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Division of the Middle Sudetes and their Foreland — a proposal of modification

Within the Middle Sudetes and their Foreland (after E. Bederke, 1929) two zones of fold structures, divided by the Niemcza Zone passing into the Upper Nysa Kłodzka Graben, can be distinguished. These are the Mid-Eastern Sudetes, occupying the area between the Niemcza Zone on the east up to the Ramzova Overthrust, characterized by folds running N-S and NNE-SSW and the Kłodzko - Góry Sowie Block on the west. This block is as the Góry Sowie Block described. He is surrounded and underlayed by ultrabasic and basic rocks and characterized by folds running NNW-ESE. Movements of the block to the east effected in folding of Mid-Eastern and Eastern Sudetes. The Cadomian Imbramowice metamorphic massif localized west from the Niemcza Zone is characterized by folds running SW-NE. Analysis of the fold direction led to the conclusions that it should be treated as a part of Mid-Eastern Sudetes Foreland while taking into account the Niemcza Zone as a part of the Middle Sudetes Foreland.

INTRODUCTION

The Sudetes together with the Fore-Sudetic Block, although differing in morphology, create together a tectonic structure (Sudetic Structure) characterized by the same geological development. The above mentioned units are separated by the Marginal Sudetic Fault which was developed following the Old Variscan Dislocation and is responsible for uplifting of the Fore-Sudetic Block. As a consequence of the uplifting processes the Fore-Sudetic Block has been affected by deep erosion (H. Cloos, 1922) especially manifested within the synclinal units of the Bardo and Świebodzice structures, preserved only within the Sudetic Block (J. Oberc, 1967). Some of the units cut by the marginal dislocation, which developed in 2 phases, such as: Góry Kaczawskie Structure, Góry Sowie Block and metamorphic massifs localized E and SE from the block occur both within the Sudetic and Fore-Sudetic blocks.

