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PRE-VARISCAN VOLCANIC-SEDIMENTARY SUCCESSION OF THE CENTRAL SOUTHERN GÓRY KACZAWSKIE, SW POLAND: OUTLINE GEOLOGY

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Abstract: A revised geological map of the central southern Góry Kaczawskie (Kaczawa Mountains) in the Western Sudetes, at the NE edge of the Bohemian Massif, based on the authors' detailed survey of volcanic rocks within a Lower Palaeozoic low-grade metamorphic succession, provides the basis for modified tectonic and stratigraphic subdivisions. In contrast to previous tectonic models, the Radzimowice slates are interpreted as a separate tectonic unit, referred to as the Radzimowice unit. It lies between two other tectonic units, the Świerzawa unit in the north, and the Bolków unit in the south, both comprising similar volcanic-sedimentary sequences.

The existing lithostratigraphic subdivisions of the volcanic rocks into a "suite of greenstones" and a "suite of volcanics and volcaniclastics" are considered unsatisfactory and a new working stratigraphic scheme is proposed. It distinguishes (1) units in inferred sequential order: Podgórki volcanic complex, Wojcieszów limestones, Osełka rhyodacites, Gackowa sandstones (these four grouped into the Miłek succession), grey slates, Lubrza trachytes, black slates & cherts and siliceous slates; and (2) units of unknown position: Chmielarz slates, Dobków slates, Radzimowice slates, and melanges. The position of the Radzimowice slates and melanges is uncertain, though they are thought to be younger than most of the sequence.

The tectonic units are interpreted as thrust sheets. The main southern outcrop of the Świerzawa unit is considered to define the overturned limb of a south verging anticline. In the Bolków unit, particular subunits probably represent different parts of the sequence which are arranged into south and SW - verging folds.

Lithological units within the Świerzawa and Bolków tectonic units are correlated. Parts of the Miłek succession in the lower part, and the Lubrza trachytes in the upper part of the sequence, are found in most sections in both tectonic units. Differences probably reflect primary lateral or vertical changes in the sedimentary and volcanic environment, though some may partly have a tectonic origin.

Key words: volcanic-sedimentary succession, lithostratigraphy, greenschist facies, tectonic structure, Variscan orogen, Sudetes.

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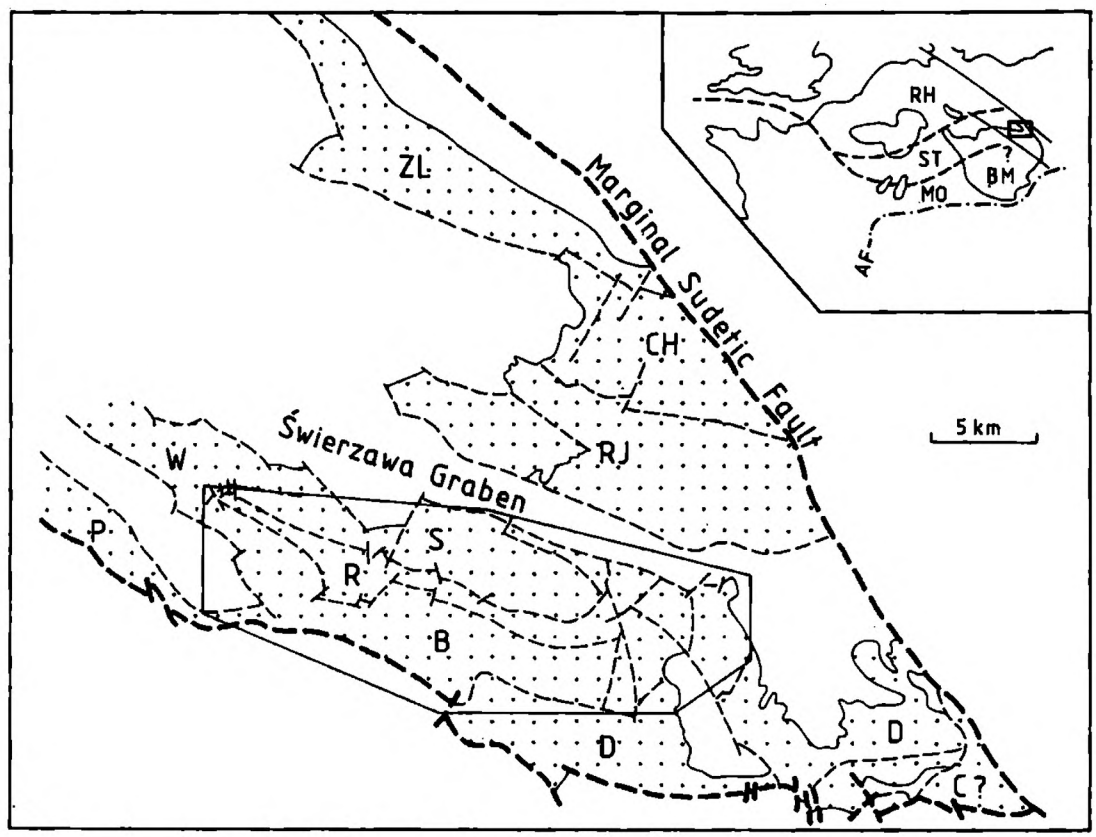

Fig. 1 Tectonic units of the Góry Kaczawskie (based on Teisseyre, 1967, and Jerzmański, 1965; modified in the area south of the Świerzawa Graben). Units: *B* – Bolków; *C* – Cieszów; *CH* – Chełmiec; *D* – Dobromierz; *P* – Pilchowice; *R* – Radzimowice; *RJ* – Rzeszówek-Jakuszowa; *S* – Świerzawa; *W* – Wleń; *ZL* – Złotoryja-Luboradz. Rectangle = area of Fig. 2. Inset map shows the location of the Góry Kaczawskie in the European Variscan belt. *AF* – Alpine Front; *BM* – Bohemian Massif; *MO* – Moldanubian Zone; *RH* – Rhenohercynian Zone; *ST* – Saxothuringian Zone

INTRODUCTION

The Góry Kaczawskie in the Western Sudetes, at the NE edge of the Bohemian Massif, form a large outcrop of low grade metamorphic volcanic-sedimentary rocks (the Kaczawa succession of Baranowski *et al.*, 1990) of ?Cambrian/Ordovician to Lower Carboniferous age. (The rocks are metamorphosed under the greenschist facies, though, for brevity, the prefix meta- is omitted.) The succession has been tentatively correlated with the Bavarian facies of the Saxothuringian Zone (e.g. Franke, 1989) but its position within the Sudetic mosaic still remains controversial (e.g. Aleksandrowski, 1990; Don, 1990).

Baranowski *et al.* (1990) outlined the geology of the Góry Kaczawskie and proposed an accretionary prism model to explain the structure of the area. The hypothesis is based on: (1) tectonic style, i.e. the presence of thrust sheets and melange bodies; (2) the presence of metasedimentary rocks interpreted as

oceanic and ocean-trench sediments; (3) the distribution of these rocks among the sheets and melange bodies. Trace element and Nd-isotope data from all the tectonic units of the Góry Kaczawskie suggest evolution from a within-plate, possibly initial-rift environment, to more evolved rifting regime, producing basalts of T-MORB and N-MORB characteristics (Furnes *et al.*, 1990). The basin is considered to have opened during ?Cambrian-Ordovician times, and the accretionary prism probably formed between the late Devonian and early Carboniferous (Baranowski *et al.*, 1987, 1990). The sequence of relatively high P/T followed by medium P/T metamorphic mineral assemblages in metabasites of the area is consistent with this model (Kryza *et al.*, 1990).

This paper provides a revised geological map of the central part of the southern Góry Kaczawskie (Świerzawa and Bolków units sensu Teisseyre, 1963; Fig. 1), the result of six years fieldwork of the authors. The fieldwork focussed on detailed examinations of the volcanic rocks and on their position within the stratigraphic sequence. An attempt is made to define more precisely the lithostratigraphic nomenclature and subdivisions of the volcanic rocks, and to reconcile them with the stratigraphic schemes developed by previous authors. New field observations, in particular of younging directions, locally inconsistent with earlier tectonic models, are used to construct new structural cross-sections for the area. These data provide a framework for detailed petrological and geochemical studies of the sequence, the results of which will be published elswhere.

PREVIOUS STUDIES

The geology of the Góry Kaczawskie has been the subject of considerable interest since the first mapping in the 1920s and 1930s. The history of research has been outlined in Baranowski *et al.* (1990) and only the most significant papers dealing with the stratigraphy and structure are briefly reviewed below.

Stratigraphy

Early stratigraphic schemes, based on scarce paleontological evidence (Hundt, 1922; Gürich, 1929) and regional correlations, were developed by Bederke (1932) and Dahlgrün (1934). Subsequent biostratigraphic findings (Jerzmański, 1965; Kornaś, 1963; Jaeger, 1964; Gorczyca-Skała, 1966; Gunia, 1967) were used by Teisseyre (1967) to revise these schemes and to propose a succession ranging in age from Eocambrian (Radzimowice slates) to Devonian (graptolitic slates). More recent biostratigraphic studies (e.g. Urbanek *et al.*, 1975; Urbanek 1978; Chorowska, 1978) indicated that the Kaczawa succession ranges in age from ?Cambrian to early Carboniferous (Visean), and that the final deformation and metamorphism occurred during the Variscan orogeny (e.g. Teisseyre, 1977; Oberc, 1980; Baranowski *et al.*, 1987, 1990).

Haydukiewicz (1987a) compared stratigraphic sequences in different tectonic units of the Góry Kaczawskie and distinguished a number of informal lithostratigraphic suites. These suites were incorporated into the stratigraphic framework of the Kaczawa succession outlined by Baranowski *et al.* (1990) and they form the basis for the modified scheme proposed below (Fig. 4).

Within the area, the only rocks with biostratigraphic control occur in the eastern part of the Bolków unit. They include black graptolitic slates of Silurian age (Zimmermann & Haack, 1935), and conodont-bearing Upper Devonian siliceous slates in the northern and western vicinity of Bolków (Haydukiewicz & Urbanek, 1986).

