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RELATIONSHIP BETWEEN RELIEF AND TECTONICS ON THE NORTH-EASTERN BORDER OF THE HOLY CROSS MOUNTAINS

The question of the role of tectonics in the origin of relief and development of Quaternary deposits has been often raised in Poland lately. The dependence is obvious in areas considered as mobile but it is less easily acceptable in areas regarded as stable and, besides, having a thick Quaternary cover. In the author's opinion the north--eastern margin of the Holy Cross Mountains belongs to areas where the relief is markedly dependent on tectonics.

The relief of the north-eastern margin of the Holy Cross Mountains is characterized by the occurrence of lower and lower altitude

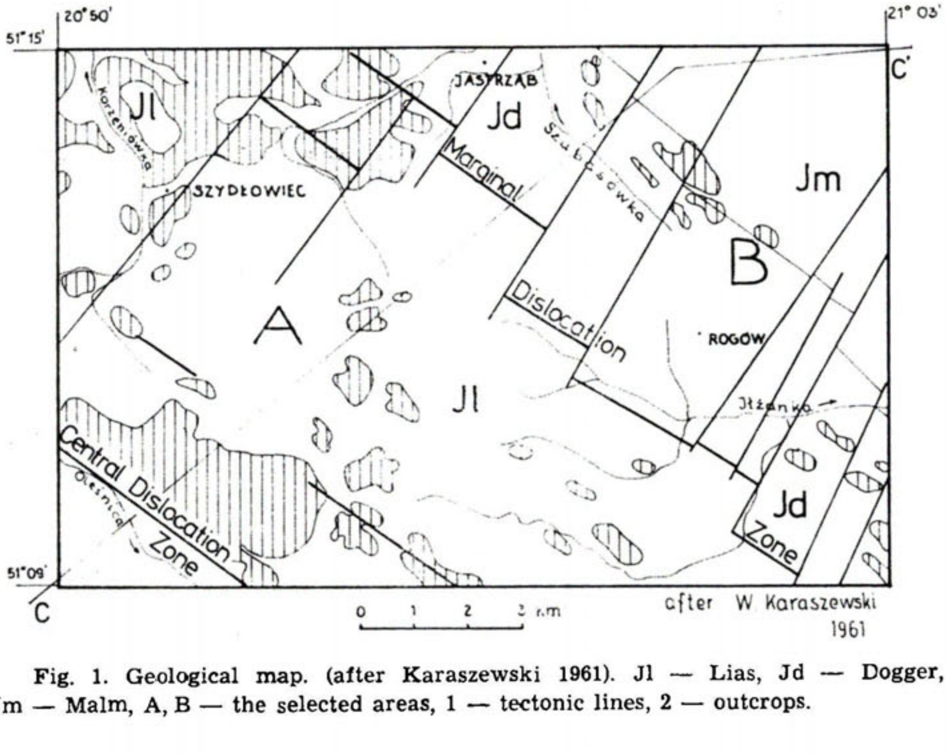

Fig. 1. Geological map. (after Karaszewski 1961). Jl — Lias, Jd — Dogger, Jm — Malm, A, B — the selected areas, 1 — tectonic lines, 2 — outcrops.

