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METHOD OF INVESTIGATIONS OF DENSITY DISTRIBUTION IN GEOLOGICAL FORMATIONS ABOVE THE SEA LEVEL IN LOWER SILESIA AND SOME RESULTS OBTAINED

(5 Figs. and 1 Tab.)

Metodyka badań rozkładu gęstości utworów geologicznych występujących nad poziomem morza na Dolnym Śląsku i niektóre ich wyniki

(5 fig i 1 tab.)

Abstract: The execution of gravity measurements requires the determination of density distribution of geological formations above the reduction level. The correct solution of this problem is of particular importance in the case, when the cristalline rocks of great density differentiation appear above the reduction level. Then it is necessary to establish the special method of determination of density distribution. Such method, elaborated by the present authors was tested on the granitic massif of Karkonosze (Lower Silesia).

INTRODUCTION

To calculate Bouger anomalies one should know the density distribution within geological formations occurring above the reduction level. In areas where sediments of fairly uniform density lie horizontally or subhorizontally above this level — which usually is equivalent to the sea level — the problem is relatively simple (A. Dąbrowski, Z. Kaczkowska, 1965, Z. Fajkiewicz, T. Rejman, 1965). For this purpose sufficient data may be obtained by density measurements carried out on core samples from a few wells. The situation is different in areas where crystalline rocks of varying densities of vertical or almost vertical lithological boundaries occur above the reduction level. In such cases special methods should be applied to learn the density distribution. In Poland, in the Lower Silesia region differentiated crystalline complexes occur above the sea level. In connection with this the Geological

Institute initiated preliminary studies which would enable to find an adequate method (collective work, 1962). The project has been elaborated by the present authors in cooperation with Mr. and Mrs. M. and J. Szałamacha of the Lower Silesian Branch of the Geological Institute in Wrocław. The examinations have been carried out by the Second Laboratory of Physical Parameters of Rocks under the supervision of R. Blus (Enterprise for Geophysical Prospecting).

METHODS

As already mentioned the densities of certain crystalline complexes of a differentiated petrographic character may vary within broad limits. The lithological boundaries are usually sharp and vertical or subvertical. Thus, contrary to the areas where sedimentary rocks occur, the principle of continuous horizontal changes in density does not apply here and it should be assumed that the density values change stepwise at the boundaries of complexes petrographically different. In consequence the boundaries between the complexes should be defined. Also it should be learned whether the density distribution within one given complex is random and can be characterized by an average value, or there is a certain pattern in the density distribution and it can be represented by isodenses.

A geological map of appropriate accuracy can be used for finding the boundaries between the complexes.

To learn the regularities of the density distribution within the given complex the density measurements should be carried out on samples of predominating rocks. The Karkonosze Mountains and their cover for which detailed geological maps are available have been chosen for the experimental area.

The boundaries between the complexes have been defined on the basis of 1 : 200 000 map of Lower Silesia elaborated by L. Sawicki (1965).

Subsequently on consultations with Mr. and Mrs. M. and J. Szałamacha, twenty eight natural exposures and quarries of rocks predominating in the given complex have been selected. Whenever possible the sampling followed a regular grid pattern. The number of samples depended on the size and accessibility of the exposures and varied from 15 to 305 pieces per one outcrop. The distance between the sample locations ranged from one to several meters. A detailed sketch with sample locations plotted has been made for each exposure. Such „mapping" provided material which was expected to answer following questions:

1. what are the differences in densities among the certain petrographic rock types within the given exposure (random or regular distribution, horizontal or vertical changes).
2. particularly whether or not a difference exists between the upper wheathered and the lower less altered portions of the rock.

3. how many samples are necessary to calculate the average density value characterizing the given rock type with adequate accuracy.

The density measurements have been carried out in the field laboratory of the Second Laboratory of Physical Parameters of Rocks (Enterprise for Geophysical Prospecting), the GS-2 density meter being used. This instrument enabling direct density measurements in g/cubic cm does not require additional calculations. It has been constructed at the Enterprise for Geophysical Prospecting. The accuracy of the measurements is 0.01 g/cubic cm.