The age of the volcanic rocks of the area remains problematic. The thick composite volcanic sequences of the Świerzawa and Bolków units (Figs. 1 & 2) are associated with the Wojcieszów limestones and grey slates regarded to be, respectively, of ?Cambrian and Ordovician age (Gunia, 1967; Gorczyca-Skała, 1966; Teisseyre, 1967). This observation is supported by a preliminary U-Pb age of 511 ± 39 Ma from zircons in a trachyte in the Świerzawa unit (C.Pin, pers. commun., 1988).

The slates with associated alkali basaltic sills in the Świerzawa unit are considered to be of Ordovician age (Teisseyre, 1967; Furnes *et al.*, 1990). From conodont evidence (Urbanek & Baranowski, 1986), the Radzimowice slates are not older than Ordovician.

Structure

The Góry Kaczawskie are divided into northern and southern parts by the Świerzawa Graben (Fig. 1), which is infilled with Stephanian/Lower Permian molasse. In the southern part, Gürich (1882) considered that the Radzimowice slates defined the core of a syncline. Later, Bederke (1932), Block (1938), and particularly Schwarzbach (1939) interpreted this southern area as a large, southerly overturned anticline, with the oldest (considered then as Algonkian) Radzimowice slates in the core, and Cambrian greenstones and Ordovician slates on both limbs. Schwarzbach (1939) suggested that the repetition of supposed Silurian cherts under the Radzimowice slates indicated the presence of a nappe structure.

Teisseyre (1956, 1963, 1967) developed the nappe concept and defined several tectonic units in the central and eastern part of the southern area: the lowermost, and probably autochthonous, Świerzawa unit, overthrust by three southward verging nappes – the Bolków, Dobromierz and Cieszów units (Figs. 1 & 5). The nappes were subsequently folded to form the Bolków-Wojcieszów anticline (Teisseyre, 1963).

Haydukiewicz (1987b) and Baranowski *et al.* (1990) questioned part of this interpretation and distinguished two main tectonic elements within the area: (1) thrust sheets and, possibly, nappes (containing fragments of the ?Cambrian-Devonian sequence), and (2) polygenetic melange bodies (mostly

tectonized and metamorphosed sedimentary breccias). The faults bounding the tectonic elements are nowhere exposed and their position is only inferred from the outcrop pattern; they are assumed to lie parallel to the foliation (Haydukiewicz, in Baranowski *et al.*, 1990). The orientation of foliation and fold axes varies in different tectonic units and this has not been satisfactorily interpreted yet.

REASSESSMENT OF THE MAIN TECTONIC SUBDIVISIONS

The geological map shown in Figure 2 is based on the authors' fieldwork carried out in 1982 - 1988, as well as on information from earlier works listed in the explanation to Figure 2. The map provides the basis for the reassessment of tectonic and stratigraphic subdivisions.

The mapped area is distinctive in the widespread distribution of a composite volcanic assemblage associated with crystalline limestones and slates. These rocks form two WNW - ESE aligned outcrops separated by a 0.5 - 2 km wide belt of the Radzimowice slates. The eastern part of the study area, which is largely covered by thick Cenozoic deposits, was interpreted by Teisseyre (1956, 1963) as the hinge zone of the Bolków - Wojcieszów antiform.

The Świerzawa unit sensu Teisseyre (1956, 1963) was composed mainly of a supposed Cambrian volcanic sequence (greenstones, keratophyres) overlain by Ordovician grey slates. On Teisseyre's (1956, fig. 1; 1963, fig. 1) schematic maps, this unit was designated to comprise the outcrop between the Świerzawa Graben in the north and the Radzimowice slates in the south, excluding the small Dobków area (DA in Fig. 3). The unit was interpreted (Teisseyre, 1963) as the normal limb of an asymmetric, south-verging anticline.

The Radzimowice slates and the adjacent to the south volcanic-sedimentary sequence (together with the Dobków area) were considered to comprise a stratigraphical succession and were grouped into a single tectonic unit, termed the Bolków unit (Teisseyre, 1956, 1963). It was interpreted as a southward verging nappe overthrusting the Świerzawa unit.

A revised subdivision of the area is shown in Figure 3. The boundaries of the Świerzawa unit are approximately as proposed by Teisseyre (1963): the Świerzawa Graben to the north; a probable thrust separating the unit from the Radzimowice slates to the south, and the tectonic contact with the melange body at Janówek in the NW. The unit is subdivided into three subunits referred, from W to E, as S1, S2 and S3. Two small areas in the east, the Dobków and Chmielarz areas (DA and CA in Fig. 3), comprising distinctive lithologies are included here into the Świerzawa unit, though their positions remain problematic.

The Bolków unit of Teisseyre (1956) included two distinct elements, the Radzimowice slates and the mixed volcanic-sedimentary succession. Teis-

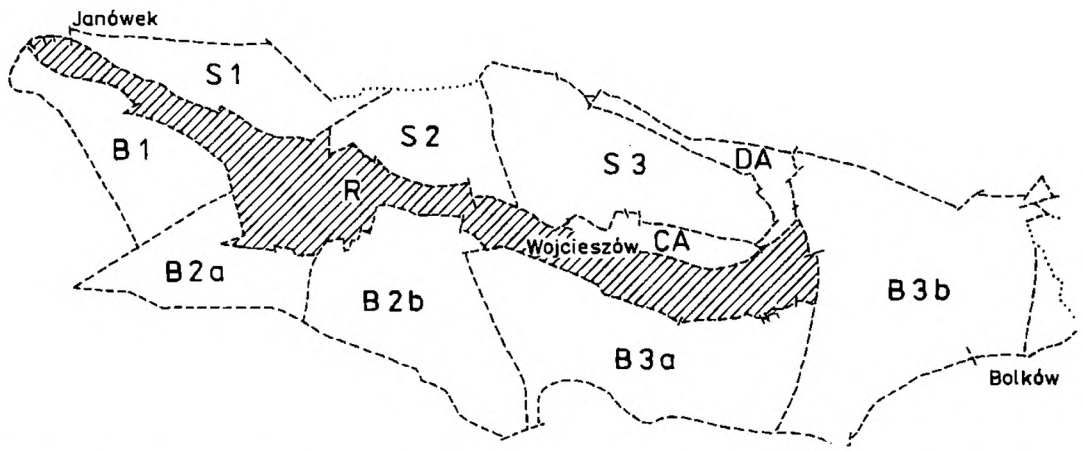

Fig. 3 Subdivision of the central southern Góry Kaczawskie. *S1*, *S2* and *S3* = subunits of the Świerzawa unit; *B1*, *B2* and *B3* = subunits of the Bolków unit; *R* – Radzimowice unit; *CA* – Chmielarz area; *DA* – Dobków area

seyre (1956, 1963) noted an apparent interdigitation between the Radzimowice slates and the Wojcieszów limestones of the latter succession, via a variegated rock assemblage ("Lindenweg-Gesteine" after Block, 1938), and interpreted this as a gradational contact. However, he also noted the possibility of a tectonic intermingling at that contact. Baranowski (1988) and Baranowski *et al.* (1990) interpreted both northern and southern contacts of the Radzimowice slates as tectonic. We agree with this interpretation and, consequently, we propose to restrict the definition of the Bolków unit to encompass only the volcanic-sedimentary succession south and east of the Radzimowice slates outcrop. The northern boundary of the Bolków unit would be the fault at the southern margin of the Radzimowice unit (Baranowski, 1988), while the southern boundary would follow, from west to east, the Wleń Graben, the faulted contact with the Karkonosze granite, and the tectonic contact between the Bolków and Dobromierz units (Fig. 2). The eastern and northeastern peripheries of the Bolków unit comprise the boundary with the melange body at Bolków, and the Świerzawa Graben, respectively.

The Bolków unit so redefined is subdivided, as is the Świerzawa unit, into three subunits of significantly different lithologies: B1, B2 and B3. Within subunits B2 and B3 smaller sectors, a and b, can be distinguished. The boundaries between these subunits are placed along faults.

LITHOLOGY AND WORKING STRATIGRAPHIC SCHEME

A formal stratigraphy for the area is considered premature due to: (1) considerable lateral lithological variation, locally poorly understood due to

