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GEOMORPHOLOGICAL OBSERVATIONS IN THE AREA OF THE BEČVA GEODYNAMIC POLYGON (THE MORAVSKOSLEZSKÉ BESKYDY MOUNTAINS)

INTRODUCTION

The Bečva geodynamic polygon is located on the orographical contact of the Radhošťská pahorkatina Hills and the Vsetínské vrchy Hills, between which the eastern headland of the Rožnovská brázda Furrow is situated. The erosion-denudational relief of the Rožnovská pahorkatina Hills on Upper Cretaceous and Paleogene flysh rocks of the Silesian nappe (Menčik *et al.* 1983) is an isoclinal structural step-like system with characteristic features of the three stages of destructional development. The same character is to be seen also in the Vsetínské vrchy Hills whose relief has been developing on Paleogene to Eocene sediments of the Magura nappe. The Rožnovská brázda Furrow, following in the eastern part the Magura nappe's denuded margin, was modelled mainly by the Rožnovská Bečva river erosion and is partly filled by fluvial, proluvial and slope sediments of Quaternary age.

A geodynamic polygon is situated in the Rožnovská Bećva valley between the dam and Horní Bečva village (49°25' N, 18°17' E). The altitudinal difference of the geodynamic polygon is 115 m (540 to 655 m a.s.l.) and its total length is 4.9 km. In the dissected relief of the montain landscape, it crosses the Rožnovská Bečva river roughly in the meridian direction (Fig. 1) and gets progressively divided into three branches. The total number of evaluated levelling points of the Bečva geodynamic polygon is 39, out of which are 11 rock and 4 deep stabilizations, 10 levelling stones, 7 cellar-provided and 7 cellarless constructions.

Geological and geomorphological interpretation of repeated geodetical measurements of the vertical component of the recent Earth's surface movements of endogenic, exogenic and anthropogenous origin in the Bečva geodynamic polygon (Kalvoda and Zeman 1979) is very likely to lead to the detection of tectonic movements. The results of repeated high precision levelling in the years 1971–1978 and detailed analysis of the natural

