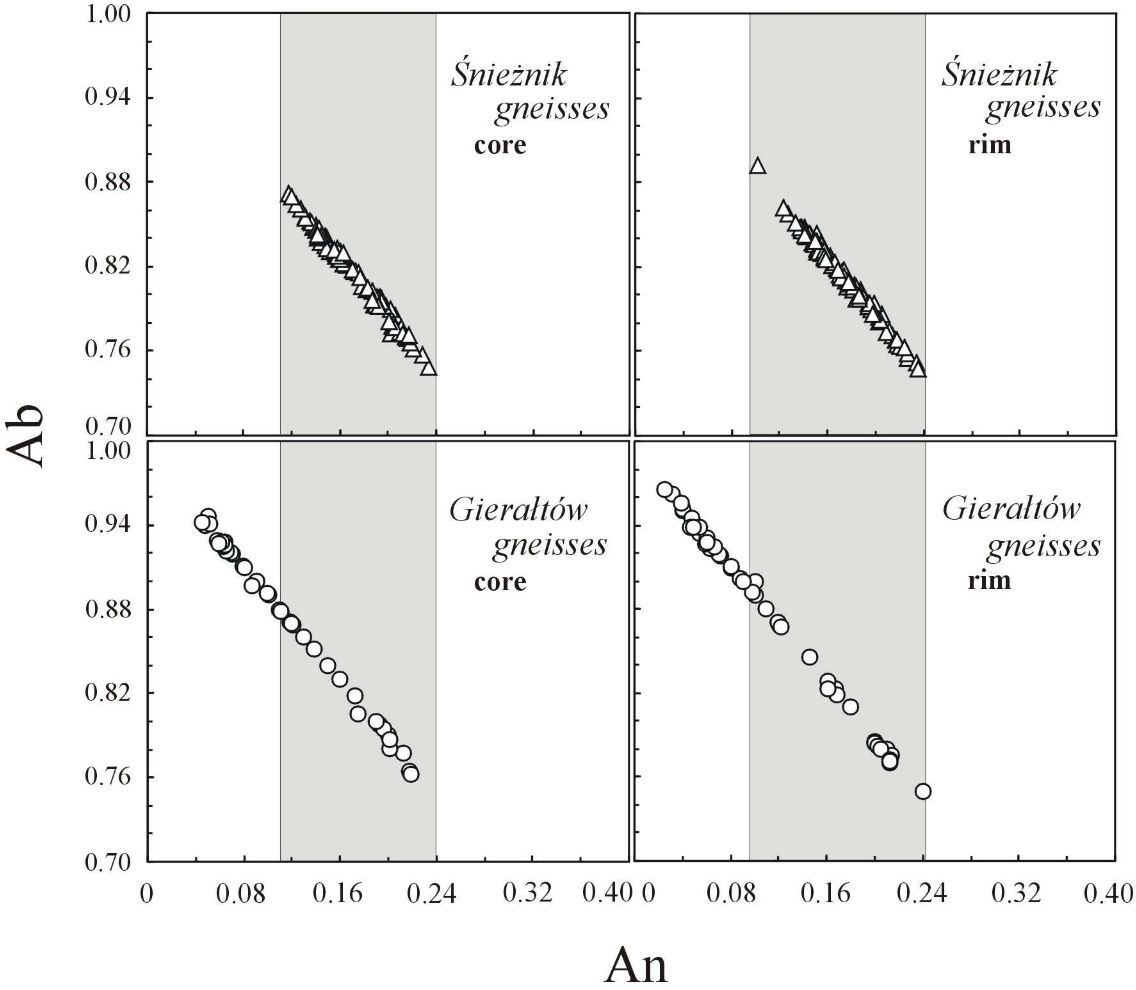

Fig. 12. Plagioclase compositions of Śnieżnik and Gierałtów gneisses. For better visualization, the range in Śnieżnik gneisses is indicated by a grey field.

Analytical methods

Mineral composition of phengite, biotite and plagioclase were determined in polished thin-sections of nine representative samples with a CAMECA SX-50 electron microprobe at the *Mineralogisches Institut, Universität Würzburg, Germany*. Operating conditions were a 15 kV acceleration voltage, 10 nA beam current and counting time of 20-30 s. The beam diameter was set at 3-5 µm. Natural and synthetic mineral standards were used. The raw data were corrected with a ZAF procedure using the PAP software provided by Cameca.

Bulk rock compositions were analysed at *Activation Laboratories Ltd, Ancaster, Ontario.* Major element concentrations were determined with XRF. Trace elements (including REE) were determined by ICP-MS, using sample solutions based on a lithium metaborate/lithium tetraborate fusion, followed by acid digestion.

ID-TIMS analyses (isotope dilution – thermal ionization mass spectrometry) of Rb–Sr, Sm–Nd and U–Pb were carried out at the *Zentrallabor für Geochronologie, Institut für Mineralogie Universität Münster, Germany*. For preparation of whole rock powders, fresh sample material was crushed in a jaw-crusher and an aliquot was ground in a tungsten carbide mill. For mineral separation, the remaining material was further reduced in size by grinding for a few seconds in a tungsten carbide mill or with a disc mill. Following sieving, fines were removed and mica was enriched with a Frantz magnetic separator and/or by adherence to a sheet of paper. After hand-picking the mica packages under a stereomicroscope, possible contaminants located between individual sheets were removed by grinding under ethanol in an agate mortar and pestle. Mica concentrates (optically pure >99%) were then washed in ethanol (p.a.) in an ultrasonic bath and afterwards repeatedly rinsed in ultrapure H_2O. Sample digestion for Rb–Sr and Sm–Nd whole rock studies was carried out in Teflon® bombs within screw-top steel containers. In a first step, whole rock powders were mixed with a ^{87}Rb-^{84}Sr and a ^{149}Sm-^{150}Nd spike in Teflon® screw-top vials and dissolved in a HF–HNO_3 (5:1) mixture on a hot plate overnight. The solution was then reduced to a small volume by evaporation on a hot-plate. After adding fresh HF–HNO_3 (5:1), the sample containers were transferred into a Teflon® bomb within a steel autoclave. After a few days at 180 °C, a few drops of $HClO_4$ were added to the solutions to break down fluorides during drying on a hot-plate. After complete evaporation, 6N HCl was added to the residue to remove remaining fluorides in a second evaporation step. Rb, Sr and bulk REE were separated by standard ion-exchange procedures (AG 50W-X8 resin) on quartz glass columns using 2.5 N and 6 N HCl as eluents. Sm and Nd were extracted from the REE fraction using Teflon® powder coated with 2-ethyl-hexyl phosphoric acid and 0.2 N and 0.4 N HCl as eluents.

Mineral separates for Rb–Sr analyses (phengite: *c.* 2-16 mg; biotite: *c.* 3-11 mg) were mixed with a ^{87}Rb–^{84}Sr spike in teflon screw-top vials and dissolved in a HF–HNO_3 (5:1) on a hot plate overnight. After drying, 6N HCl was added to the residue. This mixture was homogenized on a hot plate overnight. After a second evaporation to dryness, Rb and Sr were separated by standard ion-exchange procedures (AG 50W-X8 resin) on quartz glass columns using 2.5 N HCl as eluent.