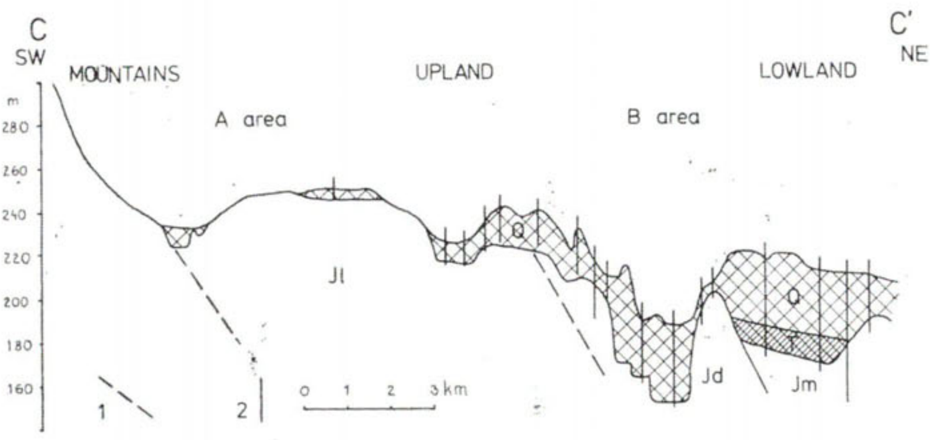

Fig 2. Geological cross-section along line C-C'. Jl — Lias, Jd — Dogger, Jm — Malm, T — Tertiary, Q — Quaternary 1 — tectonic lines, 2 — borings.

levels and the direction of the forms, both concave and convex (Kosmowska-Suffczyńska 1983a — Fig. 2). The specific character of the tectonics consists here in the occurrence of a number of longitudinal and transversal tectonic lines (Fig. 1). Among major longitudinal dislocations, stretching on a larger area, the Central Dislocation and the Marginal Dislocation, almost parallel to the former, are well known (Karaszewski 1961; Pożaryski 1974). Transversal dislocations cross longitudinal dislocations almost perpendicularly. They have a strike-slip character (Jaroszewski 1972).

Some morphotectonic units can be distinguished in the studied area (Fig. 2). The Holy Cross Mountains end along the Central Dislocation (in morphological sense) and then the upland begins. The Gielniów Ridge descends from 350—400 m a.s.l. to 250 m a.s.l. and a vast wet valley stretches along the fault (the Oleśnica valley). Along the next, Marginal Dislocation there is a visible break of the slope utilized and additionally emphasized by a rectilinear valley (the Szabasówka Valley) running along the margin of the fault, while the altitude decreases to 210 m a.s.l. This step-wise lowering of the relief toward the North-East is much more visible in the relief of sub-Quaternary bedrock than in the present-day relief.

Besides that clearly stated connection between the tectonic lines and the macro relief, the author has observed further relations concerning the system of river valleys and dry valley network, the specifity of glacial forms occurring here and of isolated forms of rock hills. These questions will be discussed here with special attention given to the problem of the valley directions.

Numerous large valleys of that relief zone, or their segments are of tectonic origin (e.g. the valleys of the rivers Kamienna, Kamionka, Żarnówka, Korzeniówka and others). Besides the particular valley forms developed directly on fault lines, the analysis of the valley system clearly shows that directions compatible with the course of the tectonic lines, i.e. SE-NW and NE-SW are privileged. Valleys often run parallel to one another and change direction on the square. Even small forms, such as dry valleys, frequently run in rectilinear rows in spite of opposite directions of their dip (Kosmowska-Suffczyńska 1983 a). The finest instances of this type may be found near

