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Preliminary results of the geophysical interpretation (stripping method) in respect to the pre-Permian basement of southwestern Poland

Application of the stripping method produced new image of the gravimetric anomalies originating from the pre-Permian basement. Preliminary interpretation of these anomalies, ascribed to the older than Permian deposits and to the deep earth's crust structure was presented. The gravimetric modelling of the pre-Permian deposits from selected profiles was an important element of this interpretation.

INTRODUCTION

The below presented results come from the report describing the results of investigations carried out, over the area localized south from 52° parallel of latitude and west from 19° meridian i.e. SW quarter of the map at the 1:500 000 scale, by a big team of geologists and geophysicists from the State Geological Institute, including also the geologists from Lower Silesian Branch of the Institute and by geophysicists from the Geophysical Enterprise (C. Królikowski ed. et al., 1988).

The stripping method of interpretation is based upon differentiation of the gravimetric anomalies observed on the earth's surface into two parts — one related to the distinct overlay and the second connected with its basement. The analysis of the latter part gives the possibility of drawing conclusions on geology of the basement complexes. Application of the stripping method requires good knowledge of the structure and density distribution in overlying rocks. The seismic method supplies relatively good recognition of the Permian – Mesozoic complex while the recognition of pre-Permian basement is insufficient. This involves the growth of interest in other

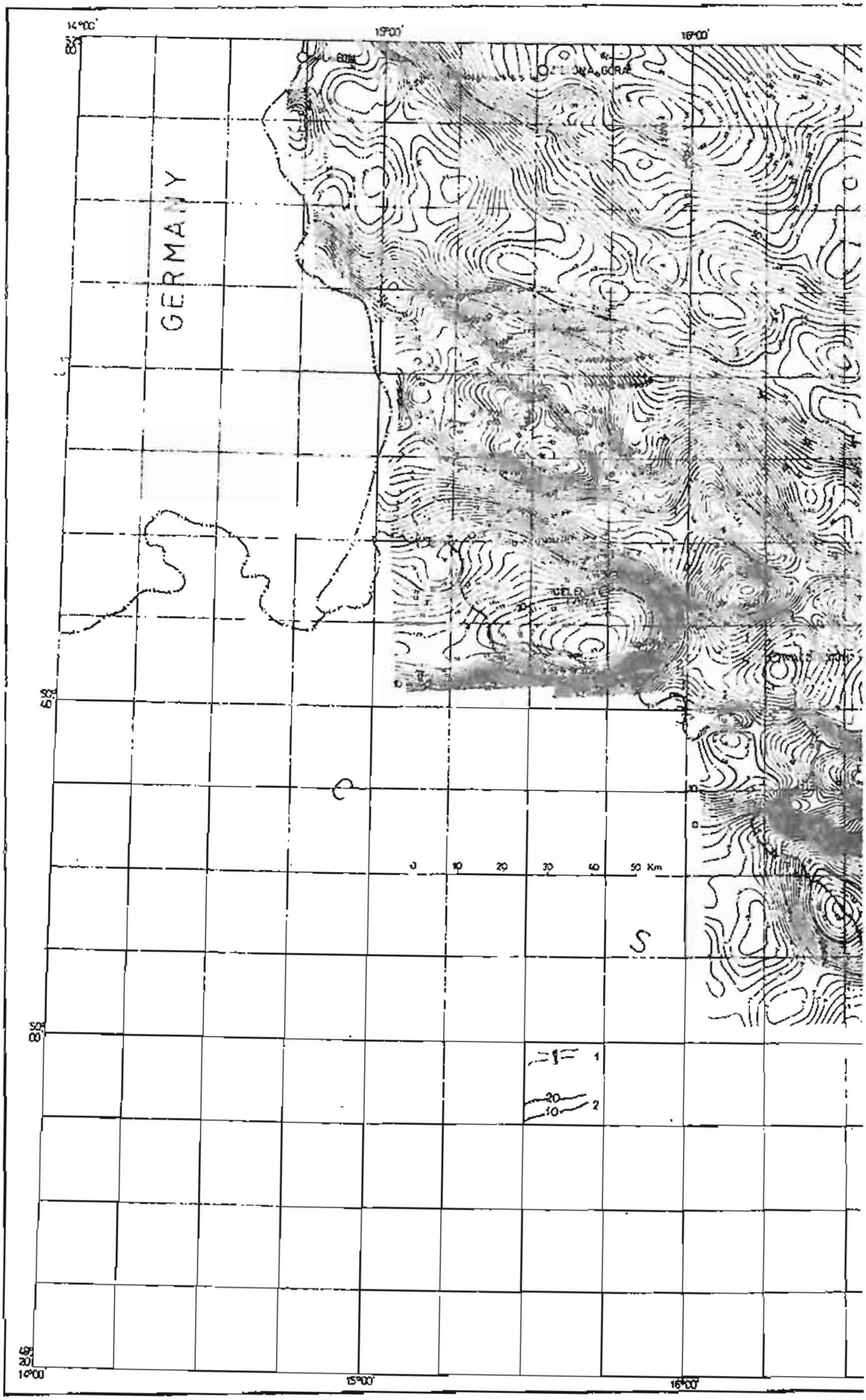
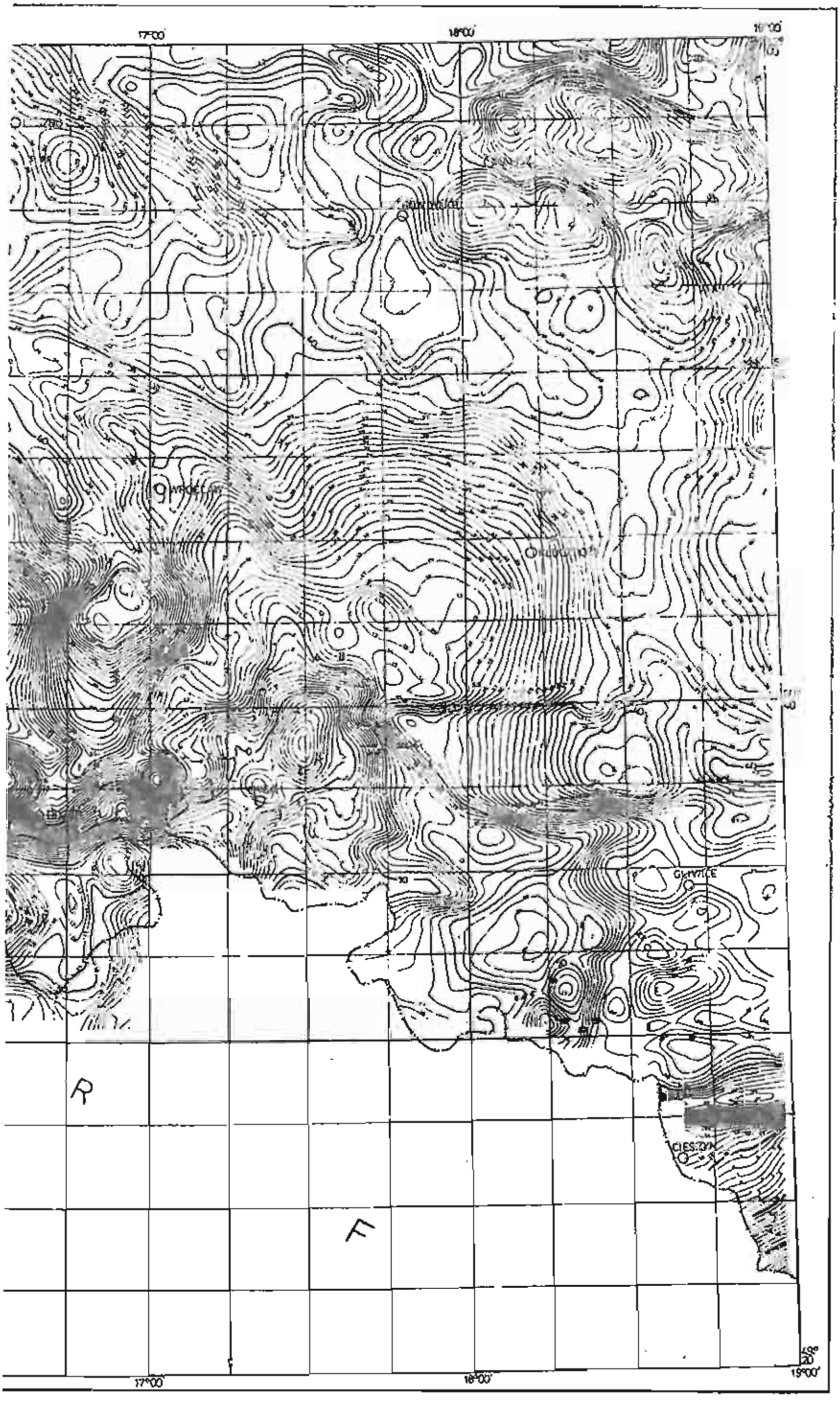


Fig. 1. Map of gravimetric anomalies originating from the pre-Permian basement
1 — isolines at 1 mGal interval; 2 — isolines at 10 mGal interval



Mapa anomalii grawimetrycznych od podłoża podpermskiego

1 — izolinie, których odstęp wynosi 1 mGal; 2 — izolinie, których odstęp wynosi 10 mGal