DATA PROCESSING AND ANALYSIS

Sketches of the exposures (fig. 1—4) have been marked with density values determined in the laboratory and subsequently isodenses have been drawn every 0.05 g/cubic cm. As shown by the chaotic pattern of the isodenses the density distribution is irregular both horizontally and vertically. It can be assumed that the density of certain petrographic rock types depends only on local variations in mineral composition. This is also indicated by the fact that rocks fairly uniform as to their mineral composition (granites, gneisses) are characterized by fairly stable densities, while petrographically differentiated rocks (schists) show bigger differences in density. No density changes that could be related to the degree of wheathering or the rock's pre- metamorphic structure (bedding, folding etc.) have been observed.

The arithmetic and modal mean values based on the measurement results have been calculated for the separate exposures. The values are listed in Table 1.

The modal mean values have been defined by constructing Gauss curves (figs. 1—4). Most of the curves show only one maximum thus indicating that none of the rocks examined contains two or more classes of different density values.

In general the modal means equal the arithmetic means or these two values differ only slightly. Only in five cases the difference exceeded 0.03 g/cubic cm. To establish a minimum amout of measurements necessary for defining an adequately accurate average density for the separate rock types, diagrams have been completed, the number of measurements being plotted on the abscissa, the mean value on the ordinate (fig. 1—4). These diagrams show that the minimum number of measurements necessary for the determination of the average density varies depending on the rock type.

At the assumed average accuracy of 0.01 g/cubic cm this amount varies from five measurements for fine-grained gneisses to 240 measurements for chlorite-sericite phyllites with pyrite admixture. The calculated average values have been plotted on a map with marked sample

