Annales Societatis Geologorum Poloniae (1992), vol. 62: 63 – 73
PL ISSN 0208-9068

A N-TRENDING PHOTOLINEAMENT IN THE RUDAWY JANOWICKIE MTS. (WEST SUDETES, POLAND) AND ITS TECTONIC SIGNIFICANCE

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Mroczkowski, J., 1992. A. N-trending photolineament in the Rudawy Janowickie Mts. (West Sudetes, Poland) and its tectonic significance. *Ann. Soc. Geol. Polon.*, 62: 63 – 73.

A b s t r a c t: The Thematic Mapper satellite image shows in the West Sudetes a N-trending double photolineament, roughly following the Rudawy Janowickie Mts. on the eastern flank of the Karkonosze Granite Massif. The double photolineament coinciding with polymetallic mineralization reflects likely an important fracture zone otherwise indicated by sedimentological and geomorphological data. This photolineament is characterized by its length (more than 80 km), longevity (Early Carboniferous through Recent) and location at the border of areas which have different geological history.

K e y w o r d s: photolineament, fracture zone, uplift, Sudetes Mts.

Manuscript received 15 October 1990, revised accepted November 17, 1991

INTRODUCTION

The Thematic Mapper satellite image covering a vast part of the West Sudetes, shows a N-trending double photolineament* or two subparallel, closely adjacent photolineaments (Figs. 1, 2, 3) roughly following the eastern boundary of the Karkonosze Granite. This photolineament (or photolineaments) can also be detected on the earlier Landsat images, but only in fragments (Mroczkowski & Ostaficzuk, 1985). The Thematic Mapper image presents this structure as a distinct line that appears in the vicinity of Radzimowice in the Góry Kaczawskie Mts. and strikes southwards with a minor deflection to the west. In the Góry Ołowiane, nearby Kaczorów (Fig. 2) it

**The term "photolineament" is used in this paper, although a satellite image is an effect of complicated processing of satellite data rather than an ordinary photograph of the earth surface.*

diverges to form two SSW trending segments, parallel to the main range of the Rudawy Janowickie. At the Polish – Czecho-Slovakian frontier they are 2 km apart. Farther south they turn to be almost meridional in Czecho-Slovakia and come closer to one another being still recognizable near Hradec Kralove. Accordingly the two features are at least 80 km long; their width on the satellite image is up to 1 mm at a scale of 1 : 250 000, which in the field gives 1/4 km.

The aim of this paper is to prove the existence of an important tectonic fracture along the Rudawy Janowickie range.

GEOLOGICAL SETTING

In order to reveal possible links of the examined photolineaments with a geological structure, a geological sketch map (Fig. 2) has been compiled from the maps of Zimmermann & Berg (1932), Berg (1936; 1940), Szałamacha (1956; 1957). The photolineaments (or a double photolineament) cut across different geological units and show no obvious relation to the local geology. They cut through the epimetamorphic series of the Góry Kaczawskie on the north and continue southwards down the border zone between the Karkonosze Granite and its partly hornfelsed metamorphic envelope (Fig. 2). Farther south the two photolineaments transect thick Kulm deposits in the Intra-Sudetic Basin. In Czecho-Slovakia, the photolineaments run across an area of a thick cover of Permian and Cretaceous deposits.

Contrary to other photolineaments in the Karkonosze and Góry Izerskie region (Mroczkowski & Ostaficzuk, 1985) the discussed features show no obvious relation to the lithological boundaries, cataclastic and mylonitic zones, mapped faults, veins, etc. The only exception occurs in the northern part of the Rudawy Janowickie (Fig. 2) where the thrust at the boundary between the Leszczyniec volcanic rocks and the Przypkowice phyllites (Oberc, 1960; Szałamacha, J. & Szałamacha, M., 1968; Teisseyre, J., 1968) seems to coincide with the described photolineaments. This rises the question concerning the nature of the detected meridional photolineament.