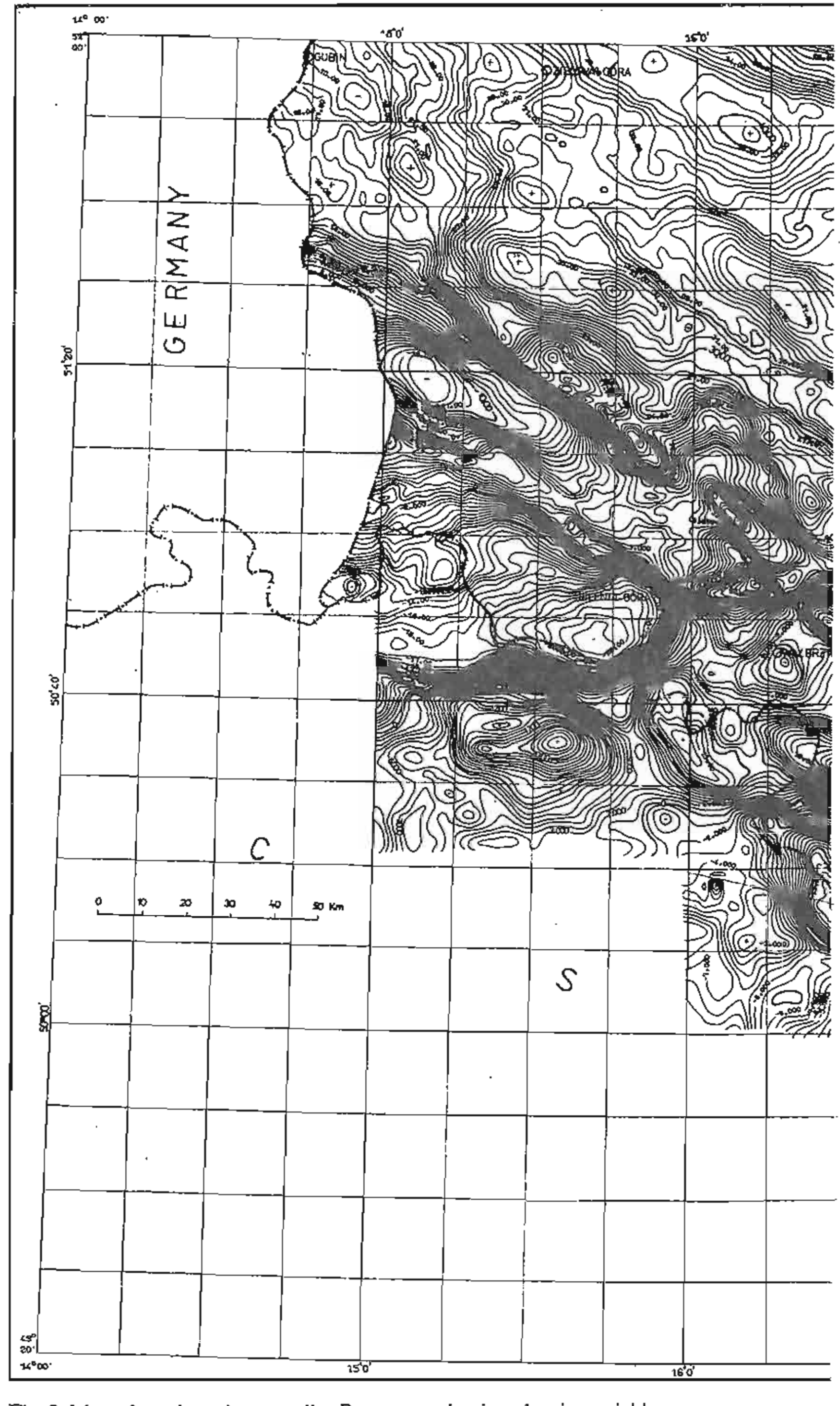
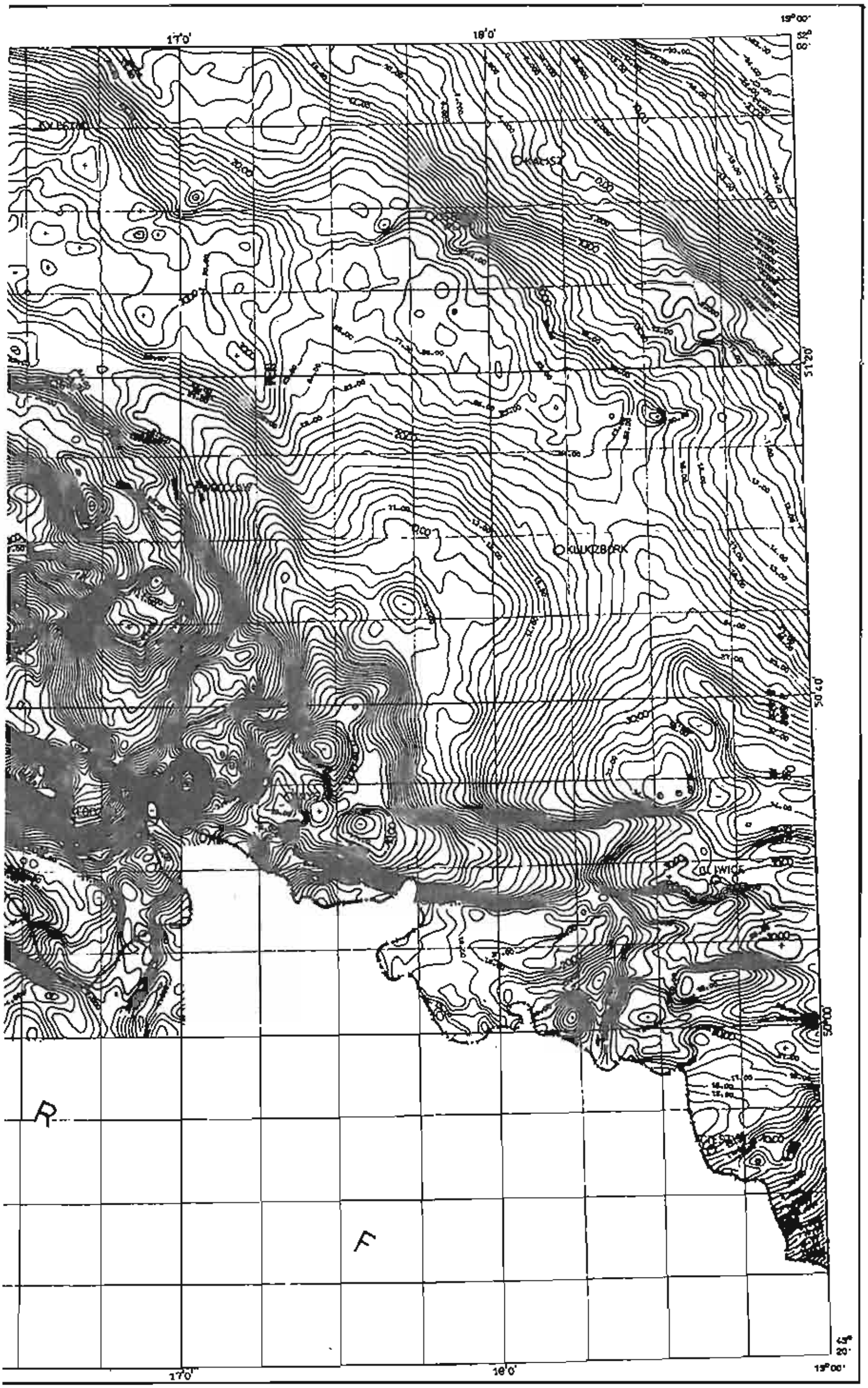
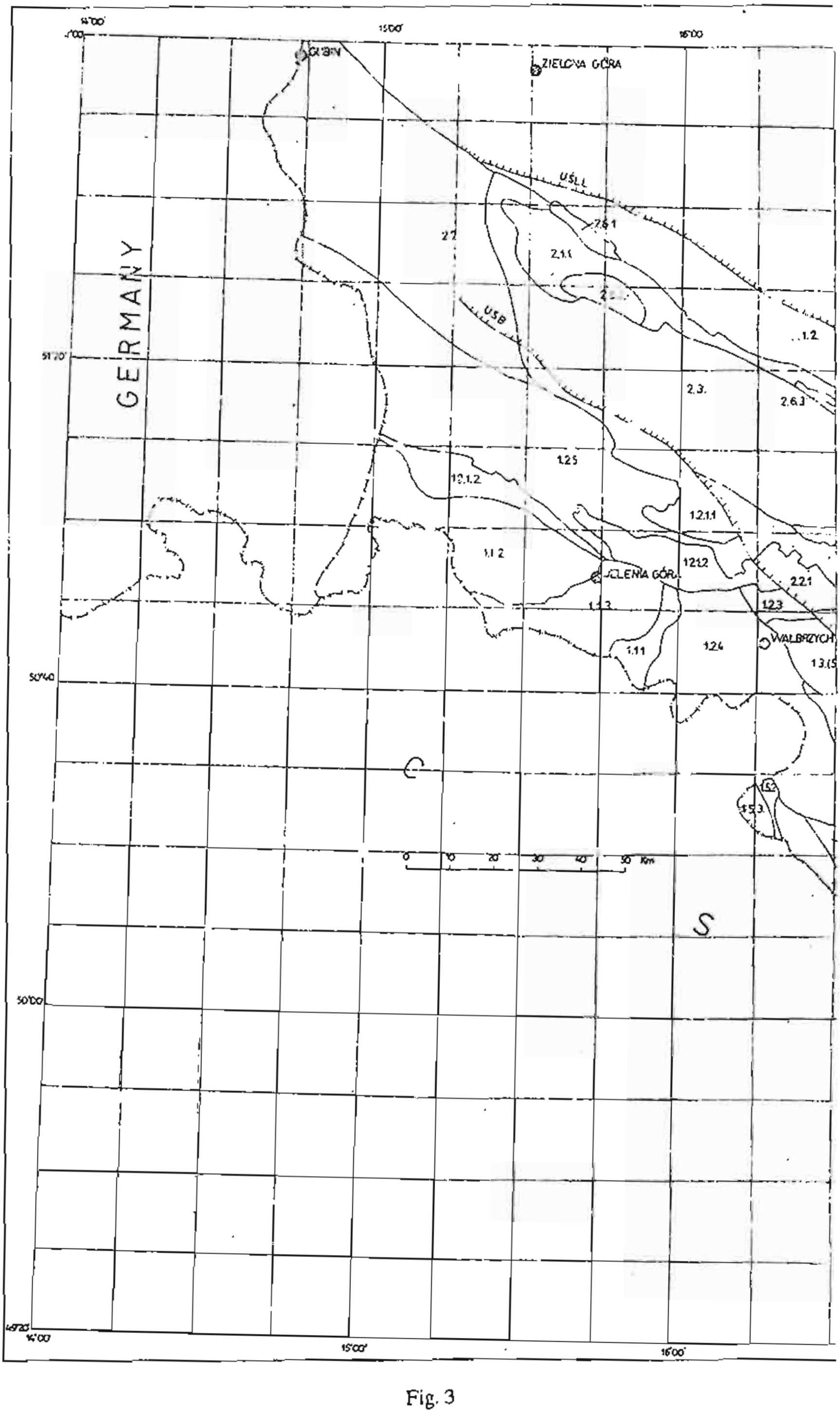


Fig. 2. Map of gravimetric anomalies; Bouguer reduction, density variable
For explanations see Fig. 1



Mapa anomalli grawimetrycznych (redukcja Bouguera, gęstość zmienna)
Objaśnienia jak na fig. 1


15°00'
16°00'
GUBIN
ZIELONA GÓRA
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51°20'
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WAŁBRZYCH
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2.3.
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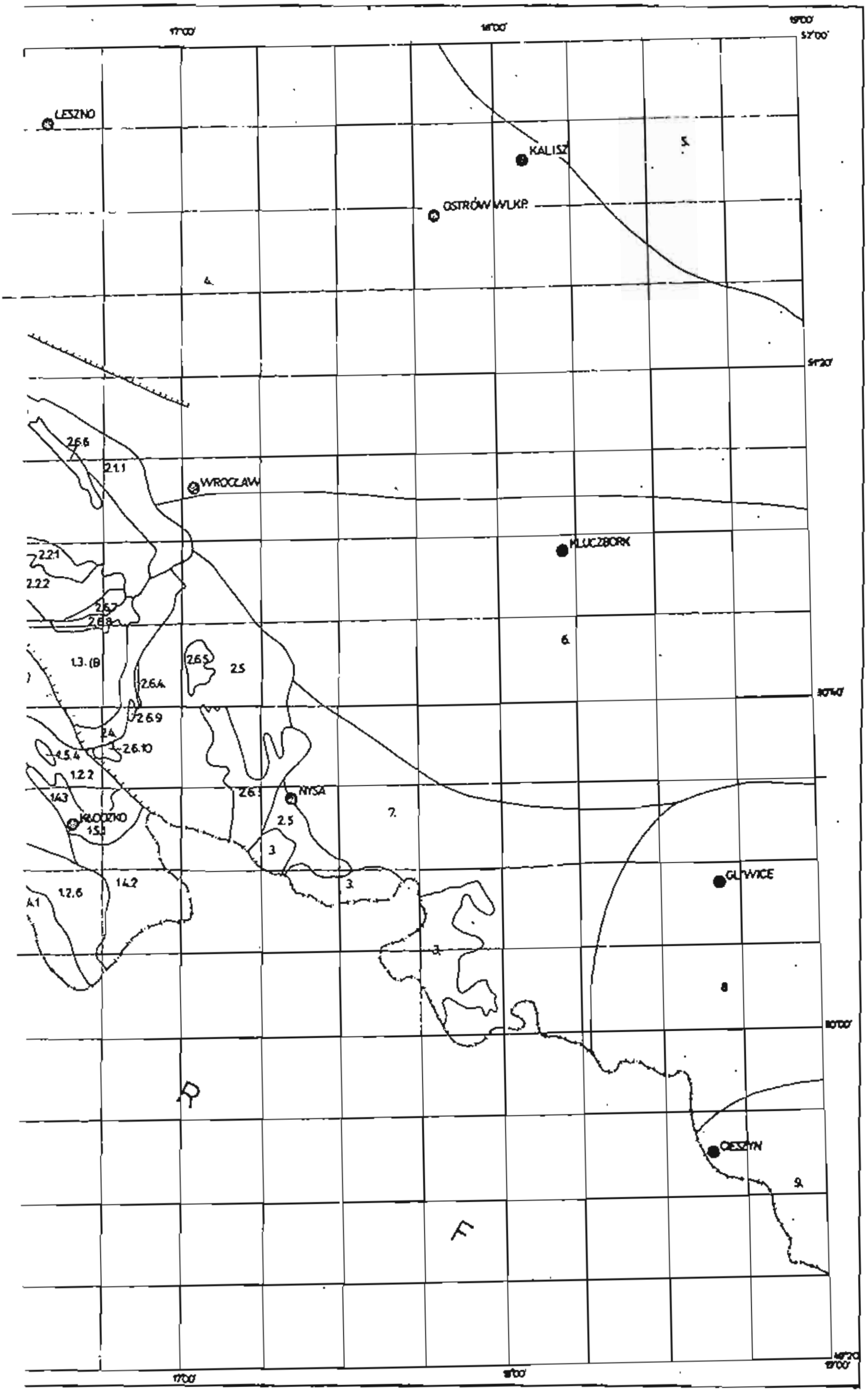
1.1.1

Fig. 3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18°00'
19°00'
52°00'
51°20'
50°40'
50°00'
49°20'

Fig. 3

Fig. 3. Sketch map of structural units of the Sudetes, Fore-Sudetic Block and neighbouring areas after A. Grocholski, L. Sawicki ed. et al. (1982) and J. Znosko (1974)

Sudetes — K a r k o n o s z e - G ó r y I z e r s k i e M a s s i f : 1.1.1. — Eastern Karkonosze metamorphic massif, 1.1.2 — Góry Izerskie metamorphic massif, 1.1.3 — intrusion of Karkonosze granitoids; V a r i s c a n f o l d s t r u c t u r e s a n d V a r i s c a n a n d y o u n g e r d e p r e s s i o n s : 1.2.1 — pre-Upper Carboniferous Palaeozoic of Góry Kaczawskie Mts (1.2.1.1 — northern part, 1.2.1.2 — southern part), 1.2.2 — Bardo Structure, 1.2.3 — Świebodzice Depression, 1.2.4 — Intra-Sudetic Depression, 1.2.5 — North Sudetic Synclinorium, 1.2.6 — Upper Nysa Graben; G ó r y S o w i e B l o c k : 1.3(S) — Góry Sowie Block within the Sudetes, 1.3(B) — Góry Sowie Block within Fore-Sudetic Block; y o u n g e r c r y s t a l l i n e b a s e m e n t : 1.4.1 — Góry Bystrzyckie Structure, 1.4.2 — metamorphic massif of Śnieżnik Mt. and neighbouring structures, 1.4.3 — Kłodzko metamorphic massif; g r a n i t o i d a n d b a s i c b o d i e s : 1.5.1 — Kłodzko — Złoty Stok granitoid massif, 1.5.2 — Kudowa granitoid massif, 1.5.3 — Novy Hradec granitoids, 1.5.4 — Nowa Ruda gabbro and diabases; **Fore-Sudetic Block and neighbouring structures** — M i d d l e O d r a m e t a m o r p h i c m a s s i f : 2.1.1 — within the Fore-Sudetic Block, 2.1.2 — within the Fore-Sudetic Monocline; S t r z e g o m – S o b ó t k a M a s s i f : 2.2.1 — Strzegom - Sobótka Massif cover metamorphic, 2.2.2 — Strzegom - Sobótka granitoid intrussion; 2.3 — p r e - U p p e r C a r b o n i f e r o u s m e t a m o r p h i c m a s s i f o f K ą t y W r o c ł a w s k i e – K r z y ż o w a ; 2.4 — N i e m c z a l i n e a m e n t ; 2.5 — W z g ó r z a S t r z e l i ń s k i e m e t a m o r p h i c m a s s i f a n d n e i g h b o u r i n g s t r u c t u r e s ; 2.6 — g r a n i t o i d , b a s i c a n d u l t r a b a s i c r o c k s : 2.6.1 — Niegosławice granitoids, 2.6.2 — Leszno granitoids, 2.6.3 — Lubiąż granitoids, 2.6.4 — Niemcza granitoids, 2.6.5 — Strzelin – Žulova granitoid massif; 2.6.6 — hypothetic ultrabasic Kąty Wrocławskie – Malczyce intrusion, 2.6.7 — Sobótka gabbro massif, 2.6.8 — Gogołów — Jordanów serpentinite massif, 2.6.9 — Niemcza serpentinites, 2.6.10 — Braszowice gabbro and serpentinites; 2.7 — Ż a r y P e r y c l i n e ; 3. — **Morawian – Silesian young Variscan zone**; 4. — **Fore-Sudetic Monocline**; 5.— **Łódź Basin**; 6. — **Silesian – Cracow Monocline**; 7.— **Eastern Sudetes**; 8.— **Upper Silesian Coal Basin**; 9. — **Carpathians**; U.Śl.L. — Silesian – Lubusza Fault; U.S.B — Marginal Sudetic Fault