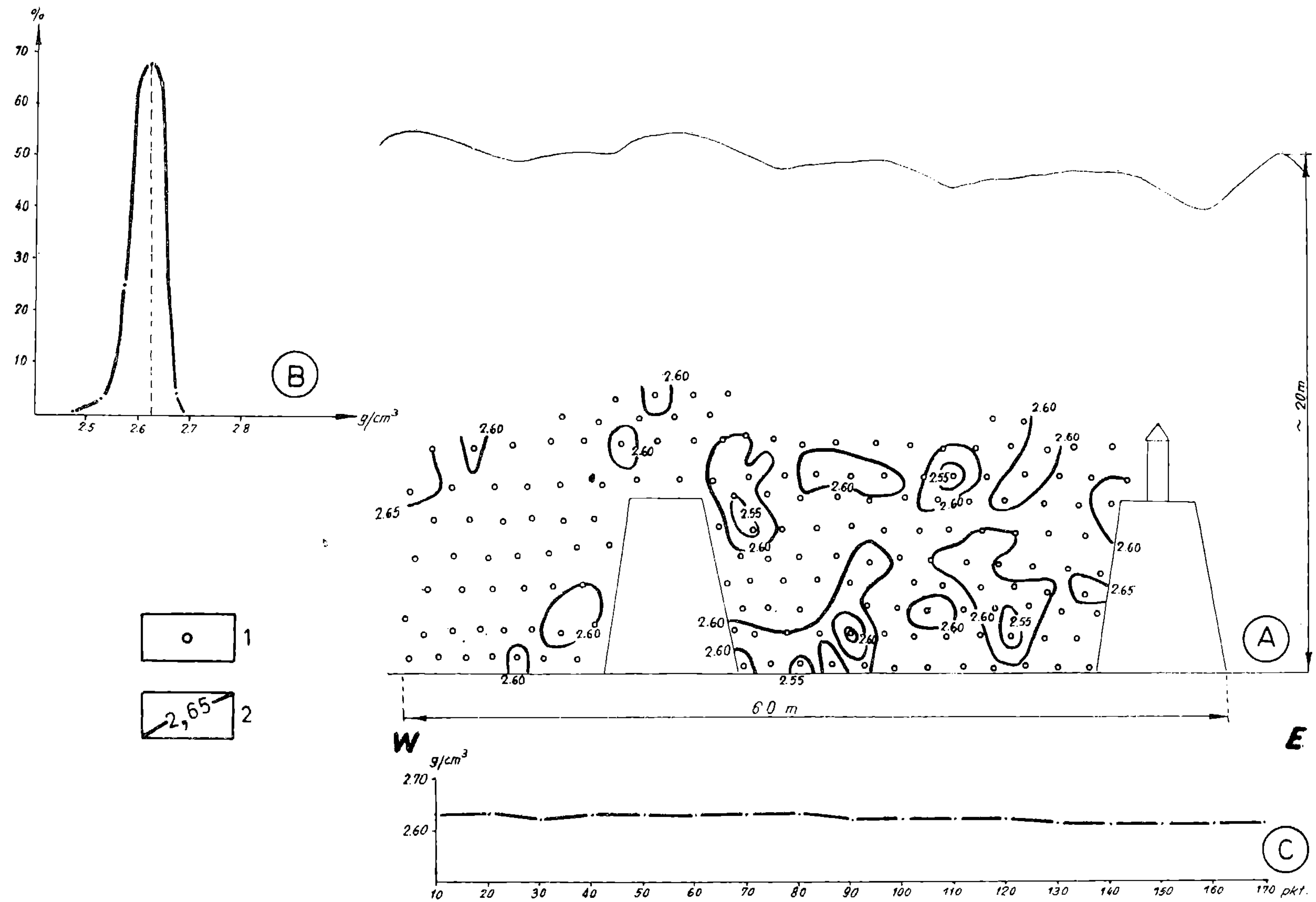


Fig. 1. A — Sketch of the exposure No 6. Finely-laminated gneisses. 1 — place where the sample was taken out and the value of density in g/cubic cm; 2 — isodense and the value of density in g/cubic cm; B — Gauss curve; C — diagram of the mean value of density/number of measurements ratio

Fig. 1. A — Szkic odkrywki nr 6. Gnejsy cienkolaminowane. 1 — miejsce pobrania próbki i wartość gęstości w g/cm³; 2 — izodensa i wartość gęstości w g/cm³; B — krzywa Gaussa; C — wykres zależności wartości średniej gęstości od ilości pomiarów