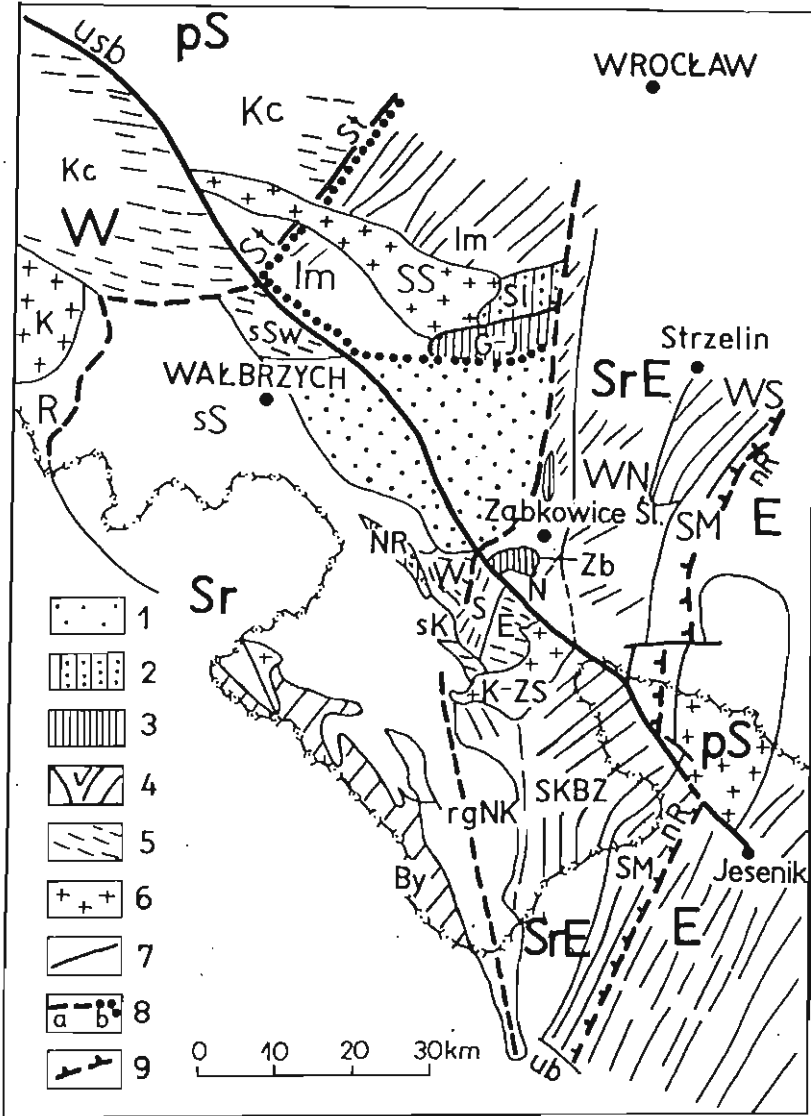


Fig. 1. Position of the Mid-Eastern Sudetes and of their Foreland

1 — Góry Sowie Block; 2 — basic rocks; 3 — ultrabasic rock; 4 — lineation of the Cadomian metamorphic massifs (and Eastern Sudetes Palaeozoic); 5 — lineation and fold directions of the Palaeozoic; 6 — Variscan granitoids; 7 — some more important dislocations; 8 — boundaries of Middle Sudetes and Mid-Eastern Sudetes tectonic structures (a), version of Imbramowice and Wzgórza Niemczańskie massifs linked together (b); 9 — eastern boundary of the Mid-Eastern Sudetes (Ramzova Overthrust); By — Góry Bystrzyckie metamorphic massif; E — Eastern Sudetic Structure; Im — Imbramowice Unit (massif); K — Karkonosze granite massif; Kc — Kaczawa Structure; K-ZS — Kłodzko — Złoty Stok granitoid massif; N — Niemcza Zone (unit); nR — Ramzova Overthrust; NR — gabbro (and diabases) of Nowa Ruda; pS — Fore-Sudetic

The concept of "Middle Sudetes" has been introduced for the first time by E. Bederke in 1929. The Author did not present the detailed division of the Sudetic Structure but only the modification of the division further proposed by H. Cloos (1922). After H. Cloos the division of Sudetic Structure is as follow:

1. The Western Sudetes and their Foreland including all the tectonic units of a higher order up to the Góry Sowie Block and Upper Nysa Kłodzka Graben in the W; the Świebodzice Structure distinguished by H. Teisseyre (1956) has been considered as a part of Intra-Sudetic Synclinorium.

2. The Eastern Sudetes and their Foreland including crystalline and sedimentary series of Jeseník and Strzelin – Żulova granitoid massif.

3. North-South Zone (Nord-Süd Zone) developed between the Eastern and Western Sudetes including Śleza Group, Niemcza and Złoty Stok syenites, gabbro and serpentinites of Ząbkowice Śląskie, Góry Bardzkie Mts and Upper Nysa Kłodzka Graben.

After E. Bederke (1931) the border between the Eastern and Western Sudetes (the Middle Sudetes treated as the part of the Western Sudetes) is running along the Ramzova Overthrust (described for the first time by F. Kretschmer in 1897 as the Moldanubian Overthrust) and extending within the Fore-Sudetic Block parallel to the eastern boundary of the Niemcza Zone (Niemcza Dislocation after J. Oberc, 1987). The North-South Zone distinguished by H. Cloos is localized within the Middle Sudetes and their Foreland, while the boundary between Western and Eastern Sudetes runs after E. Bederke (1929) along the western boundaries of the

Block; G-J — serpentinite massif of Gogołów – Jordanów; R — Rudawy Janowickie metamorphic massif; rgNK — Upper Nysa Kłodzka Graben; sK — Kłodzko Structure; Sl — Śleza gabbro massif; SKBZ — metamorphic massif of Śnieżnik, Krowiarki, Góry Białskie, Góry Złote; SM — Stare Město Zone; Sr — Middle Sudetes; sS — Strzegom – Sobótka granitoid massif; SrE — Mid-Eastern Sudetes; sSw — Świebodzice Structure; St — Strzegom Fault; ub — Bušin Fault; usb — Marginal Sudetic Fault; W — Western Sudetes; WN — Wzgórza Niemczańskie metamorphic massif; WS — Wzgórza Strzelińskie crystalline massif; WSE — Bardo Structure (W — western part, S — middle part, E — eastern part); Zb — Ząbkowice Śląskie serpentinites and gabbro