Szkic jednostek strukturalnych Sudetów, bloku przedsudeckiego i obszarów sąsiednich

Sudety — b l o k k a r k o n o s k o - i z e r s k i : 1.1.1 — metamorfik wschodnich Karkonoszy, 1.1.2 — metamorfik izerski, 1.1.3 — intruzja granitoidów Karkonoszy; w a r y s c y j s k i e s t r u k t u r y f a ł d o w e o r a z z a p a d l i s k a w a r y s c y j s k i e i m ł o d s z e : 1.2.1 — przedgórnokarboński paleozoik Gór Kaczawskich (1.2.1.1 — część północna, 1.2.1.2 — część południowa), 1.2.2 — struktura bardzka, 1.2.3 — depresja Świebodzic, 1.2.4 — depresja śródsudecka, 1.2.5 — synklinorium północnosudeckie, 1.2.6 — rów górnej Nysy; b l o k G ó r S o w i c h : 1.3(S) — w zasięgu Sudetów, 1.3(B) — w zasięgu bloku przedsudeckiego; m ł o d s z e p o d ł o ż e k r y s t a l i c z n e : 1.4.1 — struktura Gór Bystrzyckich, 1.4.2 — metamorfik Śnieżnika i struktury sąsiednie, 1.4.3 — metamorfik kłodzki; c i a ł a g r a n i t o i d o w e i z a s a d o w e : 1.5.1 — masyw granotoidowy kłodzko-złotostocki, 1.5.2 — masyw granitoidowy Kudowy, 1.5.3 — granotoidy nowohradeckie, 1.5.4 — gabra i diabazy noworudzkie; **blok przedsudecki i jednostki sąsiednie** — m e t a m o r f i k ś r o d k o w e j O d r y : 2.1.1 — w zasięgu bloku przedsudeckiego, 2.1.2 — w zasięgu monokliny przedsudeckiej; m a s y w S t r z e g o m i a – S o b ó t k i : 2.2.1 — metamorfik osłony masywu Strzegomia – Sobótki, 2.2.2 — intruzja granitoidów Strzegomia – Sobótki; 2.3 — p r z e d g ó r n o k a r b o ń s k i m e t a m o r f i k K ą t ó w W r o c ł a w s k i c h – K r z y ż o w e j ; 2.4 — l i n e a m e n t N i e m c z y ; 2.5 — m e t a m o r f i k W z g ó r z S t r z e l i ń s k i c h i s t r u k t u r y s ą s i e d n i e ; 2.6 — c i a ł a g r a n i t o i d o w e , z a s a d o w e i u l t r a z a s a d o w e : 2.6.1 — granitoidy Niegosławic, 2.6.2 — granitoidy Leszna, 2.6.3 — granitoidy Lubiąża, 2.6.4 — granitoidy niemczańskie, 2.6.5 — masyw granitoidowy Strzelina – Žulovej, 2.6.6 — domniemana ultrazasadowa intruzja Kątów Wrocławskich – Malczyc, 2.6.7 — masyw gabrowy Sobótki, 2.6.8 — masyw serpentynitowy Gogołowa – Jordanowa, 2.6.9 — serpentynity Niemczy, 2.6.10 — gabra i serpentynity Braszowic; 2.7 — p e r y k l i n a Ż a r ; 3. — **młodowaryscyjska strefa morawsko-śląska**; 4. — **monoklina przedsudecka**; 5. — **niecka łódzka**; 6. — **monoklina śląsko-krakowska**; 7. — **Sudety Wschodnie**; 8. — **Zagłębie Górnośląskie**; 9. — **Karpaty**; U.Śl.L .— uskok śląsko-lubuski; U.S.B. — sudecki uskoki brzeżny geophysical methods data and using of the stripping and gravimetric modelling methods to the analysis of these data.

The stripping method has been applied only in the area of younger than Carboniferous deposits, while the analysis and transformation of anomalies originating from the pre-Permian basement were carried out at the whole area of southwestern Poland, including also the Sudetes and the Fore-Sudetic Block.

Application of the stripping method in southwestern Poland is the continuation of similar studies carried out in northwestern part of the country (C. Królikowski, A. Grobelny, 1987; A. Grobelny, C. Królikowski, 1989).

At least three factors involving the preference of application of the stripping method in reference to the pre-Permian basement can be distinguished. These respectively are:

— big interest of many geologists in pre-Permian basement complex as a possible resource of new mineral deposits;

— dissatisfacting, up till date, results of applied seismic methods;

— relatively good structural and density recognition of the younger deposits.

According to the tittle the paper presents the results of geophysical interpretation and only general remarks on geology of the bodies producing gravimetric anomalies. Further, more detailed geological analyses of the anomalies will be continuated with the participation of geologists from the Lower Silesian Branch of State Geological Institute.

The Authors wish to express their thanks to Mr. Z. Żółtowski for his assistance and help in technical preparing of the Figures.

GENERAL CHARACTERISTIC OF THE GRAVIMETRIC ANOMALIES ORIGINATING FROM THE PRE-PERMIAN BASEMENT

The results of the interpretation of gravimetric anomalies recognized in Sudetes and Fore-Sudetic Block were presented in at least several papers. Among them the most important reports: A. Kozera et al. (1981), S. Bachnacki, A. Sođko (1984), T. Kruczek et al. (1985) gave the detailed, mostly qualitative analyse of bigger and smaller units of the gravity field. The subtraction effect is related to the deposits younger than Carboniferous. The result map of the pre-Permian basement anomalies (Fig. 1) differs from the Bouguer gravity map, which has been compiled upon variable rock density above sea level only for the areas of significant thickness younger than Carboniferous deposits (Fig. 2).

The biggest changes occurred in northern part of the map, especially in the region of Żary Monocline, Fore-Sudetic Monocline and Łódź Basin (Fig. 3). Among them amplitude variation and changes of the shape of one of the main Polish positive regional anomalies — the Krosno — Ostrzeszów high, extending from Zielona Góra up to Gliwice are manifested. It may be assumed, as already mentioned before (A. Witkowski ed. et al., 1981) that the sources of the Krosno – Ostrzeszów high are related to pre-Permian formations, most probably to the crystalline basement.

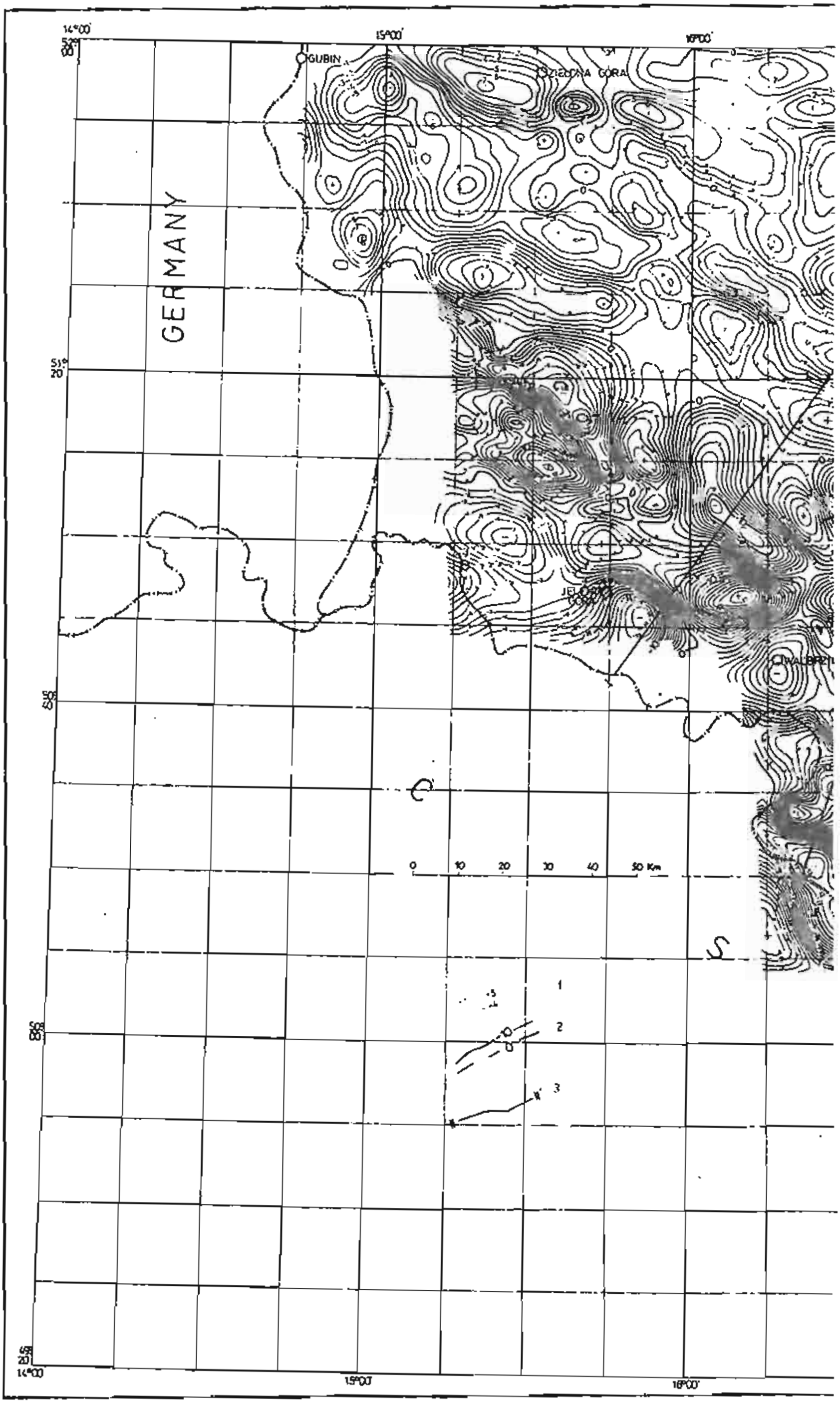
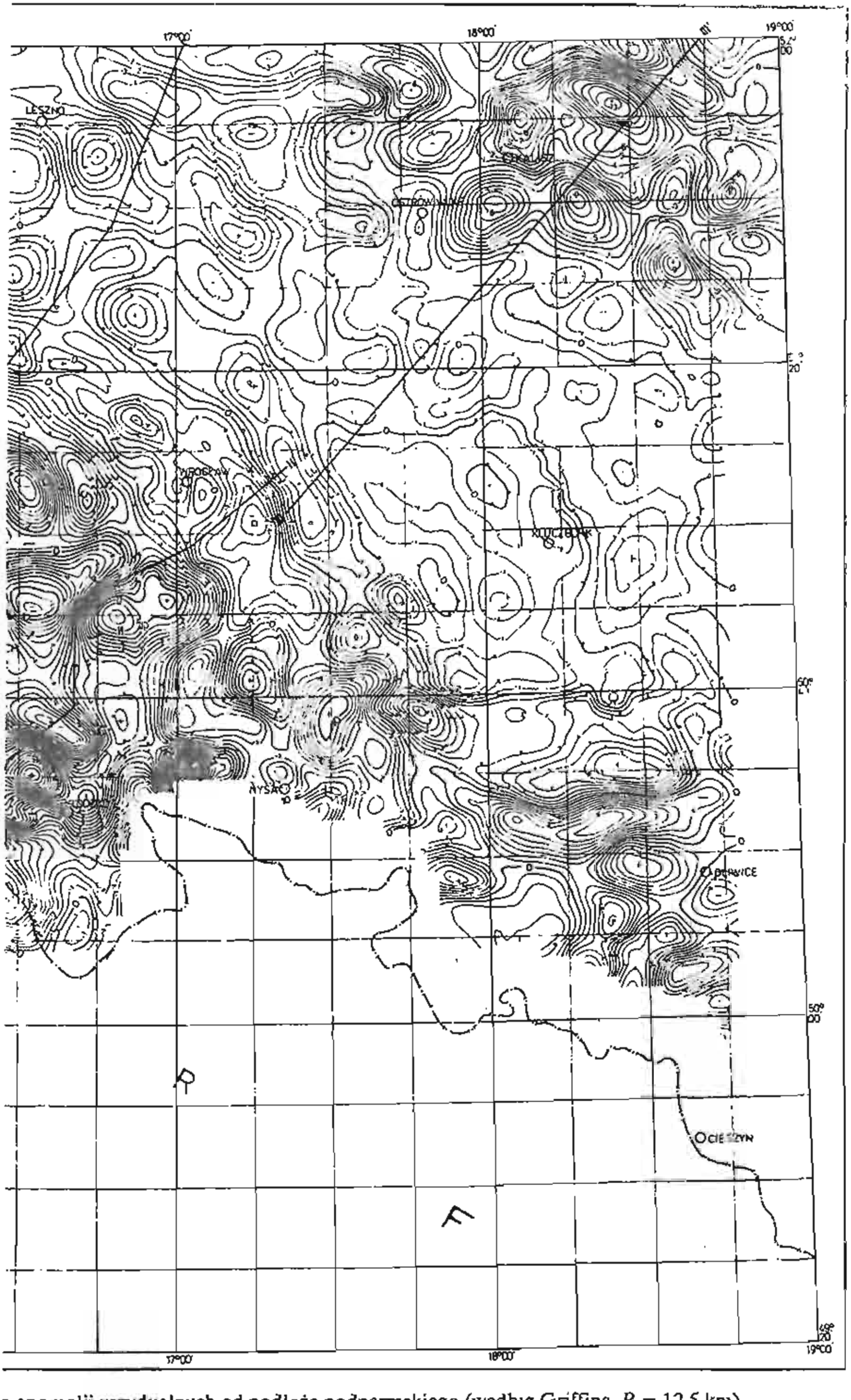