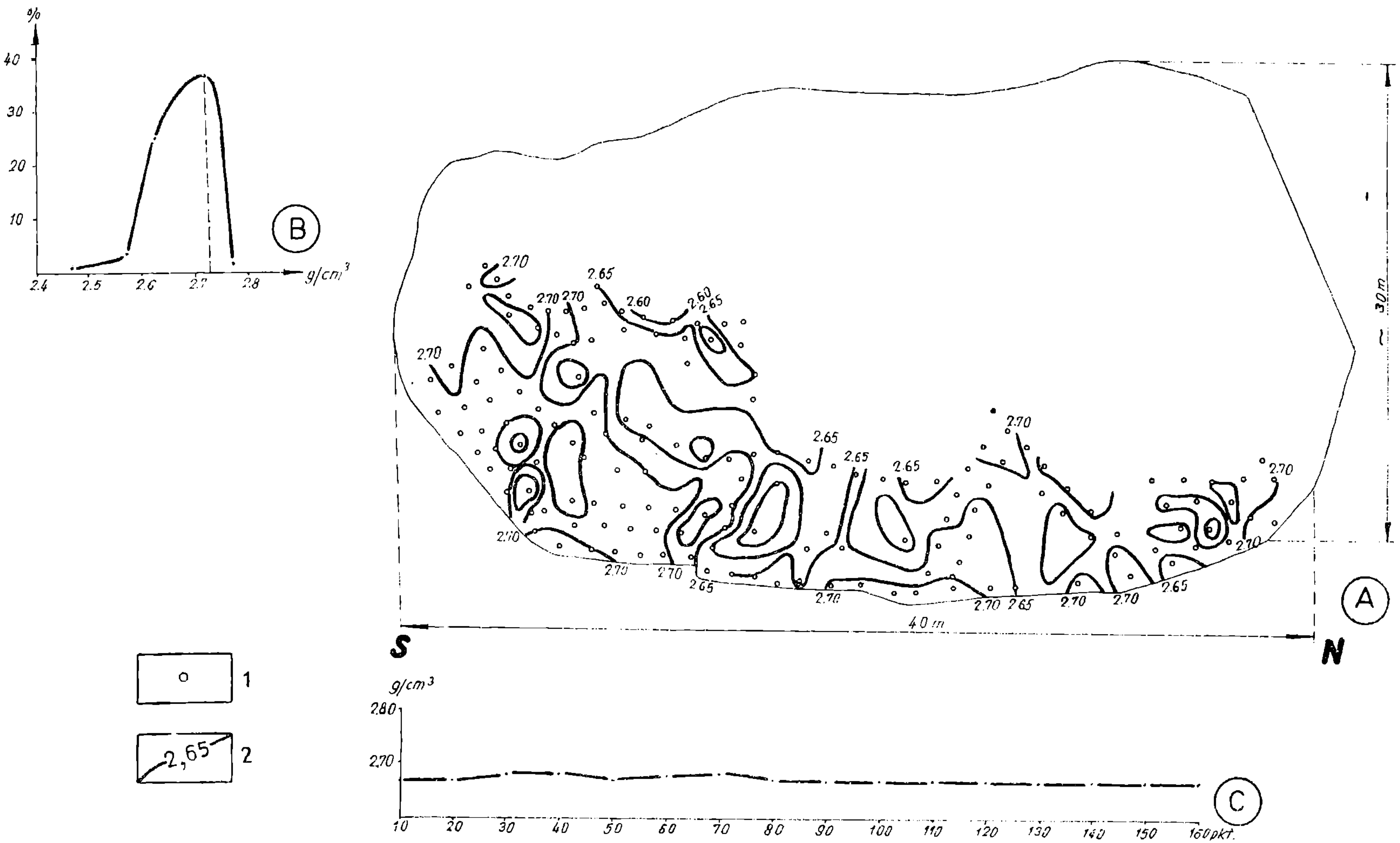


Fig. 2. A — Sketch of the exposure No 8. Granodiorite gneisses. 1 — place where the sample was taken out and the value of density in g/cubic cm; 2 — isodense and the value of density in g/cubic cm; 3 — Gauss curve; 4 — diagram of the mean value of density/number of measurements ratio

Fig. 2. A — Szkic odkrywki nr 8. Gnejsy granodiorytowe. 1 — miejsce pobrania próbki i wartość gęstości w g/cm³; 2 — izodensa i wartość gęstości w g/cm³; B — krzywa Gaussa; C — wykres zależności wartości średniej gęstości od ilości pomiarów