For mass-spectrometric analysis, Rb was loaded with H_2O on Ta filaments and Sr was loaded with TaF_5 on W filaments. Sm and Nd were analysed on Re filaments in a triple filament configuration using HCl as loading agent. Mass-spectrometric analysis was carried out using a VG Sector 54 multicollector mass spectrometer (Sr, Sm, Nd) and a NBS-type Teledyne mass spectrometer (Rb). Correction for mass fractionation is based on a ^{86}Sr/^{88}Sr ratio of 0.1194. Rb ratios were corrected for mass fractionation using a factor deduced from multiple measurements of Rb standard NBS 607. Total procedural blanks were <0.1 ng for Rb and <0.15 ng for Sr. Based on repeated measurements, the ^{87}Rb/^{86}Sr ratios were assigned an uncertainty of 1% (2σ). For the ^{87}Sr/^{86}Sr ratios, within-run uncertainties are reported at the $2\sigma_m$ level. In the course of this study, repeated runs of NBS standard 987 gave an average ^{87}Sr/^{86}Sr ratio of 0.710285 ± 0.000022 (2σ, n = 24). Correction for mass fractionation is based on ^{146}Nd/^{144}Nd ratio = 0.7219. Total procedural blanks were <0.30 pg for Sm and <0.25 pg for Nd. The ^{147}Sm/^{144}Nd ratios were assigned external uncertainties of 0.3 %. Uncertainties of the ^{143}Nd/^{144}Nd ratios are reported on the within-run $2\sigma_m$ level. Repeated runs of the LaJolla standard gave an average ^{143}Nd/^{144}Nd ratio of 0.511859 ± 0.000032 (2σ, n= 12). All ages and elemental concentrations were calculated using the IUGS recommended decay constants by means of the Isoplot program version 2.49 (Ludwig 1991).

For ID-TIMS U–Pb analyses, hand-picked zircons were washed in 7N HNO_3 at 80 °C for 25 min. Subsequently, individual zircon grains were placed in multi-sample Teflon® microcapsules (Parrish, 1987) and dissolved for four days in HF-HNO_3 (4:1) at 180 °C. Dissolved zircons were spiked with a mixed ^{233}U-^{205}Pb tracer solution, dried at 80 °C, redissolved in 6N HCl and equilibrated at 180 °C for one day. After drying at 80 °C, the samples were loaded on a single Re filament using a mixture of silica gel and 6N HCl–0.25N H_3PO_4. Isotope ratios of Pb and U were measured with a Daly-type detector in ion-counting mode on a VG Sector 54 thermal ionization mass spectrometer (TIMS). Pb and U (as UO_2^+) were run sequentially on the same filament at temperatures of 1250 to 1350 °C and 1300 to 1450 °C, respectively. Average measured precision (2σ error) of Pb isotope ratios was 0.8 % (^{206}Pb/^{204}Pb), 0.18 % (^{207}Pb/^{206}Pb), and 0.06 % (^{206}Pb/^{205}Pb). Ratios were corrected individually for mass fractionation by 1.4 ± 0.8 ‰/amu ($^{207}Pb/^{206}Pb$, $^{206}Pb/^{205}Pb$), and 1.5 ± 0.8 ‰/amu ($^{206}Pb/^{204}Pb$), based on multiple analyses of NBS 982 standard. $^{233}U/^{238}U$ ratio was measured better than ± 0.13 % (2σ) and mass fractionation was corrected by 2.0 ± 0.8 ‰/amu based on analyses of NBS U-500 standard. For each charge of samples, the maximum Pb blank was assumed to be equivalent to the amount of the common Pb in the most radiogenic sample. The small sample size in combination with moderate U concentrations required the analysis of radiogenic Pb amounts as low as 4.8 pg. Consequently, analytical blanks had to be controlled at low level. In the course of this study, the Pb blank decreased from 3 pg to 1 pg due to improved reagents and sample handling. For initial lead correction, isotopic compositions were calculated according to the model of Stacey & Kramers (1975), assuming zircon crystallization at 360 Ma. In all samples $^{206}Pb_{rad}/^{206}Pb_{tot}$ is sufficiently high to obtain precise $^{206}Pb/^{238}U$ ages. The U blank was too small to be measured and was thus assumed to amount 20 % of the individual Pb blank, based on experience with the analysis of mg-sized samples. Uncertainties in $^{206}Pb/^{238}U$, $^{207}Pb/^{235}U$ and $^{207}Pb/^{206}Pb$ ages were calculated using the algorithm of Ludwig (1980) and errors are quoted at the 2σ level. Software Isoplot/Ex, rev. 2.49 (Ludwig 2001) was used for the concordia plot.

Sensitive ionization mass spectrometry (SIMS) was carried out by use of a sensitive high-resolution ion microprobe (SHRIMP) at the *Research School of Earth Sciences at Canberra (RSES).* For dating clean zircon separates were mounted in epoxy , together with the RSES reference zircons FC1 and SL13. Photomicrographs in transmitted and reflected light were taken of all zircons and these, together with SEM cathodoluminescence (CL) images, were used to reveal the internal structures of the sectioned grains and to target specific areas within the zircons for spot analysis, *e.g.* metamorphic rims or inherited cores. U–Pb analyses were acquired in a number of sessions using SHRIMP II at the RSES. The data were reduced in a manner similar to that described by Williams (1998, and references therein), using the SQUID Excel Macro of Ludwig (2000). To correct for U-Pb discrimination the measured Pb/U ratios were normalised relative to a value of 0.1859 for the $^{206*}Pb/^{238}U$ ratio of the FC1 reference zircons, equivalent to an age of 1099 Ma (Paces & Miller, 1989). Uranium and Th concentrations were determined relative to the SL13 standard. Uncertainties given for individual analyses (ratios and ages) are at the 1σ level, however uncertainties in any calculated weighted mean ages are reported as 95% confidence limits. Concordia plots, regressions and weighted mean age calculations were carried out using Isoplot/Ex (Ludwig, 1999).

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Table 1. Bulk-rock compositions of Śnieżnik gneisses. Major elements were determined by XRF, trace elements by ICP-MS. Oxides in wt%, trace elements in ppm.

Sample	113	118	119	124	125	126	127	142	148	149	156	158	162	163	164
SiO_2	76.50	74.07	70.58	72.25	70.85	72.49	73.48	73.12	71.28	70.63	74.18	71.73	74.94	73.46	76.08
Al_2O_3	12.75	13.63	14.72	14.67	15.36	14.10	14.50	14.22	14.94	15.50	13.13	15.05	13.08	12.89	12.22
$Fe_2O_3^T$	1.15	2.28	3.01	2.13	2.23	2.84	1.51	2.10	2.29	1.94	2.41	2.34	2.26	2.21	2.19
MnO	0.02	0.04	0.04	0.03	0.03	0.04	0.02	0.02	0.03	0.03	0.04	0.03	0.04	0.05	0.07
MgO	0.19	0.57	0.80	0.68	0.66	0.71	0.36	0.49	0.67	0.53	0.60	0.50	0.43	0.43	0.41
CaO	0.47	1.03	1.33	0.89	0.88	1.51	1.80	1.11	1.06	1.19	0.70	1.22	0.55	0.71	0.97
Na_2O	2.88	3.15	3.43	3.28	3.61	3.35	3.37	3.12	3.19	3.53	3.45	3.86	3.20	2.59	3.06
K_2O	5.91	4.52	4.50	4.63	4.94	4.20	4.45	4.85	5.05	5.57	4.28	4.01	4.38	5.50	4.00
TiO_2	0.12	0.31	0.39	0.31	0.31	0.38	0.23	0.27	0.30	0.25	0.28	0.32	0.23	0.23	0.22
P_2O_5	0.09	0.12	0.16	0.17	0.18	0.18	0.14	0.15	0.17	0.16	0.15	0.20	0.18	0.17	0.14
LOI	0.40	0.75	1.27	1.29	1.13	0.67	0.45	0.92	1.05	0.72	1.18	1.04	1.03	0.95	0.70
Total	100.48	100.46	100.22	100.32	100.17	100.45	100.30	100.36	100.04	100.06	100.39	100.30	100.31	99.19	100.04
A/CNK	1.38	1.57	1.59	1.67	1.63	1.56	1.51	1.57	1.61	1.51	1.56	1.66	1.61	1.47	1.52
NK/A	0.69	0.56	0.54	0.54	0.56	0.54	0.54	0.56	0.55	0.59	0.59	0.52	0.58	0.63	0.58
V	6	23	34	24	25	31	18	19	23	18	23	26	17	15	14
Cr	-	-	20	-	-	-	-	-	-	-	21	-	-	-	37
Ni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-
Zn	32	38	58	42	67	43	-	47	54	45	54	46	43	54	53
Ga	14	16	19	17	19	18	16	20	20	19	20	20	19	17	18
Ge	-	-	0.9	-	-	0.7	-	1.2	1.1	1.3	1.4	1.4	1.3	1.0	1.4
Rb	183	188	179	151	184	151	136	195	192	191	218	136	206	260	199
Sr	32	57	100	127	122	93	127	88	107	143	81	110	43	47	44
Y	44	33	45	28	31	40	27	47	32	32	40	13	36	32	42
Zr	87	153	201	152	154	166	141	124	148	108	137	152	126	128	107
Nb	4.9	7.9	9.6	8.1	8.0	8.5	4.9	8.2	8.5	7.4	9.5	9.1	8.2	7.9	8.4
Sn	3	3	3	2	2	3	2	3	2	3	5	2	3	6	4
Cs	2.7	6.0	5.3	3.7	5.5	3.3	3.9	8.0	6.5	4.5	3.3	3.8	4.0	6.4	9.3
Ba	120	406	651	821	991	648	933	507	803	1,070	434	839	389	414	289
Ta	1.1	1.5	1.2	1.1	0.9	1.2	0.8	1.1	0.9	1.0	1.4	1.0	1.4	1.4	1.5
Tl	1.1	0.6	0.9	0.5	1.3	0.7	0.5	1.0	0.9	0.9	1.0	0.5	0.8	1.3	0.9
Pb	28	11	12	53	18	16	16	26	37	32	31	31	19	28	23
Bi	0.3	-	0.2	-	-	-	-	0.6	0.7	0.6	0.5	0.9	0.4	0.3	0.6
Th	11.1	12.3	15.7	12.5	13.3	15.1	9.28	11.7	12.1	10.1	12.0	6.77	10.5	9.54	10.1
U	2.9	3.2	2.7	2.1	2.1	3.3	1.5	2.3	2.7	2.7	2.4	2.3	3.7	2.7	3.4
Hf	3.1	4.5	5.6	4.5	4.4	4.9	4.0	4.2	5.0	3.6	4.4	4.7	4.0	4.0	3.8