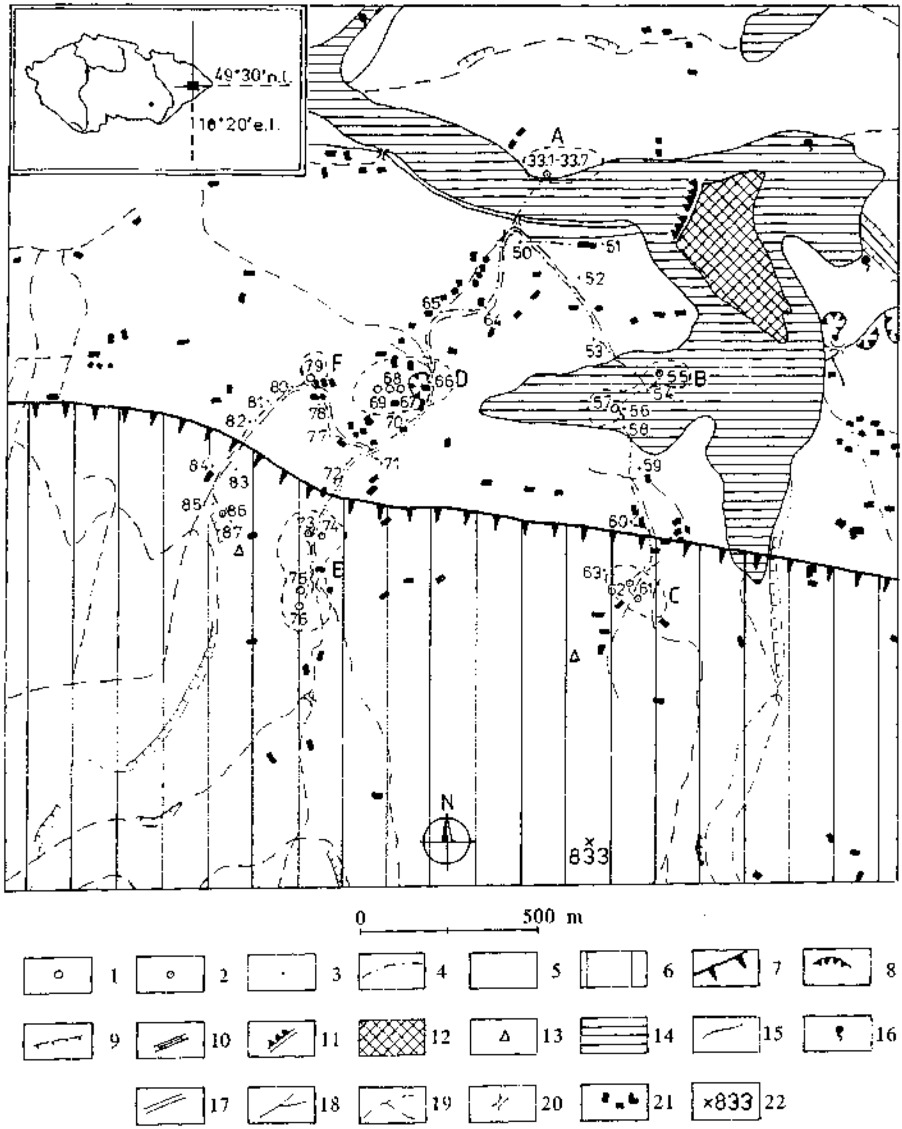

Fig. 1. The area of the Bečva geodynamic polygon in the Moravskoslezské Beskydy Mountains. 1–3 levelling points (with number) and their class of stability: 1 — Ist class, 2 — IInd class, 3 — IIIrd and IVth class (for explanation see the key to table 1); 4 — the layout of the polygon branches; 5–7 principal geological units: 5 — Silesian nappe, 6 — Magura nappe, 7 — Magura thrust; 8–22 anthropogenous landforms: 8 — quarries, 9 — cuttings, 10 — dumps, 11 — dams, 12 — water basin, 13 — stone dumps, 14 — anthropogenously modelled relief, 15 — constructed beds of water courses, 16 — sources, 17 — main roads, 18 — secondary roads with asphalt surface, 19 — main field and wood tracks, 20 — bridges, 21 — brick and wood houses, 22 — summit with altitude in metres a.s.l.; A to F — groups of levelling points. Sketch drawing in the left upper part of this figure demonstrates the geographical position of the studied area

conditions of the Bečva geodynamic polygon, which transects the contact of the Silesian and Magura nappes, made it possible to determine the proportion of individual exogenic and endogenic processes on the movement of points of various types and the degree of stability. The measured maximum vertical amplitudes of exogenic movements of the Earth's surface attained as much as 6 mm in 8 years. The upper limit of the range of the vertical component of tectonic movement during the same period amounts to less than 1 mm. This indicated a tendency to uplifting of the Magura nappe with respect to the Silesian nappe. These results were one of the motives for a detailed geomorphological mapping (Prášek 1985, 1993; Kalvoda and Prášek 1987), the aim of which was to establish the main stages of relief development and to contribute to the evaluation of the geodynamic regime of the Moravskoslezské Beskydy Mts.

OBSERVATION OF RECENT EARTH'S SURFACE MOVEMENTS

A historic-genetical analysis of landforms along the contact line of the Silesian and Magura nappes in the upper part of the Rožnovská Bečva catchment area has proved the decisive influence of geological structure on relief development. Morphostructural units had been formed in the Neogene and their tectonic differentiation ended in the Lower Pleistocene (comp. Roth 1986; Kalvoda and Prášek 1987). In the Quaternary, the relief development was being influenced by changes of climate-morphogenetic processes (periglacial conditions were essential) and by mild regionally differentiated uplifts of the Moravskoslezské Beskydy Mts. Possible relief-building effects of the Late Quaternary tectonic movements have been obliterated by denudation.

Landforms in the Bečva geodynamic polygon region are presented in a geomorphological sketch map (Fig. 2). The levelling circuit's branches cut the anthropogenously modelled Bečva valley bottom (levelling points 33.3 to 63, respectively points 33.3 to 70 and 77 to 87), as well as the slope sediments zone, the selectively denuded ridges of the Istebňany sandstones and the structural denudational slope in the frontal part of the Magura nappe. The

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Ryc. 1. Obszar poligonu geodynamicznego Bečva w Beskidach Morawsko-Śląskich.
1–3 — punkty niwelacyjne oznaczone numerami i klasy ich stabilności: 1 — I klasa, 2 — II klasa, 3 — III i IV klasa (objaśnienia w kluczu do Tabeli 1), 4 — plan ciągów poligonowych, 5–7 — główne jednostki geologiczne: 5 — płaszczowina śląska, 6 — płaszczowina magurska, 7 — nasunięcie magurskie, 8 — 22 formy antropogeniczne: 8 — kamieniołomy, 9 — podcięcia, 10 — nasypy, 11 — zapory, 12 — baseny wodne, 13 — zapory kamienne, 14 — rzeźba przekształcona przez człowieka, 15 — sztuczne koryta, 16 — źródła, 17 — drogi główne, 18 — drogi drugorzędne z pokryciem asfaltowym, 19 — główne trakty polne i leśne, 20 — mosty, 21 — domy murowane i drewniane, 22 — wierzchołki z podanymi wysokościami w metrach n.p.m.; A do F — grupy punktów niwelacyjnych. Szkic w lewym górnym rogu przedstawia lokalizację badanego obszaru