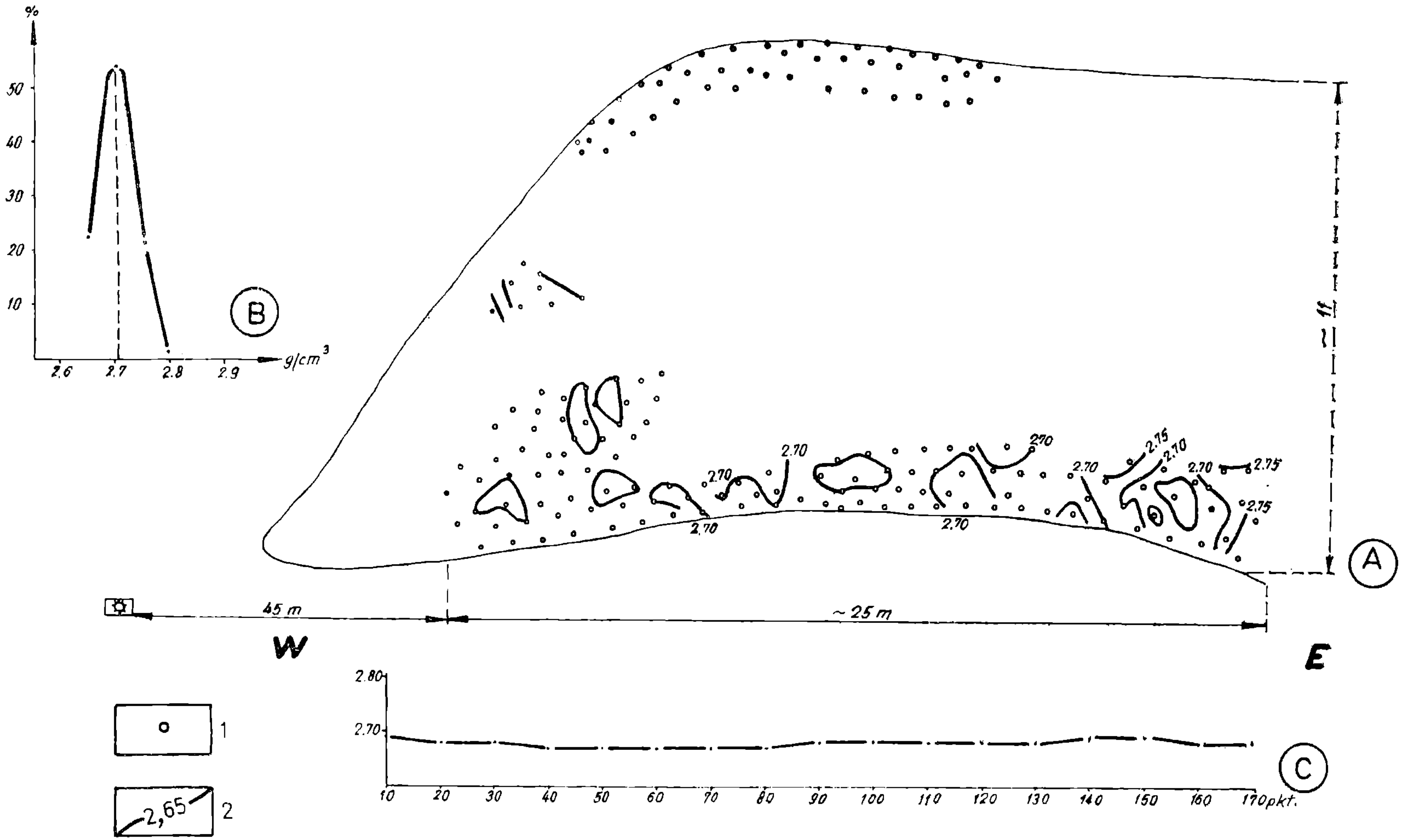


Fig. 3. A — Sketch of the exposure No 9. Greywackes-phyllites. 1 — place where the sample was taken out and the value of density in g/cubic cm; 2 — isodense and the value of density in g/cubic cm; B — Gauss curve; C — diagram of the mean value of density/number of measurements ratio

Fig. 3. A — Szkic odkrywki nr 9. Szarogłazy-fyllity. 1 — miejsce pobrania próbki i wartość gęstości w g/cm³; 2 — izodensa i wartość gęstości w g/cm³; B — krzywa Gaussa; C — wykres zależności wartości średniej gęstości od ilości pomiarów