Table 2. Bulk-rock compositions of Gierałtów gneisses. Major elements were determined by XRF, trace elements by ICP-MS. Oxides in wt%, trace elements in ppm.

Sample	103	104	107	108	110	111	114	115	120	121	122	128	129	130	146	147	150	151	152	154	155	160	161	166	167
SiO_2	76.16	72.47	76.13	76.74	74.06	75.54	76.76	69.36	71.65	72.78	73.16	76.34	76.29	77.11	73.06	74.71	77.36	77.30	76.29	77.58	77.71	73.55	76.92	77.56	74.28
Al_2O_3	12.59	14.28	12.88	12.79	13.58	13.42	12.45	18.05	15.00	13.62	13.72	12.71	12.54	12.51	13.89	12.86	12.32	12.23	12.97	12.17	12.53	13.86	12.42	12.30	13.22
$Fe_2O_3^T$	1.50	2.15	1.68	1.26	1.98	1.62	1.53	1.18	2.56	2.76	2.60	1.61	1.69	1.41	2.40	1.81	1.34	1.34	1.34	1.38	1.24	1.76	1.33	1.30	2.36
MnO	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.04	0.03	0.02	0.03
MgO	0.20	0.48	0.19	0.19	0.36	0.24	0.20	0.09	0.70	0.63	0.65	0.27	0.26	0.17	0.51	0.35	0.10	0.13	0.26	0.11	0.05	0.50	0.12	0.10	0.48
CaO	0.85	1.40	0.40	0.68	1.41	1.06	0.81	4.26	1.66	1.13	1.19	1.15	1.06	0.74	1.09	0.97	0.68	0.57	0.80	0.48	0.38	1.24	0.54	0.46	1.16
Na_2O	3.04	3.51	2.55	3.40	3.65	3.49	3.05	5.99	3.18	3.13	3.26	3.20	2.76	3.28	3.10	2.99	3.30	3.21	4.08	3.60	3.75	3.80	3.21	3.38	2.99
K_2O	4.71	4.48	5.30	4.88	4.03	4.40	4.70	0.48	4.35	4.77	4.61	4.11	4.78	4.30	5.02	4.86	4.82	4.58	3.47	3.95	4.25	4.12	5.02	4.71	4.67
TiO_2	0.17	0.28	0.09	0.14	0.26	0.17	0.15	0.12	0.37	0.39	0.36	0.19	0.19	0.13	0.29	0.21	0.08	0.10	0.19	0.07	0.03	0.18	0.10	0.08	0.26
P_2O_5	0.05	0.18	0.20	0.03	0.08	0.05	0.05	0.06	0.17	0.10	0.09	0.06	0.06	0.05	0.13	0.10	0.05	0.05	0.09	0.05	0.04	0.07	0.05	0.04	0.17
LOI	0.55	0.91	1.05	0.35	0.59	0.42	0.50	0.59	0.83	0.75	0.56	0.58	0.38	0.56	0.78	0.55	0.32	0.41	0.54	0.77	0.40	0.77	0.56	0.54	0.86
Total	99.85	100.17	100.50	100.46	100.03	100.43	100.19	100.20	100.48	100.10	100.23	100.24	100.04	100.26	100.31	99.42	100.39	99.95	100.05	100.16	100.40	99.87	100.31	100.48	100.49
A/CNK	1.46	1.52	1.56	1.43	1.49	1.50	1.45	1.68	1.63	1.51	1.51	1.50	1.46	1.50	1.51	1.46	1.40	1.46	1.55	1.52	1.49	1.51	1.42	1.44	1.50
NK/A	0.62	0.56	0.61	0.65	0.57	0.59	0.62	0.36	0.50	0.58	0.57	0.58	0.601	0.61	0.59	0.61	0.66	0.64	0.58	0.62	0.64	0.57	0.66	0.66	0.58
V	11	21	6	10	20	11	9	13	30	32	29	14	14	8	22	14	-	6	12	-	-	10	-	-	18
Cr	-	-	-	-	-	-	-	-	20	21	29	31	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	-	-	-	-	-	-	-	-	-	-	32	80	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	-	-	-	26	-	-	-	-	-	-	-	-	17	-	12	-	-	-	-	11	-	-	-	24	-
Zn	-	-	85	-	-	-	-	-	39	51	62	-	-	-	72	68	-	65	31	39	-	60	-	36	49
Ga	16	18	19	17	16	16	16	30	18	18	17	17	18	17	20	17	18	19	21	20	23	16	18	19	18
Ge	-	0.6	1.3	-	0.5	-	0.5	3.8	0.7	0.5	0.9	0.7	0.9	0.6	1.1	1.0	1.7	1.3	1.5	1.3	1.6	1.1	1.4	1.1	1.1
Rb	178	138	315	173	136	156	209	24	148	190	169	181	217	198	188	182	232	250	234	179	235	103	288	261	185
Sr	44	115	17	33	78	52	37	449	128	91	87	88	103	68	112	61	50	31	68	34	16	172	20	19	69
Y	36	44	22	36	29	28	52	51	37	30	29	50	50	51	36	35	57	52	43	40	29	21	58	40	43
Zr	120	137	76	113	148	149	116	132	139	192	192	129	129	98	140	108	69	81	125	68	30	115	73	79	137
Nb	6.5	8.2	8.6	6.5	7.0	7.0	6.8	11.2	8.9	8.4	8.2	6.8	7.1	6.6	9.8	6.7	6.6	7.6	10.7	6.7	5.2	5.3	7.2	6.7	7.7
Sn	2	2	22	2	2	7	6	19	2	2	2	3	2	3	9	5	3	9	5	4	3	2	4	4	3
Cs	4.7	1.7	7.2	2.2	2.6	3.3	5.0	1.0	3.9	7.7	6.3	4.5	5.4	4.3	4.3	4.1	6.3	6.7	6.5	1.4	1.0	1.6	6.0	1.9	3.1
Ba	352	660	114	250	623	311	252	40	869	780	748	349	423	221	537	302	131	163	418	159	35	924	149	74	414
Ta	1.1	1.0	2.3	1.5	1.1	1.0	1.4	2.8	1.0	1.1	1.1	1.3	1.3	1.5	1.2	0.9	1.5	1.2	2.3	0.8	0.4	1.0	1.2	0.7	1.1
Tl	0.7	0.6	2.1	0.8	0.5	0.5	1.0	0.1	0.6	1.2	0.8	0.7	1.3	0.8	0.8	0.8	1.0	1.0	1.0	0.8	0.9	0.5	1.4	1.1	0.9
Pb	13	15	20	18	8	7	12	17	16	18	37	10	16	14	32	33	34	25	31	20	8	25	29	13	30
Bi	0.2	-	3.5	0.3	0.4	0.5	0.3	0.7	-	0.1	0.1	-	0.2	0.2	0.9	1.1	1.0	0.5	0.6	0.4	0.4	1.2	0.5	0.3	0.4
Th	16.6	12.8	7.6	30.0	18.4	18.6	16.9	20.4	14.3	19.2	18.9	18.8	18.2	16.5	13.5	10.8	14.2	15.4	15.8	3.85	1.60	9.29	15.9	10.3	12.1
U	3.2	2.7	8.2	4.5	2.7	2.8	3.7	12.6	3.1	3.4	4.1	3.6	2.9	3.6	3.1	2.7	4.5	6.0	5.2	1.4	0.6	2.2	3.8	2.8	3.7
Hf	3.9	4.0	2.8	4.0	4.5	5.0	4.0	5.4	4.1	5.7	5.7	4.5	4.5	3.6	4.7	3.7	3.2	3.3	4.7	3.1	1.5	4.0	3.2	3.4	4.4