Fig. 4. Map of the residual anomalies from the sub-Permian basement (after Griffin, $R = 12.5$ km)
1 — isolines at 1 mGal interval; 2 — isolines at 10 mGal interval; 3 — the course of modelled profile



Mapa anomalii rezydualnych od podłoża podpermskiego (według Griffina, $R = 12{,}5$ km)
1 — izolinie, których odstęp wynosi 1 mGal; 2 — izolinie, których odstęp wynosi 10 mGal; 3 — przebieg [illegible] profilu

On northeastern part of the result map, within the Łódź Basin, demonstrated on the Bouguer map as a wide gradient zone, a wide anomaly with amplitude of 56 mGal occurred. The existence of the above mentioned anomaly is evident, while precious determination of its shape and amplitude because of insufficient structural and density recognition of the Permian and Mesozoic sediments in the area may be incorrect.

The positive anomaly connected to the Middle Odra metamorphic massif, especially in its nortwestern part, can be less distinctly separated from the Krosno — Ostrzeszów high. Therefore the gravity depression separating the Middle Odra metamorphic massif anomaly from the Krosno — Ostrzeszów high, wide on the Bouguer gravity map is characterized by a smaller width and smaller northwestern extent.

Decay of the negative and appearance of the positive anomaly as manifested in the area of North Sudetic Synclinorium indicates a relationship between the anomaly and the Permian – Mesozoic complex.

Negligible decrease of 10 mGal of the value of negative Silesian — Opole anomaly may be considered as the result of low thickness of overlying, mainly Cretaceous sediments.

More detailed characteristic of the above mentioned anomalies and of their sources will be given in further chapters of this paper.

ANOMALIES ORIGINATING FROM THE "SHALLOW BASEMENT" (FIG. 4)

With respect to adequate transformations the anomalies originating from the pre-Permian basement were separated (Fig. 1) and residual and regional anomalies were calculated. Taking into account the radius of transformation the residual anomalies can be related mainly to the anomaly producing bodies localized in the upper parts of the pre-Permian formations. The term "shallow basement" used in the tittle of this chapter should be understood in the sense of upper parts of the pre-Permian formations. As the pre-Permian formations are the subject of special interest, the map of residual anomalies for the radius of 12.5 km (Fig. 4) will be first of all the base for below presented analysis. The map of residual anomalies and the horizontal gradient analysis were also used for the complementation of the contour map of local anomalies originating from the pre-Permian basement (Fig. 5). Contours originating from the high horizontal gradient have been recognized as faults or contact zones between rock complexes of diversified density.

The description of residual anomalies due to the pre-Permian basement in successive geological units is given below. Fig. 3 gives the names and extent of mentioned units.

The image of residual anomalies in the Fore-Sudetic area (excluding the Fore-Sudetic Block) can be differentiated into two parts: western part including the Żary Perycline and western part of the Fore-Sudetic Monocline, characterized by fold — and block-type of tectonic deformations of the pre-Permian basement, and eastern part constituted by eastern part of the Fore-Sudetic Monocline and great majority of the Silesian — Cracow Monocline characterized by undisturbed field and broadening of anomalies.

After A. Żelichowski (C. Królikowski ed. et al., 1990) — remarks to the interpretation of geophysical results — it may be assumed, that the area localized west from the line passing from Wrocław to Kalisz can be recognized as a zone of folded Culm of relatively small thickness of Lower Carboniferous deposits manifested in the axes of positive anomalies (due to uplift of older, metamorpized Cambrian - Devonian deposits — Żaków — Święcichowa and Brenna schists) while the negative anomalies could reflect Culm and argillaceous Upper Devonian deposits of bigger thickness. The pattern of residual anomalies in the above mentioned area thus indicate the changes of thicknesses of Culm formations and provide new data to the recent image of the pre-Permian basement (K. Wierzchowska-Kucuła, 1987). After A. Żelichowski, the area localized east from the Wrocław — Kalisz Fault, could be characterized by bigger thickness of Culm deposits which could mask the influence of older deposits on the gravimetric anomalies image. The only one sharply outlined positive anomaly localized northeast of Kalisz may be connected with the uplift of the pre-Carboniferous deposits or with the rise of calcareous Devonian and lowermost Carboniferous deposits out of the range of the Culm sedimentation zone. In opposite, the positive anomaly situated east of Wrocław running along the Laskowice Graben is not connected with the Variscan fold zone and may be caused by different position of the crystalline basement blocks.

Distinct, positive anomaly of parallel course, situated in the southern part of the Silesian — Cracow Monocline, limited south and north by the zone of hightened gradient may originate from lifted, "cut" into the Silesian — Opole Depression, pre-Permian basement block, containing heavy (calcareous) Devonian or older deposits in the basement of Carboniferous.

Band of several positive anomalies localized in the northeastern part of the Fore-Sudetic Block can be connected with the Middle Odra metamorphic massif. The granitoid intrusion anomalies are not manifested probably because of the small size of the granitoid bodies.

The presence of several broad and deep negative anomalies localized in the southwestern extremal part of the Fore-Sudetic Block is a characteristic feature of the region. By analogy to the Strzegom intrusion their relation to similar light rocks seems to be probable.

The negative Strzegom — Sobótka anomaly including also the southern part of metamorphic mantle, could indicate the shallow depth of granitoid under the metamorphic mantle. The extension of anomaly to northeast, out of the range of the massif may be the result of continuation of the granitoid massif in northeastern direction. The smaller value of the anomaly demonstrated in the region seems to be related to deeper occurrence of low density or less thick body.

The Strzegom — Sobótka negative anomaly is bordered from the eastern side by a positive anomaly related to basic and ultrabasic rocks of the Ślęża Group.

With respect to gravimetry the southern extension of the Ślęża and Jordanów anomalies could indicate the continuation of the basic and ultrabasic rocks under the

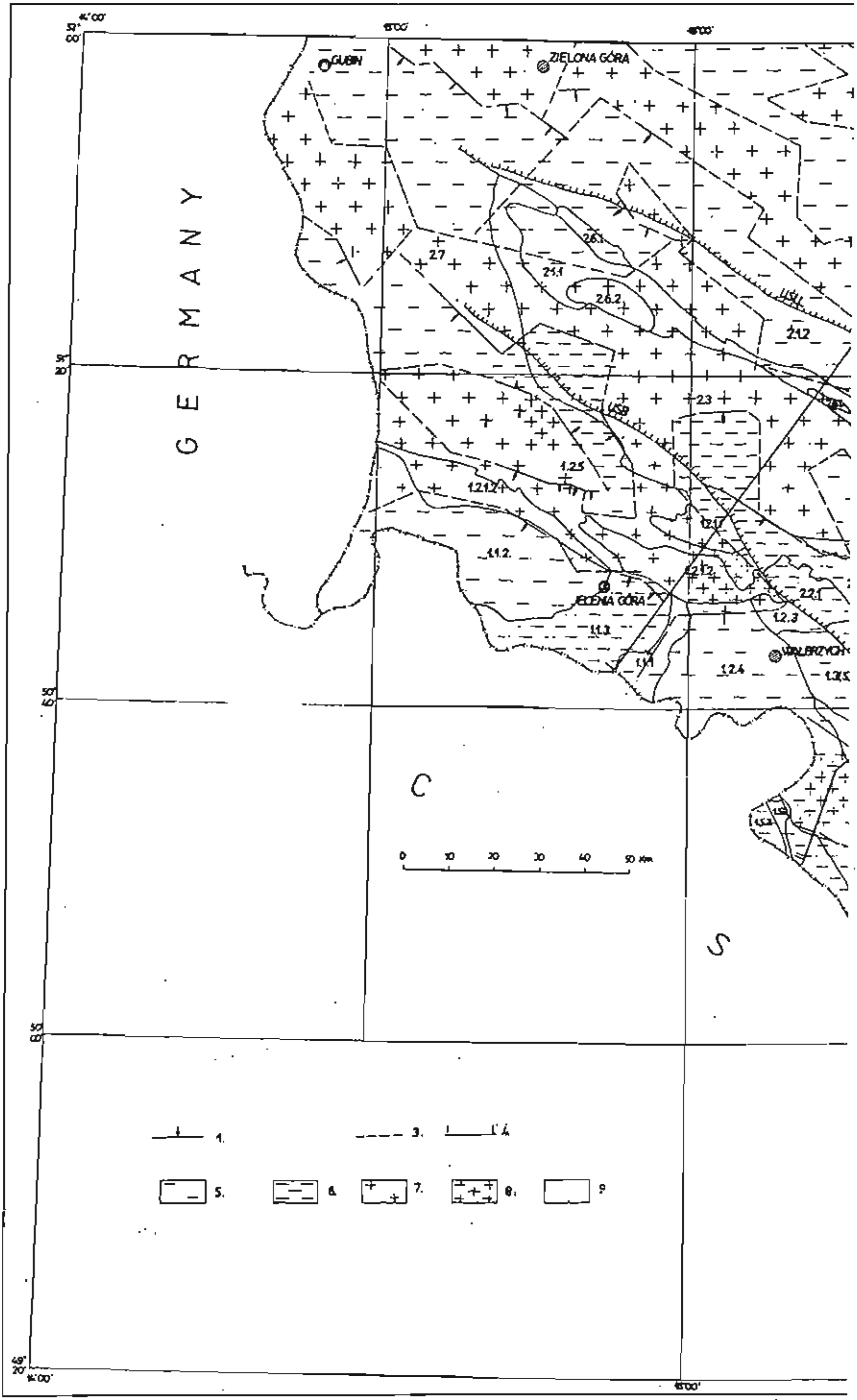

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Fig. 5

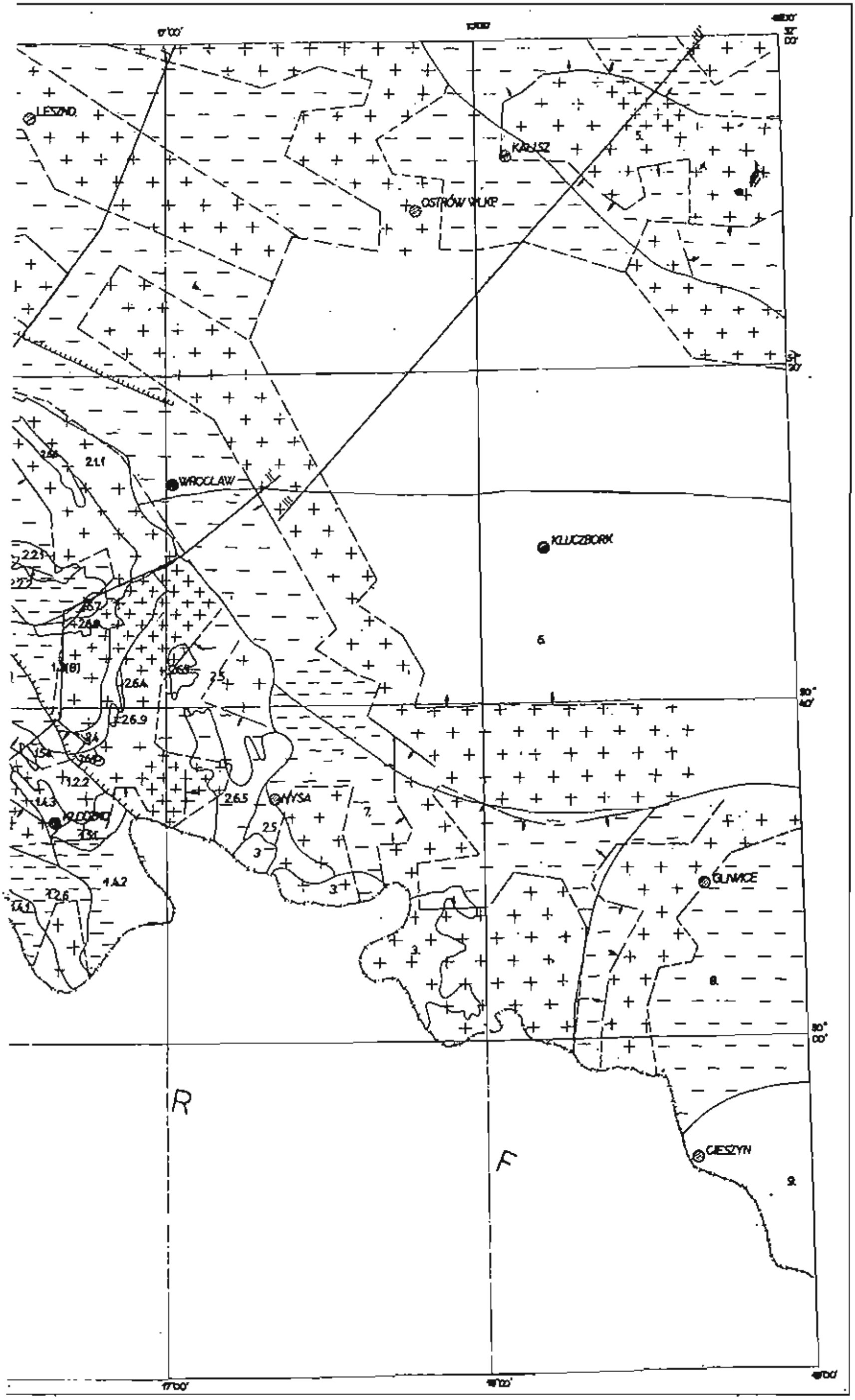
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Fig. 5

Góry Sowie gneisses (J. Oberc, 1972; A. Grocholski, L. Sawicki ed. et al., 1982; J. Znosko, 1984).