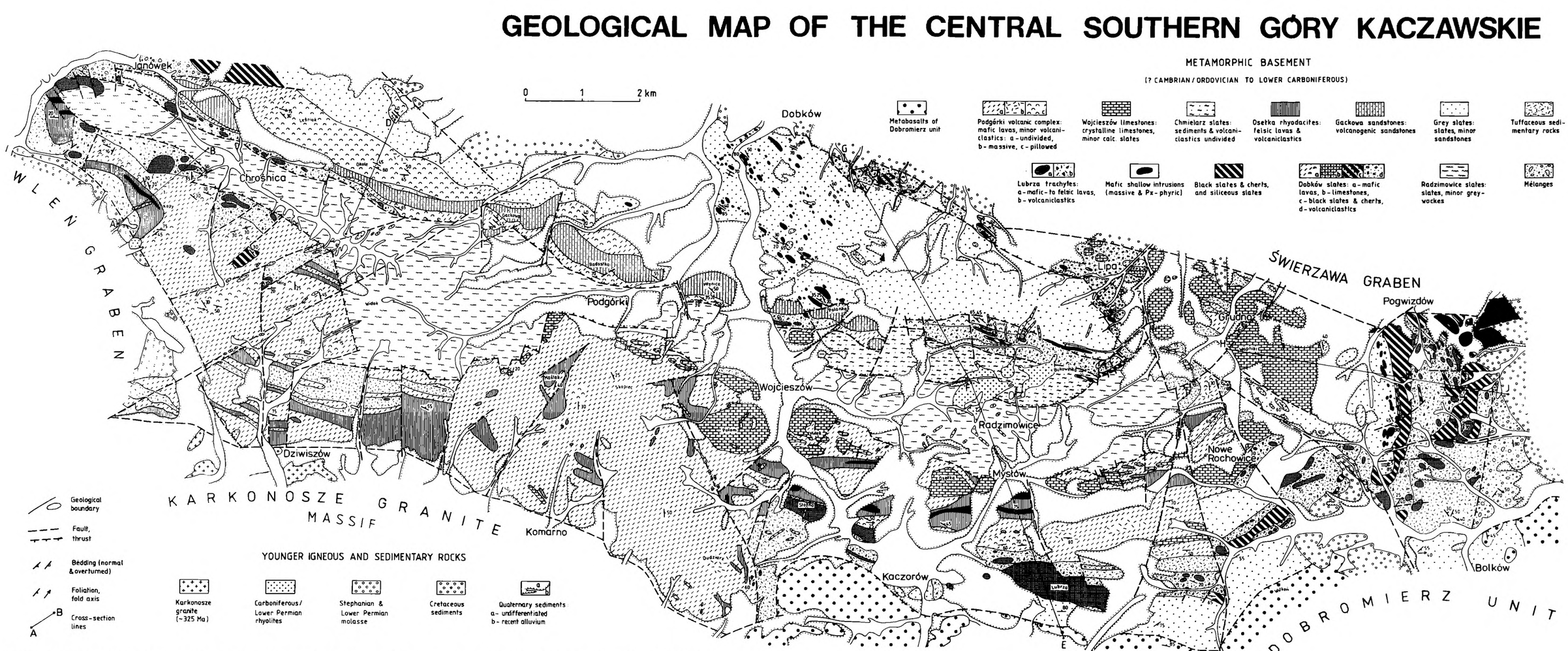

Fig. 2 Geological map of the central southern Góry Kaczawskie (based on authors' mapping carried out in 1982-1988, and on information from the following earlier works: Awdankiewicz, 1989; Baranowski, 1988; Baranowski & Lorenc, 1981; Baranowski *et al.*, 1986, 1987; Haydukiewicz & Urbanek, 1986; Mormul, 1985; Teisseyre, 1976; Zimmermann, 1932; Zimmermann & Berg, 1932, and Zimmermann & Haack, 1929)

lack of exposure, (2) the uncertain, primary or tectonic, nature of a number of boundaries, (3) the probable vertical repetition of similar lithologies, and (4) scarce palaeontological and isotopic age evidence. However, the authors' reassessment of the volcanic rocks suggests that previous subdivisions into units such as "greenstones", "volcanics and volcaniclastics", "porphyroids" and "keratophyres" are not satisfactory. A revised stratigraphic scheme is given below. Most of the lithologic units are arranged in inferred sequential order; the lowest four are grouped into the Miłek succession (Fig. 4). This sequential order is based on several lines of evidence, including (a) indications of the younging direction in volcanic and sedimentary rocks, (b) observations of the rock sequences along the profiles (where not disturbed by tectonic boundaries), and (c) scarce biostratigraphic and radiometric data. The positions of a few other units, the Chmielarz slates, Dobków slates, Radzimowice slates and melanges, are uncertain due to tectonic boundaries, poor exposure or insufficient information available. In the new scheme below, the informal units of the latest subdivisions after Haydukiewicz (1987a, and in Baranowski *et al.*, 1990) are given in brackets.

Units in inferred sequential order:

Miłek succession

1. Podgórki volcanic complex	(part of suite of greenstones)
2. Wojcieszów limestones	(suite of limestones, Wojcieszów l.)
3. Osełka (meta)rhyodacites	(? part of suite of volcanics and volcaniclastics)
4. Gackowa (meta)sandstones	
5. grey slates	(suite of metasandstones, metamudstones and metaclaystones)
6. Lubrza (meta)trachytes	(part of suite of volcanics and volcaniclastics)
7. black slates & cherts, and siliceous slates	(suite of graphitic slates and lydites, and suite of clay- and clay-siliceous slates)

Units of unknown position:

a. Chmielarz slates	
b. Dobków slates	
c. Radzimowice slates	
d. melanges	(melanges)

Compared with the latest stratigraphic subdivisions of Haydukiewicz (1987a) and Baranowski *et al.* (1990), emphasis here is put on the volcanic and volcaniclastic rocks. In those schemes, all these rocks were considered jointly as "volcanic rocks (greenstones, greenschists, keratophyres, porphyroids)" (Baranowski *et al.*, 1990, fig. 3), or divided into two suites: "suite of greenstones" and "suite of volcanics and volcaniclastics" (Haydukiewicz, 1987a). The term "suite of greenstones" used to describe all metabasalts in different tectonic units of the Góry Kaczawskie can be misleading, as these rocks are probably of different ages and provenance (Furnes *et al.*, 1990).

Here, in the lower part of the sequence in both the Świerzawa and Bolków units, a thick and widespread assemblage of mafic volcanic rocks is designated as the Podgórki volcanic complex. These metabasalts represent a sort of matrix which encompasses and interdigitates, usually in a complex way, with acidic volcanic rocks (the Osełka rhyodacites, formerly termed "porphyroids"), and with two sedimentary units: the Wojcieszów limestones and the Gackowa sandstones (equivalent in rank to formations). All these rocks are grouped into the Miłek succession. Bimodal lavas ("keratophyres") and associated volcaniclastic rocks higher in the sequence are designated as a separate unit, and termed the Lubrza trachytes. This unit is mostly underlain or interdigitated with the grey slates, and overlain by the black slates and cherts (Fig. 4).

An important uncertainty in the scheme is the position of the grey slates in relation to the Miłek succession. In the Świerzawa unit, the slates seem to underlie this succession but, probably, the contact between them is tectonic. In the Bolków unit, the grey slates occur between the Miłek succession and the Lubrza trachytes, but their thickness varies considerably (Fig. 4). Minor bodies of similar slates, often containing volcanic material, are intercalated in the lower and middle part of the sequence, and are shown on the map as undifferentiated tuffaceous sedimentary rocks (Fig. 2). The highest sedimentary unit in the sequence, the black slates & cherts and siliceous slates, comprises two subdivisions distinguished by Haydukiewicz (1987a) and mapped locally near Bolków and in the Rzeszówek-Jakuszowa unit (RJ in Fig. 1). It was impossible for the authors to map them separately over the whole study area.

The lithological characters and distribution of the informal units, in inferred ascending order for the most of the sequence, are described below.

The **Podgórki volcanic complex** consists of pillow basalts, subordinate massive lavas, pillow breccias, and hyaloclastites, most of transitional tholeiitic-alkaline character (Furnes *et al.*, 1989, 1990; Kryza *et al.*, 1989). They have been interpreted as geochemically comparable with ocean-island basalts (Narębski, 1980; Baranowski *et al.*, 1984), or with initial-rift volcanics (Narębski *et al.*, 1986; Kryza & Muszyński, 1988; Furnes *et al.*, 1989, 1990). In the Świerzawa unit, the Podgórki volcanic complex can be subdivided into a lower pillow lava (up to 500 m thick) and an upper pillow lava (ca. 100 m). To the west, the latter passes laterally into shallow water or subaerial basaltic

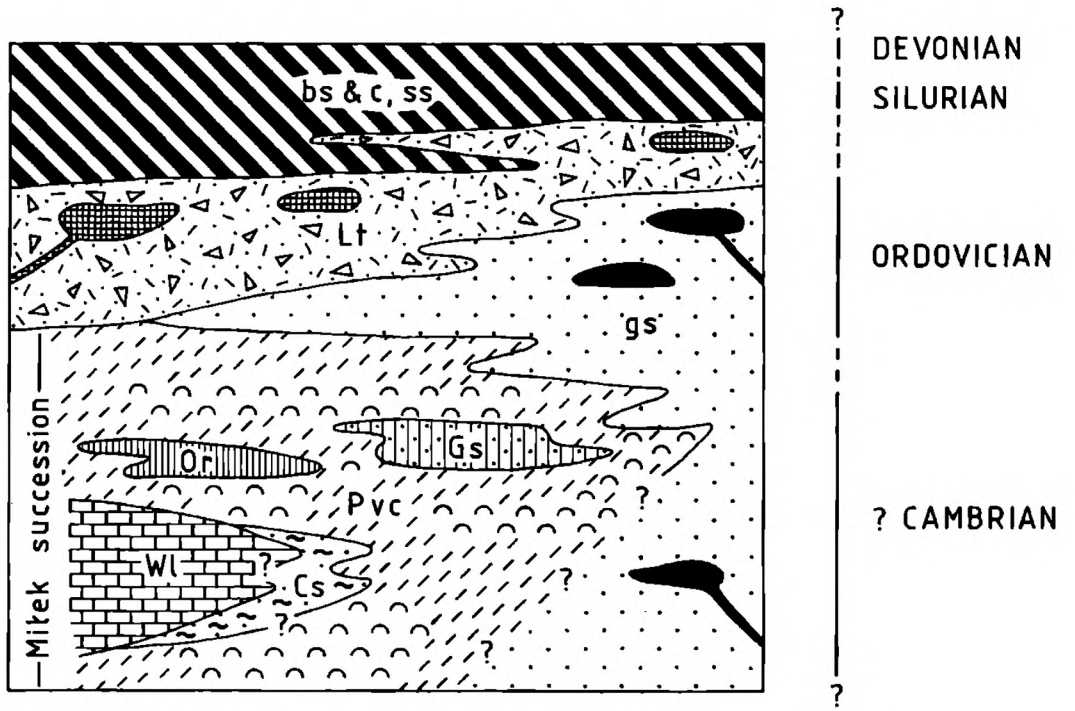

Fig. 4 Tentative stratigraphic scheme for part of the sequence of the central southern Góry Kaczawskie. Units in inferred ascending order: Miłek succession: *Pvc* – Podgórki volcanic complex, *Wl* – Wojcieszów limestones, *Cs* – Chmielarz slates, *Or* – Osełka rhyodacites, and *Gs* – Gackowa sands-tones; *gs* – grey slates with mafic shallow intrusions (*black*); *Lt* – Lubrza trachytes: volcaniclastics (*chaotic hatching*) and mafic-to-felsic lavas (*grid*); *bs&c, ss* – black slates & cherts and siliceous slates. Lithological graphic symbols as in Figure 2. *Question marks* indicate uncertain relationship between the Miłek succession and the grey slates, and also uncertain position of the Chmielarz slates. *Broken line* between periods in the time scale on the right side is to show imprecise age limits of particular units

lavas. The two pillow lava bodies are separated by the Gackowa sandstones (Fig. 2). In the central area S2, the lower pillow lava wedges out eastwards, while the upper pillow lava, with pillow breccias, becomes thicker. In the east (S3), the thick pillow lavas are more alkaline (Furnes *et al.*, 1989) and their relation to the sequence is unclear.