Table 3. Rare earth element analyses (measured by ICP-MS) of Śnieżnik gneisses (A) and Gierałtów gneisses (B). All concentrations are given in ppm.

(A)

Sample	113	118	119	124	125	126	127	142	148	149	156	158	162	163	164
La	10.7	19.2	31.0	11.4	21.0	28.7	19.3	27.9	18.9	21.0	27.9	10.0	18.6	18.8	19.2
Ce	25.5	43.3	61.8	40.9	57.0	59.0	41.9	54.4	47.0	44.5	54.8	40.5	40.8	38.2	39.4
Pr	2.82	4.60	7.12	2.60	5.10	6.99	4.30	6.04	4.34	4.71	6.31	2.12	4.43	4.26	4.49
Nd	10.7	17.7	27.5	9.88	19.6	26.4	16.5	23.6	16.8	18.5	25.2	8.60	17.4	17.1	17.8
Pm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sm	2.94	4.00	6.06	2.26	4.54	5.83	3.65	5.31	3.77	4.16	5.50	1.85	3.98	3.98	3.98
Eu	0.25	0.43	0.71	0.47	0.82	0.72	0.89	0.77	0.64	0.69	0.58	0.41	0.38	0.40	0.38
Gd	3.73	4.13	6.14	2.75	4.55	5.75	4.01	5.51	3.70	3.95	5.53	1.56	4.05	3.97	4.30
Tb	0.85	0.79	1.14	0.58	0.88	1.06	0.70	1.13	0.82	0.80	1.02	0.33	0.82	0.77	0.82
Dy	6.29	5.22	7.32	4.23	5.55	6.67	4.51	7.29	5.23	5.14	6.82	2.25	5.71	5.18	6.14
Ho	1.49	1.15	1.54	0.98	1.16	1.41	0.98	1.53	1.15	1.12	1.42	0.48	1.21	1.06	1.38
Er	5.05	3.67	4.80	3.33	3.51	4.34	2.94	4.77	3.76	3.58	4.58	1.60	4.03	3.41	4.69
Tm	0.84	0.62	0.75	0.54	0.53	0.65	0.43	0.71	0.56	0.57	0.68	0.25	0.64	0.53	0.76
Yb	5.40	3.94	4.56	3.47	3.19	4.17	2.70	4.25	3.55	3.51	4.38	1.69	4.15	3.47	5.22
Lu	0.79	0.55	0.63	0.49	0.43	0.58	0.38	0.61	0.52	0.49	0.58	0.26	0.62	0.48	0.79

(B)

Sample	103	104	107	108	110	111	114	115	120	121	122	128	129	130	146	147	150	151	152	154	155	160	161	166	167
La	23.0	26.3	8.15	6.61	11.8	5.30	7.01	15.8	25.5	25.2	22.5	13.1	26.6	17.8	9.84	9.78	12.0	19.0	25.0	13.9	8.37	16.4	13.1	15.9	27.1
Ce	50.1	53.2	18.9	26.0	37.9	21.1	36.1	43.2	56.0	52.9	52.3	51.6	56.4	42.2	39.5	34.7	31.2	42.7	51.8	29.9	22.3	42.6	30.5	36.7	55.6
Pr	5.29	5.94	2.14	1.75	3.09	1.65	1.92	4.68	5.89	5.74	5.15	3.48	6.40	4.43	2.45	2.41	3.36	4.90	5.89	3.67	2.80	3.56	3.45	4.34	6.19
Nd	20.0	22.8	7.97	7.02	12.2	6.76	7.78	19.2	22.4	21.6	19.6	13.2	24.4	17.0	9.92	9.63	13.3	19.0	23.0	14.5	12.0	13.5	13.6	16.8	23.7
Pm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sm	4.26	5.35	2.26	2.25	3.08	2.07	2.66	4.83	5.05	4.56	4.23	3.71	5.72	4.34	2.44	2.17	4.08	5.17	5.39	4.31	3.93	2.86	4.12	4.63	5.35
Eu	0.27	0.83	0.16	0.20	0.35	0.18	0.22	0.22	0.82	0.52	0.49	0.31	0.35	0.22	0.38	0.31	0.13	0.14	0.31	0.12	0.03	0.53	0.13	0.09	0.59
Gd	4.61	5.74	2.64	2.93	3.48	2.65	4.40	5.94	5.21	4.48	4.06	4.99	6.58	5.45	2.46	2.22	5.17	5.79	5.60	4.84	4.31	2.44	5.10	4.96	5.31
Tb	0.92	1.13	0.58	0.78	0.69	0.63	1.13	1.34	0.97	0.82	0.78	1.17	1.22	1.17	0.64	0.63	1.33	1.25	1.13	1.08	0.88	0.49	1.24	0.99	1.02
Dy	5.94	7.24	3.82	5.53	4.55	4.46	7.96	8.40	6.24	5.19	4.93	7.86	7.91	8.14	5.02	4.76	9.06	8.21	7.10	7.27	5.52	3.38	9.00	6.82	6.87
Ho	1.27	1.54	0.79	1.30	1.00	1.03	1.76	1.80	1.31	1.10	1.04	1.72	1.67	1.79	1.22	1.17	1.96	1.74	1.49	1.53	1.10	0.76	1.95	1.44	1.46
Er	3.80	4.60	2.46	4.62	3.17	3.46	5.55	6.56	4.01	3.43	3.28	5.34	5.18	5.55	4.47	4.14	6.45	5.64	4.79	4.76	3.12	2.68	6.65	4.75	4.62
Tm	0.58	0.69	0.41	0.81	0.50	0.60	0.88	1.05	0.60	0.54	0.53	0.84	0.83	0.89	0.73	0.65	0.99	0.87	0.77	0.66	0.45	0.45	1.06	0.74	0.71
Yb	3.58	4.14	2.74	5.71	3.13	4.01	5.33	6.04	3.66	3.41	3.46	5.18	5.03	5.46	4.66	4.34	6.42	5.44	4.79	4.12	2.77	3.03	6.85	4.81	4.45
Lu	0.48	0.54	0.38	0.89	0.45	0.59	0.75	0.90	0.48	0.48	0.49	0.72	0.70	0.77	0.67	0.65	0.90	0.75	0.67	0.55	0.37	0.46	0.98	0.68	0.61

Table 4. Selected electron microprobe analyses of feldspars from Śnieżnik gneisses. Oxides are given in wt%. Cations are calculated on the basis of 8 oxygens.