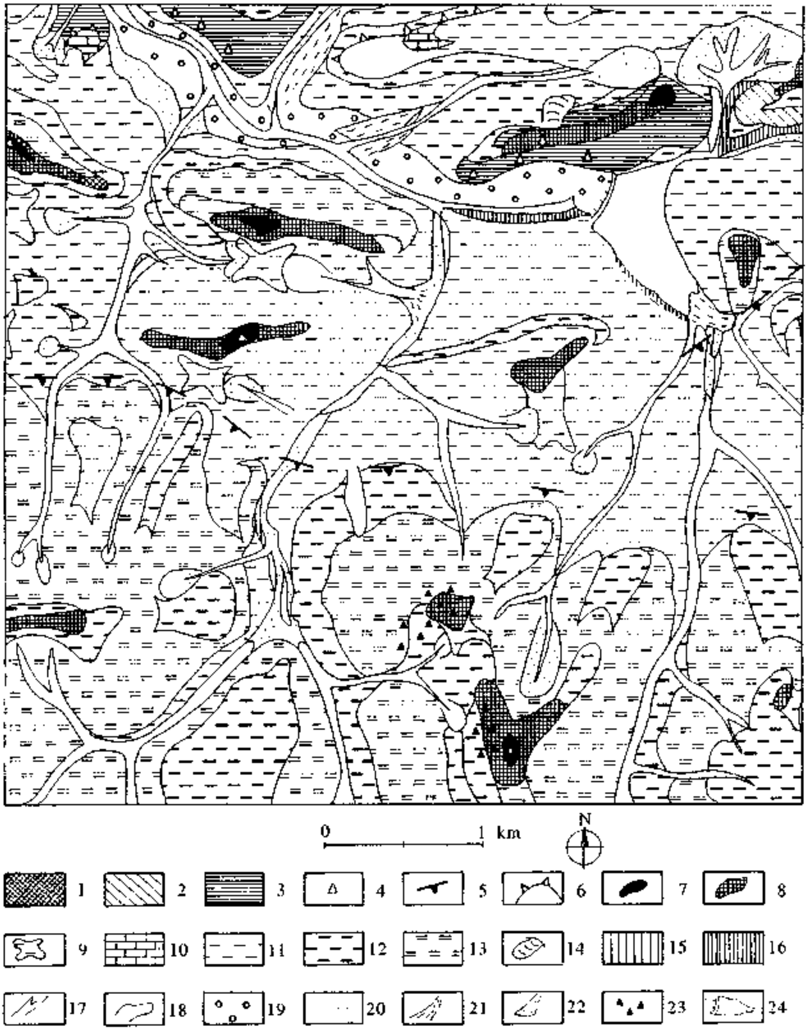

Fig. 2. Geomorphological sketch map of the Bećva geodynamic polygon area (modified after Prášek 1985, 1993). The area location and size are the same as in Fig.1. 1–14 structural and denudational landforms: 1 — structural plateaux, 2 — structural slopes (inclination between 2 and 15°), 3 — steeply inclined structural slopes (superior to 15°), 4 — rock outcrops, 5 — morphologically marked fault lines, 6 — structural edges and steps, 7 — morphologically conspicuous summits, 8 — selectively denuded ridges more resistant to weathering, 9 — selectively denuded cols on morphologically less-weathering-resistant rocks, 10 — denudational plateaux, 11 — mildly inclined denudational slopes (between 2 and 7°), 12 — medium inclined denudational slopes (between 7 and 15°), 13 — steeply inclined denudational slopes (superior to 15°), 14 — planar landslides; 15–18 erosion landforms: 15 — erosion slopes with inclination between 2 and 15°, 16 — steeply inclined erosion slopes (superior to 15°), 17 — erosion gullies and ravines, 18 — slopes, valley dells and collecting basins; 19–24 accumulation landforms: 19 — alluvium, 20 — slopes on proluvial sediments, 21 — alluvial fans, 22 — debris cones, 23 — continuous stone fields and clusters of eluvial and deluvial boulders, 24 — area of water dam

middle branch (levelling points 71 to 76), leaving the western branch beyond levelling point 70, approximately follows the bottom of the Bučkovský potok Brook subsequent valley which is deeply incised into the compact sandstones at the foot of the structural denudational slopes.