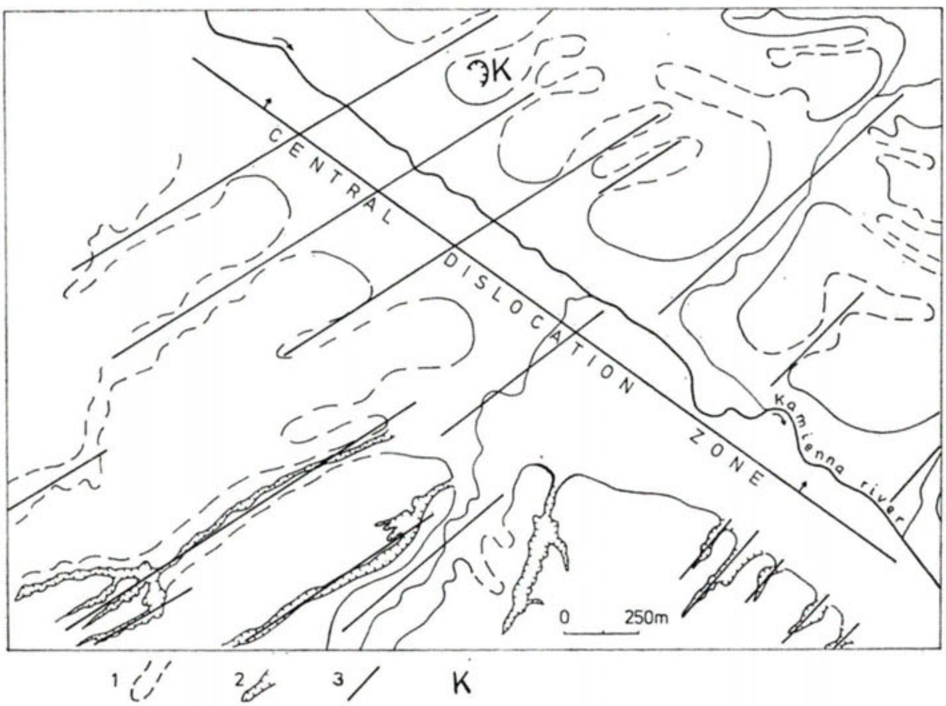

Fig. 3. Tectonic origin of dry valley directions near Wąchock. (From aerial photography). 1 — dry valleys, 2 — loess ravines, 3 — directions of tectonic lines and rock joints, 4 sandstone quarry with joints.

Wąchock (Fig. 3), where the direction of those forms is compatible with the direction of joints occurring in the nearby quarry. The dependence of the valley course on large dislocations and mesotectonics occurs independently of the lithology of pre-Quaternary rocks and of the character of the formation and thickness of Quaternary deposits.

The neighbourhood of Szydłowiec, Jastrząb and Rogów may serve as a very good example in the discussion concerning the problem of valley directions since there occur, side by side, areas of different tectonic and geological structure there (Fig. 2), (Kosmowska-Suffczyńska 1983b). Two such neighbouring areas have been selected here and called area A and area B. The analysis of valley directions was carried out on a map on the scale of 1 : 25 000. Azimuths and the length of the particular unidirectional segments of the whole valley network and then only of dry valleys were measured every 15°. The diagrams (Fig. 4 a, b, c, d, Fig. 5 a, b, c, d) present the percentage of the number

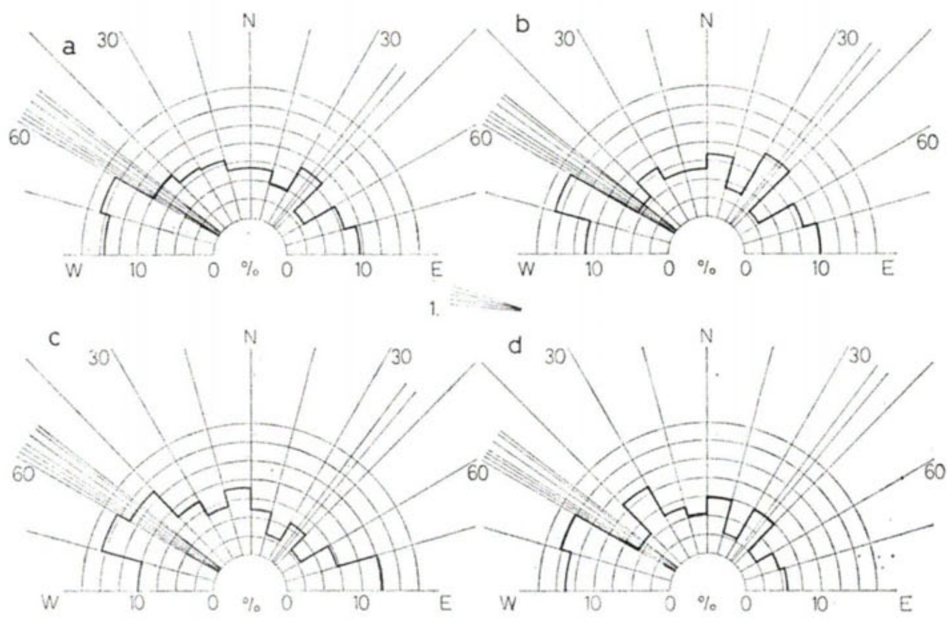

Fig. 4. Diagrams of the valley axes and tectonic line directions for area A. 1 — tectonic line azimuths

Fig. 4a — Percentage of number of segments for all valleys.
Fig. 4b — Percentage of number of segments for the dry valleys only.
Fig. 4c — Percentage of length of segments for all valleys.
Fig. 4d — Percentage of length of segments for the dry valleys only.

and length of valley segments in a given class in relation to the total measured, separately for area A and area B.