Sample	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**118**	**142**	**142**	**142**	**142**	**142**	**142**	**142**	**142**	**142**	**142**
Spot	**A4 core**	**A4 rim**	**B1 core**	**B1 rim**	**C1 core**	**C1 rim**	**C2 core**	**C2 rim**	**D1 core**	**D1 rim**	**A1 core**	**A1 rim**	**B1 core**	**B1 rim**	**B2 core**	**B2 rim**	**C1 core**	**C1 rim**	**D2 core**	**D2 rim**
SiO_2	64.33	64.23	64.41	64.23	63.58	64.78	63.88	64.74	64.81	64.29	63.32	64.17	63.72	63.50	63.24	62.92	63.21	64.17	62.38	63.44
Al_2O_3	22.22	22.44	22.63	22.23	22.31	21.99	22.80	22.55	22.09	22.34	22.81	22.49	22.98	22.98	23.11	23.54	23.38	22.70	23.28	23.09
CaO	3.38	3.50	3.33	3.47	3.77	2.70	3.69	3.52	3.10	3.23	4.10	3.72	4.02	4.07	4.34	4.45	4.34	3.81	4.20	4.12
FeO	0.03	0.00	0.03	0.04	0.01	0.06	0.03	0.02	0.00	0.00	0.06	0.10	0.03	0.05	0.05	0.08	0.10	0.09	0.07	0.00
BaO	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.03	0.00	0.01	0.01	0.00	0.05	0.00
Na_2O	9.73	9.62	9.54	9.81	9.44	10.07	9.64	9.53	9.82	9.82	9.37	9.69	9.34	9.11	8.92	8.86	9.17	9.65	8.87	9.21
K_2O	0.19	0.23	0.27	0.19	0.29	0.27	0.19	0.25	0.20	0.12	0.16	0.15	0.21	0.23	0.28	0.26	0.18	0.24	0.45	0.21
Total	99.88	100.03	100.21	100.02	99.42	99.87	100.23	100.60	100.02	99.82	99.85	100.36	100.30	99.99	99.94	100.12	100.39	100.68	99.31	100.06
Ab	83.0	82.2	82.5	82.8	80.6	85.8	81.7	81.9	84.2	84.1	79.8	81.8	79.8	79.2	77.5	77.1	78.5	81.0	77.2	79.2
An	15.9	16.5	15.9	16.2	17.8	12.7	17.3	16.7	14.7	15.3	19.3	17.3	19.0	19.5	20.9	21.4	20.5	17.7	20.2	19.6
Or	1.0	1.3	1.6	1.1	1.6	1.5	1.0	1.4	1.1	0.6	0.9	0.8	1.2	1.3	1.6	1.5	1.0	1.3	2.6	1.2
Si	2.841	2.833	2.834	2.836	2.826	2.858	2.816	2.838	2.855	2.839	2.804	2.825	2.807	2.806	2.797	2.780	2.786	2.818	2.782	2.801
Al	1.157	1.167	1.173	1.157	1.169	1.144	1.184	1.165	1.146	1.163	1.190	1.167	1.193	1.197	1.205	1.226	1.214	1.175	1.224	1.202
Ca	0.160	0.166	0.157	0.164	0.180	0.128	0.174	0.165	0.146	0.153	0.195	0.175	0.190	0.193	0.206	0.211	0.205	0.179	0.201	0.195
Fe	0.001	0.000	0.001	0.001	0.000	0.002	0.001	0.001	0.000	0.000	0.002	0.004	0.001	0.002	0.002	0.003	0.004	0.003	0.003	0.000
Ba	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000
Na	0.833	0.823	0.814	0.840	0.814	0.861	0.824	0.810	0.838	0.841	0.804	0.828	0.798	0.781	0.765	0.759	0.784	0.822	0.767	0.788
K	0.010	0.013	0.015	0.011	0.016	0.015	0.010	0.014	0.011	0.006	0.009	0.009	0.012	0.013	0.016	0.015	0.010	0.013	0.026	0.012
Total	5.002	5.001	4.994	5.011	5.005	5.008	5.009	4.992	4.997	5.003	5.007	5.009	5.001	4.992	4.991	4.994	5.003	5.012	5.003	4.998

Table 5. Selected electron microprobe analyses of feldspars from Śnieżnik gneisses. Oxides are given in wt%. Cations are calculated on the basis of 8 oxygens.

Sample	148	148	148	148	148	148	158	158	158	158	158	158	164	164	164	164	164	164	164	164
Spot	A1 core	A1 rim	B1 core	B1 rim	C2 core	C2 rim	C2 core	C2 rim	G1 core	G1 rim	G2 core	G2 rim	D2 core	D2 rim	F4 core	F4 rim	H1 core	H1 rim	I2 core	I2 rim
SiO_2	62.99	62.71	64.67	64.78	63.63	62.38	64.61	64.23	65.17	65.22	64.06	64.40	64.97	64.81	64.30	64.58	63.68	64.43	63.70	64.22
Al_2O_3	23.40	23.49	22.26	22.02	23.01	22.83	22.48	22.26	21.94	21.92	22.37	22.48	22.35	22.22	22.51	22.44	22.93	22.34	22.84	23.08
CaO	4.41	4.77	3.38	2.87	3.94	4.17	3.29	3.37	2.84	3.09	3.46	3.69	3.04	2.94	3.39	3.21	3.90	3.32	4.00	3.92
FeO	0.00	0.04	0.01	0.00	0.00	0.03	0.07	0.05	0.01	0.08	0.00	0.00	0.06	0.06	0.04	0.00	0.06	0.01	0.12	0.16
BaO	0.02	0.02	0.00	0.00	0.00	0.04	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.02	0.03	0.01	0.00	0.00	0.00	0.00
Na_2O	8.99	8.80	9.90	9.76	9.19	9.42	9.66	9.70	9.88	9.93	9.62	9.57	9.97	9.72	9.64	9.65	9.49	9.68	9.12	9.23
K_2O	0.22	0.33	0.25	0.26	0.25	0.27	0.26	0.27	0.21	0.20	0.27	0.23	0.34	0.29	0.27	0.30	0.21	0.20	0.29	0.30
Total	100.03	100.15	100.47	99.70	100.03	99.14	100.39	99.90	100.08	100.44	99.77	100.35	100.71	100.06	100.20	100.19	100.26	99.99	100.06	100.93
Ab	77.7	75.5	83.0	84.7	79.7	79.1	82.9	82.7	85.2	84.4	82.2	81.4	84.0	84.2	82.5	83.0	80.5	83.1	79.2	79.6
An	21.1	22.6	15.6	13.8	18.9	19.4	15.6	15.9	13.5	14.5	16.3	17.3	14.2	14.1	16.0	15.3	18.3	15.7	19.2	18.7
Or	1.2	1.9	1.4	1.5	1.4	1.5	1.5	1.4	1.3	1.1	1.5	1.3	1.9	1.7	1.5	1.7	1.2	1.1	1.7	1.7
Si	2.785	2.774	2.841	2.860	2.809	2.789	2.839	2.838	2.866	2.862	2.833	2.832	2.846	2.853	2.832	2.841	2.807	2.841	2.812	2.811
Al	1.219	1.225	1.153	1.146	1.197	1.203	1.164	1.159	1.137	1.134	1.166	1.165	1.154	1.153	1.169	1.164	1.191	1.161	1.189	1.191
Ca	0.209	0.226	0.159	0.136	0.186	0.200	0.155	0.159	0.134	0.145	0.164	0.174	0.143	0.139	0.160	0.151	0.184	0.157	0.189	0.184
Fe	0.000	0.002	0.000	0.000	0.000	0.001	0.002	0.002	0.001	0.003	0.000	0.000	0.002	0.002	0.002	0.000	0.002	0.000	0.004	0.006
Ba	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Na	0.771	0.754	0.844	0.836	0.787	0.817	0.823	0.831	0.843	0.845	0.825	0.816	0.846	0.829	0.823	0.823	0.811	0.827	0.781	0.784
K	0.013	0.018	0.014	0.015	0.014	0.015	0.015	0.015	0.012	0.011	0.015	0.013	0.019	0.016	0.015	0.017	0.012	0.011	0.016	0.017
Total	4.997	5.000	5.011	4.992	4.993	5.026	4.998	5.005	4.993	4.999	5.004	5.000	5.010	4.993	5.002	4.997	5.008	4.998	4.992	4.993

Table 6. Selected electron microprobe analyses of feldspars from Gierałtów gneisses. Oxides are given in wt%. Cations are calculated on the basis of 8 oxygens.