The thickness of mafic volcanic rocks of the Podgórki volcanic complex in the Bolków unit is variable, in places exceeding 1 000 m. Moderately to strongly foliated metabasalts, locally with volcaniclastic rocks, are as common as pillow lavas. They are associated with tuffaceous and rhyodacitic rocks in the west, and also with the Wojcieszów limestones in the east (Fig. 2). In the western subunit B1, a 150 - 200 m thick assemblage of mafic lavas, of variably pillowed, massive, platy and lensoid appearance, is the best exposed part of the complex.

The **Wojcieszów limestones** comprise isolated carbonate lithosomes, up to 500 m thick, which crop out in a fairly regular belt along the central and eastern part of the Bolków unit (Fig. 2). The limestones form lenses which are

intimately intercalated with the greenstones (Baranowski & Lorenc, 1986). They are locally interstratified with calcareous slates and tuffaceous rocks which grade into schistose greenstones. Lorenc (1983) considered the limestones to have been deposited on volcanic highs in an open sea.

Along the northern periphery of the B2b sector, a belt of small limestone bodies appears to be the western continuation of the much thicker limestones of the eastern part of the Bolków unit. The apparent thickness in sector B3a reaches 1 500 m, but the real thickness is unknown. To the SW of Nowe Rochowice (Fig. 2), the repetition of limestones may be due to overthrusting (Haydukiewicz, in Baranowski *et al.*, 1990) or folding.

The positions of the relatively large limestone outcrops north of the Radzimowice slates east of Wojcieszów, and in the Dobków area remain problematic.

The **Osełka rhyodacites** ("porphyroids") are found along the outcrop of the Bolków unit as cream coloured, aphanitic, quartz-microphenocryst bearing and usually strongly foliated rocks derived from lavas or volcaniclastics. They are associated with tuffaceous sedimentary rocks and mafic lavas in the west of the unit, and also with crystalline limestones in the east. Their thickness is generally less than 50 m, though locally it may be more than 200 m. The Osełka rhyodacites include thin (5 - 20 m) aligned bodies of massive basic rocks, probably sills, along the B1 and B3a subunits.

The **Gackowa sandstones**, 50 to 150 m thick, form a persistent belt along the outcrop of the Świerzawa unit. The sandstones are light grey to yellow in colour, fine-grained, and of felsic composition. Locally, thin intercalations of rocks resembling the rhyodacitic lavas or pyroclastic rocks of the Bolków unit occur. All the rock assemblage has been interpreted as keratophyres (Zimmermann, 1941; Ansilewski, 1954), tuffs and tuffites (Baranowski *et al.*, 1984) and sandstones (Gürich, 1882; Pacholska, 1975). We consider them to be mainly sandstones containing large amounts of reworked volcanic material derived from rhyodacitic volcanic or volcaniclastic rocks.

The **grey slates**, likely up to 1 000 m thick, are composed of alternating mudstones and sandstones which were interpreted as turbidites (Baranowski *et al.*, 1986). Locally, the slates enclose numerous basic sills, up to 50 m thick (Kryza & Muszyński, 1988). The sequence includes well preserved sedimentary structures, parallel and small-scale cross lamination, grading, and load casts. Locally, in its upper part, it contains intercalations of tuffaceous sedimentary rocks which Haydukiewicz (1987a) referred to as laminated variegated mudstones.

In the Świerzawa unit, grey turbiditic slates hosting numerous alkaline basic sills are well exposed in the eastern subunit S3, while in the west, they are overlain by thick Upper Carboniferous and Permian molasse and Cenozoic deposits.

In the easternmost part of the Bolków unit (B3b), grey slates are predominant and occur in both limbs of the Stare Rochowice syncline (Haydukiewicz

& Urbanek, 1986). Their contact with the underlying sequence can nowhere be observed. Upwards, the slates include intercalations of tuffaceous and volcaniclastic rocks, and are conformably overlain by the Lubrza trachytes.

The grey slates appear to vary widely in thickness across the area and show differing relationships to the volcanic rocks. It is still uncertain to what extent this is due to lateral and vertical lithological variability and to what extent to tectonic discontinuities (Fig. 4).

The **Lubrza trachytes** comprise usually rather small but widespread high level intrusions or extrusions (domes), predominantly of trachytic composition. They are composed of massive, aphanitic rocks, grading from nearly black to light grey in colour, and from alkali basaltic to pantelleritic in composition (Furnes *et al.*, 1989; Kryza *et al.*, 1989). The Lubrza trachytes unit also comprises up to 500 m of variable mafic to felsic volcaniclastic rocks, with indistinct primary features of pyroclastic flow and fall deposits (Furnes *et al.*, 1989; Awdankiewicz, 1989), and associated tuffaceous sedimentary rocks. Most common are moderately to strongly foliated rocks, grey or laminated, with greenish and purple laminae.

The rocks of the Lubrza trachytes in the Świerzawa unit and in the western part of the Bolków unit display considerable lithological and geochemical similarities and can be correlated (Kryza *et al.*, 1989). They are generally absent from the central parts of both units, while in the eastern part of the Bolków unit, in the Stare Rochowice syncline, an intervening thick sequence of grey slate occurs between the trachytes and the Miłek succession. The trachytic unit thickens from about 50 m in the west of the syncline to more than 200 m in the NE. Northwest of Bolków, the western limb of the syncline contains basic sills with sparse volcaniclastic rocks, while the eastern limb comprises a thick sequence of variable volcaniclastic and tuffaceous sedimentary rocks, and numerous intermediate- to acid lava bodies. This contrast may be due to primary lateral variability (Fig. 8), though tectonism may play a part.

The **black slates and cherts**, up to 100 m thick, locally contain Silurian graptolites (Zimmermann & Haack, 1935) and conformably overlie the Lubrza trachytes in the east of the Bolków unit. Similar lithologies occur locally in the Chmielarz and Dobków areas (Fig. 3) but their stratigraphic position is not clear.

The **siliceous slates**, which have not been distinguished from the black slates and cherts on the map (Fig. 2), are composed mainly of grey pelitic and silica-rich slates, up to 100 m thick, containing late Devonian conodonts (Haydukiewicz & Urbanek, 1986; Haydukiewicz, 1987a). This indicates that pelagic sedimentation continued into Devonian times (Baranowski *et al.*, 1990).

The **Chmielarz slates** ("Lindenweg-Gesteine" after Block, 1938). They were defined by Block as an association of greenish slates composed of quartz, sericite, feldspar, and chlorite, at least partly of detrital origin, with

thin intercalations of limestones and greenstones. These rocks were thought to represent an intermediate facies between greenstones and limestones at the base of the Cambrian sequence. However, Teisseyre (1956) interpreted them as transitional between the Radzimowice slates and the Wojcieszów limestones, though he did not exclude the possibility that the rocks were separated by tectonic contacts.

The main outcrop of the Chmielarz slates lies to the north of the Radzimowice unit, east of Wojcieszów (Figs. 2 & 3). It is poorly exposed and its relationship both to the Radzimowice slates and to the volcanogenic sequence to the north is uncertain. Their main outcrop is shown in Figure 2 as a separate undifferentiated unit.

The **Dobków slates** comprise volcanic and sedimentary rocks of unknown age within a narrow outcrop adjacent to the fault bounding the S side of the Świerzawa Graben, east of the Kaczawa valley (DA in Fig. 3). The name "slates" is only provisional here, because it does not reflect properly the considerable lithological variation of the rock assemblage, which contains crystalline limestones, black cherts, volcaniclastic and tuffaceous sedimentary rocks and pillow lavas. The internal structure of the Dobków area and the relationship of the Dobków slates with the stratigraphic sequence elsewhere is unknown. They may partly represent a lateral continuation of the Miłek succession.

The **Radzimowice slates** are bound to the south and north by faults (Baranowski, 1988; Kryza *et al.*, 1989; Baranowski *et al.*, 1990). In the area northwest of Chrośnica (Fig. 2), they pass laterally into quartzites. The eastern boundary is not well understood due to lithological and tectonic complexities and poor exposure (Baranowski, 1988).

The Radzimowice slates comprise an assemblage of dark-grey slates (laminated mudstones), with thin intercalations of siliceous slates, greywackes and quartzites and are thought to represent shaly flysch deposited in an oceanic trench floor or immature slope basin environment (Baranowski, 1988). They have been documented by conodonts as no older than Ordovician but the upper age limit is unknown (Urbanek & Baranowski, 1986).

The **melanges** occur at two localities, Janówek and Bolków. The melange at Janówek lies at the NW border of the study area (Fig. 2) and it consists of blocks and larger rafts of sandstones, cherts, and volcanic rocks in a muddy matrix with disrupted lamination (Haydukiewicz, 1987b).

The melange at Bolków, in the eastern part of the area (Fig. 2), was also recognized by Haydukiewicz (1987b). It is lithologically similar but, as yet, has not been studied in detail. In particular, its northern extent is unknown and it is unclear whether diabase bodies east of Pogwizdów (Fig. 2) are, in fact, large rafts within the melange.