NATURE OF THE MERIDIONAL PHOTOLINEAMENTS IN THE RUDAWY JANOWICKIE

In an attempt to explain the meridional photolineaments (I and II in Fig. 2) it is worth to consider the occurrence of polymetallic mineralization along them, particularly in areas of the intersection with second order photolineaments. The mineralization sites include Miedzianka (copper mined from early medieval times till 20 th century), Rędziny, Leszczyniec, the Upa river valley and Lampertice in Czecho-Slovakia. In the light of earlier metallogenic investigation in the Sudetes, suggesting an influence of three hypothetical NNE-

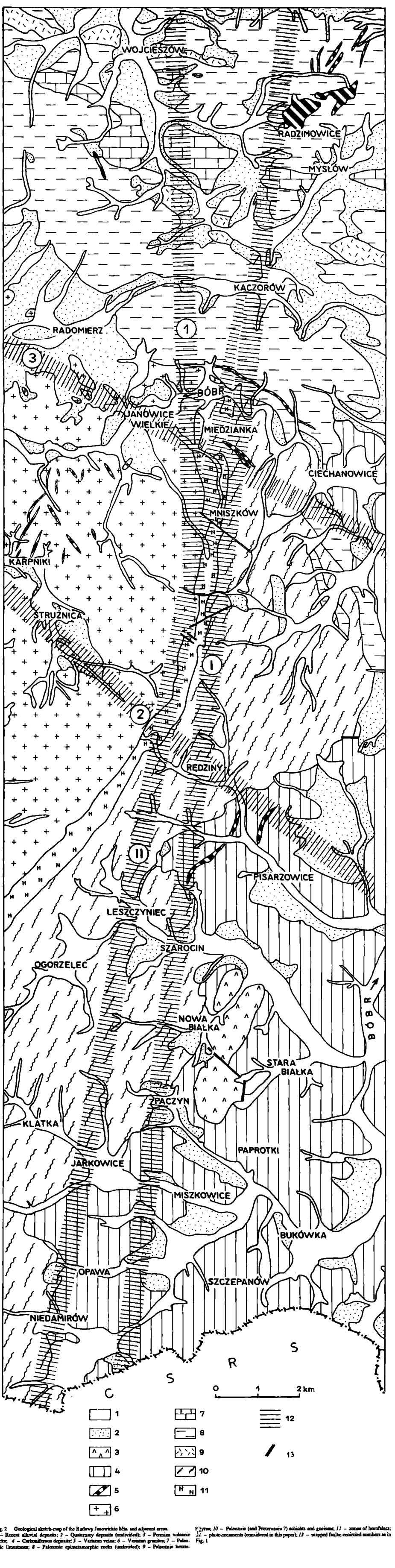

Fig. 2 Geological sketch-map of the Rudawy Janowickie Mts. and adjacent areas. *1* – Recent alluvial deposits; *2* – Quaternary deposits (undivided); *3* – Permian volcanic rocks; *4* – Carboniferous deposits; *5* – Variscan veins; *6* – Variscan granites; *7* – Paleozoic limestones; *8* – Paleozoic epimetamorphic rocks (undivided); *9* – Paleozoic metamorphites; *10* – Paleozoic (and Proterozoic ?) schists and gneisses; *11* – zones of borefelses; *12* – photolineaments (considered in this paper); *13* – mapped faults; encircled numbers as in Fig. 1