The negative anomaly localized southeast from the Ślęża and Jordanów anomaly is partly following the geological lines of the Strzelin granitoids. The position of the anomaly indicates, that the northern part of the above mentioned granitoids runs further to the west under the rocks of the Niemcza – Kamieniec metamorphic massif. The Niedźwiedź positive anomaly localized further to the south, containing also the part of Strzelin – Žulova Massif may indicate the disruption or narrowing of the massif.

As the result of subtraction of the effects from Permian – Mesozoic and Cainozoic of the North Sudetic Synclinorium, a positive anomaly of considerable amplitude was recognized. The presence of this amplitude could indicate the occurrence of heavy greenstones and diabases in the metamorphic basement of the unit. The positive anomaly situated in the southeastern part of the Kaczawa complex, on the Middle Sudetic Synclinorium border may be of a similar origin.

The presence of low, negative anomaly occurring both on the map of residual and regional anomalies may indicate that the "roots" of the Karkonosze granitoids arc localized at considerable depth.

The negative anomaly in Wałbrzych region may be a reflection of not-subtracted effects from the Carboniferous deposits while a narrow, negative anomaly occurring in the southern part of the Góry Sowie gneisses may indicate their considerable thickness or the presence of an narrow granitoid intrusion.

The southern part of the Middle Sudetic Synclinorium as well as the Kłodzko metamorphic massif and Bardo Structure are covered by positive anomalies. The character of the field shows the presence of the same rock-type in the basement of this part of the Middle Sudetic Synclinorium as observed in the northern part of the Kłodzko metamorpic massif. The drop of anomaly value to the southeast, along the line passing Bardo Structure — Kłodzko — Złoty Stok syenite massif — Lądek — Śnieżnik metamorphic massif could indicate the thickness increase of the syenites and of the gneisses.

The southern part of Kłodzko region is characterized by low anomalies, decreasing to the west. The low negative anomaly manifested along the Góry Bystrzyckie and

Fig. 5. Map of local anomalies contours originating from the pre-Permian basement

1 — fault of determined direction of shift or contact zone of two differing in density bodies, direction of density drop marked; 2 — geological units boundaries (description of units — see Fig. 3); 3 — anomalies boundaries; 4 – gravimetric modelling sections; 5–6 — negative residual anomalies: 5 — from –10 to 0 mGal value, 6 — from –20 to 0 mGal value; 7–8 — positive residual anomalies: 7 — from 0 to 10 mGal value, 8 — from 0 to 20 mGal value; 9 — the area of Fore-Sudetic Monocline and Silesian – Crocow Monocline eharacterized by slight gravimetric disturbances; for other explanations see Fig. 3

Mapa konturów anomalii lokalnych pochodzących od podłoża prepermskiego

1 — uskok o określonym kierunku zrzutu bądź kontakt dwóch ośrodków o różnych gęstościach z podanym kierunkiem spadku gęstości; 2 — granice jednostek geologicznych (objaśnienia jednostek jak przy fig. 3); 3 — granice anomalii; 4 — przekroje modelowania grawimetrycznego; 5–6 — ujemne anomalie rezydualne o wartościach: 5 — od –10 do 0 mGal, 6 — od –20 do 0 mGal; 7–8 — dodatnie anomalie rezydualne o wartościach: 7 — od 0 do 10 mGal, 8 — od 0 do 20 mGal; 9 — obszar monokliny przedsudeckiej i śląsko-krakowskiej; pozostałe objaśnienia jak na fig. 3

Góry Orlickie metamorphic massif can indicate the presence of lighter granitoids in the bottom of gneisses.

The low negative anomaly localized northeast of Nysa on the Silesian — Cracow Monocline border may indicate the occurrence of light, granitoid-type rocks of Strzelin — Žulova Massif, in the bigger area than shown on *Geological Map of Poland and of Neighbouring Countries* (1984).

Another negative anomaly manifested on the border between Silesian — Cracow Monocline and Upper Silesian Basin may be connected with bigger thickness of Lower Carboniferous deposits, lighter than the surrounding basement rocks of the basin while the positive anomaly occurring to the south could be interpreted as an effect of lower thickness of the Lower Carboniferous deposits.

The sources of the negative and positive anomalies observed in the western part of the Upper Silesian Basin can be explained in the similar way.

ANOMALIES ORIGINATING FROM THE "DEEPER BASEMENT"

The term "deeper basement" should be understood as the depth below 4–5 km. The anomalies originating from the deeper basement are demonstrated on the maps of regional anomalies. The radius was accepted at 12.5 km.

Two different kind of areas can be distinguished on the map of regional anomalies (Fig. 6): northern area and a part of eastern constituted by the area of high, positive anomalies and the second — southern part, characterized by low or even negative anomalies. The border between these two areas is marked by the axis of high gradient (Fig. 7) of the regional anomalies interpreted as a deep lineation. It follows a line passing from the southern borders of Żary Perycline to southeast through Fore-Sudetic Block to southwest of Wrocław, where it bends, bordering Ślęża Massif, Gogołów — Jordanów Massif, eastern part of Góry Sowie Massif and Wzgórza Strzelińskie metamorphic massif running parallel up to Kluczbork and further meridionally to the state boundary.

The most probable reason of the appearance of the two gravimetric areas is, in accordance to recent data on deep structure of the earth's crust, the depth differentiation of the Moho surface. More detailed discussion on this subject will be presented below while describing the gravimetric modelling results.

Further, detailed studies on regional anomalies of the northern area (block) leds to differentiation of an particular high value anomaly in the region of Zielona Góra and Leszno. A similar area (block), less distinctly manifested and less regular, appears within the Łódź Basin area. The Wrocław block anomaly seems to be very interesting, although its origin because of lack of data on earth's crust is not possible to determinate. With respect to near-surface geology its origin may be regarded as most probably related to concentration of heavy magmatic and metamorphic basic rocks.

Two very low, negative anomalies can be distinguished within the southern area. One of them covers the Karkonosze — Góry Izerskie Block and can be a great depth of the Moho surface and increasing amount of light, granitoid rocks. The other one

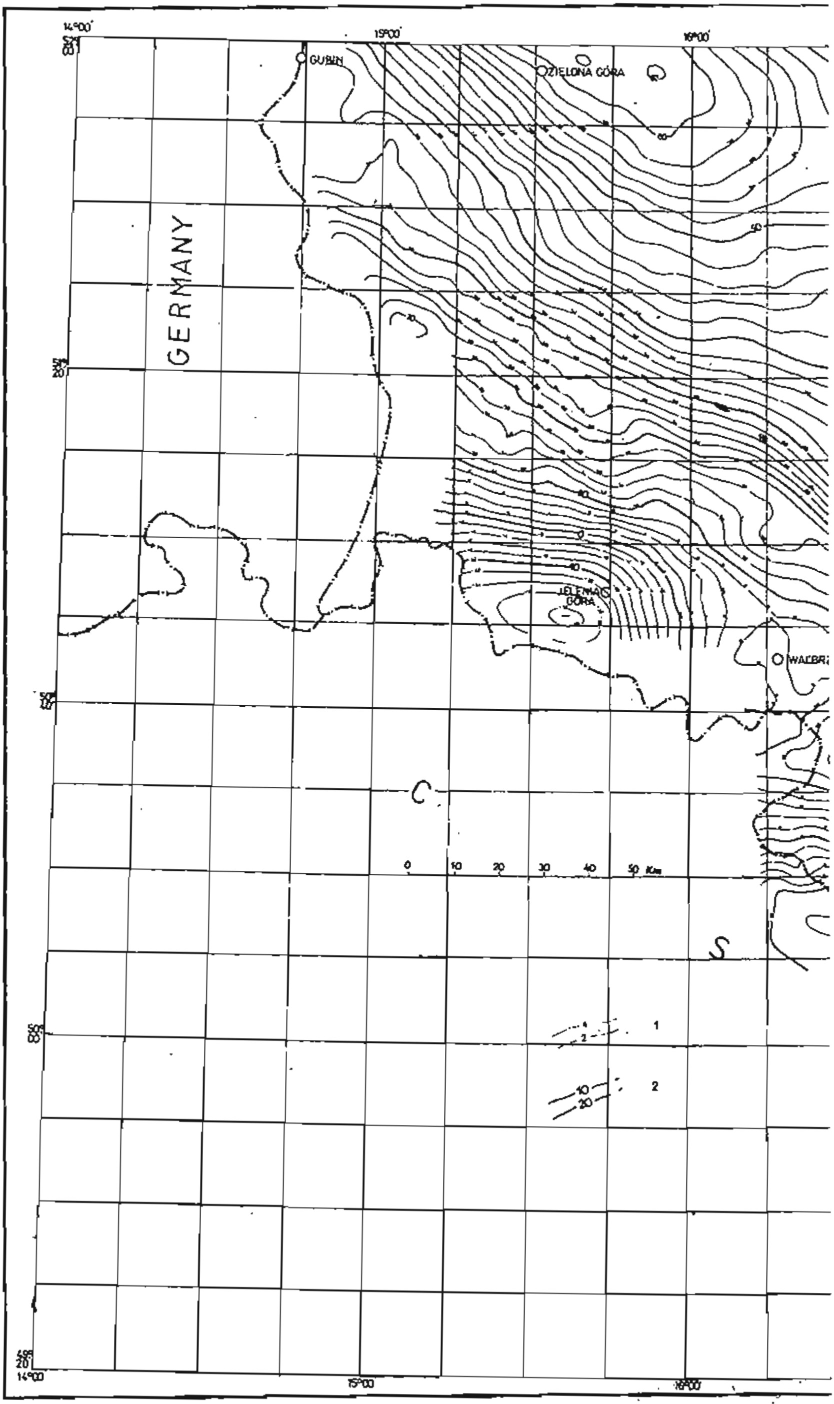
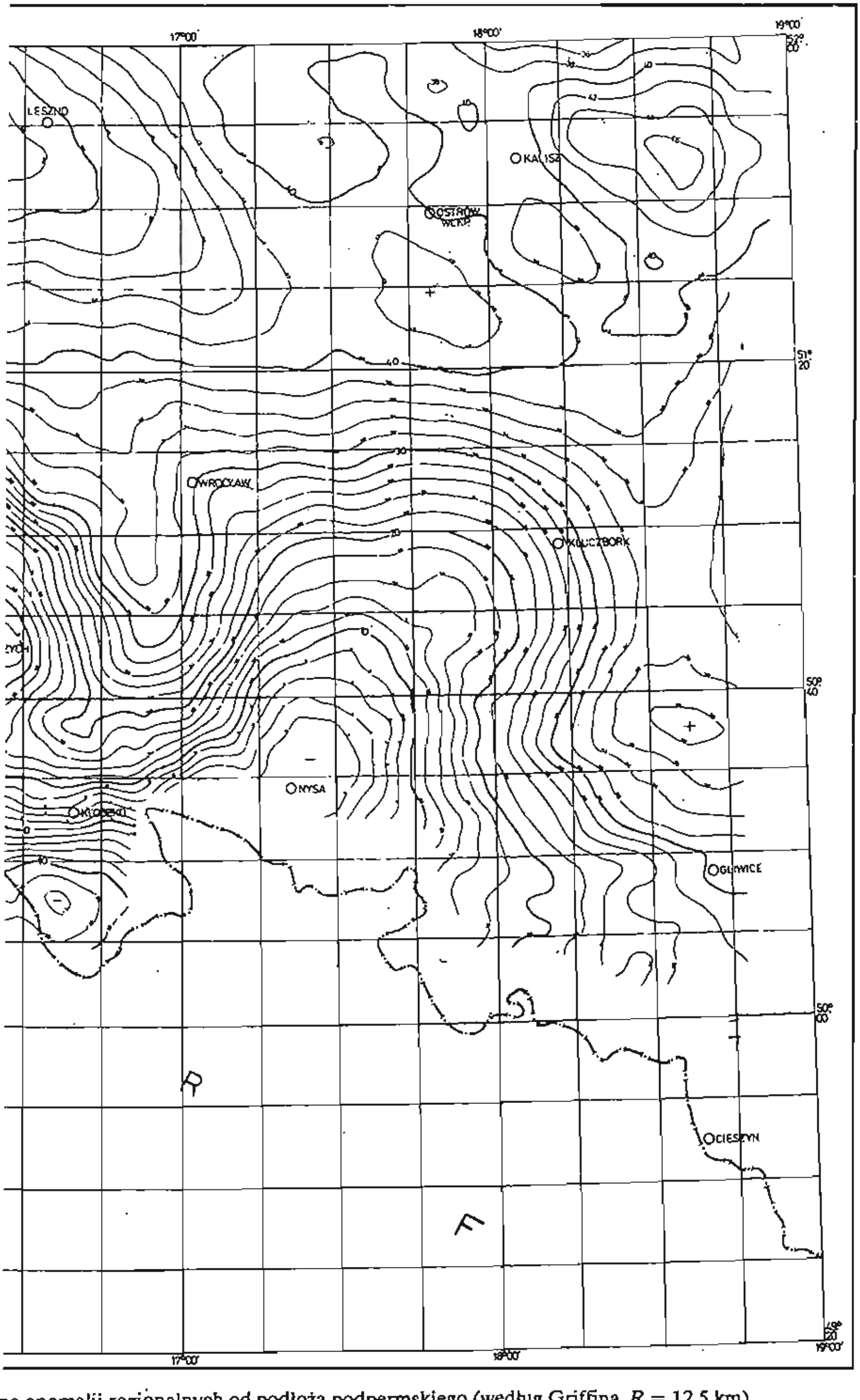