Sample	**129**	**129**	**129**	**129**	**129**	**129**	**129**	**129**	**129**	**129**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**
Spot	**A1 core**	**A1 rim**	**B1 core**	**B1 rim**	**E2 core**	**E2 rim**	**F2 core**	**F2 rim**	**H4 core**	**H4 rim**	**B4 core**	**B4 rim**	**C1 core**	**C1 rim**	**C2 core**	**C2 rim**	**D3 core**	**D3 rim**	**G1 core**	**G1 rim**
SiO_2	64.80	63.43	63.92	64.07	63.62	64.04	63.48	63.23	62.40	63.21	65.80	65.84	65.61	64.98	64.89	65.07	66.03	66.06	66.72	67.67
Al_2O_3	21.99	22.19	22.56	22.19	22.58	22.55	22.62	23.27	23.10	22.95	20.75	20.94	21.52	21.56	21.47	21.36	20.87	20.88	20.82	20.17
CaO	2.88	3.57	3.69	3.42	3.65	3.60	4.07	4.18	4.24	4.28	1.69	1.80	2.46	2.53	2.43	2.48	1.47	1.60	1.40	0.86
FeO	0.04	0.05	0.00	0.00	0.03	0.00	0.04	0.00	0.00	0.00	0.05	0.05	0.07	0.10	0.09	0.08	0.00	0.01	0.00	0.02
BaO	0.00	0.06	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.01	0.00	0.01
Na_2O	10.02	9.76	9.45	9.49	9.28	9.69	9.35	9.07	9.15	9.15	10.71	10.55	10.26	10.12	9.95	10.03	10.63	10.58	10.91	11.17
K_2O	0.20	0.15	0.20	0.26	0.35	0.23	0.24	0.25	0.20	0.28	0.23	0.16	0.17	0.14	0.21	0.22	0.20	0.22	0.23	0.22
Total	99.93	99.20	99.81	99.44	99.53	100.12	99.80	100.00	99.08	99.96	99.23	99.34	100.09	99.49	99.03	99.24	99.20	99.41	100.09	100.14
Ab	85.1	82.4	81.8	82.8	80.5	81.9	80.0	78.5	78.7	78.2	91.1	90.0	87.9	86.6	86.9	86.5	91.9	91.0	92.1	95.0
An	13.9	16.7	17.2	16.2	17.5	16.8	19.0	20.0	20.2	20.2	7.9	9.0	10.2	12.3	12.1	12.4	7.1	8.0	6.9	4.0
Or	1.0	1.0	1.0	1.0	2.0	1.3	1.0	1.4	1.1	1.6	1.0	1.0	1.9	1.1	1.0	1.1	1.0	1.0	1.0	1.0
Si	2.860	2.830	2.830	2.840	2.822	2.825	2.810	2.794	2.786	2.799	2.910	2.910	2.880	2.880	2.880	2.880	2.920	2.920	2.920	2.960
Al	1.140	1.170	1.180	1.160	1.181	1.173	1.180	1.212	1.216	1.198	1.080	1.090	1.110	1.120	1.120	1.120	1.090	1.090	1.080	1.040
Ca	0.140	0.170	0.170	0.160	0.174	0.170	0.190	0.198	0.203	0.203	0.080	0.090	0.120	0.120	0.120	0.120	0.070	0.080	0.070	0.040
Fe	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ba	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Na	0.860	0.840	0.810	0.820	0.798	0.829	0.800	0.777	0.792	0.786	0.920	0.900	0.870	0.870	0.860	0.860	0.910	0.910	0.930	0.950
K	0.010	0.010	0.010	0.010	0.020	0.013	0.010	0.014	0.011	0.016	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Total	5.010	5.020	5.000	4.990	4.996	5.010	5.010	4.996	5.008	5.003	5.010	5.000	5.000	5.000	4.990	5.000	5.000	5.000	5.010	5.000

Table 7. Selected electron microprobe analyses of feldspars from Gierałtów gneisses. Oxides are given in wt%. Cations are calculated on the basis of 8 oxygens.

Sample	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**155**	**155**	**155**	**155**	**155**	**155**	**155**	**155**	**155**	**155**
Spot	**A1 core**	**A1 rim**	**A2 core**	**A2 rim**	**B1 core**	**B1 rim**	**B2 core**	**B2 rim**	**B3 core**	**B3 rim**	**A1 core**	**A1 rim**	**B2 core**	**B2 rim**	**B3 core**	**B3 rim**	**D1 core**	**D1 rim**	**E3 core**	**E3 rim**
SiO_2	65.27	65.32	65.72	65.94	65.35	65.64	65.11	65.45	65.21	66.13	66.97	67.09	66.65	66.43	66.82	67.24	66.68	67.18	67.09	66.92
Al_2O_3	21.45	21.09	21.22	21.31	21.38	21.19	21.38	21.52	20.69	20.87	20.76	20.72	20.63	20.72	20.83	20.43	20.66	20.31	20.77	20.66
CaO	2.36	2.06	2.12	2.20	2.37	2.05	2.45	2.36	1.66	1.81	1.34	1.30	1.34	1.40	1.35	0.85	1.06	0.67	1.34	1.14
FeO	0.10	0.08	0.08	0.14	0.00	0.01	0.01	0.00	0.01	0.01	0.12	0.02	0.05	0.03	0.01	0.04	0.00	0.01	0.03	0.00
BaO	0.00	0.00	0.00	0.00	0.04	0.00	0.03	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.03	0.01	0.02
Na_2O	10.18	10.48	10.46	10.45	10.31	10.59	10.27	10.28	10.46	10.74	11.02	10.66	11.00	10.80	10.89	11.16	10.93	11.54	10.63	10.87
K_2O	0.13	0.08	0.17	0.19	0.15	0.17	0.25	0.25	0.23	0.21	0.18	0.25	0.19	0.17	0.22	0.16	0.06	0.13	0.17	0.22
Total	99.49	99.12	99.76	100.22	99.59	99.65	99.49	99.91	98.26	99.76	100.37	100.06	99.86	99.55	100.14	99.89	99.44	99.86	100.04	99.82
Ab	87.9	90.0	88.1	88.0	87.9	89.2	87.1	88.0	91.3	90.2	92.8	92.3	92.7	92.4	92.4	95.1	94.6	96.2	92.5	93.4
An	11.1	9.3	10.8	10.0	11.0	9.8	11.9	11.0	8.2	8.8	6.6	6.2	6.2	6.6	6.3	4.0	5.1	3.1	6.5	5.4
Or	1.0	0.7	1.1	2.0	1.1	1.0	1.0	1.0	0.5	1.0	0.6	1.5	1.1	1.0	1.2	0.9	0.3	0.7	1.0	1.2
Si	2.880	2.900	2.900	2.890	2.890	2.900	2.880	2.880	2.910	2.910	2.928	2.937	2.929	2.927	2.927	2.948	2.936	2.949	2.936	2.937
Al	1.120	1.100	1.100	1.100	1.110	1.100	1.120	1.120	1.090	1.080	1.070	1.069	1.068	1.076	1.075	1.056	1.072	1.050	1.071	1.069
Ca	0.110	0.100	0.100	0.100	0.110	0.100	0.120	0.110	0.080	0.090	0.063	0.061	0.063	0.066	0.063	0.040	0.050	0.032	0.063	0.053
Fe	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.001	0.002	0.001	0.000	0.002	0.000	0.000	0.001	0.000
Ba	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Na	0.870	0.900	0.890	0.890	0.880	0.910	0.880	0.880	0.910	0.920	0.934	0.904	0.937	0.923	0.925	0.949	0.933	0.982	0.902	0.925
K	0.010	0.000	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.014	0.011	0.010	0.012	0.009	0.003	0.007	0.010	0.012
Total	5.000	5.010	5.000	5.000	5.000	5.010	5.010	5.000	5.000	5.010	5.009	4.988	5.011	5.002	5.004	5.003	4.996	5.021	4.984	4.997

Table 8. Selected electron microprobe analyses of phengites from Śnieżnik gneisses. Oxides are given in wt%. Cations are calculated on the basis of 22 oxygens. H_2O based on stoichiometry.