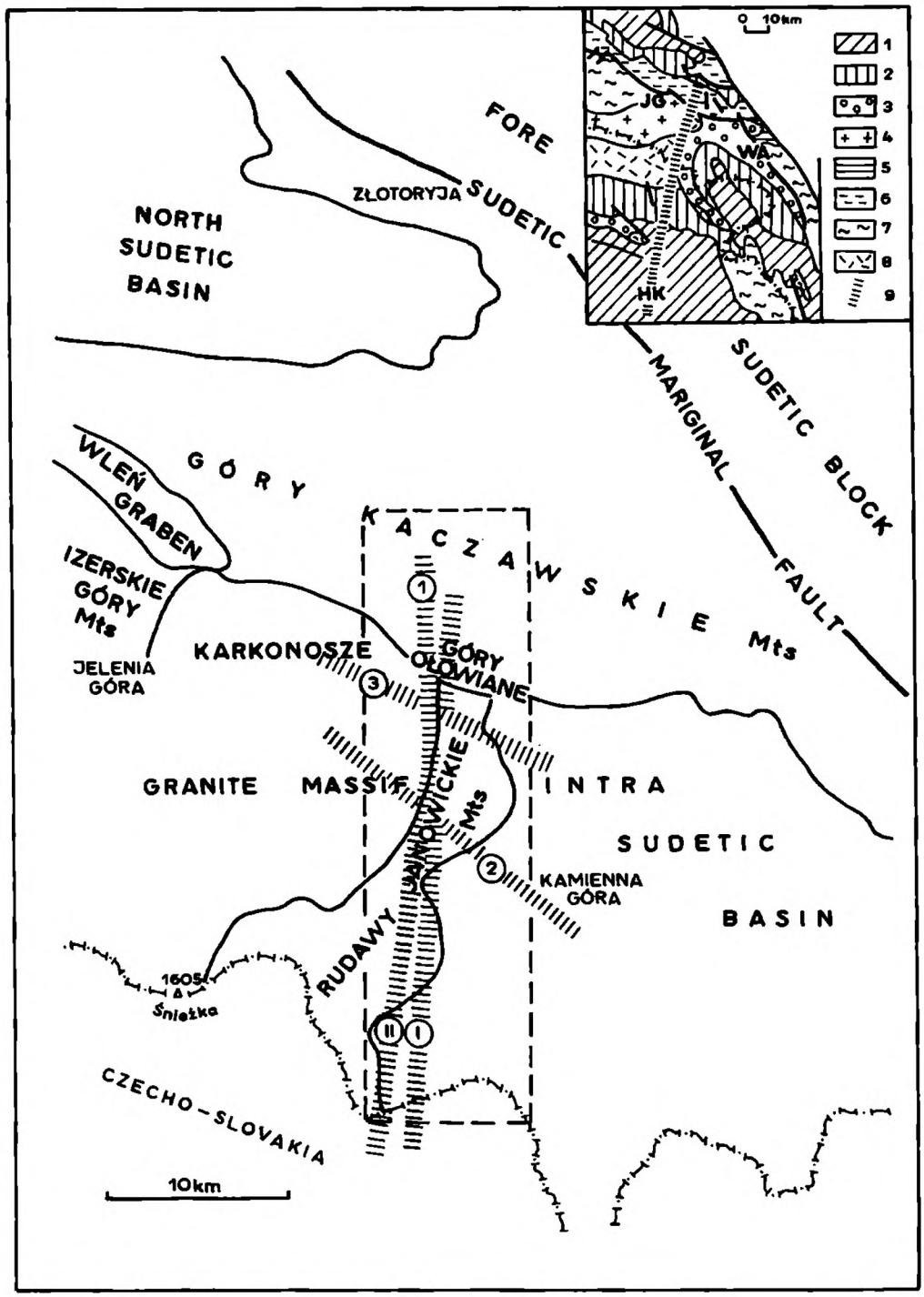

Fig. 1 Sketch to locate discussed photolineaments in the West Sudetes. I and II (encircled) – double photolineaments; ①, ②, ③ – second order photolineaments. *Dashed rectangle* – study area in Fig. 2. *Solid inset* – the double photolineament versus geology of the West Sudetes. *1* – Mesozoic deposits; *2* – Permian rocks; *3* – Carboniferous rocks; *4* – Variscan Karkonosze granite; *5* – Devonian rocks; *6* – epimetamorfic rocks of the Góry Kaczawskie; *7* – Paleozoic (and Proterozoic ?) gneisses; *8* – Paleozoic (and Proterozoic ?) crystalline schichts; *9* – photolineament; *JG* – Jelenia Góra; *WA* – Wałbrzych; *HK* – Hradec Kralove

trending lineaments in the area (Kanasiewicz & Sylwestrzak, 1970), some connections between the above mentioned ore deposits and the presence of profound crustal discontinuities are quite probable.

To the east of the Karkonosze Granite Massif, there is probably a continuation of the West Moravian deep fracture zone (cf. Zeman, 1973). Its continuation on the Polish territory was confirmed by Michniewicz (1981) who also claimed a great importance of this tectonic structure for the development of the Karkonosze Granite Massif.

The presence of the NNE-striking fracture zones in the Sudetes due to Paleozoic rifting was suggested by Dziedzic (1981, 1986). One of these zones coincides with the Rudawy Janowickie and thus remains at a very low angle to the discussed double photolineament. It is imposible, however, to compare the localization of the features in details, because of a small scale of the sketch-map published by Dziedzic (1986). Nevertheless, the fracture zone interpreted by Dziedzic (1981, 1986) as likely vital for the Paleozoic development of the North- and Intra-Sudetic Basins, occurs very close to the photolineaments.