Fig. 6. Map of regional anomalies from the pre-Permian basement (after Griffin, R = 12.5 km)
1 — isolines at 2 mGal interval; 2 — isolines at 10 mGal interval



Mapa anomalii regionalnych od podłoża podpermskiego (według Griffina, R = 12,5 km)
1 — izolinie, których odstęp wynosi 2 mGal; 2 — izolinie, których odstęp wynosi 10 mGal

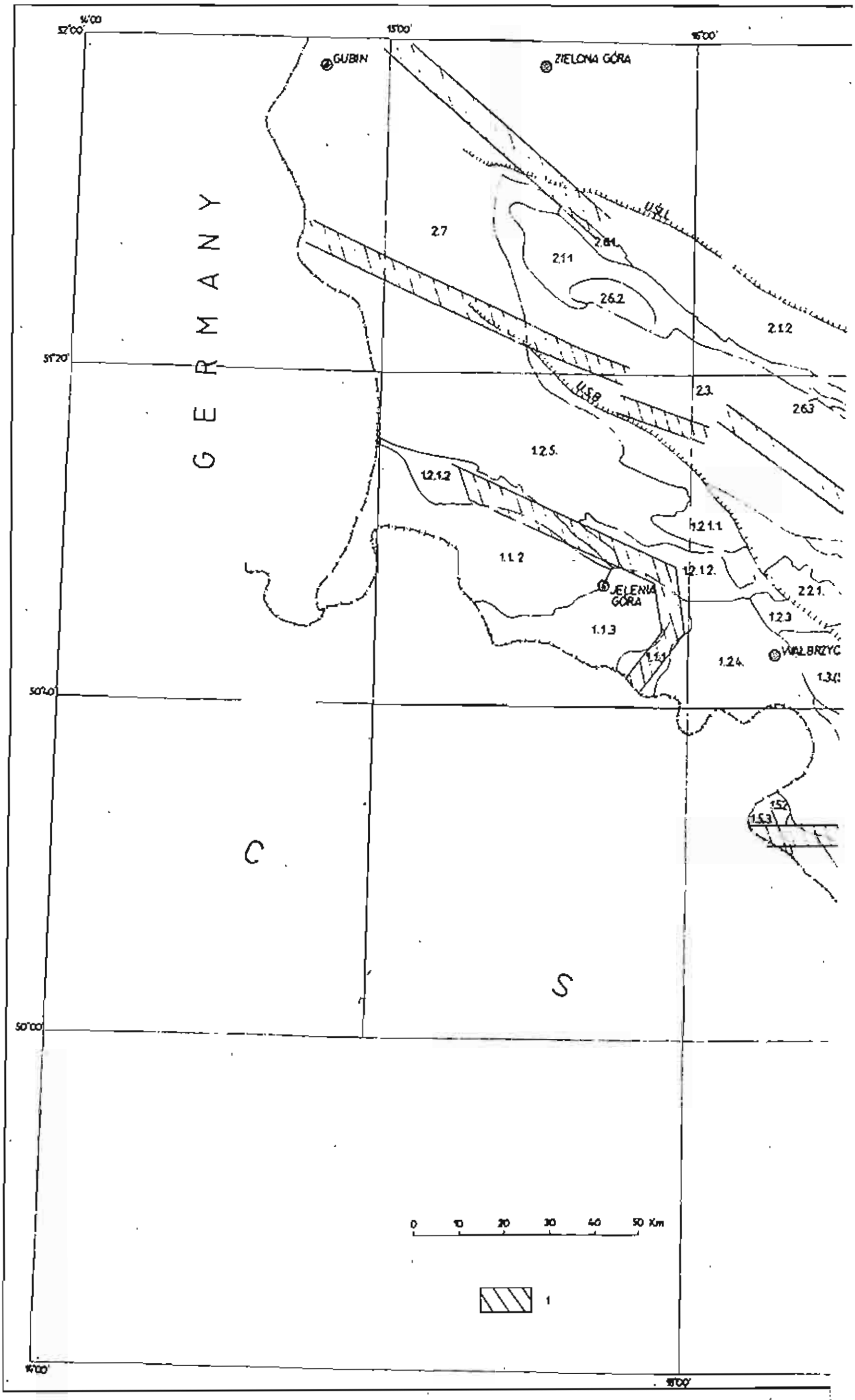
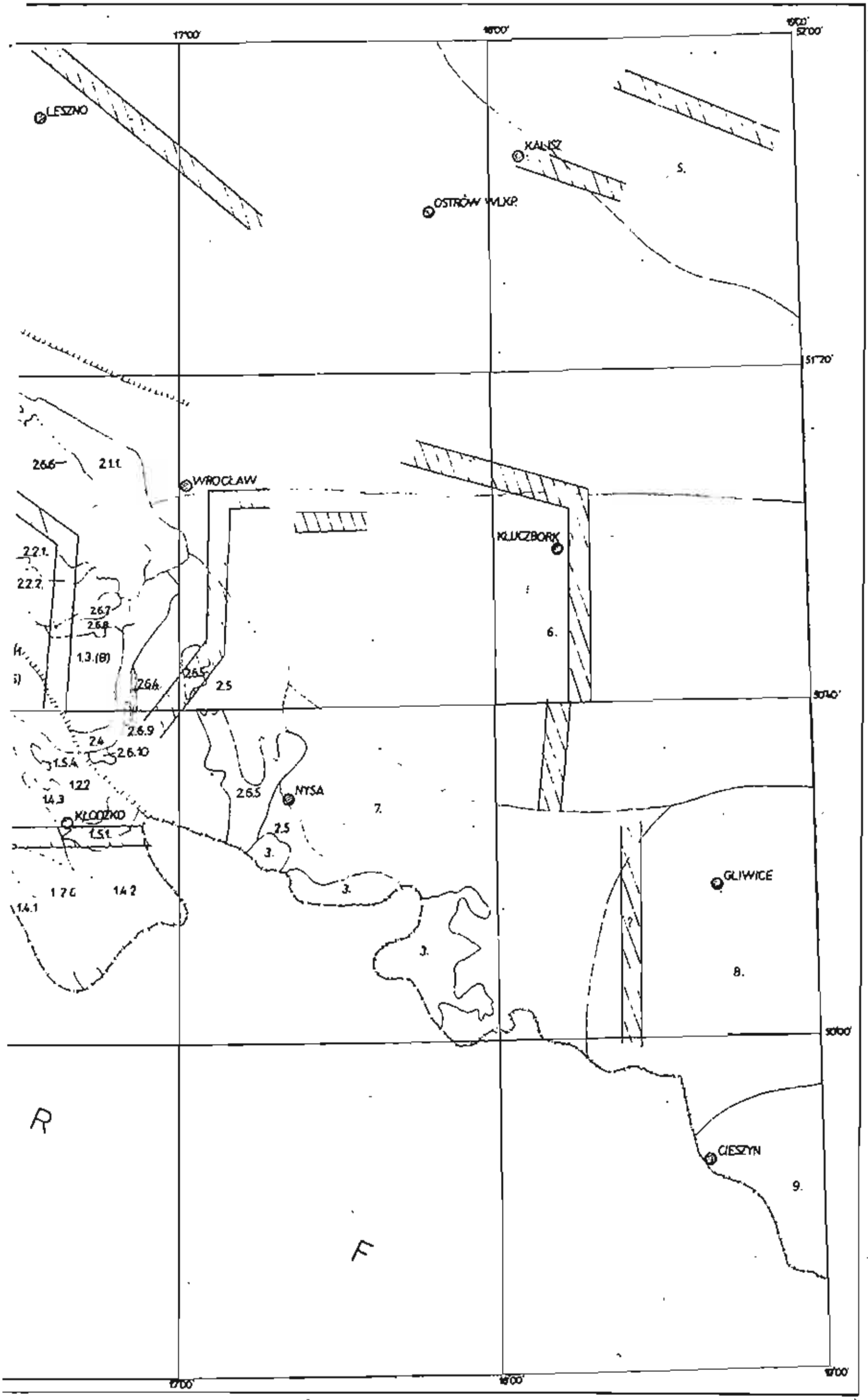


Fig. 7. Sketch map of deep lineaments

1 — zones of deep lineations in earth's crust; for other explanations see Fig. 3



Szkic wgłębnych rozłamów

1 -- strefy głębokich rozłamów skorupy ziemskiej; pozostałe objaśnienia jak na fig. 3

occurs to the south of Kłodzko parallel and can be related to granitoid rocks, too. There are no data there refering to the depth of Moho surface.

Taking into account the results of regional anomalies analysis a conclusion of big difference between residual negative anomalies of the Sudetes and Fore-Sudetic Block (Fig. 4) may be drawn. The sources of the first one can be supposed to occur in shallow (few kilometers) as well as in great depth, while the sources of the second should be localized not deeply. The massifs of light, granitoid rocks can be treated as the shallow sources, whereas the deep sources are regarded as related to descent of the Moho surface and increase of the thickness of light rocks.

Additional remark must be made to the relation between the course of deep lineations (Fig. 7) and known or hypothetic dislocations. The main lineation especially in its western part is approaching to the Marginal Sudetic Fault, but in the neighbourhood of Legnica a shift to northeast and a change of course to southeast across the middle of Fore-Sudetic Block can be observed. Further, to the north of Ślęża Massif the lineation turns to the south and runs across the Góry Sowie Block running far from the known dislocation zones. It is continued after disruption, east from the Niemcza lineament, turns to east reaching the Kluczbork region. The analyse of the course of main lineations does not confirm the existence of the Middle Odra Fault in accordance to conclusions presented by L. Sawicki ed. et al. (1989). Further course of the main lineation to south up till the state border does also not follow the course of known dislocations.

A lineation determining the southwestern border of the block manifested in vicinity of Zielona Góra and Leszno nearly follows the course of northwestern prolongation of the Middle Odra Fault. The northeastern border of the latter block can not be related to any known dislocation.

The lineation constituting the Karkonosze — Góry Izerskie Block is following the course of the Intra-Sudetic Fault whereas the lineation running south of Kłodzko is not manifested within the shallow tectonic elements over the area.

GRAVIMETRIC MODELLING OVER SELECTED PROFILES

CONSTRUCTION OF PRELIMINARY MODELS

Modelling was since several years one of the methods of gravimetric anomalies quantitative interpretation applied to study the medium up to the depth of a few kilometers. Since the last 10–15 years this method was applied as a method of deep structures of earth's crust and of the upper mantle examination (S. S. Kraskowski, 1989).

The interpretation is thus carried out over big areas or along several hundred kilometers long profile lines. The stripping method is very often applied as a first stage of gravimetric modelling, especially on the areas of thick sedimentary cover which has been recognized due to the result of seismic prospection and drillings. The stripping method simplifies the gravimetric modelling process with respect to selection of the proper scale to the degree of recognition of earth's crust structures.

Numerous analyses and interpretations of geophysical data were carried out along the international GSS VII profile. The most complete reports on geophysical modelling have been compiled by T. Grabowska and her team (T. Grabowska et al., 1984; T. Grabowska, M. Raczyńska, 1989) on the base of deep geological cross-sections running across the Polish Lowland interpreted by P. Karnkowski (1980) for the structural model of the sedimentary cover construction.

Compilation of geological cross-sections of Lower Silesia for the purposes of geophysical modelling is very difficult because of insufficient recognition of the deep pre-Permian deposits exposed on the surface or covered by thin or thick Permian-Mesozoic cover. This may explain why the conceptual sections 3–5 km deep for the Lower Silesia, with adequate changes and supplements as well as special sketches compiled by A. Żelichowski for the Fore-Sudetic Monocline, Silesian — Cracow Monocline and Łódź Basin were accepted as preliminary models.