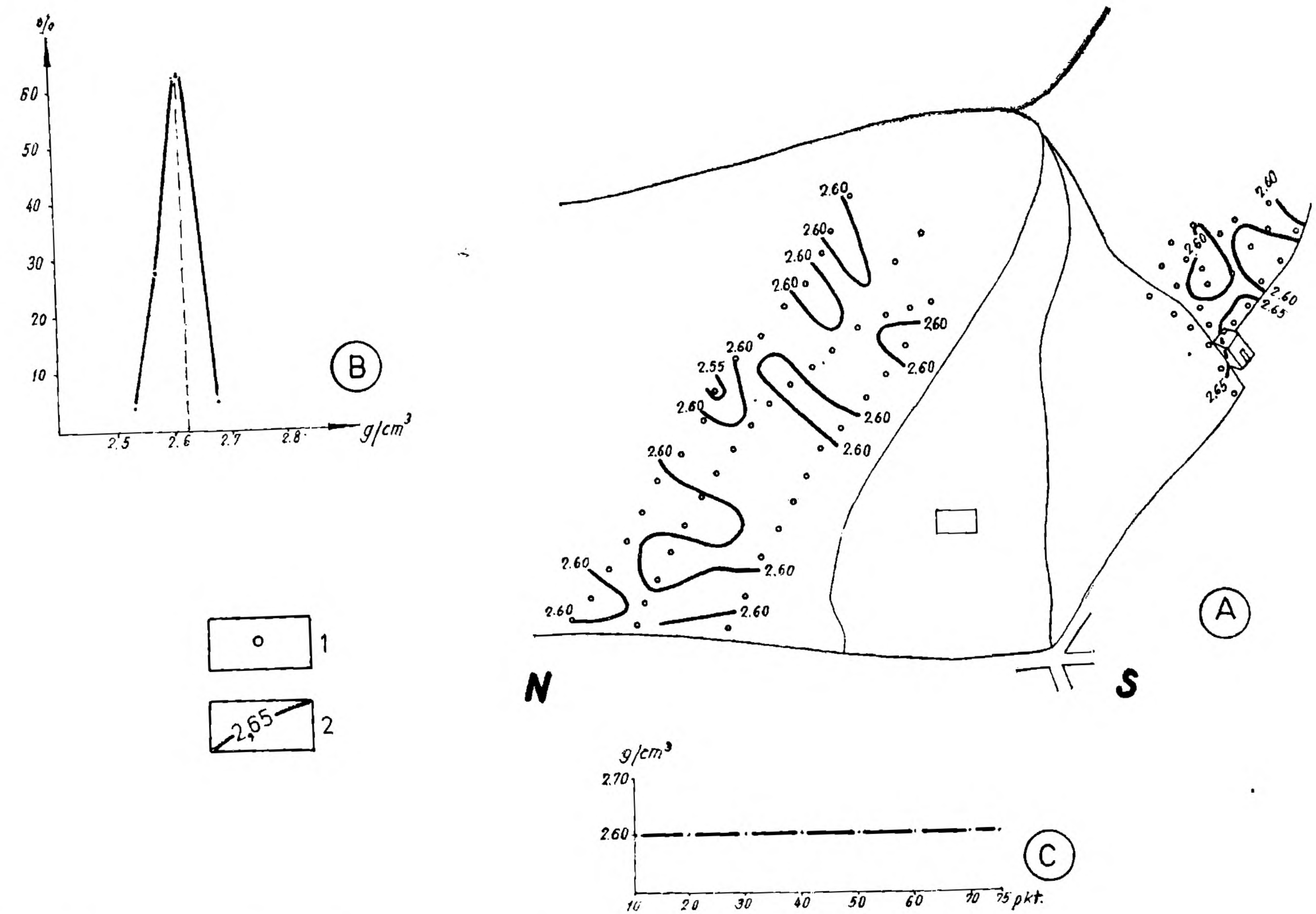


Fig. 4. A — Sketch of the exposure No 10. Izera-Rumburk granites. 1 — place where the sample was taken out and the value of density in g/cubic cm; 2 — isodense and the value of density in g/cubic cm; B — Gauss curve; C — diagram of the mean value of density/number of measurements ratio

Fig. 4. A — Szkic odkrywki nr 10. Granity izersko-rumburskie. 1 — miejsce pobrania próbki i wartość gęstości w g/cm³; 2 — izodensa i wartość gęstości w g/cm³; B — krzywa Gaussa; C — wykres zależności wartości średniej gęstości od ilości pomiarów

locations (fig. 5). This map shows that not enough exposures have been examined to define the nature of density ditribution within the separate rock complexes.