The Kulm sedimentation in the Intra-Sudetic Basin adjacent to the Rudawy Janowickie range (Fig. 1) was likely coeval with the formation of a N-trending flexure in the metamorphic envelope of the Karkonosze Granite Massif. This flexure must have been accompanied by a system of long-lived normal faults along the boundary of the Karkonosze Massif with the Intra-Sudetic Basin, mentioned by Teisseyre, A. K. (1971), though unfortunately not indicated on his map. The Kulm deposition in the Intra-Sudetic Basin during Early Carboniferous must have been controlled by an active fault in the Rudawy Janowickie. Younger deposits in the Intra-Sudetic Basin do not provide so striking evidence for the presence of an active tectonic line along the western margin of the Basin. These young deposits, however, originated farther off the margin and later became repeatedly reworked and redeposited.

According to Jerzykiewicz (1968), during the late Cretaceous, one of the source areas for he clastic marine sedimentation within the Intra-Sudetic Basin must have been an uplifted land (or island) in the area of the Rudawy Janowickie. The fractures must have been rejuvenated, since they could be recognized on a satellite image as photolineaments. According to my experience, fracture zones in the Sudetes which became inactive before the Tertiary cannot be identified on satellite images unless they separate highly differentiated terrains. For example the Sudetic Marginal Fault appears as a distinct photolineament, whereas the very important Intra-Sudetic Fault, believed to separate Caledonian and Variscan parts of the Sudetes (Don, 1984), is practically invisible on satellite images.