A general description of all melanges in the Góry Kaczawskie and a detailed map of the melange at Janówek were given by Haydukiewicz (1987b, and in Baranowski *et al.*, 1990). According to that author, the melanges are

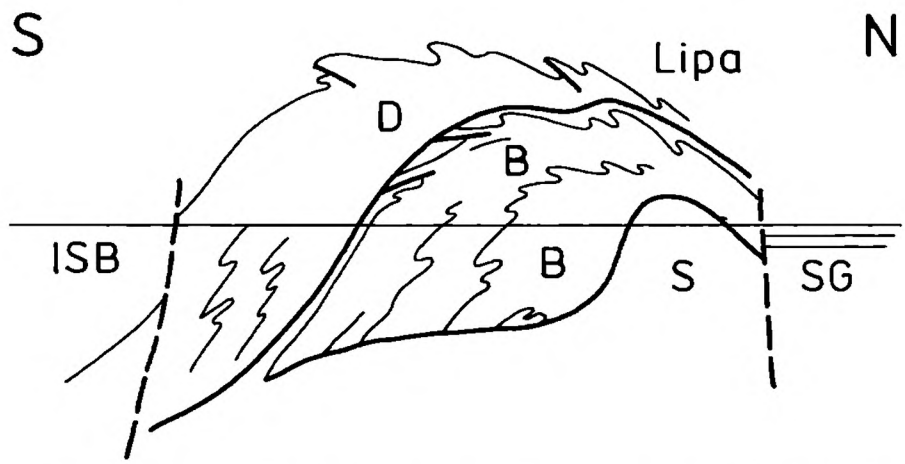

Fig. 5 Schematic cross section of the central southern Góry Kaczawskie illustrating the nappe concept (after Teisseyre, 1967). *ISB* – Intra-Sudetic Basin; *SG* – Świerzawa Graben; tectonic units: *S* – Świerzawa; *B* – Bolków; *D* – Dobromierz

most probably polygenetic, sedimentary-tectonic formations, but at least partly being products of gravity gliding and flowage.

OUTLINE STRUCTURE

A schematic cross section (Fig. 5) ilustrates the nappe concept after Teisseyre (1963). The southern Góry Kaczawskie was thought to comprise a stack of south verging nappes, subsequently folded into the Bolków-Wojcieszów antiform. Previously, Schwarzbach (1939) had interpreted the change of the bedding and foliation strikes from WNW-ESE to N-S in the east of the area to reflect transverse folding. In contrast, Teisseyre (1956, 1963) considered the ESE plunge of the axis of the antiform to be the only cause of the deflection of bedding and foliation in the northwestern vicinity of Bolków. Our observations are consistent with, but do not provide conclusive proof of, Teisseyre's model.

The interpretations outlined below, and in the cross-sections (Figs. 6 - 8), result from the analyses of data collected during the geological mapping. In particular, evidence of younging direction was deduced at a number of localities, using the geometry of pillow lavas, vesicle distribution and drain-out structures; structures in metasedimentary rocks, such as grading and the truncation of cross-sets, were also used, though these were less common. This evidence, together with analysis of the cleavage-bedding relation in sedimentary and volcanic rocks, was used for tectonic interpretation. The most important localities in this context are shown by strike-and-dip symbols in Figure 2.

The western part of both the Świerzawa and Bolków units has been studied by Furnes *et al.* (1989) and Kryza *et al.* (1989). Their structural interpretation is shown here in Figure 6. The structure is dominated by inferred thrust sheets, of which two contain lithologically and geochemically similar vol-

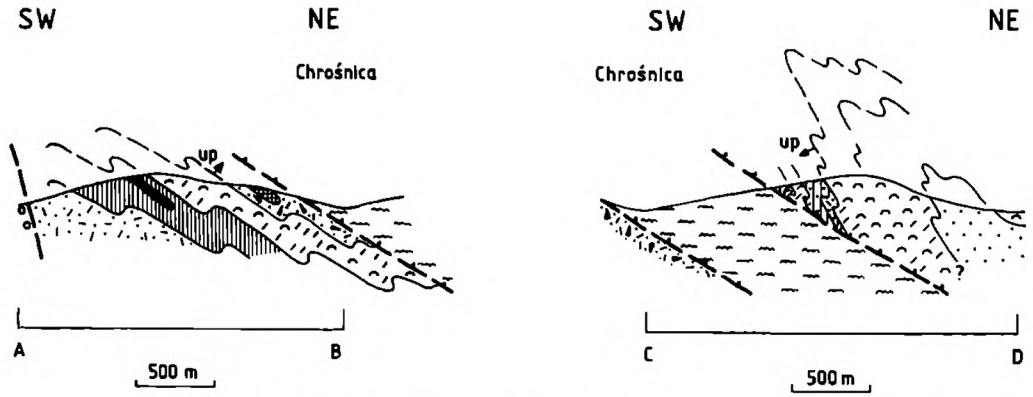

Fig. 6 Cross sections of the western part of the area. Symbols as in Fig. 2; Quaternary sediments omitted

canic-sedimentary sequences. They are separated by the Radzimowice unit. The main foliation dips moderately (40 - 50°) or gently (10 - 30°) to the northeast in the Świerzawa and Bolków units, respectively. The primary bedding can be recognized in many pillow lava outcrops and is commonly very steep or overturned in the Świerzawa unit, in contrast to a normal and gently northwards dipping attitude in the Bolków unit.

East of the section line, SE of Chrośnica (see Fig. 2), the outcrop pattern in the Bolków unit is affected by superimposed folding and by faults along which late-Variscan rhyolites were intruded.

In the fault-bounded B2b sector of the Bolków unit, the foliation has an anomalous N-S strike with a moderate eastern dip. The B2a and B2b sectors are cut by numerous N-S trending faults. The stratigraphic relationship between these sectors and their relationship to other rocks of the Bolków unit are uncertain. They are tentatively interpreted to be at a relatively low stratigraphic level and to correspond with the Miłek succession.

On a cross section through the central part of the area (Fig. 7), the Radzimowice slates are also interpreted to be thrust-bounded. The foliation here dips gently to moderately northwards in the Świerzawa unit, but is mainly very steeply inclined in the Bolków unit. The folds generally verge to the south.

The main difference between this cross section (Fig. 7) and that of Teisseyre (1963, fig. 2) stems from the younging directions indicating that the southern part of the Świerzawa unit is overturned to the south. The northern part (Dobków area) is in a normal position and dips to the north. Teisseyre (1963) considered the sequence in the Dobków area to be the northern continuation of the Bolków unit nappe. However, the above mentioned younging directions, together with some lithological and geochemical similarities, suggest the presence of a smaller antiform within the Świerzawa unit, with the grey slates, probably fault-bounded, in the core.

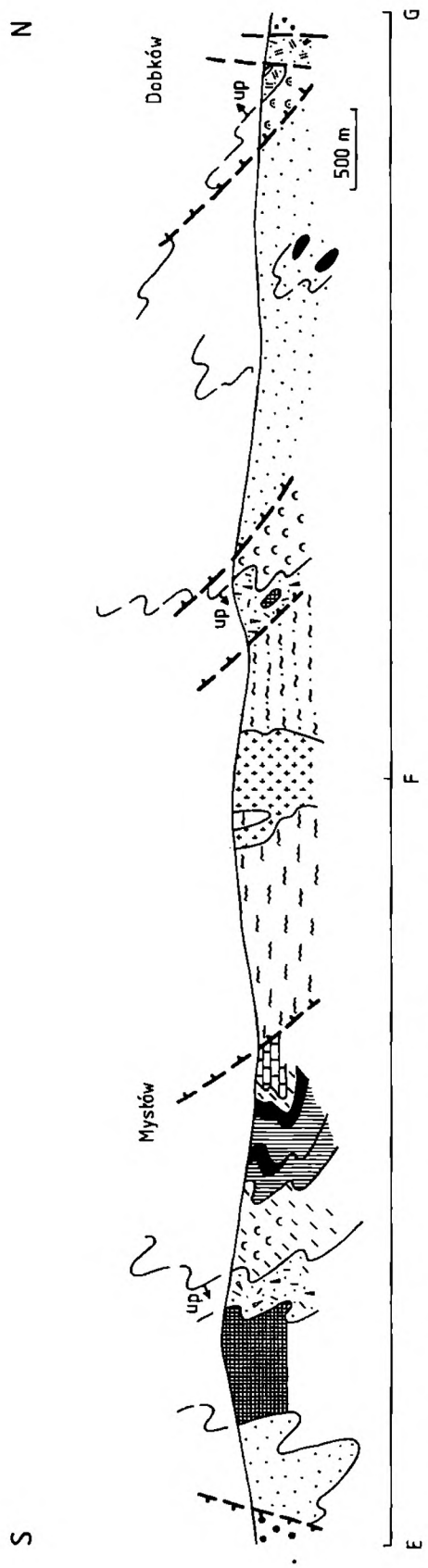

Fig. 7 Cross section of the central part of the area. Symbols as in Fig. 2; Quaternary sediments omitted

At the south end of this cross section (Fig. 7), a complex fold structure is implied. The southward younging direction, inferred by Schwarzbach (1939) and Teisseyre (1963), is supported by way-up evidence in the volcanic rocks. The hinge zone of a synform lies close to the southern te-ctonic boundary of the Bolków unit.

The eastern part of the Bolków unit is subdivided by N-S trending faults into two sectors, B3a in the west and B3b in the east (Figs. 2 & 3). The western B3a sector is characterized by a regular E-W trending outcrop pattern. The main foliation is mostly parallel or slightly oblique to lithological boundaries and dips at a steep to moderate angle to the north or, rarely, steeply to the south. Rare evidence of way-up indicators within the volcanic rocks (Fig. 2) usually points to the south. Eastwards, in the B3b sector, the lithological boundaries and the main foliation progressively change the strike from E-W, through SW-NE, to N-S; this change has been interpreted to reflect the Bolków-Wojcieszów antiform (Teisseyre, 1956, 1963; Haydukiewicz & Urbanek, 1986). To the east, there is a probable thrust contact with the Bolków melange, and, to the north, a fault separating the Bolków unit from the Świerzawa Graben. To the NW, the relationships between the Bolków unit, Radzimowice slates and Świerzawa unit remain unclear because of thick head deposits.