Pozycja Sudetów środkowo-wschodnich i ich przedpola

1 — blok sowiogórski; 2 — skały zasadowe; 3 — skały ultrazasadowe; 4 — lineacja w metamorfikach kadomskich (i paleozoiku Sudetów Wschodnich); 5 — lineacja i kierunki fałdów w utworach paleozoicznych; 6 — granitoidy waryscyjskie; 7 — niektóre ważniejsze uskoki; 8 — granice struktur tektonicznych Sudetów środkowych i środkowo-wschodnich (a), wersja granicy przyłączeniowej metamorfików Imbramowic i Wzgórz Niemczańskich (b); 9 — wschodnia granica Sudetów środkowo-wschodnich (nasunięcie ramzowskie); By — metamorfik Gór Bystrzyckich; E — struktura wschodniosudecka; Im — jednostka Imbramowic; K — masyw granitowy Karkonoszy; Kc — struktura kaczawska; K-ZS — masyw granitoidowy kłodzko-złotostocki; N — strefa (jednostka) Niemczy; nR — nasunięcie ramzowskie; NR — gabra (l diabazy) noworudzkie; pS — blok przed-sudecki; G-J — masyw serpentynitowy Gogołowa – Jordanowa; R — metamorfik Rudaw Janowickich; rgNK — rów górnej Nysy Kłodzkiej; sK — struktura kłodzka; Sl — masyw gabbrowy Ślezy; SKBZ — metamorfik śnieżnicki, Krowiarek, Gór Białskich, Gór Złotych; SM — strefa Starego Města; Sr — Sudety środkowe; sS — masyw granitoidowy Strzegomia – Sobótki; SrE — Sudety środkowo-wschodnie; sSw — struktura Świebodzic; St — uskoki Strzegomia; ub — uskoki buszyński; usb — uskoki sudecki brzeżny; W — Sudety Zachodnie; WN — metamorfik Wzgórz Niemczańskich; WS — krystalinik Wzgórz Strzelińskich; WSE — struktura bardzka (W — część zachodnia, S — część środkowa, E — część wschodnia); Zb — serpentynity i gabra Ząbkowic Śląskich

Świebodzice Structure, Intra-Sudetic Synclinorium and along southern part of the Kaczawa Structure.

The above mentioned regional division, not taking into consideration the historical aspect, is utilized up till now but the Author is presenting the opinion of pre-Sudetic extend of the Ramzova Overthrust along the eastern slope of the Wzgórza Strzebińskie Hills (J. Oberc, 1968).

The paper does not include the problems of division of the Sudetes into structural stages (J. Oberc, 1960). The utilized concept of "Middle Sudetes" includes also their Foreland.

DIFFERENTIATION OF THE STRUCTURAL UNITS OF THE MIDDLE SUDETES

Big differentiation of structural units observed within the Middle Sudetes is illustrated on Fig. 1. The differentiation is manifested by:

- age of formations and deformations within distinct units;
- direction and vergence of folds;
- diastrophic character of sedimentary structures (deep-marine sediments including flysch and volcanites, molasse series with subsequent volcanites, shelf sediments), presence of superimposed folds.

The biggest differentiation is manifested west from the line running along the eastern edge of the Góry Sowie Block up to the southern part of Góry Bystrzyckie and Góry Orlickie Mts. The oldest elements (Moldanubian rocks of the Góry Sowie Block) and the deepest, undercrust ultrabasic and basic rocks surrounding the Góry Sowie Massif and forming a main, most uplifted part of the Sudetic Structure are the most characteristic units of the region. In the neighbourhood of the Góry Sowie Block several younger, Upper Palaeozoic units: Bardo, Świebodzice, Niemcza structures and Intra-Sudetic Synclinorium are observed (partially overlying the block or lying on basic and ultrabasic rocks). Uplifting of the Moldanubian Block relative above the level of surrounding structures required long-lasting and multi-phase movements. The detrital material has been delivered from the above mentioned region since Upper Devonian (E. Bederke, 1929).