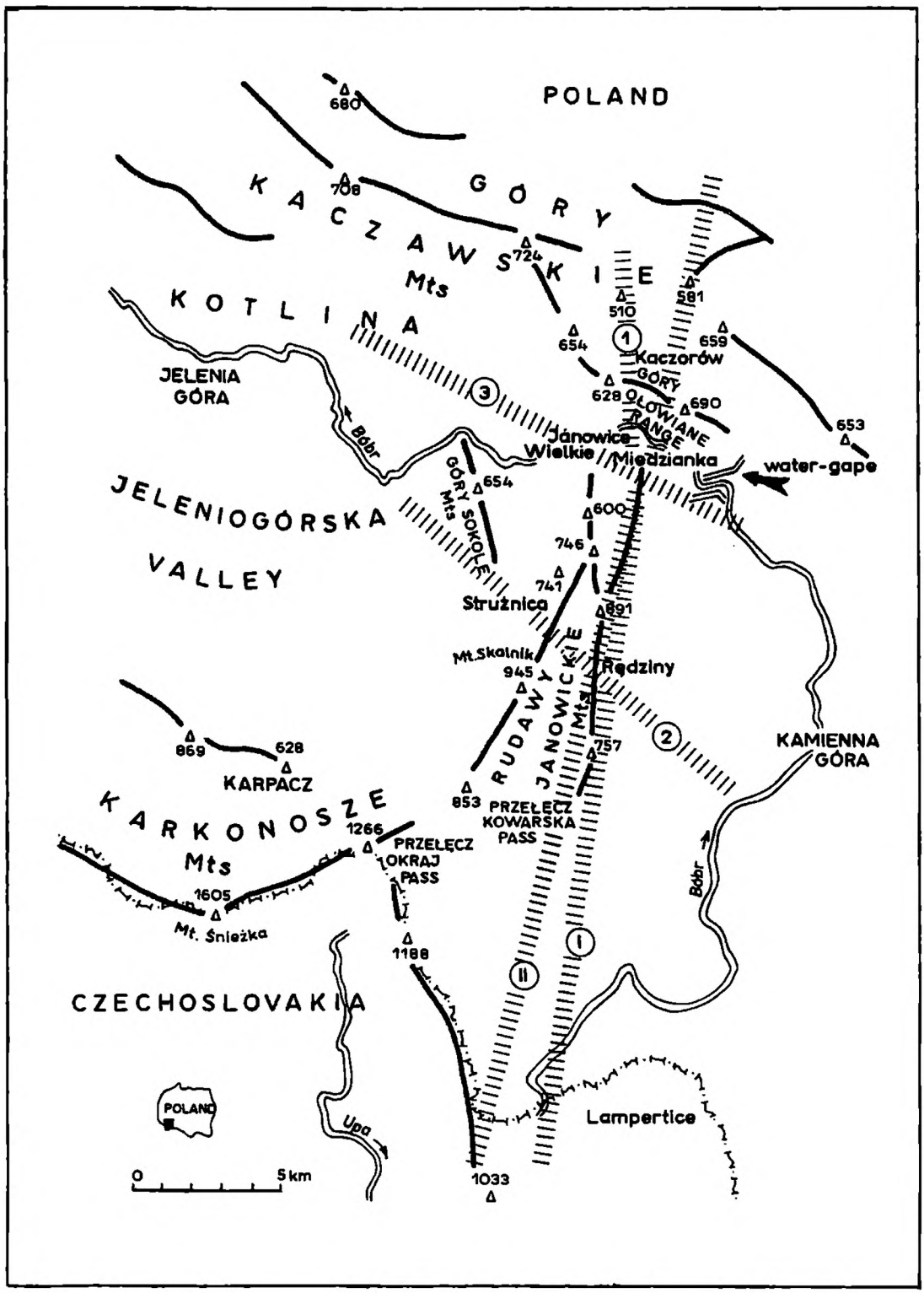

Fig. 3 Sketch-map of prominent ranges of the Rudawy Janowickie region

GEOMORPHOLOGICAL FEATURES OF THE PHOTOLINEAMENT ZONE

There are some geomorphological indications allowing to link the N-trending photolineaments with the Quaternary faults on which (among others) the Rudawy Janowickie have been uplifted relative to the Intra-Sudetic Basin. Recent positive movements in that region are well demonstrated by a river-gape of the Bóbr river valley a few km above the village of Janowice Wielkie (Fig. 3). The Bóbr river deflects here its course from the east and south-east through a 150 m deep, narrow and steep meandering valley that separates the Rudawy Janowickie and Góry Ołowiane (Fig. 3). About 0,5 km west of Janowice Wielkie, just below the zone of the described photolineaments, the Bóbr river valley widens to the west, with lowered banks at the entrance to the Kotlina Jeleniogórska Valley.

The considered photolineaments south of Janowice Wielkie and nearby Mount Skalnik (945 m), and in the vicinity of the Ogorzelec village coincide with small but steep valleys, likely representing very young geomorphological forms.

One of the southern tributaries of the Bóbr river running parallel to the photolineament zone and flanked by steep slopes in the vicinity of Janowice Wielkie is dammed up about 1 km above the stream mouth by an embankment composed of granite rocks occurring both in situ and as boulders. The damming caused a sharp turn of the stream course to the west. The stream cuts through it and creates such a (mini-gorge). This is an example of a very young form of relief that can be related to the discussed photolineaments.

On the satellite image one can observe two river valleys crossing at the high angle the main range of the Rudawy Janowickie: between the villages of Rędziny and Strużnica and between Okraj Pass and Kowarska Pass in the southern part of the Rudawy Janowickie range. Since the Rudawy Janowickie is a distinct watershed, no streams run now arcoss it. The lower parts of the valleys are used by streams running down from the range to the west and east, immediately to the Bóbr river in its upper reach, above the town of Kamienna Góra. The second valley joins the Bóbr river, too, but in its lower part, in the area of the Kotlina Jeleniogórska Valley. These two traces of valleys once cutting through the main range of the Rudawy Janowickie, are now elevated to the level of ca. 700 m, which suggest relatively recent uplift of this range, with gentle hilltops and steep-sided valleys.

Many picturesque tors, tens of meters high, notorious as a tourist atraction in that area, occur along the photolineaments zone, on slopes and hilltops of the Rudawy Janowickie. Their connection with the photolineaments is difficult to demonstrate, though in the Karkonosze, similar granite tors are clustered around the most important tectonic discontinuities (Mroczkowski & Ostaficzuk, 1985).

SECOND ORDER PHOTOLINEAMENTS

Besides the two photolineaments described above some others are present on the satellite image of the Rudawy Janowickie. They are less distinct and visible on shorter distance. Three of these photolineaments seem to be connected with fault zones. The photolineament present in the northern part of the area (① on Fig. 2), running almost exactly N-S comes at a low angle to the main meridional photolineament. Two other NW-trending photolineaments of second order occur between Rędziny and Strużnica and south of Miedzianka (② and ③ on Fig. 2).

DISCUSSION

The double photolineament zone, running meridionally along the Rudawy Janowickie, is well legible over a distance of at least 80 km. However it cannot be related to any mapped tectonic fault, nor proved in the field. On the other hand, there are a number of indirect indications that the photolineament zone may actually reflect a major tectonic feature.