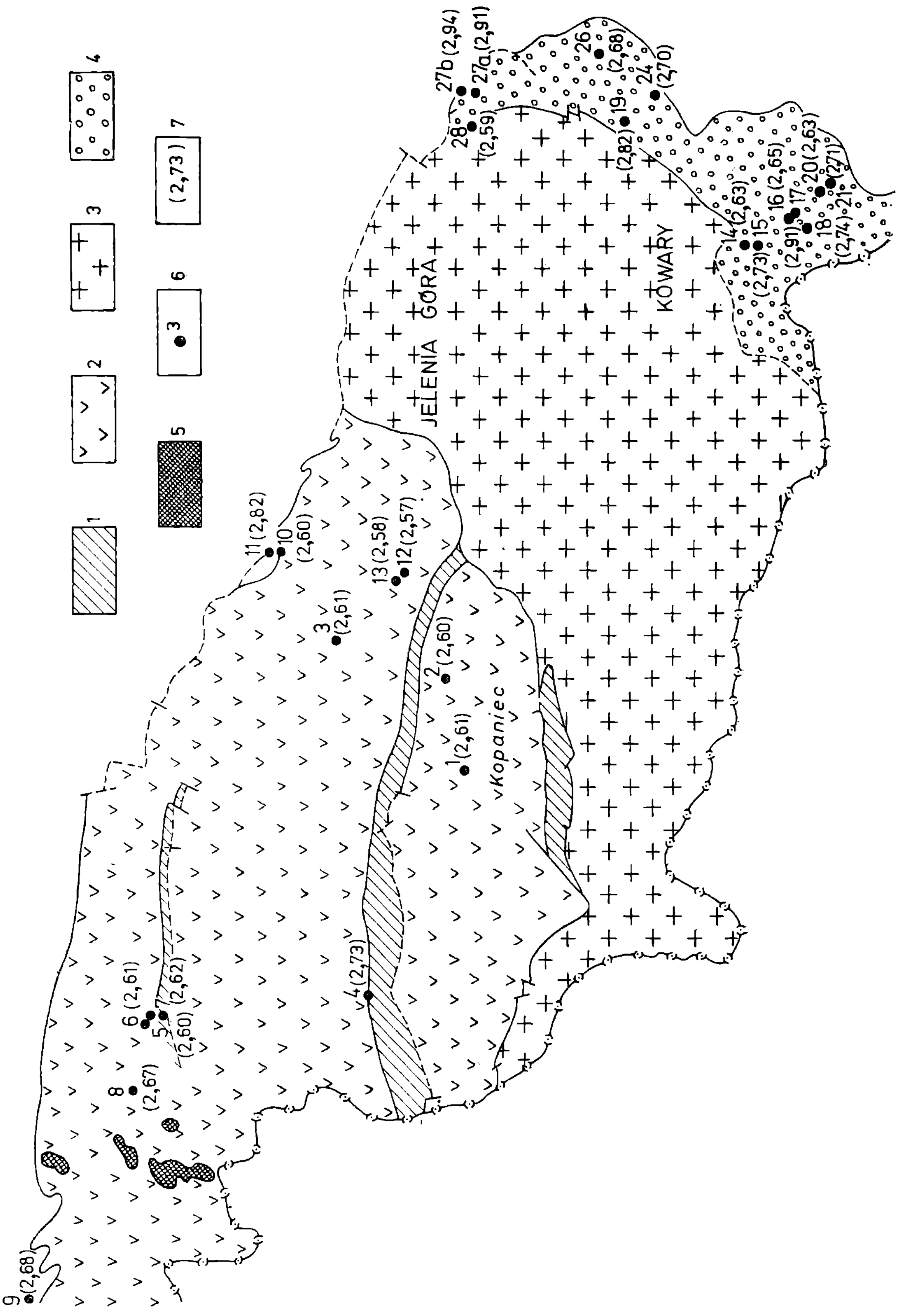
Table 1

Exposure No	Rock type	Number of samples	Modal mean	Arithmetic mean	Minimum number of measurements necessary to define the arithmetic mean
1	Fine-grained gneisses	16	-	2,61	5
2	Leucogranites	40	2,57	2,60	?
3	Quartz breccia	180	2,62	2,61	110
4	Mica schists	190	2,72	2,73	120
5	Augen-lenticular gneisses	60	2,57	2,60	50
6	Finely laminated gneisses	170	2,63	2,61	130
7	Quartzitic mica schists	175	2,63	2,62	60
8	Granodioritic gneisses	160	2,65	2,67	80
9	Greywackes-phyllites	170	2,70	2,68	160
10	Izera-Rumburk granites	75	2,63	2,60	10
11	Basalts	42	2,95	2,82	?
12	Granites, gneisses	108	2,57	2,57	20
13	Gneisses	105	2,58	2,58	60
14	Porphyritic granites	145	2,63	2,63	60
15	Finely laminated gneisses	40	2,73	2,73	20
16	Sericite-chlorite phyllites	150	2,75	2,65	120
17	Greenstones	68	2,94	2,91	50
18	Crystalline limestones greenstones	140	2,75	2,74	120
19	Dolomitic marbles	100	2,82	2,82	?
20	Chlorite-hornblenda gneisses	160	2,63	2,63	60
21	Amphibolites	245	2,65	2,71	110
24	Cataclasites	125	2,75	2,70	100
26	Sericite-chlorite schists with pyrite	305	2,70	2,68	240
27a	Amphibolites	100	2,95	2,91	80
27b	Mica schists	50	2,94	2,94	20
28	Granites	50	2,58	2,59	30