Areas A and B differ basically as to their geological structure and tectonics. Their border line runs in conformity with the border line between rocks of the Lias and the Dogger, and farther of the Malm.

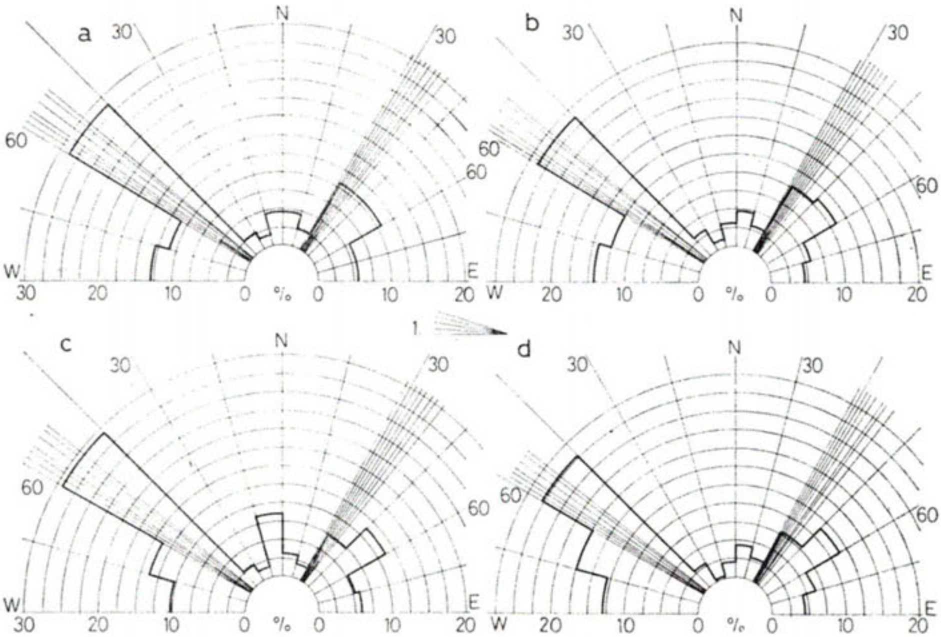

Fig. 5 — Diagrams of valley axes and tectonic line directions for area B. 1 — tectonic lines azimuths.

Fig. 5a — Percentage of number of segments for all valleys.

Fig. 5b — Percentage of number of segments for the dry valleys only.

Fig. 5c — Percentage of length of segments for all valleys.

Fig. 5d — Percentage of length of segments for the dry valleys only.

It is a tectonic border line consisting of the above-mentioned powerful Marginal Dislocation.

Area A is built exclusively of Liassic rocks. The lithological formation of the Lias is relatively uniform. There are different kinds of sandstones and subordinately, mudstones. Liassic sandstones frequently outcrop on the surface. The thickness of the Quaternary is small here, it does not exceed 5—6 m, except in the zone of glacial hills where it reaches 20 m. The tectonics of the area is relatively simple, a monoclinal structure generally prevails with a small dip of strata directed NE. The strike of the strata runs from NW to SE. There also occur small local anticlinal and synclinal structures, e.g. the Starachowice—Szydłowiec syncline (Karaszewski 1961; Pożaryski 1974). A characteristic feature of the tectonics in this area is the occurrence of longitudinal dislocations, while the transversal direction of tectonic lines is poorly developed. The relief of the studied area is relatively monotonous, relieved, in places, with hills of glacial origin. The altitude reaches 225—250 m a.s.l. A distinct slope inclined towards the Dogger rocks can be observed. It runs compatibly with the above-mentioned longitudinal tectonic line. Numerous small dry valleys issue to the permanent river network. They are short, with a hardly marked bottom and mild slopes. They are usually from 0.5 to 0.75 km long. Besides those small forms, there occur some longer dry valleys, up to 2.0 km long, which most usually begin at the foot or on the slopes of glacial forms.