(1) The Early Carboniferous faults along which the Rudawy Janowickie area was elevated in respect to the adjacent Intra-Sudetic Basin (being filled at the same time by thick Kulm deposits - cf. Teisseyre, 1971), were likely to coincide with the photolineaments.

(2) The Rudawy Janowickie likely remained an elevated source area for the Intra-Sudetic Basin not only during the Early Carboniferous but also later, for example in Late Cretaceous time (Jerzykiewicz, 1968).

(3) Some geomorphological features of the Rudawy Janowickie resemble forms associated with the important tectonic lines in the Karkonosze and Góry Izerskie Block (cf. Mroczkowski & Ostaficzuk, 1985).

(4) In the zone of the photolineaments under consideration, especially at their intersections with other photolineaments, polymetallic mineralizations are widespread, locally giving rise to deposits, mostly copper, mined in historical times. Connection of abundant polymetallic mineralizations with deep fracture zones is a commonly known phenomenon.

(5) Some recent regional considerations suggest the presence of a deep fracture zone or a transform fault coinciding with the Rudawy Janowickie range. Those proposing a prolongation of the West Moravian deep fracture zone (Zeman, 1973; Michniewicz, 1981) or a transform fault separating (among others) two basins of rift type (Intra-Sudetic and North-Sudetic; Dziedzic, 1986), are the most interesting. A hypothetic course of the lines differs a little from the course of the photolineament zone considered in this paper.

(6) Numerous occurrences of Tertiary volcanic rocks are known from the area west of the photolineament zone, while they are absent east of it. Volcan-

ism of Late Carboniferous – Early Permian age developed on both sides of the zone, but its development and timing a little differed on the west and east.

(7) Much alike situation was matched by sedimentary infillings in the North-Sudetic and Intra-Sudetic Basins, both being separated by the considered photolineament zone. In the latter, sedimentation started earlier and resulted in different development and thickness of Carboniferous, Permian and Triassic deposits than in the former. Beginning from the Late Permian, sedimentary units in the Intra-Sudetic Basin were highly reduced in thickness, or disappeared, on the contrary to their equivalents in the North-Sudetic Basin. Further differences are visible in the occurrence of Variscan vein rocks, which is more common in the region west of the meridional photolineaments.

The facts listed above allow to conclude that the areas situated west and east of the phptolineament zone were differentiated not only by the activity of volcanoes in Tertiary time, but also by a rate of subsidence of the mentioned Sudetic basins and by other geological processes. The difference in distribution of tension and compression within the areas situated on both sides of the photolineament zone could play a role in this differentiation, too.

According to numerous authors, one of the most important faults in the Sudetes is the NW-trending Intra-Sudetic Fault (for the comprehensive discussion see Schmuck, 1957; Teisseyre, 1957; Oberc, 1964; Smulikowski, 1966; Oberc-Dziedzic & Oberc, 1972; Oberc-Dziedzic, 1978; Don, 1984). Nevertheless, many doubts were cast upon the course, continuity and significance of this fault and it was very difficult to map it over its whole supposed length. The existence of the Intra-Sudetic Fault has been accepted by most geologists for its presence well explains some important differences in the geological structure of the regions located on both sides of this fault (Don, 1984). In my opinion it may be possible that some of these differences result from more complex subdivision of the Sudetes than that proposed by Don (1984). Besides the Intra-Sudetic Fault, there can exist a very important tectonic line, which is reflected by the zone of two almost paralell photolineaments of meridional course along the Rudawy Janowickie. Some areas that have been thought to be separated by the Intra-Sudetic Fault, are, in fact, situated on both sides of the Rudawy Janowickie tectonic zone, too. This zone by virtue of its length, duration in geological time and separation of geological regions of different development shoul be considered as an important deep fracture zone.

CONCLUSIONS

The basic question put in this paper is what actually represents the double meridional photolineament running along the Rudawy Janowickie Mts and well visible on the Thematic Mapper satellite image over a distance of at least 80 km. Such lines, well legible on satellite images. most often point to tec-

tonic discontinuities. Athough the case under cosnideration lacks undobtful field evidence for discontinuities like a mappable fault, zones of cataclasis, mylonitization, etc., numerous indirect premises lead to the conclusion that the photolineament zone dose indeed reflect an important tectonic line. Among these premises, the undoubtful uplift of the Rudawy Janowickie Mts, first marked in the Early Carboniferous and repeatedly reactivated till the Quaternary, the appearance of polymetallic mineralization and the suggestions from several authors claiming the presence in this region of an important deep fracture zone or a transform fault, seem to be the most striking.