Attachment of measured density to certain rock complexes has been also difficult. Recognition of pre-Permian rock density distribution of Sudetes and Fore-Sudetic Block is good by comparison with other geological regions of the country, however limited to near-surface zone. Making extrapolation of these data into deeper zones one must take into account the relations between rock density and pressure. The density measurements for the remaining area were examined on the basis of the density measurements of the rock samples from bore-cores of few boreholes. The cross-sections along the line of Śnieżka Mt. – Dolsk 1 and Laskowice – Kalisz IG 1 (Fig. 4) are presenting also structural models of the earth's crust in appropriate smaller vertical scale. They have been constructed on the basis of deep seismic soundings from the VII International Profile (A. Guterch et al., 1975) and from the LT-4 Regional Profile (A. Guterch et al., 1980) however there was no possibility of earth's crust models compiling the Zieleniec – Miłochów IG 1 profile because of lack of deep seismic surveys. The extrapolation of the results from the VII International Profile for the purposes of the latter profile could have been risky because of different geology.

The density characteristic of the earth's crust and of the upper mantle has been based on velocity distribution of seismic waves and on correlation between density and velocity. For earth's crust the G. J. Golizdra (1988) formula was used:

$$\sigma = 0.188\,\nu + 1.632$$

where: σ — in g/cm^3; ν — in km/s.

In the velocity range of 2.5–7.0 km/s the calculated density values are very similar to the values calculated from the known J. E. Nafe, C. L. Drake (1957) relation. For the upper mantle the F. Birch (1964) formula was used:

$$\sigma = 0.328\,\nu + 0.613$$

In respect to small changes of limit velocity within the Moho surface (8.0–8.2 km/s) included within the precission interval a density homogeneity of the upper mantle was accepted.

Prepared, as described above, structural-density profiles were the basis for calculation of the gravity effects and comparing its results to the curve of pre-Permian basement anomaly.

THE RESULTS OF MODELLING

The analysis of gravimetric effects leads to the conclusions that the curve of gravimetric effects calculated for analyzed models differs from pre-Permian basement anomalie curve of a distinct profile. The corrections of preliminary models, in respect of structural and density characteristic models was necessary in order to denivelate the differences. Evidenced by geological or seismic survey methods borders were not changed. Also the density corrections had to be included in the density differentiation accepted for certain rock types.

Important changes introduced into the preliminary sections are presented below.

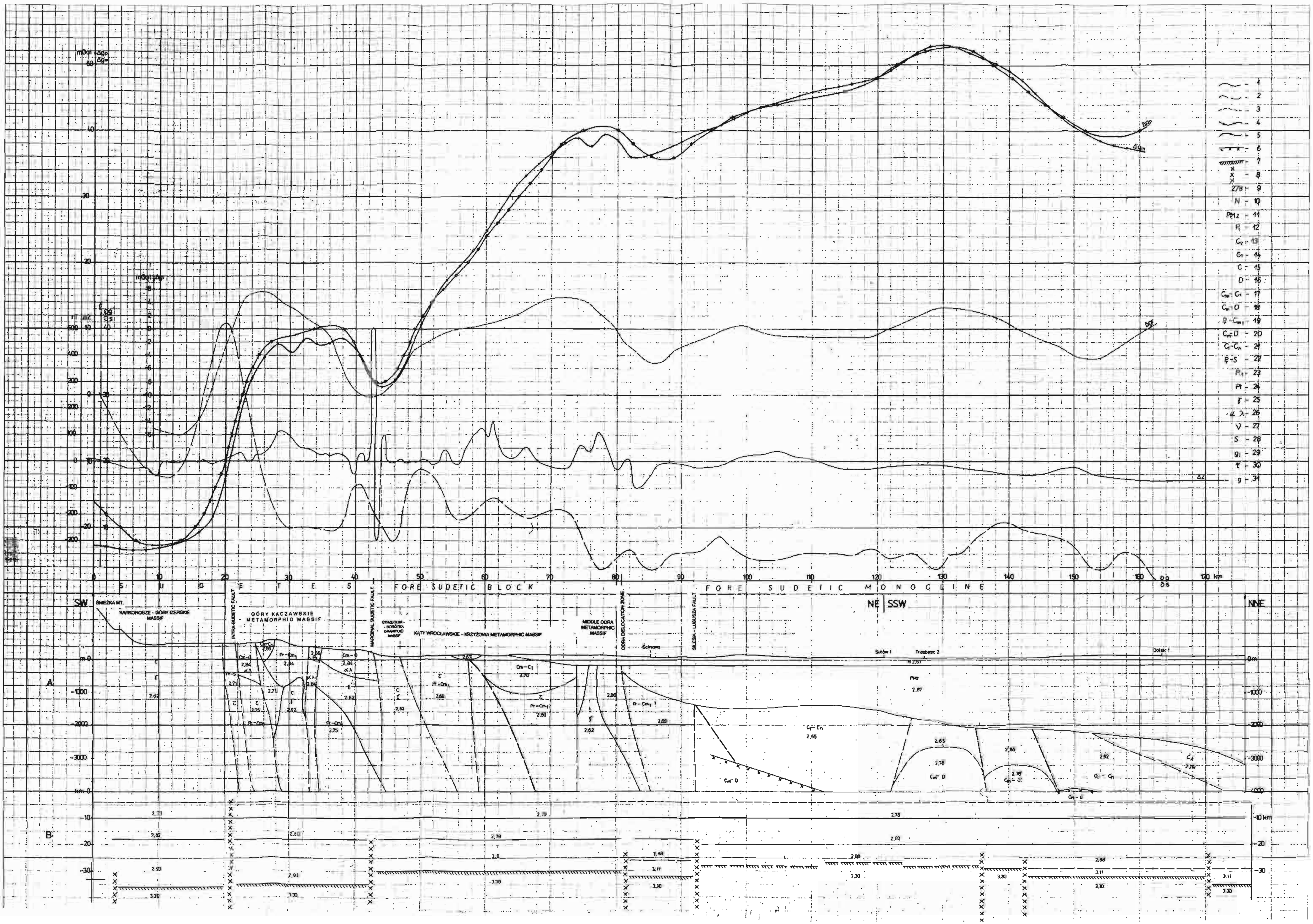
ŚNIEŻKA MT. – DOLSK 1 GEOLOGICAL SECTION (FIG. 8)

Essential changes in relation to the preliminary section have been introduced into the Góry Kaczawskie metamorphic massif. The rock density calculated in the southern edge, within the 1000 m thick, near-surface zone has been augmented to 2.84 g/cm^3. This value can indicate the high content of basic rocks, as manifested above in the description of local anomalies. As a consequence of deep, negative anomaly localized in the northern edge of metamorphic massif a granitoid intrusion has been introduced into the basement of metamorphic rock. The thickness of metamorphic near-surface serie has been diminished.

A possibility of junction of the Karkonosze and Strzegom granitoid massifs within the basement of Góry Kaczawskie metamorphic massif, as suggested by H. Okulus and H. Margul (1973–1974) due to interpretation of the semi-detailed gravimetric map can not be excluded. However the above presented data indicate that the contact of the two above mentioned granitoid complexes could exist only in a form of narrow isthmus at a shallow (few kilometers) depth since the image of regional anomalies (Fig. 6) indicates the granitoid massif of Fore-Sudetic Block "roots" localized at shallow depth.

Introducing of block (folds) of bigger density (2.78 g/cm^3) into the basement of Fore-Sudetic Monocline over the distance of 120–150 km was necessary. As the refraction border considered to be treated as the top of consolidated basement, interpreted by A. Żelichowski as metamorphized Cambrian – Devonian deposits is manifested to the north it may be assumed that the above mentioned border runs further to south, raising slightly (not dropping) in the neighbourhood of introduced blocks. The occurrence of the above mentioned blocks is related to a residual anomaly.

The image of residual anomalies constrained the density increase of the Upper Carboniferous deposits. The hypothetic existence of the latter could be based on the data projected on the profile of Wycisłowo IG 1 borehole.



mGal Δgp, Δgm
Δgp
Δgm
Δz
SUDETES
FORE-SUDETIC BLOCK
FORE SUDETIC MONOCLINE
SW
NNE
NE | SSW
ŚNIEŻKA MT.
KARKONOSZE - GÓRY IZERSKIE MASSIF
INTRA-SUDETIC FAULT
GÓRY KACZAWSKIE - METAMORPHIC MASSIF
MARGINAL SUDETIC FAULT
STRZEGOM - SOBÓTKA GRANITOID MASSIF
KĄTY WROCŁAWSKIE - KRZYŻOWA METAMORPHIC MASSIF
MIDDLE ODRA METAMORPHIC MASSIF
ODRA DISLOCATION ZONE
SILESIA - LUBUSZA FAULT
Ścinawa
Sułów 1
Trzebosz 2
Dolsk 1
A
B
km

Fig. 8. Gravimetric modelling along Śnieżka Mt. – Sułów 1 – Dolsk 1 profile

1 — vertical component curve of the magnetic field ΔZ; 2 — horizontal gradient curve after Rosenbach; 3 — residual anomalies curve from the sub-Permian basement after Griffin R = 12.5 km; 4 — gravimetric anomalies curve from the sub-Permian basement; 5 — gravimetric anomalies curve from the assumed model; 6 — refraction horizon 5800–6500 m/s after S. Młynarski's map; 7 — Moho surface; 8 — zones of deep lineaments; 9 — rock density in g/cm^3; 10 — Neogene; 11 — Permian – Mesozoic; 12 — Rotliegendes; 13 — Upper Carboniferous; 14 — Lower Carboniferous; 15 — Carboniferous; 16 — Devonian; 17 — Cambrian – Lower Carboniferous; 18 — Cambrian – Ordovician; 19 — pre-Cambrian – Lower Cambrian; 20 — Cambrian – Devonian; 21 — Lower Carboniferous – Upper Carboniferous; 22 — pre-Cambrian – Sylurian; 23 — Lower Palaeozoic; 24 — Proterozoic basement; 25 — granites, syenites, granitoids; 26 — diabases and greenstones, 27 — gabbro rocks; 28 — serpentinites; 29 — Kowary gneisses; 30 — mica schists and paragneisses; 31 — gneisses in general

Modelowanie grawimetryczne wzdłuż profilu Śnieżka – Sułów 1 – Dolsk 1

1 — krzywa składowej pionowej pola magnetycznego ΔZ; 2 — krzywa gradientu poziomego według Rosenbacha; 3 — krzywa anomalii rezydualnych od podłoża podpermskiego według Griffina R = 12,5 km; 4 — krzywa anomalii grawimetrycznych od podłoża podpermskiego; 5 — krzywa anomalii grawimetrycznych od założonego modelu; 6 — poziom refrakcyjny ok. 5800–6500 m/s według S. Młynarskiego; 7 — powierzchnia Moho; 8 — strefy wgłębnych rozłamów; 9 — gęstość skał w g/cm^3; 10 — neogen; 11 — permo-mezozoik; 12 — czerwony spągowiec; 13 — karbon górny; 14 — karbon dolny; 15 — karbon; 16 — dewon; 17 — kambr – karbon dolny; 18 — kambr – ordowik; 19 — prekambr – kambr dolny; 20 — kambr – dewon; 21 — karbon dolny – karbon górny; 22 — prekambr – sylur; 23 — dolny paleozoik; 24 — podłoże proterozoiczne; 25 — granity, syenity, granitoidy; 26 — diabazy i zieleńce; 27 — gabra; 28 — serpentynity; 29 — gnejsy kowarskie; 30 — łupki łyszczykowe i paragnejsy; 31 — gnejsy w ogólności

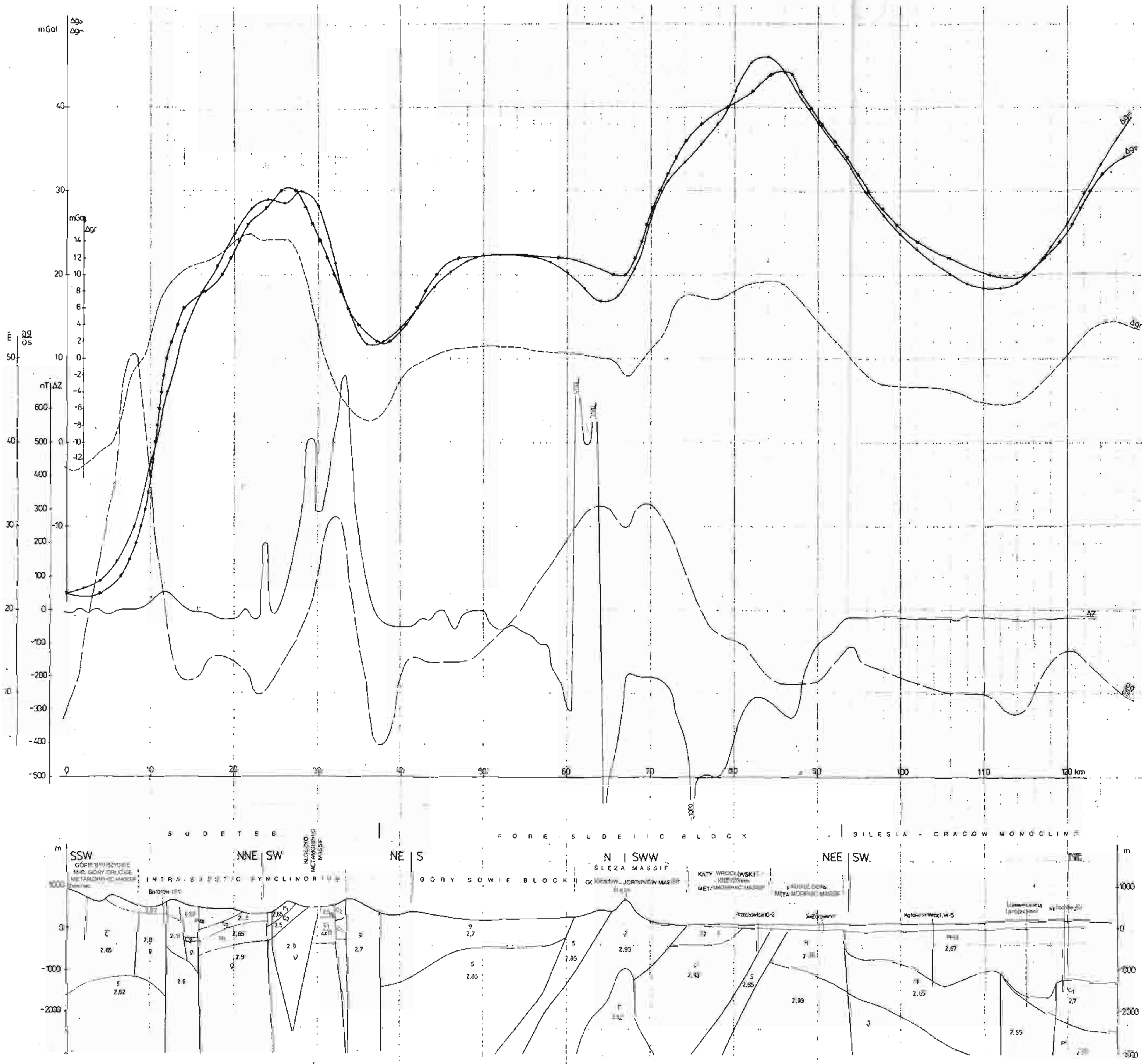


Fig. 9. Gravimetric modelling along Zieleniec – Batorów IG 1 – Ślęża – Miłochów IG 1 profile
For explanations see Fig. 8
Modelowanie grawimetryczne wzdłuż profilu Zieleniec – Batorów IG 1 – Ślęża – Miłochów IG 1
Objaśnienia jak na fig. 8