→

Fig. 5. Map with marked sample locations. 1 — schists; 2 — gneiss (Izera Block); 3 — Karkonosze granite; 4 — East Karkonosze structures; 5 — basalte; 6 — exposures number; 7 — mean value of density in g/cubic cm

Fig. 5. Mapa z lokalizacji miejsc pobrania próbek. 1 — łupki metamorficzne; 2 — gnejsy (blok Izerski); 3 — granit Karkonoszy; 4 — struktury wschodnich Karkonoszy; 5 — bazalty; 6 — numer odkrywki; 7 — średnia wartość gęstości w g/cm^3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FINAL CONCLUSIONS

The experimental density examinations of the crystalline rocks of the Karkonosze Mountains and the adjacent areas resulted in the following conclusions:

1. No relations between the wheathering and the density changes have been recognized, consequently it is not essential whether the samples come from the upper or from the bottom parts of the exposure.
2. No regularities in density distribution related to the original structure of the rock have been observed. Thus a systematic „mapping" of the exposures is not required and the samples may be taken from casual points of the exposure.
3. The amount of samples should depend on the rock type. For this purpose the experience gained by the authors and reported in the present paper should be utilized.
4. For future examinations a bigger number of exposures within the given rock complex should be sampled. The number of samples should be sufficient to establish the nature of the density distribution within the given complex.

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REFERENCES
WYKAZ LITERATURY

Dąbrowski A., Kaczkowska Z. (1965), Mapa średnich gęstości warstwowych utworów występujących w Polsce nad poziomem morza. *Kwart. geol.*, 9, nr 1, pp. 203—215, Warszawa.

Fajklewicz Z., Rejman T. (1965), Mapy ciężarów objętościowych skał, *Technika poszuk.* nr 14, p. 1—4. Warszawa.

Praca zbiorowa pod redakcją N. B. Dortman i M. L. Ozierskiej (1962), Collective work edited by N. Dortman and M. L. Ozierskaja (1962), Metodiczeskoje rukowodstwo po opredeleniju fiziczeskich swojstw gornych porod i poleznych iskopajemych, pp. 279—410, Moskwa.

Sawicki L. (1965). Mapa geologiczna Regionu Dolnośląskiego (bez osadów czwartorzędowych) 1 : 200 000, *Inst. Geol.* Warszawa.

STRESZCZENIE

Wykonywanie pomiarów grawimetrycznych pociąga za sobą konieczność ustalania rozkładu gęstości utworów geologicznych występujących nad poziomem redukcji. Właściwe rozwiązanie tego zagadnienia jest szczególnie ważne tam, gdzie nad poziomem redukcji znajdują się skały krystaliczne o dużym zróżnicowaniu gęstościowym. W takim przypadku należy opracować specjalną metodykę określania rozkładu gęstości. Metodykę taką, opracowaną przez autorów niniejszego artykułu, wypróbowano na obszarze masywu granitowego Karkonoszy (Dolny Śląsk). Na podstawie mapy geologicznej wyróżniono kompleksy skał jednorodnych petrograficznie. Korzystając z naturalnych odsłonięć i kamieniołomów, pobierano próbki tych skał dla określenia laboratoryjnego ich gęstości. Zebrany materiał pozwolił ustalić, ile próbek należy pobierać dla poszczególnych typów skał celem określenia średniej wartości gęstości. Okazało się także, że ilość wykorzystanych odkrywek i kamieniołomów była niewystarczająca dla sporządzenia mapy rozkładu gęstości.

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