Summarizing, the presence of the significant tectonic line in the Rudawy Janowickie is very probable. It has likely been active since at least Early Carboniferous time. This has been matched by both depositional history of the North- and Intra-Sudetic Basins and Tertiary volcanism different on either side of the hypothetic line.

ACKNOWLEDGEMENTS

I express my thanks to my colleagues from Polish Academy of Sciences, especially to Dr A. Żelaźniewicz, Dr S. Ostaficzuk, Dr A. Pacholska and Dr S. Achramowicz for discussion and help in the preparation of this paper. Thanks are also due to Institute of Geological Sciences, Polish Academy of Sciences for financial support under Project CPBP 03.04.

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Streszczenie

POŁUDNIKOWY FOTOLINEAMENT W RUDAWACH JANOWICKICH I JEGO ZNACZENIE TEKTONICZNE

Jerzy Mroczkowski

Na zdjęciu satelitarnym Thematic Mapper obejmującym Sudety zachodnie, widoczny jest wyraźny południkowo przebiegający podwójny fotolineament usytuowany mniej więcej wzdłuż Rudaw Janowickich. Jego czytelność na zdjęciu i zasięg (co najmniej od wsi Kaczorów w Górach Kaczawskich po okolice miasta Hradec Kralove w Czechosłowacji, a więc około 80 km), sugerują, że stanowi on odbicie jakiejś ważnej linii tektonicznej. Przebieg tego fotolineamentu nie pokrywa się jednak z wykartowanymi uskokami, granicami litologicznymi (Fig. 1, 2), nie jest też akcentowany przez obecność żył, stref kataklazy lub mylonityzacji. Istnieje natomiast szereg przesłanek pośrednio wskazujących na obecność jakiejś ważnej linii dysjunkcji o przebiegu zbliżonym do opisywanego fotolineamentu. Ważniejsze spośród nich to: (1) pojawianie się w jego sąsiedztwie polimetalicznego okruszcowania (m.in. w rejonie Miedzianki, gdzie wydobywano miedź od czasów średniowiecza), (2)

obecność szeregu młodych form geomorfologicznych, świadczących o niedawnym podniesieniu pasma Rudaw Janowickich (Fig. 3), (3) dane z badań sedymentologicznych sugerujące podniesienie obszaru Rudaw względem basenu śródsudeckiego we wczesnym karbonie, co spowodowało m.in. osadzenie się w zachodniej części basenu kulmowych konglomeratów, interpretowanych jako piedmontowe osady Pra-Rudaw (A. K. Teisseyre 1971).

Zarówno wczesnokarbońskie jak i młodsze ruchy podnoszące obszar Rudaw Janowickich musiały się odbywać wzdłuż dyslokacji o kierunku w przybliżeniu południkowym. Istnienie w omawianym obszarze takich dyslokacji o charakterze rozłamu, ryftu, lub uskoku przesuwczego było sugerowane przez Kanasiewicza i Sylwestrzaka (1970), Zemana (1973), Dziedzica (1981, 1986), Michniewicza (1981). Sugestie takie wynikały z analizy ogólnej sytuacji geologicznej regionu i miały charakter hipotez.

Omawiany podwójny fotolineament oddziela od siebie obszary o pewnych istotnych różnicach w budowie geologicznej. Spośród nich zwracają uwagę: brak wulkanitów trzeciorzędowych na wschód od fotolineamentu, przy ich licznym pojawianiu się na zachód od niego; szereg różnic w rozwoju wulkanizmu waryscyjskiego i w przebiegu sedymentacji w dwóch basenach: śródsudeckim i północnosudeckim, położonych po obu stronach fotolineamentu, a pozornie bardzo zbliżonym do siebie budową geologiczną.

W świetle przytoczonych faktów wydaje się bardzo prawdopodobne, że omawiany fotolineament odzwierciedla ważną linię dyslokacyjną, aktywną co najmniej od wczesnego karbonu do czwartorzędu włącznie, być może z dłuższymi lub krótszymi przerwami. Długość tej dyslokacji, jej długowieczność, fakt że oddziela ona od siebie obszary o dość istotnych różnicach w rozwoju geologicznym sugerują, że może ona mieć charakter głębokiego rozłamu tektonicznego.