The results of repeated very precise levelling measurements are appropriate for application to geological and geomorphological problems only after a detailed comparative analysis of the possible causes of movements of different levelling points (Kalvoda and Pašek 1975). Differences in the points relative positions after repeated measurements are, however, the sum of shifts caused by tectonics, relief-building processes of exogenous origin and by the ageing of the constructions. The possibility of using different kinds of geodetic measurements for monitoring the Earth's surface movements, e.g. repeated levelling, triangulation and the Global Positioning System, is being applied by many natural science and technological specializations. Examples of very specialized geomorphological investigation in the Czech Republic are the papers of Demek (1973, 1988) on the Javorníky Mountains (the Moravian Flysh Carpathians). These works were aimed at investigating debris movements on the slopes of Hradisko Hill (773 m a.s.l.). From 1967 to 1984, the slow movements of more than 100 stone and conglomerate blocks, ranging in diameter from 20 cm to several meters, were measured by a special geodetic network with c. 6 fixed points. Values of vertical movements of the blocks were up to 20 mm per 9 years, and horizontal movements were 40 mm per 18 years (Demek 1988). However, this was deliberate investigation of block movements related to the geodetic stabilization points of the special network. Our investigations (e.g. Kalvoda and Pašek 1975; Kalvoda and Zeman 1979, 1982; Kalvoda *et al.* 1994) were solely directed towards the geomorphological interpretation of measured relative movements of permanent geodetic points of different types and foundation depth.

An analysis of the geological, geomorphological and engineering-geological features of the levelling points' sites of the Bečva geodynamic polygon enables us to determine a set of possible main causes of established movements

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Ryc. 2. Szkic geomorfologiczny poligonu geodynamicznego Bečva (zmodyfikowane wg Prášek 1985, 1993). Lokalizacja obszaru i jego wielkość jak na Ryc. 1. 1–14 formy terenu strukturalne i denudacyjne: 1 — płaskowyż strukturalny, 2 — stoki strukturalne o nachyleniach 2–15°, 3 — strome stoki strukturalne powyżej 15°, 4 — odsłonięcia skalne, 5 — linie uskoków zaznaczone w morfologii, 6 — załomy i stopnie strukturalne, 7 — wyraźne wierzchołki, 8 — grzbiety założone na utworach bardziej odpornych na wietrzenie, 9 — przełęcze założone na mniej odpornych utworach, 10 — płaskowyż denudacyjny, 11 — łagodnie nachylone stoki denudacyjne (2–7°), 12 — średnio nachylone stoki denudacyjne (7–15°), 13 — strome stoki denudacyjne (powyżej 15°), 14 — osuwiska; 15–18 erozyjne formy terenu: 15 — stoki erozyjne o nachyleniach od 2–15°, 16 — strome stoki erozyjne (powyżej 15°), 17 — rynny erozyjne i wciosy, 18 — niecki stokowe i nisze; 19–24 formy akumulacyjne: 19 — aluwia, 20 — stoki na utworach proluwialnych, 21 — stożki aluwialne, 22 — stożki gruzowe, 23 — pola gruzowe i nagromadzenia bloków pochodzenia eluwialnego i deluwialnego, 24 — obszar zapory wodnej

(Table 1). Geodetical measurements carried out for several years and an analysis of the natural conditions has allowed a detailed complex evaluation of the recent movements of the Earth's surface. The precision and application limits of our experiment were monitored by repeated high-presicion levelling and by geomorphological analysis.

To evaluate the vertical components of the movements connected with recent tectonic processes, it was appropriate to compare the groups of nearby levelling points of Ist and IInd class of stability. These are the groups and points (see Fig. 1): A — 33.1 to 33.7; B — 55 to 57; C — 61 to 62; D — 66, 67, 68 and 69; E — 73, 74, 75 and 76; F — 79. Within all the A to F groups of points, altitudes are oscillating within the limits of geodetical uncertainties, while the results of mutual comparison of different groups prove the endogenic components of the Earth's surface movements. Comparison of the movements of other levelling points of III-rd and IV-th classes of stability with the nearest stability group of I-st and II-nd classes depicts the extent of the exogenic movements, and at the same time, leads to a closer estimation of their causes (Fig. 3).

The survey of the horizontal component of the movements, which may be several times larger than the vertical ones, was much more complicated than the levelling measurements. Triangulation measurements were done only three times and their numerical analysis showed that the measurement levels of the changes of the horizontal component the of Earth's surface movements were of the same order as the geodetical uncertainties of measurement (Fig. 4). Nevertheless, up to now, the geomorphological interpretation of triangulation measurements on the Bečva geodynamic polygon cannot be correctly done.