The units of western part of the Middle Sudetes are characterized by differentiated geology which can not be illustrated on a map. The main units are as follow:

1. Sedimentary serie of the Bardo Structure (0-C₁), folded during the Sudetic Phase is characterized by the presence of fold thrust, slices and napps (in the southern part). The rocks display only anchimetamorphism. In the middle part of the structure meridional superimposed folds of the Asthurian age are observed.
2. Kłodzko Structure (0-D₁), displaying fold structure and epimetamorphic processes probably of Young Caledonian age (excluding older Cadomian elements).
3. Świebodzice Structure (D₃-C₁ gatt.) characterized by presence of non-metamorphosed rocks and medi-type platform folds formed during the Nassau Phase.

4. Intra-Sudetic Synclinorium (C_1-T_1 , Kr_2) of platforme structure with elements of Asthurian intrusive tectonics. Compressive tectonic activity had also manifested during the Laramide Phase.

The geology of the Niemcza Zone is not sufficiently recognized up till now the zone is treated as the branch of the Bardo Structure. Also the Imbramowice Unit is not sufficiently recognized. It is composed of epi- and mezozonal rocks showing a SW-NE lineation and considered to be older than the Sudetic folding processes manifested within the Góry Kaczawskie Mts. A distinct similarity between the Imbramowice Unit and Wzgórza Niemczańskie Hills of the eastern part of Middle Sudetes is observed. It must be noted, that the Imbramowice and Wzgórza Niemczańskie metamorphics are separated from the Niemcza Zone (J. Oberc, 1987).

A smaller differentiation of the units is observed within the eastern part of the Middle Sudetes. The folds of the Imbramowice Unit and Wzgórza Niemczańskie Hills are showing the NNE-SSW direction with deviation and eastern vergence. The rocks display the mezometamorphic and folding processes of Cadomian epoch (J. Oberc, 1966). Later the area has been affected by fold and intrusive processes related with the Old-Variscian and Asthurian phases which followed the same (or almost the same structural plan).

The East-Sudetic Structure, located east from the Ramzova Overthrust, is characterized by the presence of napp rebuilding processes within Proterozoic and Middle Devonian sediments. Analogous structures are also observed in the part of Wzgórza Strzelińskie Hills, west from the Ramzova Overthrust only in the Fore-Sudetic Block.

The above mentioned features of geology of the eastern part of the Middle Sudetes may be explained by repeating in geological time processes of removing of the western part of Middle Sudetes (and Western Sudetes) to the east.

CONCLUSIONS AND PROPOSITION

The both parts of the Middle Sudetes — eastern and western parts — classified up till now as a part of Western Sudetes are differing in geology and geological development.

The western part (together with adjacent part of the Fore-Sudetic Block) is characterized by higher heterogeneity of higher tectonic units, bigger geological complications, number of phases and differentiation of tectonic deformations observed even within the equal age formations than the eastern part. The eastern part although showing many features characteristic for the geology of the eastern part (fold direction and fold vergence) displays similarity to the N-S Zone differentiated by H. Cloos (1922). The similarity is more distinct taking into account that Wzgórza Strzelińskie Hills displaying the features characteristic for the Eastern Sudetes though are localized west from the Ramzova Overthrust (J. Oberc (1968). The Sudetic and Fore-Sudetic zones of eastern part of Middle-Sudetic Structure demonstrate diversity and great differentiation of structural units. They are a result of deeper erosion of the Fore-Sudetic Unit, reaching 2.5 km (J. Oberc, 1968). The Moho-discontinuity within this zone is localized 6 km shallow than in Sudetes (36 km

Table 1

Units showing the East-Sudetic direction (SW-NE) within the Middle Sudetes and their Foreland

N		S	
Fore-Sudetic Block		Sudetes	
E (SE)	Ramzova Overthrust — Ramzova Nappe (Stare Město Unit) X Wzgórza Strzelifskie Structure (X) Wzgórza Niemczańskie Synclinorium X Niemcza Zone containing granitoides (X), X Imbramowice metamorphic massif (X)		Ramzova Overthrust Stare Město Unit X Góry Bialskie, Góry Złote crystalline massifs X Śnieżnik crystalline massif +X Krowiarki crystalline massif southern part of Góry Bystrzyckie and Góry Orlickie crystalline massifs + Bardo Structure including Kłodzko – Złoty Stok granitoides (+) (X) Intra-Sudetic Synclinorium (+)
W (NW)	Góry Sowie Block		Góry Sowie Block