Area B has a different structure: it is built of various rocks of the Dogger and the Malm. The Dogger consists of alternating clayey, shaly and sandstone series. They form a characteristic relief where a number of parallel small ridges constitute the Middle-Jurassic cuesta. The direction of those forms is compatible with the strike of strata. Besides the clayey and sandstone series, mudstones, conglomerates, marly deposits and zoogenic breccia occur subordinately. The Malm formation is entirely different. It consists of carbonate rocks which rarely outcrop on the surface. The Quaternary here is very thick, it reaches 50 m in some places and generally its thickness is 30—40 m, and below, there frequently occur non-consolidated deposits of the continental Tertiary which are over 10 m thick (Kosmowska-Suffczyńska 1983b — Fig. 7). The tectonics of area B differs basically from the tectonics of area A. Besides the longitudinal tectonic lines also transversal ones are well developed. They run close to one another at distances of 0.4 to 2.5 km and maintain the same direction. A displacement of ca 5.0 km to the SE of whole Jurassic blocks occurs along the dislocations. The relief is more varied here than in area A. There occurs a number of glacial hills frequently overlaying rock heights. The altitudes range from 205 m to 225 m a.s.l. Besides the valley complex of the Iłżanka with its tributaries and of the Szabasówka, where we can observe a striking disproportion between the wide valley and the narrow stream of water flowing in it, the area is waterless, and dry short valleys prevail.

An analysis of the percentage of unidirectional segments in the whole valley network and in dry valleys of area A, carried out in selected classes (Fig. 4 a, b, c, d) reveals a rather even distribution, with the predominance of directions within the N 60—75 W interval, i.e. the one directly adjoining the direction of the longitudinal tectonic lines. The values of the measured azimuths of the longitudinal tectonic lines are N 50—60 W. The next high percentage occurs within class N 45—60 W, which means a compatibility with the directions of the tectonic lines. It seems important for our problem that the percentage of directions of valley segments is low within the N 30—45 E sector, i.e.

within the angle interval where poorly developed transversal tectonic lines occur.

The analysis of valley directions in area B (Fig. 5 a, b, c, d) reveals a striking compatibility with the orientation of tectonic lines, in spite of the fact that it is an area of considerably thick Quaternary and Tertiary deposits covering the bed-rock. It is also worthy of notice that the connections with tectonics are much better marked here than in area A, where the thickness of Quaternary deposits is much smaller or they do not occur at all. In area B the directions of valleys both in the number of segments and their length, reflect perfectly the pattern of perpendicular tectonic lines. All the analysed diagrams show clearly the predominance of valley directions within the N 45—60 W sector, i.e. within the sector of longitudinal tectonic lines. The percentage of these directions exceeds, as a rule 25%, and it reaches 29.5% of the whole length of the valley network. The other prevailing direction comes within in the N 30—45 E sector or within the adjoining N 45—60 E sector, while the directions of the transversal tectonic lines of this area range from N 30 E to N 40 E. It should be remembered that this direction does not occur in area A where transversal tectonic lines can be found only subordinately.

It may be stated, from the analysis of the area, that the directions of discontinuous tectonics. Moreover, it appears that several score metres thick non-consolidated Quaternary or, in places Tertiary deposits covering the bedrock do not prevent the valley system, even small dry valleys, from setting along directions of tectonics. The valley system here varies as to age and geological structure. A dense network of borings (Kosmowska-Suffczyńska 1983b) shows that variety. Here belong: old valleys of pre-Quaternary origin the bottoms of which are hidden under a thirty-metres thick sand and gravel cover of Quaternary deposits while the Tertiary occurs in their slopes, deep-cut valleys —witnesses of complicated events in the Pleistocene—filled among others with two horizons of varved clay separated by boulder clay, numerous small dry valleys originating in glacial forms and connected with the deglaciation of that area during the Riss glaciation, and finally, a number of short denudational valleys cut in the slopes of larger valleys.

From the relationship between tectonics and relief also exemplified by small and short valleys developed on the deposits of the Riss glaciation, the question of age of the tectonics arises.