A subradial set of faults (Fig. 2) has been distinguished in the hinge zone of the antiform. Northwest of Bolków, a narrow fault-bounded

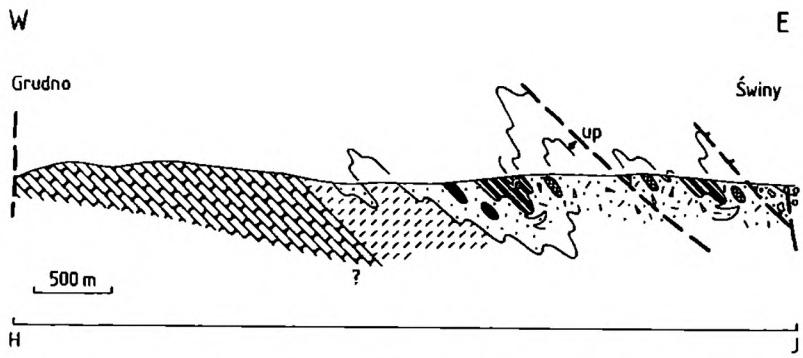

Fig. 8 Fig. 8. Cross section of the eastern part of the area. Symbols as in Fig. 2; Quaternary sediments omitted

NW-SE trending zone, ca. 300 m wide, includes several lensoid bodies of volcanic rocks enclosed within grey slates. The volcanic rocks are basaltic to andesitic in composition and display cataclastic textures.

From detailed mapping of selected small areas, structural observations, and new paleontological evidence, A. Haydukiewicz (pers. commun., 1987), reinterpreted the eastern closure of the Świerzawa and Bolków units. His tectonic model is based on a large isoclinal fold, the Stare Rochowice syncline, partly tectonically eroded, with the Devonian siliceous slates and the Silurian black slates and cherts in the core, and Ordovician volcanic rocks and the grey slates in the limbs. Mesoscopic folds, with an axial planar cleavage commonly at a small angle to the syncline axis, indicate a second episode of deformation. The overall arcuate pattern of the outcrops around the eastern closure of the Bolków-Wojcieszów antiform, the change of the foliation strike from longitudinal to meridional, together with the subradial fault pattern, mark a third deformation phase. Haydukiewicz's model was supported by recent mapping NW of Bolków (Fig. 2) and is incorporated in the simplified cross section in Figure 8. The folds shown in this cross section represent the main, second phase of folding. The relation of this fold phase to the folding depicted elswhere (Figs. 6 & 7) is not known with certainty. However, the similarity of overall style may indicate a genetic relation between them.

Structural analysis of the region is not complete, but some further information and interpretation made by A. Haydukiewicz can be found in Baranowski *et al.* (1990).

DISCUSSION AND CONCLUSIONS

The results of earlier studies summarized by Baranowski *et al.* (1990) and the new data presented above suggest that Teisseyre's (1956, 1963) subdivision of the area into the Świerzawa and Bolków tectonic units, and the boundaries of these units, should be modified. Because of their tectonic boundaries

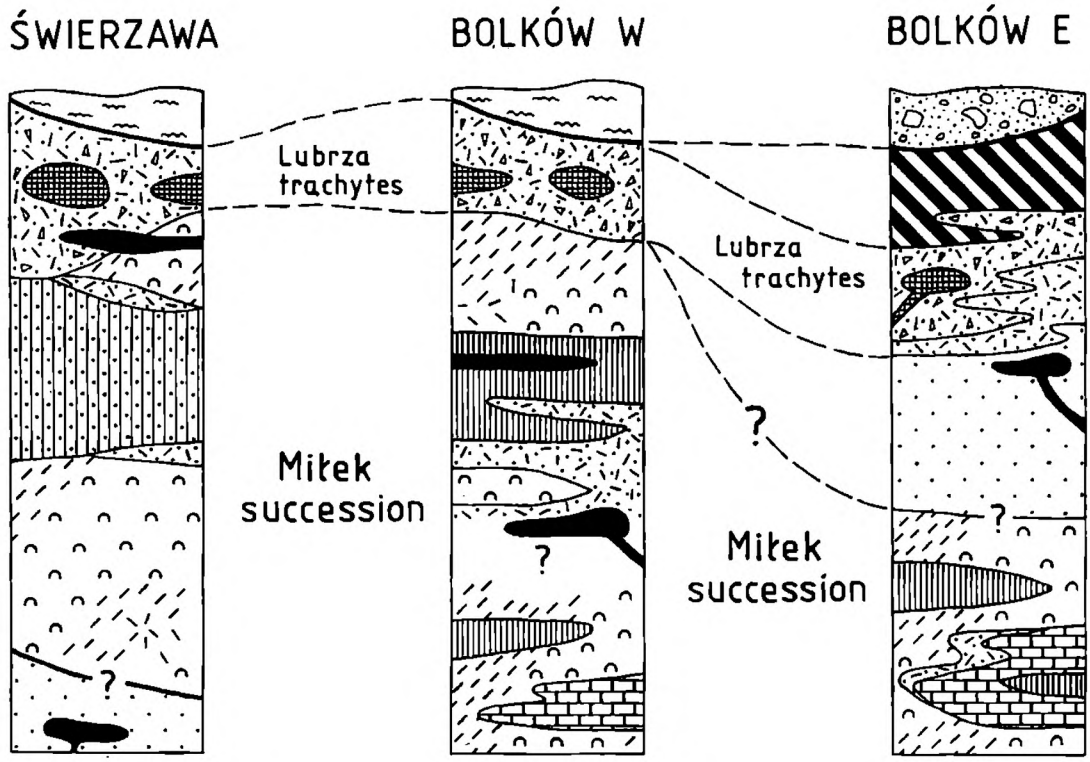

Fig. 9 Generalized lithological logs for the Świerzawa unit, and for the western and eastern parts of the Bolków unit. Not to scale. Symbols as in Fig. 2

and characteristic lithology (see Baranowski, 1988; Baranowski *et al.*, 1990), the Radzimowice slates are regarded, provisionally, as a separate tectonic unit, termed the Radzimowice unit. Consequently, the name of the Bolków unit becomes restricted to the volcanic-sedimentary sequence south, and partly east, of the Radzimowice slates. The names "Świerzawa unit" and "Bolków unit" are proposed to be retained as the names of main tectonic, fault-bounded units, though the interpretation of their internal structure differs in many important points from that proposed originally by Teisseyre (1956, 1963; compare Fig. 5 with Figs. 6 to 8).

The revised map incorporates new lithological data, particularly regarding the volcanogenic rocks. Where sufficiently exposed, the mafic rocks have been classified into shallow intrusives, pillowed and mafic lava flows and volcaniclastic rocks. The felsic rocks have also been subdivided with regard to their original character. The rhyodacitic rocks ("porphyroids") of the Bolków unit are mostly of extrusive or volcaniclastic derivation. Textural and compositional features of the Gackowa sandstones in the Świerzawa unit (Pacholska, 1975; Kryza *et al.*, in prep.) suggest a relation to these rhyodacitic rocks. The alkaline lavas of basaltic- to trachytic composition (keratophyres) form lava flows or small shallow intrusions, usually within volcaniclastic rocks. In the

proposed stratigraphic scheme, emphasis is put on the designation of all these volcanogenic rocks, and an attempt is made to arrange them into a sequential order. However, some lithological units have as yet uncertain relations.

Generalized lithological logs of the Świerzawa and Bolków units are given in Figure 9. Some lithologies, e.g. the Miłek succession in the lower part, and the Lubrza trachytes in the upper part of the sequence, can be recognised in most sections in both tectonic units. However, particular sections differ lithologically and in proportions of sedimentary and volcanic rocks. These differences probably reflect primary lateral or vertical changes in the sedimentary and volcanic environment, though they may result from tectonic causes in part. The lateral facial changes in the Świerzawa unit appear to follow those in the Bolków unit to the south, and it suggests that the original geographic separation of these two units may not have been great.

Evidence for relative age is provided by structural way-up indicators, together with some paleontological and isotopic age data. The scarcity of the latter makes it difficult to establish a precise stratigraphy. Further, the preliminary U-Pb zircon age from an acidic lava of the Lubrza trachytes from the Świerzawa unit (511 ± 39; C.Pin, pers. commun., 1987) is not consistent with the position of similar volcanic rocks which appear just below the Silurian black slates and cherts in the eastern Bolków unit; the latter suggests a Silurian or Ordovician rather than a Cambrian age. The relationship between the basic sill – slate association in the northern part of the Świerzawa unit and the rest of the rock sequence remains enigmatic; so far no paleontological or isotopic ages have been obtained.

Overall, the moderate to steep dip of both bedding and foliation, and breaks in lithological continuity across strike, suggest that it is simpler to regard the units as thrust sheets rather than nappes in the sense of Teisseyre (1963). The main southern outcrop of the Świerzawa unit is interpreted to comprise the overturned limb of a south verging anticline. However, the structure of the eastern part of that unit is uncertain. It may be an antiform with the volcanic-sedimentary sequences on the northern and southern limbs, probably separated from the underlying grey slates by thrusts.

The structure of the Bolków unit is even more complicated. It seems, however, that the subunits represent different fragments of the sequence which are arranged into S and SW - verging folds. The relationship between individual subunits is rather poorly understood. The sequence youngs to the north in the western part, and generally to the south in the eastern part of this unit. This may mean that the western and eastern parts of the Bolków unit define fragments of, respectively, normal and overturned limbs of the S-verging folds. Whether this unit represents a nappe, as described by Teisseyre (1956, 1963), remains an open question.

The structural patterns outlined here are tentative only, and result from the analysis of data routinely collected during the regional geological mapping. Many problems remain, concerning the structure and its interpretation in

terms of the nature and sequence of tectonic transport directions. The resolution of these, at least in part, would require a separate, detailed study.