+ — western branch of the Cadomian tectogene SE-NW, N-S; X — eastern branch of the Cadomian tectogene SW-NE, S-N; (X) — Variscan Units on the eastern branch; (+) — Variscan Units on the western branch

— A. Guterch et al., 1975). It may be assumed, that not all the units of the eastern part of the Sudetic Block have been exposed by the erosion.

The western boundary of the units of the eastern part of the Middle Sudetes Foreland (of the Fore-Sudetic Block) can not be displaced out of the range of the meridional edge of the Góry Sowie Block. However the Middle Sudetes it can be based following the above mentioned criteria:

A. Criterion of the boundaries of the Łądek virgation branches (H. Teisseyre, 1956; *Virgation der Sudeten* — H. Cloos, 1922). After J. Oberc (1972) the above mentioned boundary runs along the axis of the Kamienica Syncline, the criterion is not useful as the two branches of the virgation are characterized by analogous meridional course.

B. Meridional course of the fold axes. The criterion would require treating the southern part of the Góry Bystrzyckie and Góry Orlickie structures passing into the Karkonosze Mts as a eastern part of Middle Sudetes and determining the boundary diagonal to the fold axes south from the Góry Sowie Block.

C. Upper Nysa Kłodzka Graben extend. Would be the most favourable criterion (although with some remarks) of determining the eastern boundary of the Middle Sudetic Structure.

Despite the above mentioned complications there is still a need of dividing the Middle Sudetes into 2 higher units of distinct western boundary within the Sudetes.

Taking into account the necessity of separating of different higher units from the one side and the need of preserving the compulsory terms from the other side, the Author proposes to determinate the area localized between the Niemcza Zone and the Upper Nysa Kłodzka Graben and Ramzova Overthrust on the east as the "Mid-Eastern Sudetes", preserving the term "Middle Sudetes" for the rest part.

Looking into the proposition and arguments leading to the above mentioned conclusion (including genetical relations between the both zones of the Middle Sudetes) the Niemcza Zone (Niemcza Dislocation — J. Oberc, 1987) should be considered as the main boundary between the eastern and western part. The middle (rebuild) part of the Bardo Structure, taking into account the fold direction, can be treated as the continuation of the Niemcza Zone. As the position of the Niemcza — Kłodzko — Złoty Stok "syenites" is probably related genetically to the same discontinuity they may be treated, together with the eastern part of the Bardo Structure as a equivalent of the Niemcza Zone. As the consequence the Bardo Structure is divided into two parts — one part belonging to the Mid-Eastern Sudetes while the remaining to the Middle Sudetes.

Analogous complications are observed within the northern part of the area. The Cadomian Imbramowice metamorphic massif of the Kłodzko — Góry Sowie Block (J. Oberc, 1987) forming together with Wzgórza Niemczańskie metamorphic massif one tectonic unit is divided by the Niemcza Zone (Niemcza Dislocation). Taking into consideration the extend of the dislocation, the Imbramowice metamorphic massif could belong to the Middle Sudetes Foreland, while taking into account the course of the fold structures (metamorphic lineation) to the Mid-Eastern Sudetes Foreland. The Mid-Eastern Sudetes Foreland could contact along the Strzegom Dislocation the Middle Sudetes Foreland.

THE MIDDLE SUDETES AS A ELEMENT OF MIDDLE EUROPE BLOCK STRUCTURE

The concept of "Middle Sudetes" is a geographical term adapted by geologists. The neighbouring part of the Fore-Sudetic Block is described by the geographical concept as the Middle Sudetes Foreland. The concept includes the main part of Sudetic Foreland manifested as flat surface with isolated hills and even mountain elevations of crystalline massifs (Fore-Sudetic insular area). The highest elevation is the Ślęża Mt. (718 m absolute height).