Sample	**118**	**118**	**118**	**142**	**142**	**142**	**148**	**148**	**148**	**158**	**158**	**158**	**164**	**164**	**164**
Spot	**B3**	**D3**	**D4**	**A3**	**D1**	**G4**	**A3**	**B1**	**B2**	**A2**	**B1**	**C3**	**A2**	**A5**	**C5**
SiO_2	47.05	46.92	48.50	50.22	49.97	49.25	50.00	47.17	46.56	46.78	47.07	48.54	46.41	46.29	48.40
TiO_2	0.63	0.82	0.50	0.47	0.32	0.37	0.22	0.65	0.71	0.63	0.61	0.44	0.29	0.35	0.33
Al_2O_3	31.19	32.70	29.90	28.22	27.68	27.15	28.86	32.10	33.79	32.02	31.74	29.51	35.11	35.07	32.35
Cr_2O_3	0.00	0.00	0.03	0.03	0.00	0.02	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
MgO	1.53	1.24	1.91	2.34	2.49	2.46	2.29	1.53	1.11	1.28	1.49	2.00	0.78	0.82	1.41
CaO	0.03	0.00	0.02	0.00	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
MnO	0.02	0.02	0.07	0.04	0.05	0.05	0.03	0.00	0.00	0.01	0.08	0.05	0.02	0.03	0.05
FeO	3.62	2.80	3.60	3.49	4.02	4.65	3.18	2.42	2.08	3.50	3.56	3.99	1.72	1.99	2.46
BaO	0.06	0.03	0.02	0.01	0.08	0.05	0.22	0.04	0.09	0.11	0.12	0.15	0.00	0.09	0.00
Na_2O	0.24	0.30	0.25	0.25	0.26	0.19	0.35	0.34	0.37	0.27	0.22	0.22	0.47	0.54	0.29
K_2O	10.52	10.39	10.38	10.31	10.26	10.44	10.16	10.54	10.59	10.57	10.59	10.65	10.43	10.33	10.14
H_2O	4.43	4.47	4.46	4.48	4.45	4.40	4.48	4.46	4.48	4.44	4.46	4.45	4.50	4.50	4.51
Total	99.32	99.69	99.62	99.86	99.60	99.04	99.82	99.26	99.79	99.63	99.93	100.00	99.73	100.01	99.94
Si	6.370	6.294	6.528	6.723	6.732	6.707	6.692	6.349	6.228	6.313	6.335	6.538	6.186	6.166	6.436
Ti	0.064	0.083	0.051	0.048	0.033	0.038	0.022	0.066	0.072	0.064	0.062	0.045	0.029	0.035	0.033
Al	4.976	5.170	4.743	4.452	4.394	4.357	4.552	5.091	5.327	5.093	5.035	4.684	5.516	5.506	5.070
Cr	0.000	0.000	0.003	0.003	0.000	0.002	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Mg	0.309	0.247	0.383	0.468	0.499	0.499	0.457	0.307	0.222	0.258	0.299	0.402	0.154	0.162	0.280
Ca	0.004	0.000	0.003	0.000	0.001	0.003	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000
Mn	0.002	0.002	0.008	0.004	0.006	0.006	0.003	0.000	0.000	0.002	0.009	0.006	0.002	0.004	0.006
Fe	0.410	0.314	0.405	0.391	0.453	0.529	0.356	0.273	0.233	0.395	0.401	0.450	0.192	0.222	0.273
Ba	0.003	0.002	0.001	0.000	0.004	0.003	0.012	0.002	0.005	0.006	0.006	0.008	0.000	0.005	0.000
Na	0.063	0.078	0.066	0.066	0.068	0.051	0.092	0.090	0.095	0.071	0.057	0.056	0.120	0.138	0.076
K	1.817	1.778	1.782	1.760	1.763	1.813	1.735	1.809	1.807	1.820	1.819	1.830	1.774	1.755	1.719
Total	14.018	13.966	13.972	13.915	13.954	14.008	13.922	13.988	13.988	14.022	14.023	14.018	13.974	13.992	13.893

Table 9. Selected electron microprobe analyses of phengites from Gierałtów gneisses. Oxides are given in wt%. Cations are calculated on the basis of 22 oxygens. H_2O based on stoichiometry.

Sample	103	103	103	103	114	114	114	114	129	129	129	155	155	155	155
Spot	D1	E1	F1	G1	B1	G5	H2	J1	C4	E6	E7	B3	B4	E2	F4
SiO_2	46.73	46.05	49.97	46.60	49.00	46.12	48.95	46.35	46.31	47.95	49.36	45.98	47.60	46.29	46.70
TiO_2	0.99	0.72	0.60	0.90	0.94	0.83	0.80	0.77	0.72	0.82	0.82	0.15	0.25	0.19	0.26
Al_2O_3	32.33	33.02	27.40	32.38	28.59	33.05	28.84	32.78	32.88	29.68	29.56	33.23	31.15	33.24	32.74
Cr_2O_3	0.00	0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.03	0.00	0.00	0.00
MgO	1.06	1.07	2.34	1.11	1.79	0.92	1.67	0.97	1.12	1.78	1.87	0.46	0.75	0.44	0.56
CaO	0.01	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00
MnO	0.02	0.03	0.05	0.05	0.07	0.07	0.04	0.06	0.00	0.07	0.03	0.02	0.00	0.01	0.02
FeO	3.01	3.12	4.05	3.19	4.00	3.02	4.15	3.37	2.84	3.27	3.05	4.01	4.78	4.07	4.49
BaO	0.04	0.02	0.06	0.09	0.07	0.05	0.00	0.00	0.06	0.06	0.01	0.00	0.00	0.00	0.02
Na_2O	0.46	0.41	0.26	0.36	0.28	0.48	0.25	0.40	0.38	0.35	0.28	0.49	0.54	0.60	0.52
K_2O	10.52	10.54	10.54	10.81	10.28	10.60	10.64	10.54	10.49	10.63	10.51	10.45	10.08	10.14	10.13
H_2O	4.45	4.44	4.45	4.46	4.44	4.45	4.45	4.45	4.44	4.42	4.49	4.42	4.44	4.44	4.45
Total	99.61	99.44	99.72	99.96	99.47	99.62	99.77	99.69	99.26	99.07	99.97	99.24	99.58	99.40	99.90
Si	6.290	6.220	6.740	6.270	6.620	6.220	6.600	6.250	6.251	6.503	6.599	6.238	6.436	6.258	6.293
Ti	0.100	0.070	0.060	0.090	0.100	0.080	0.080	0.080	0.074	0.084	0.082	0.015	0.026	0.019	0.027
Al	5.130	5.254	4.354	5.136	4.551	5.253	4.585	5.207	5.231	4.743	4.658	5.313	4.963	5.296	5.200
Cr	0.000	0.002	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.003	0.000	0.000	0.000
Mg	0.213	0.216	0.469	0.222	0.361	0.184	0.335	0.195	0.226	0.359	0.374	0.093	0.150	0.088	0.112
Ca	0.001	0.000	0.001	0.000	0.001	0.004	0.000	0.001	0.003	0.000	0.000	0.000	0.001	0.000	0.000
Mn	0.000	0.000	0.010	0.010	0.010	0.010	0.000	0.010	0.000	0.008	0.003	0.003	0.000	0.001	0.002
Fe	0.340	0.350	0.460	0.360	0.450	0.340	0.470	0.380	0.320	0.370	0.341	0.455	0.540	0.460	0.506
Ba	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.001	0.000	0.000	0.000	0.001
Na	0.120	0.110	0.070	0.090	0.070	0.130	0.060	0.100	0.099	0.091	0.072	0.128	0.141	0.157	0.136
K	1.810	1.810	1.810	1.860	1.770	1.820	1.830	1.810	1.807	1.838	1.793	1.809	1.738	1.748	1.742
Total	14.006	14.042	13.967	14.042	13.933	14.045	13.971	14.030	14.013	14.004	13.922	14.057	13.997	14.027	14.019

Table 10. Selected electron microprobe analyses of biotites from Śnieżnik gneisses. Oxides are given in wt%. Cations are calculated on the basis of 22 oxygens. H_2O based on stoichiometry.