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References

Aleksandrowski, P., 1990. Early Carboniferous strike-slip displacements at the northeast periphery of the Variscan belt in Central Europe. *International Conference on Paleozoic Orogens in Central Europe - Geology and Geophysics*, Göttingen, 4 pp, (Abstract).

Ansilewski, J., 1954. The keratophyres of the Kaczawa Mts. *Arch. Miner.*, 18 (1): 131 – 162, Warszawa, (In Polish, English summary).

Awdankiewicz, M., 1989. *Geologia i petrografia serii epimetamorficznych rejonu Gorzanowic.* Unpublished MSc thesis, Wroclaw University, 36 pp, Wrocław, (In Polish only).

Baranowski, Z., 1988. Lithofacies characteristic of trench-fill metasediments in the Radzimowice slate (Paleozoic), Sudetes, SW Poland. *Ann. Soc. Geol. Polon*, 58 (3 – 4): 325-383, Wrocław, (In Polish, English summary).

Baranowski, Z., Haydukiewicz, A., Kryza, R., Lorenc, S., Muszyński, A., Solecki, A. & Urbanek, Z., 1990. Outline of the geology of the Góry Kaczawskie (Sudetes, Poland). *N. Jb. Geol. Paläont. Abh.*, 179 (2/3): 223 – 257.

Baranowski, Z., Haydukiewicz, A., Kryza, R., Lorenc, S., Muszyński, A. & Urbanek, Z., 1986. *Rozpoznanie rozprzestrzenienia sekwencji stratygraficznych i kompleksów chaotycznych w rejonie Dobkowa.* Unpublished report of CPBP 03.04 Project of the Polish Academy of Sciences, pp 38, Wrocław, (In Polish only).

Baranowski, Z., Haydukiewicz, A., Kryza, R., Lorenc, S., Muszyński, A. & Urbanek, Z., 1987. Rozwój struktury wschodniej części Gór Kaczawskich na podstawie dotychczasowego rozpoznania stratygrafii, warunków sedymentacji i wulkanizmu. In: Baranowski, Z. et al.(eds.), *Guidebook of 58 Meeting of the Polish Geological Society*, Kraków, 61 – 73, (In Polish only).

Baranowski, Z. & Lorenc, S., 1981. The geological position of the Wojcieszów limestones in relation to the greenstone (spilitic-keratophyric) series of the southeastern Kaczawskie Mts, Sudetes. *Geol. Sudetica*, 16 (2): 49 – 59, Wrocław, (In Polish, English summary).

Baranowski, Z. & Lorenc, S., 1986. A volcanic-carbonate association in the Góry Kaczawskie, Western Sudetes. *Geol. Rdsch.*, 75 (3): 595 – 599.

Baranowski, Z., Lorenc, S., Heinish, H. & Schmidt, K., 1984. Der Kambrische Vulkanismus des Bober-Katzbach-Gebirges (Kaczawskie Góry, West-Sudeten, Polen). - *N. Jb. Geol. Paläont. Mh.*, 1984 (1): 1 – 26.

Bederke, E., 1932. Probleme der Sudetengeologie. *Jb. Schles. Ges. Cult., Naturwiss.*, 105: 191 – 193, Breslau.

Block, W., 1938. Das Altpaläozoikum des östlichen Bober- Katzbachgebirges. *Geotek. Forsch.*, 2: 55

– 104, Stuttgart.

Chorowska, M., 1978. Visean limestones in the metamorphic complex of the Kaczawa Mts (Sudetes). *Rocz. Pol. Tow. Geol.*, 48: 245 – 261, Kraków, (In Polish, English summary).

Dahlgrün, F., 1934. Zur Altersdeutung des Vordevons im westsudetischen Schiefergebirge. *Z. dt. geol. Ges.*, 86: 385 – 393, Hannover.

Don, J., 1990. The differences in Paleozoic facies-structural evolution of the West Sudetes. *N. Jb. Geol. Paläont. Abh.*, 179 (2/3): 307 – 328.

Franke, W., 1989. Tectonostratigraphic units in the Variscan belt of central Europe. *Geol. Soc. America Special Paper*, 230: 67 – 90.

Furnes, H., Kryza, R. & Muszyński, A., 1989. Geology and geochemistry of Early Paleozoic volcanics of the Świerzawa Unit, Kaczawa Mts, W. Sudetes, Poland. *N. Jb. Geol. Paläont. Mh.*, 1989 (3): 136 – 154.

Furnes, H., Kryza, R., Muszyński, A., Pin, C. & Garmann, L.B., 1990. Trace element and Nd isotope geochemistry of the Kaczawa Mts (Polish Sudetes) volcanics: Evidence for early Paleozoic continental break-up ?. *International Conference on Paleozoic Orogens in Central Europe - Geology and Geophysics*, Göttingen, 4 pp, (Abstract).

Gorczyca-Skała, J., 1966. Structural research in the boundary area between the Kaczawa Mts and Izera Region. *Bull. Acad. Pol. Sci., Sér. Sci. Géol. Géogr.*, 14: 171 – 179, Warszawa.

Gunia, T., 1967. Cambrotrypa (Tabulata) from metamorphic rocks of the Western Sudetes. *Rocz. Pol. Tow. Geol.*, 37: 417 – 427, Kraków, (In Polish, English summary).

Gürich, G., 1882. Beiträge zur Kenntnis der niederschlesischen Tonschieferformation. *Z. dt. geol. Ges.*, 34: 691 – 734, Hannover.

Gürich, G., 1929. Silesicaris von Leipe und die Phyllokariden überhaupt. *Mitt. Miner. Geol. Staatsinst.*, 11: 21 – 90, Hamburg.

Haydukiewicz, A., 1987a. Sekwencja stratygraficzna w kompleksie kaczawskim. In: Baranowski, Z. et al.(eds.), *Guidebook of 58 Meeting of the Polish Geological Society*, 95 – 102, Kraków, (In Polish only).

Haydukiewicz, A., 1987b. Melanże Gór Kaczawskich. In: Baranowski, Z. et al.(eds.), *Guidebook of 58 Meeting of the Polish Geological Society*, 106 – 112, Kraków, (In Polish only).

Haydukiewicz, A. & Urbanek, Z., 1986. The metamorphosed Devonian rocks in the Bolków unit (the Kaczawskie Mts, Sudetes). *Geol. Sudetica*, 20: 185 – 196, Wrocław, (In Polish, English summary).

Hundt, R., 1922. Beiträge zur Kenntnis der Graptolitenfauna Deutschlands (westthüringisches Schiefergebirge, Kellerwald, Katzbachgebirge). *Jb. Preuss. Geol.* L.-A., 41: 148 – 207, Berlin.

Jaeger, H., 1964. Monograptus hercynicus in den Westsudeten und das Alter der Westsudeten - Hautpfaltung, Teil I. *Geologie*, 13 (3): 249 – 277, Berlin.

Jerzmański, J., 1965. Geology of north-eastern part of the Kaczawa Mts and their eastern extent. *Biul. Inst. Geol.*, 185: 109 – 193, Warszawa, (In Polish, English summary).

Kornaś, J., 1963. Stratygrafia syluru wschodniej części Gór Kaczawskich. *Kwart. Geol.*, 7 (4): 696 – 697, Warszawa, (In Polish only).

Kryza, R. & Muszyński, A., 1988. Metamorphosed diabasic sill-sediment complex from Wojcieszów: Mineralogical and geochemical evidence of Lower Paleozoic early-stage rifting in the Western Sudetes, SW Poland. *Mineralogia Polonica*, 19: 3 – 18, Warszawa.

Kryza, R., Muszyński, A. & Furnes, H., 1989. Early Paleozoic volcanism in the Kaczawa Mts: Lithological and geochemical correlations between the western parts of the Świerzawa and Bolków units. In: Narębski, W. & Majerowicz, A. (eds.), *Lower and Upper Paleozoic metabasites and ophiolites of the Polish Sudetes. MCASSC Conference Guidebook*, 190 – 205, Wrocław.

Kryza, R., Muszyński, A. & Vielzeuf, D., 1990. Glaucophane- bearing assemblage overprinted by greenschist-facies metamorphism in the Variscan Kaczawa complex, Sudetes, Poland. *J. Met. Geol.*, 8: 345 – 355.

Lorenc, S., 1983. Petrogenesis of the Wojcieszów crystalline limestones (Góry Kaczawskie Mts). *Geol. Sudetica*, 18 (1): 61 – 119, Wrocław, (In Polish, English summary).

Mormul, J., 1985. *Zdjęcie geologiczne okolic Wojcieszowa Dolnego (Góry Kaczawskie)*. Unpublis-

hed MSc thesis, Wrocław University, 46 pp, Wrocław, (In Polish only).

Narębski, W., 1980. Paleotectonic setting of the Circum-Karkonosze Lower Paleozoic spilite-keratophyre suites based on geochemistry of iron group elements. *Rocz. Pol. Tow. Geol.*, 50: 3 – 25, Warszawa.

Narębski, W., Dostal, J. & Dupuy, C., 1986. Geochemical characteristics of Lower Paleozoic spilite-keratophyre series in the Western Sudetes (Poland): Petrogenetic and tectonic implications. *N. Jb. Miner. Abh.*, 153 (3): 243 – 258.

Oberc, J.,1980. Early to Middle Variscan development of the West Sudetes. *Acta Geol. Polon.*, 30: 27 – 52, Warszawa.

Pacholska, A., 1975. Petrography of metasandstones of the Świerzawa Unit in the Kaczawa Mts (Góry Kaczawskie). *Geol. Sudetica*, 10 (1): 105 – 116, Wrocław, (In Polish, English summary).

Schwarzbach, M., 1939. Die Tectonic des Bober-Katzbach-Gebirges. *Jb. Schles. Ges. Cult., Naturwiss.*, 113: 1 – 52, Breslau.

Teisseyre, H., 1956. Świebodzice Depression as a geological unit. *Biul. Inst. Geol.*, 106: 5 – 60, Warszawa, (In Polish, English summary).