The relief directions compatible with the pattern of tectonic lines are marked not only in the valley system but also in the distribution of glacial forms of the *kame* type related to the deglaciation of the

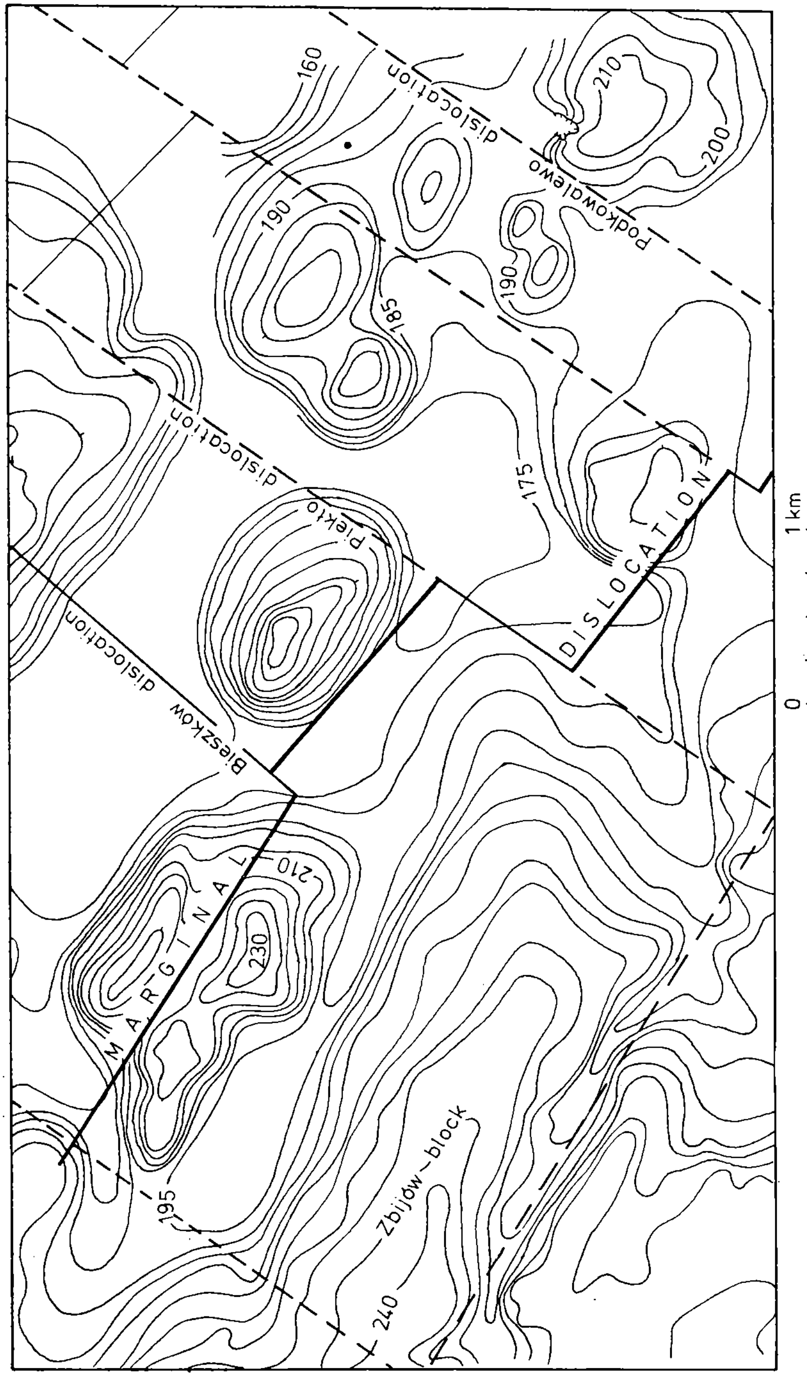

Fig. 6. An example of the relation between tectonics and relief. 1 — contour lines of sub-Quaternary surface. (Tectonics after W. Karaszewski).

Odra ice-sheet of the Riss glaciation. The run of the longitudinal axes of hills built of fluvioglacial deposits also displays compatibility with the directions of longitudinal and transversal dislocations. The observed relation brings up the problem of the tectonic conditioning of drainage directions (marginal in relation to the rising hill) during the deglaciation of the Riss ice-sheet.