Sample	**118**	**118**	**118**	**118**	**142**	**142**	**142**	**142**	**148**	**148**	**148**	**158**	**158**	**158**	**158**
Spot	**A3**	**B2**	**G1**	**G3**	**D8**	**D9**	**F3**	**F5**	**D6**	**F1**	**G1**	**A3**	**B2**	**B5**	**C1**
SiO_2	36.16	35.81	35.55	35.55	34.96	35.14	35.44	35.01	35.60	34.90	34.91	35.68	35.25	35.55	34.76
TiO_2	2.97	2.78	2.77	3.50	2.47	2.53	2.81	3.17	3.21	3.51	2.52	3.08	3.48	3.03	3.13
Al_2O_3	17.50	17.59	17.42	17.60	17.15	17.19	17.87	17.74	17.55	16.77	17.46	17.64	17.50	17.12	17.20
Cr_2O_3	0.02	0.04	0.00	0.00	0.01	0.00	0.00	0.04	0.03	0.04	0.03	0.00	0.01	0.03	0.08
MgO	6.26	5.70	5.78	5.62	6.40	5.95	6.10	5.91	6.37	6.71	6.40	6.16	6.07	6.48	6.43
CaO	0.02	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
MnO	0.36	0.36	0.42	0.33	0.20	0.27	0.18	0.20	0.24	0.31	0.25	0.25	0.29	0.29	0.24
FeO	23.06	23.97	24.24	23.92	23.84	24.31	23.62	23.50	23.80	24.00	24.61	23.86	24.04	23.97	25.05
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Na_2O	0.09	0.14	0.06	0.03	0.12	0.29	0.11	0.17	0.06	0.08	0.13	0.11	0.11	0.11	0.09
K_2O	9.05	9.37	9.31	9.21	9.10	8.84	9.16	9.19	9.21	9.09	9.24	9.26	9.21	9.22	8.91
H_2O	3.89	3.87	3.85	3.87	3.80	3.81	3.86	3.84	3.89	3.84	3.84	3.89	3.87	3.87	3.85
Total	99.37	99.61	99.40	99.62	98.05	98.37	99.18	98.77	99.96	99.24	99.38	99.93	99.82	99.67	99.74
Si	5.581	5.552	5.534	5.506	5.512	5.528	5.504	5.468	5.491	5.446	5.452	5.507	5.459	5.511	5.414
Ti	0.345	0.324	0.325	0.407	0.293	0.299	0.328	0.372	0.373	0.412	0.296	0.357	0.405	0.353	0.367
Al	3.183	3.214	3.197	3.213	3.187	3.187	3.271	3.266	3.191	3.084	3.213	3.208	3.195	3.128	3.157
Cr	0.002	0.005	0.000	0.000	0.001	0.000	0.000	0.005	0.003	0.005	0.004	0.000	0.001	0.003	0.010
Mg	1.439	1.317	1.341	1.297	1.503	1.395	1.412	1.377	1.465	1.560	1.490	1.418	1.401	1.499	1.493
Ca	0.004	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001
Mn	0.047	0.047	0.056	0.043	0.027	0.035	0.024	0.026	0.032	0.041	0.033	0.032	0.038	0.038	0.031
Fe	2.977	3.108	3.156	3.098	3.144	3.198	3.068	3.070	3.070	3.132	3.215	3.079	3.113	3.108	3.263
Ba	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Na	0.027	0.042	0.019	0.010	0.036	0.089	0.033	0.051	0.017	0.023	0.041	0.033	0.032	0.034	0.028
K	1.783	1.853	1.850	1.820	1.831	1.775	1.815	1.832	1.813	1.809	1.840	1.823	1.819	1.823	1.771
Total	15.387	15.462	15.477	15.395	15.534	15.511	15.457	15.466	15.454	15.513	15.583	15.459	15.463	15.498	15.535

Table 11. Selected electron microprobe analyses of biotites from Gierałtów gneisses. Oxides are given in wt%. Cations are calculated on the basis of 22 oxygens. H_2O based on stoichiometry.

Sample	103	103	103	114	114	114	129	129	129	150	150	150	155	155	155
Spot	A5	A9	F3	A2	H3	J3	D1	E2	G1	C1	E1	F1	B2	C2	D2
SiO_2	34.79	35.34	34.53	34.54	34.71	34.08	34.02	34.56	34.74	34.36	33.92	33.89	32.96	32.51	34.06
TiO_2	2.86	2.39	2.94	2.93	2.90	2.89	3.28	3.05	2.89	1.61	2.02	1.76	1.44	1.40	1.33
Al_2O_3	17.88	17.82	16.93	17.87	17.51	17.70	18.13	18.40	17.66	18.59	18.56	19.01	18.46	18.84	19.23
Cr_2O_3	0.05	0.00	0.00	0.02	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.01	0.01
MgO	4.29	4.73	4.87	3.77	3.70	3.40	4.18	4.42	4.26	2.67	2.48	2.53	1.48	1.43	1.53
CaO	0.03	0.05	0.07	0.02	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.01
MnO	0.22	0.26	0.28	0.41	0.38	0.42	0.33	0.28	0.47	0.53	0.57	0.51	0.24	0.21	0.24
FeO	25.10	25.21	26.65	26.55	26.81	27.86	26.30	25.61	25.79	27.92	28.10	28.29	31.69	31.19	29.54
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.00	0.00
Na_2O	0.15	0.07	0.07	0.12	0.08	0.09	0.07	0.05	0.12	0.10	0.11	0.09	0.13	0.13	0.08
K_2O	9.43	9.45	8.60	9.22	9.29	9.32	9.06	9.43	9.20	9.29	9.15	8.98	8.86	8.61	8.89
H_2O	3.80	3.82	3.78	3.80	3.79	3.78	3.80	3.83	3.80	3.76	3.74	3.75	3.69	3.67	3.74
Total	98.60	99.14	98.70	99.25	99.15	99.57	99.17	99.65	98.96	98.81	98.66	98.84	99.01	98.03	98.67
Si	5.490	5.540	5.470	5.460	5.490	5.410	5.369	5.408	5.483	5.490	5.435	5.413	5.354	5.318	5.466
Ti	0.340	0.280	0.350	0.350	0.340	0.340	0.390	0.360	0.343	0.190	0.243	0.212	0.176	0.172	0.160
Al	3.328	3.295	3.162	3.326	3.266	3.311	3.372	3.394	3.285	3.498	3.505	3.580	3.534	3.631	3.638
Cr	0.006	0.000	0.000	0.003	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.001	0.002	0.002
Mg	1.010	1.105	1.150	0.887	0.874	0.804	0.984	1.032	1.002	0.636	0.592	0.603	0.358	0.350	0.366
Ca	0.006	0.008	0.012	0.004	0.000	0.001	0.001	0.003	0.000	0.000	0.000	0.000	0.000	0.008	0.002
Mn	0.030	0.030	0.040	0.050	0.050	0.060	0.044	0.037	0.063	0.070	0.077	0.069	0.032	0.029	0.032
Fe	3.320	3.310	3.530	3.510	3.550	3.700	3.472	3.352	3.404	3.730	3.765	3.779	4.305	4.266	3.964
Ba	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.000	0.000
Na	0.050	0.020	0.020	0.040	0.020	0.030	0.021	0.014	0.037	0.030	0.034	0.026	0.041	0.041	0.024
K	1.900	1.890	1.740	1.860	1.880	1.890	1.825	1.884	1.853	1.890	1.871	1.829	1.836	1.796	1.820
Total	15.472	15.484	15.477	15.478	15.478	15.546	15.478	15.484	15.475	15.534	15.522	15.513	15.642	15.612	15.476