Teisseyre, H., 1963. The Bolków-Wojcieszów anticline - a representative Caledonian structure in the Western Sudetes. *Prace Inst. Geol.*, 30: 279 – 300, Warszawa, (In Polish, English summary).

Teisseyre, H., 1967. Najważniejsze zagadnienia geologii podstawowej w Górach Kaczawskich. In: Teisseyre, H.(ed.), *Guidebook of 40th Meeting of Pol. Geol. Soc.*: 11 – 30; Warszawa, (In Polish only).

Teisseyre, H., 1976. *Szczegółowa mapa geologiczna Sudetów, Arkusz Bolków, 1 : 25 000*, Warszawa, (In Polish only).

Teisseyre, H., 1977. *Objaśnienia do szczegółowej mapy geologicznej Sudetów, Arkusz Bolków, 1 : 25 000*, 60 pp, Warszawa, (In Polish only).

Urbanek, Z., 1978. The significance of Devonian conodont faunas for the stratigraphy of epimetamorphic rocks of the northern part of the Góry Kaczawskie. *Geol. Sudetica*, 13: 7 – 30, Wrocław.

Urbanek, Z. & Baranowski, Z., 1986. Revision of age of the Radzimowice slates from the Góry Kaczawskie, Western Sudetes. *Ann. Soc. Geol. Polon.*, 56 (3-4): 399 – 408, Wrocław.

Urbanek, Z., Baranowski, Z. & Haydukiewicz, A., 1975. Geological consequences of the occurrence of the Devonian conodonts in metamorphic rocks of the northern part of the Kaczawa Mts. *Geol. Sudetica*, 10: 155 – 169, Wrocław, (In Polish, English summary).

Zimmermann, E., 1932. *Geologische Karte von Preussen und benachbarten deutschen Ländern*, 1 : 25 000, Blatt Hirschberg. Preuss. Geol. Landesanst., Berlin.

Zimmermann, E., 1941. *Geologische Karte des Deutschen Reiches. Erläuterungen zu Blatt Kauffung. Lief.* 276, 95 pp, Berlin.

Zimmermann, E. & Berg, G., 1932. *Geologische Karte von Preussen und benachbarten deutschen Ländern*, 1 : 25 000, Blatt Kauffung. Preuss. Geol. Landesanst., Berlin.

Zimmermann, E. & Haack, W., 1929. *Geologische Karte von Preussen und benachbarten deutschen Ländern, 1 : 25 000, Blatt Bolkenhain*. Preuss. Geol. Landesanst., Berlin.

Zimmermann, E. & Haack, W., 1935. *Erläuterungen zur geologischen Karte von Preussen und benachbarten deutschen Ländern, 1 : 25000, Blatt Bolkenhein. Lief. 246*, Preuss. Geol. Landesanst., 48 pp, Berlin.

Streszczenie

PRZEDWARYSCYJSKA SUKCESJA WULKANICZNO-OSADOWA CENTRALNEJ CZĘŚCI POŁUDNIOWYCH GÓR KACZAWSKICH: ZARYS GEOLOGII

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Artykuł stanowi syntetyczne podsumowanie wyników 6-letnich terenowych badań geologicznych, wykonanych przez autorów w środkowej części południowych Gór Kaczawskich (Fig. 1), na obszarze wydzielonych przez Teisseyre'a (1956, 1963) jednostek Świerzawy i Bolkowa. Głównym rezultatem tych badań jest mapa geologiczna (Fig. 2), istotnie różniąca się od dotychczasowych ujęć kartograficznych, szczególnie w sposobie wydzieleń i w obrazie rozprzestrzenienia skał wulkanogenicznych. Na mapie przedstawiono wyniki własnych szczegółowych badań kartograficznych, obok informacji zaczerpniętych z wcześniejszych map i publikacji. Nowa mapa stanowi podstawę do: (1) propozycji modyfikacji wydzieleń głównych jednostek tektonicznych; (2) scharakteryzowania litologii uporządkowanej według nowego roboczego schematu stratygraficznego; i (3) sporządzenia przekrojów geologicznych ilustrujących proponowaną interpretację tektoniczną obszaru badań.

Propozycja zmodyfikowanego zasadniczego podziału tektonicznego jest przedstawiona na Figurze 3. W odróżnieniu od dotychczasowego modelu Teisseyre'a (1956, 1963), proponuje się uznać obszar wychodni łupków radzimowickich za odrębną jednostkę tektoniczną – jednostkę Radzimowic. Znajduje to uzasadnienie w jej tektonicznych granicach (nasunięcia) i uwydatnione jest ponadto poprzez odmienność charakteru litologicznego tej jednostki, w porównaniu z jednostkami sąsiednimi (Baranowski, 1988). W konsekwencji, termin "jednostka Bolkowa" zostaje ograniczony do wychodni skał wulkaniczno-osadowych, przylegającej od południa i wschodu do jednostki Radzimowic – a więc do obszaru znacznie mniejszego w porównaniu z "jednostką Bolkowa" w rozumieniu Teisseyre'a (1963). Granice jednostki Świerzawy zasadniczo pokrywają się z tymi, jakie wyznaczył Teisseyre (1963), chociaż wciąż problematyczną jest pozycja zespołów skalnych tzw. obszaru Dobkowa i obszaru Chmielarza (DA i CA na Fig. 3).

Nazewnictwo skał wulkanogenicznych zostało uściślone i ujednolicone. Zaproponowano nowy roboczy schemat stratygraficzny (Fig. 4), próbując ustalić następstwo poszczególnych wydzieleń litologicznych w oparciu m.in. o: (a) wskaźniki stropu w skałach pochodzenia wulkanicznego i osadowego, (b) obserwowane w terenie następstwo poszczególnych zespołów skalnych w profilach, i (c) dostępnych, chociaż ciągle nielicznych danych biostratygraficznych i radiometrycznych. Niektóre zespoły skalne pozostawiono jako jednostki o nieznanej pozycji stratygraficznej.

Jednostki według przypuszczalnego następstwa stratygraficznego:

sukcesja Milka

1. kompleks wulkaniczny Podgórek
2. wapienie wojcieszowskie
3. (meta)ryodacyty Osełki
4. (meta)piaskowce Gackowej

5. szare metamułowce
6. (meta)trachity Lubrzy
7. czarne łupki ilaste i krzemionkowe, i łupki krzemionkowo-ilaste

Jednostki o nieznanej pozycji:

a. łupki Chmielarza
b. łupki Dobkowa
c. łupki radzimowickie
d. melanże

Zebrano wiele obserwacji i pomiarów pierwotnych struktur wulkanicznych i osadowych, spośród których szczególne znaczenie mają cechy wskazujące na kierunek stropu i spągu, takie jak różne rodzaje warstwowania (gradacyjne, przekątne), ścięcia erozyjne i struktury pogrązowe w skałach osadowych, oraz niektóre cechy law poduszkowych (kształt poduszek, rozkład pęcherzyków wewnątrz pukli, struktury typu "drain-out" i in.). Wzajemną orientację pierwotnego warstwowania względem głównej foliacji wykorzystano do interpretacji tektonicznych, które pokazano na przekrojach (Fig. 6 - 8). Przekroje te różnią się w wielu istotnych punktach od wcześniejszych interpretacji tektonicznych Teisseyre'a (1963; Fig. 5). Do ważniejszych różnic należy stwierdzenie przeciwnego kierunku "młodnienia" sekwencji skalnej w głównym pasie wychodni skał wulkanicznych i osadowych wzdłuż południowego brzegu jednostki Świerzawy, i w konsekwencji zinterpretowanie tego pasa jako skrzydła odwróconego (a nie normalnego jak u Teisseyre'a, 1963) antyklinalnego fałdu o wergencji południowej (Fig. 6 i 7). Na podkreślenie zasługuje też układ podobnych do siebie zespołów skalnych w zachodniej części jednostek Świerzawy i Bolkowa, przypominający jakby synformę, w "jądrze" której zalega tektonicznie ograniczona jednostka Radzimowic (Fig. 6). Jednostka Bolkowa jako całość jest skomplikowaną strukturą tektoniczną, z dominacją fałdów o wergencji południowej. Kierunek "młodnienia" sekwencji jest generalnie ku północy w części zachodniej tej jednostki, i na ogół ku S i E w części środkowej i wschodniej. W części wschodniej jednostki Bolkowa potwierdza się obecność dużej struktury synklinalnej ("synklina Starych Ro-

chowic" według Haydukiewicza i Urbanek, 1986), wtórnie wygiętej w antyformę Bolków-Wojcieszów (Teisseyre, 1956, 1963).

Figura 9 przedstawia zgeneralizowane profile litologiczne jednostki Świerzawy oraz zachodniej i wschodniej części jednostki Bolkowa. Wykazują one pewne podobieństwa, m.in. na wszystkich trzech, w dolnej części sekwencji, występują podobne elementy litologiczne sukcesji Miłka, zaś w górnej części – zespół skalny trachitów Lubrzy. Są też jednak istotne różnice co do rodzaju, miąższości i proporcji ilościowych poszczególnych odmian skalnych w różnych profilach. Różnice te odzwierciedlają zapewne głównie pierwotne zróżnicowanie środowiska wulkanizmu i sedymentacji w czasie i w przestrzeni, chociaż niektóre mogą być efektem erozji tektonicznej.

Wiele szczegółów w zakresie stratygrafii i tektoniki centralnej części południowych Gór Kaczawskich pozostaje niejasnych. Dlatego autorzy nie mogą zaproponować kompletnego podziału litostratygraficznego na formalne jednostki, ani też przedstawić w sposób systematyczny i całościowy interpretacji struktur tektonicznych. Niemniej, przedstawione wyniki badań terenowych wnoszą sporo nowych elementów do znajomości geologii tego obszaru, porządkują przynajmniej częściowo nazewnictwo skał i schemat stratygraficzny, oraz dostarczają nowych danych strukturalnych do interpretacji tektonicznych. Dla autorów pracy, prezentowany materiał stanowi bazę do szczegółowych badań petrologicznych i geochemicznych skał wulkanicznych południowej części Gór Kaczawskich.