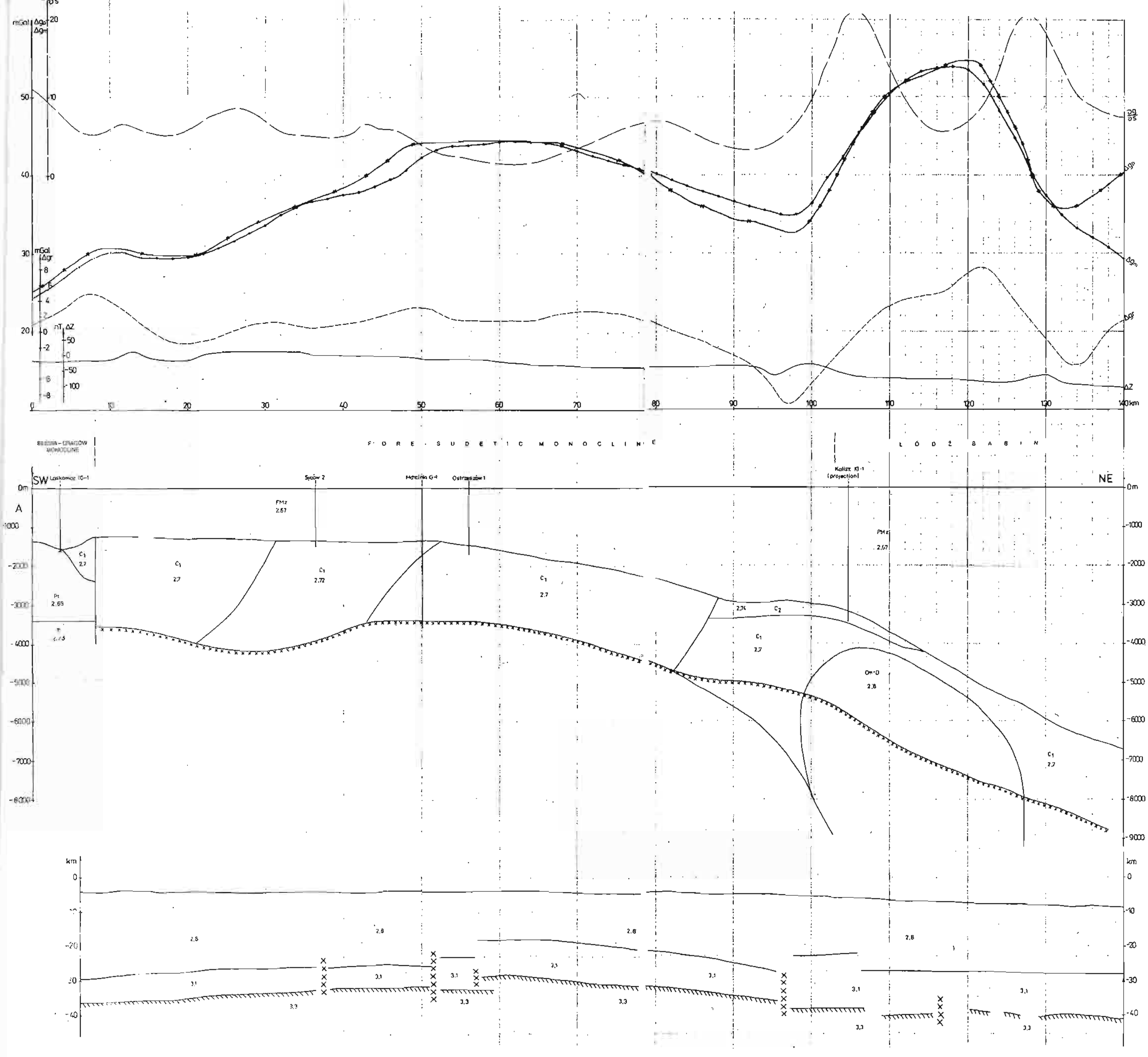


Fig. 10. Gravimetric modelling along Laskowice IG 1 – Syców 2 – Kalisz IG 1 profile
For explanations see Fig. 8
Modelowanie grawimetryczne wzdłuż profilu Laskowice IG 1 – Syców 2 – Kalisz IG 1
Objaśnienia jak na fig. 8

In respect to the rules of construction of the model of earth's crust as presented above, one important change has been introduced. A presence of a transitional zone between the earth's crust and the upper mantle at the depth of 28–32 km is signalized within the Fore-Sudetic Monocline, beginning from the hypothetic Silesian — Lubusza Fault up to 142 km as seen in the deep seismic soundings results (A. Guterch et al., 1973). In spite of determination, the deeper depth as the crust bottom, the Authors of the cited paper state, that each of the borders due to its dinamic and kinematic properties may be regarded as the crust bottom. For the broad Krosno — Ostrzeszów high modelling, the upper boundary was considered as the Moho surface. The depth of Moho surface at the area should be still an open problem which will be explained after compiling the results of the projected GB-2 profile.

The course of vertical component of the magnetic field has been drawn in the upper part of the profile. Small anomalies situated on the Fore-Sudetic Block are related to Tertiary basalts which are not marked on the profile.

ZIELENIEC – BATORÓW IG 1 – ŚLĘŻA – MIŁOCHÓW IG 1 GEOLOGICAL PROFILE (FIG. 9)

In reference to the preliminary section over the the Góry Bystrzyckie and Góry Orlickie metamorphic massif the depth of granitoid body has been diminished from 1850 to 1200 m.

Within the Middle Sudetic Synclinorium a rock of greater density (2.90 g/cm^3) of the gabbro-type can be expected to occur under the Lower Palaeozoic deposits. The limitation of the gneiss thickness within the Góry Sowie Block through introducing into their basement heavy rocks (2.85 g/cm^3) of serpentinite or gabbro-type was another necessary change to be introduced.

Further change — is the diminution of the thickness of mica schists and paragneisses and simultaneous thickness increase of gabbro-type rocks within Kąty Wrocławskie — Krzyżowa metamorphic massif.

The above mentioned profile has been modelled unfortunatelly only to the depth of 2–3 km taking into assumption homogeneity of the rest of earth's crust.

LASKOWICE IG 1 – SYCÓW 2 – KALISZ IG 1 GEOLOGICAL PROFILE (FIG. 10)

In the relation to the initial model of the A profile one essential change mainly introduction within the Permian – Mesozoic of deep basement of 0.1 g/cm^3 higher density in comparison to the surrounding rocks has been made. This body has been, in accordance to A. Żelichowski suggestion, interpreted as Cambrian – Devonian structure uplifted in Lower Carboniferous. Probably this structure limited by faults and negative anomalies manifested in the near-fault zones may have been related to depression filled up with lighter rocks.

The refraction horizon, related to the consolidated Older Palaeozoic basement is generally corresponding with Moho surface in the section line. The lineations occurring within the deep parts of earth's crust on the interval 38 to 57 and 96 km are responsible for a few kilometers high uplift of the central part of earth's crust. The above mentioned uplift gives a reflexion in the structure of the crystalline basement top and in the position of the Older Palaeozoic deposits as indicated by the refraction horizon of 5800–6500 m/s limit velocity manifested in the 30–85 km interval of the profile. Part of the crust occupying the Łódź Basin displays strong tectonical engagement.

CONCLUSIONS

Due to the stripping method and adequate transformations a new structure of the anomaly originating from the pre-Permian basement at the Lower Silesia area was obtained. This new anomaly image requires further, first of all geological analyses. Taking into account the petrographical, mineralogical, satellite image data and information of geological evolution of this region, a detailed geological interpretation of the obtained anomalies and their regionalization should be made utilizing also geological and geophysical data from the Czechosloviakian side. Such project is undertaken by the geologists from the Lower Silesian Branch of State Geological Institute. The stripping method analyse was applied, up till date over the western part of the country. A continuation of relevant studies over eastern part of Poland seems to be necessary.

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WSTĘPNE WYNIKI INTERPRETACJI GEOFIZYCZNEJ (METODA STRIPPINGU) W POWIĄZANIU Z BUDOWĄ PODŁOŻA PODPERMSKIEGO W SW POLSCE

Streszczenie

W omawianym obszarze wydzielono szereg dotychczas nieznanych anomalii grawimetrycznych pochodzących głównie od utworów prepermskich. Wstępna ocena oraz próba określenia genezy ważniejszych zaburzeń jest wynikiem przeprowadzonego strippingu. Podstawą analizy były grawimetryczne mapy transformowane obejmujące obszar południowo-zachodniej Polski.

Peryklina Żar i monoklina przedsudecka, po linię Wrocław — Kalisz, jest pokryta anomaliami wyraźnie pasmowymi, ukierunkowanymi w liniach NW–SE, miejscami poprzerywanymi i poprzesuwanymi. Anomalie te świadczą prawdopodobnie o fałdowej budowie podłoża, miejscami poprzecinanego uskokami poprzecznymi. Obszar leżący na wschód od linii Wrocław — Kalisz, obejmujący monoklinę przedsudecką i północną część monokliny śląsko-krakowskiej, charakteryzuje się niezaburzonym lub słabo zaburzonym polem siły ciężkości. A. Żelichowski fakt ten tłumaczy znacznym wzrostem miąższości sfałdowanych skał karbonu, które maskują wpływ skał starszych. Dodatnia anomalia ukierunkowana równoleżnikowo w południowej części monokliny śląsko-krakowskiej, ograniczona od południa i północy strefami gradientowymi, może być wywołana wyniesionym blokiem podłoża prepermskiego. Istnieją uzasadnione przypuszczenia, iż blok ten w podłożu karbonu zawiera cięższe utwory (węglanowe) dewonu lub starsze. W północno-wschodniej części bloku przedsudeckiego notuje się ciąg anomalii dodatnich, które wiążą się z metamorfikiem środkowej Odry. Południowo-zachodnią część omawianego bloku cechuje kilka rozległych anomalii ujemnych, które częściowo kontynuują się na obszarze sudeckim. Prawdopodobnie są one wywołane lekkimi skałami intruzywnymi. Dodatnia anomalia Ślęży i Jordanowa, związana z ciężkimi skałami zasadowymi, obejmuje wschodnią część masywu sowiogórskiego i strefę Niemczy. Można przypusz zać, iż pod gnejsami Gór Sowich występują ciężkie skały zasadowe. Na południowy wschód od anomalii Ślęży i Jordanowa występuje zaburzenie ujemne, częściowo pokrywające wychodnie granitoidów strzelińskich. Usytuowanie tego zaburzenia sugeruje, iż intruzja północnej części granitoidów rozciąga się na zachód i wchodzi pod skały metamorfiku środkowej Odry. Dodatnie anomalie z synklinorium północnosudeckiego oraz południowo-wschodniej części kompleksu kaczawskiego mają podobną genezę. Przypuszcza się bowiem, iż wywołują je ciężkie zieleńce i diabazy podłoża metamorficznego. Ujemna anomalia związana z granitoidami karkonoskimi wskazuje na ich głębokie zakorzenienie. Ujemną anomalię z rejonu Nysy, na granicy z monokliną śląsko-krakowską, należy łączyć z występowaniem granitoidów mających związek z masywem strzelińsko-żulowskim. Inną anomalię ujemną na granicy monokliny śląsko-krakowskiej i zapadliska górnośląskiego należy wiązać z większymi miąższościami utworów dolnokarbońskich.

Na podstawie mapy anomalii regionalnych wyróżniono dwie prowincje grawimetryczne: północną o wysokich anomaliach oraz południową o niskich. Prowincje te przypuszczalnie rozgranicza wgłębny rozłam skorupy (fig. 8).

Na przedstawionych profilach regionalnych dokonano interpretacji ilościowej. W procesie modelowania grawimetrycznego wprowadzono na przekrojach geologicznych szereg modyfikacji zarówno w odniesieniu do "płytkiej", jak i wgłębnej" budowy skorupy ziemskiej.