Another example of the dependence of relief on tectonics is the occurrence of isolated rock hills cut off on two or three sides by tectonic lines (Fig. 6). A classical example of horst relief is an isolated hummock (Góra Piekło) of 50 m of relative height with accompanying peat in depression zone.

It may be conclulded from the numerous examples of relief from orientation that besides the major lines or zones of faults the whole north-eastern part of the margin of the Holy Cross Mountains is strongly cracked and the mesoscopic structural lines reflect the directions of the main tectonic structures.

It seems that the presented material allows to presume that in the relief zone under discussion there occurred a reanimation of the old pre-Tertiary, Tertiary, and old-Quaternary tectonics (Kosmowska--Suffczyńska 1983b — Fig. 11, 12, 13; 1984) and the whole area was subject to the general post-Riss tectonic movements. That phase could be younger than the Mazovian phase distinguished in the Polish Lowland (Baraniecka 1981) and occurring between the Mindel glaciation and Mindel/Riss interglacial period, and younger than the Sącz phase of the same age stated in the Carpathians by W. Zuchiewicz (1984). Neotectonic movements could be highly favoured by the localization of the area under discussion (Kosmowska-Suffczyńska 1983b — Fig. 4) on the important border line between two large tectonic units—the Middle Poland Anticlinorium and the Marginal Synclinorium (Pożaryski 1974). The border zone of such units is considered to be exceptionally susceptible to manifestations of neotectonics.

REFERENCES

Baraniecka M. D., 1981 „Fazy Małopolska, Kujawska i Mazowiecka jako fazy tektoniczne w czwartorzędzie Polski" [The Małopolska, Kujawska and Mazowiecka Phases Treated as Tectonic Phases in Quaternary of Poland], in: *Współczesne i neotektoniczne ruchy skorupy ziemskiej w Polsce* [Recent and Neotectonic Crustal Movements in Poland],vol. 4, Warszawa.

Jaroszewski W., 1972. Drobnostrukturalne kryteria tektoniki obszarów nieorogenicznych na przykładzie północno-wschodniego obrzeżenia mezozoicznego

Gór Świętokrzyskich" [Mesoscopic Structural Criteria of Tectonics of Non-orogenic Areas: an Example from the North-Eastern Mesozoik Margin of the Świętokrzyskie Mountains], *Studia Geologica Polonica*, No. 28, Warszawa.

Karaszewski W., 1961., *Materiały do przeglądowej mapy geologicznej Polski. Geologiczna mapa Iłży w skali 1 : 100 000* [Materials to Survey Geological Map of Poland. Geological Map of Iłża 1 : 100 000], Instytut Geologiczny, Warszawa.

Kosmowska-Suffczyńska D., 1983a., „Analiza fotointerpretacyjna okolic Wąchocka" [The Air Photograph Interpretation for the Wąchock Area], in: *Atlas: Polska na zdjęciach lotniczych* [Atlas: Poland in Air Photography], Warszawa, (in the press).

Kosmowska-Suffczyńska D., 1983b. „Rzeźba czwartorzędowa okolic Szydłowca, rola tektoniki i litologii' [Sub-Quaternary Relief in the Region of Szydłowiec, Role of Tectonics and Lithology], *Prace i Studia Geograficzne*, vol. 9 (in the press).

Kosmowska-Suffczyńska D., 1984. Zależność rzeźby od tektoniki *w północno-wschodnim obrzeżeniu Gór Świętokrzyskich* [The Influence of Tectonics on the Relief on the North-Eastern Border of the Świętokrzyskie Mountains], Lublin. Materiały Ogóln. Zjazdu PTG.

Pożaryski W., 1974. „Niż Polski. Tektonika" [Polish Lowland. Tectonics], in; *Budowa geologiczna Polski* [Geological Structure of Poland], vol. 4, Warszawa.

Zuchiewicz W., 1984. „Neotektonika Karpat polskich: fakty i wątpliwości" [Neotectonics of the Polish Carpathians: Facts and Doubts], *Studia Geom. Carp. Balc.*, vol. XVII, Kraków.