The Author (J. Oberc, 1987) presents the theory of block structure of the Mid-European Variscides divided by crossing system of deep-faults of SW-NE and NW-SE direction, with a distinct, although not of major importance, role of meridional directions. Due to the changes of compression directions in geological time as a result of changes of directions of tectonic transport, the deep-faults have been cut into separate segments showing different features and were described by different names.

The direction and characteristic of the tectonic movements has changed faults along different parts of the deep-fault zone from strike-slip, inversion faults and dip-slip faults what resulted in formation of the over-deep-fault flexures, grabens and folds. The horizontal movements of the blocks of the lithosphere resulted in folding of geosynclinal series which have developed between the blocks.

The hitherto existing concept of Middle Sudetes clasps two lithospheric blocks determined by meridional deep-fault structures, separated by the Niemcza deep-fault (Niemcza Zone). Here is supposed that these blocks continue up to the Buśin Fault. The Niemcza Zone (Niemcza Graben, J. Oberc, 1987) and the Laramide Upper Nysa Kłodzka Graben in the south have developed following the Niemcza Zone. The Niemcza deep-fault separates the Mid-Eastern Sudetes from the Middle Sudetes.

The western, Kłodzko – Góry Sowie Block (*l.c.*) is limited from the west probably by the over-deep-fault flexure slope of the Eastern Karkonosze. Within the Fore-Sudetic Block the boundary of the Kłodzko – Góry Sowie Blocks separates the Kaczawa Structure from the older, underlying Imbramowice metamorphic massif (before granitic Strzegom Fault). The Kłodzko – Góry Sowie Block is the most differentiated block of the lithosphere displaying a tectonic role compression in forming of the Mid-Eastern and Eastern Sudetes structures.

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PRÓBA MODYFIKACJI PODZIAŁU SUDETÓW ŚRODKOWYCH I ICH PRZEDPOLA

Streszczenie

H. Cloos (1922) podzielił Sudety na Wschodnie i Zachodnie, rozgraniczone strefą N–S. Każda z tych jednostek ma swoje przedpole na północ od uskoku sudeckiego brzeżnego. E. Bederke (1931) za granicę między Sudetami Zachodnimi i Wschodnimi uznał nasunięcie moldanubskie zwane częściej ramzowskim. W 1929 r. autor ten wprowadził nazwę Sudetów środkowych, które stanowią wschodnią część Sudetów Zachodnich.

W obrębie Sudetów środkowych i ich przedpola zaznaczają się dwa kierunki systemów fałdowych: WNW–ESE — w części zachodniej oraz od N–S do NNE–SSW w części wschodniej; ku południowi fałdy obu tych kierunków zbiegają się przyjmując kierunek N–S.

Granica między fałdami obu kierunków na odcinku północnym biegnie wzdłuż wschodniego brzegu bloku sowiogórskiego i w poprzek struktury bardzkiej, zgodnie z przebudowaną jej częścią środkową. Jest to rozłam Niemczy stanowiący granicę między dwoma blokami litosfery (J. Oberc, 1987). Dla części bloku wschodniego po nasunięciu ramzowskim autor proponuje nazwę Sudetów środkowo-wschodnich. W obrębie bloku kłodzko-sowiogórskiego występuje główna elewacja Sudetów obejmująca moldanubik bloku sowiogórskiego oraz otaczające go na powierzchni Ziemi i podścielające serpentynity i gabra. Ruch tego bloku ku wschodowi spowodował sfałdowanie Sudetów środkowo-wschodnich i Wschodnich.

Południowe przedłużenie wschodniego brzegu bloku sowiogórskiego zdaje się znajdować w rowie górnej Nysy Kłodzkiej. Kadomski metamorfik Imbramowic, występujący w północnej części bloku kłodzko-sowiogórskiego, nawiązuje budową i historią do metamorfiku Wzgórz Niemczańskich, od którego oddzielony jest rowem Niemczy. Rów ten założony jest na rozłame między Sudetami środkowymi i środkowo-wschodnimi. Metamorfik Imbramowic z punktu widzenia kierunków fałdów należałby do przedpola Sudetów środkowo-wschodnich, zaś z punktu widzenia rozłamu Niemczy do przedpola Sudetów środkowych.