The most conspicuous landforms changes of Holocene and/or recent age are slope movements. For instance the valley of the right affluent of the Bučkovský potok Brook has a very irregular transversal profile — its slopes have been modelled by sliding debris. A greater part of this debris field has been denuded and the object of a recent movement.

Recent landslides are prevailingly caused by lateral erosion of slopes' bases by water courses or through humen activity. In the first case, the accumulation area is not constituted and the detachment plane is very clearly visible. In the second case, landslides are caused by slope stability failure due to construction activity, mainly construction of forest tracks.

Ravines and erosion gullies are mostly of Holocene age. At present, their constitution and development is conditioned by technogenic activities. Erosion activity of the Rožnovská Bečva River has heen largely limited by construction of the Horní Bečva dam. Recent alluvial cones are relatively frequent in minor water courses and they get changed especially by a higher water state. The anthropogenous modifications of the present-day relief, including water courses regulation and rock extraction, are relatively large. Erosion was then accelerated mainly by mountain slopes deforestation.

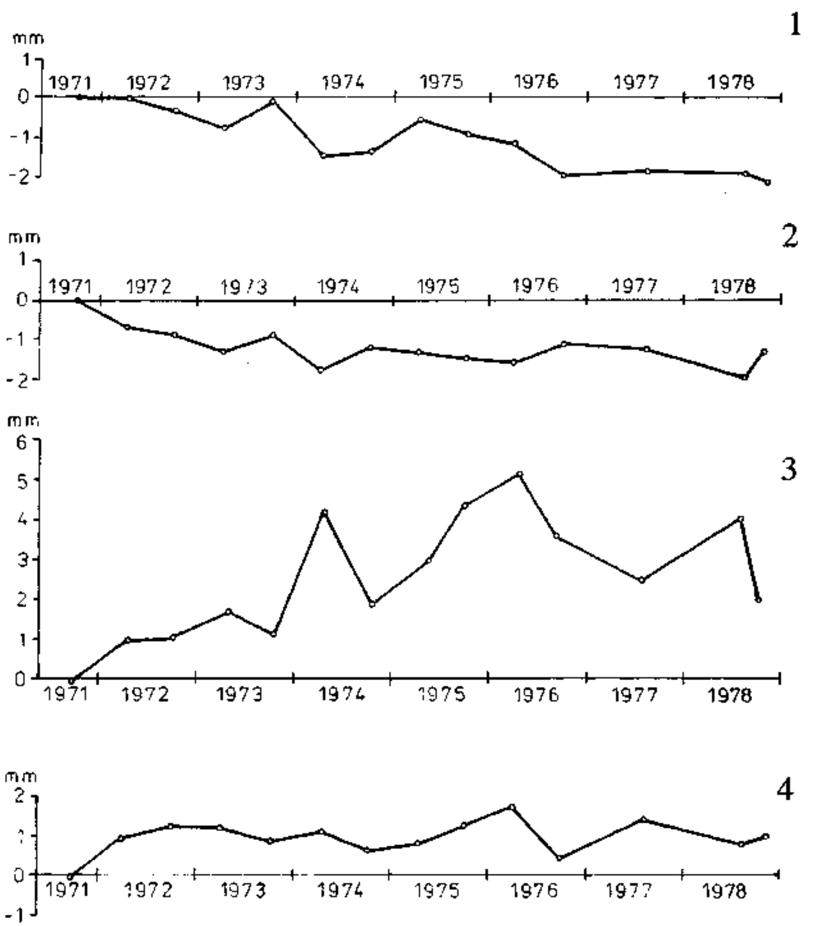

Fig. 3. Examples of characteristic types of the Earth's surface movements. 1–2 subsidence due to setting and sliding: 1 — permanent (the point 59 in relation to the point 57), 2 — occasional (the point 64 in relation to the point 66); 3–4 changes of altitude connected to recent morphotectonics: 3 — the point 86 (deep stabilization) in relation to the group of points A, 4 — the group of points E in relation to the group of points D. The graph also includes movements of exogenic origin, by subtraction of which the probable level of nearly 1 mm per 8 years has been obtained. In graph 4, the point groups did not manifest practically any movements of exogenic origin and a concordant uplift tendency of tectonic origin is obvious

Ryc. 3. Przykłady typowych ruchów powierzchni ziemi. 1–2 osiadanie związane z instalacją punktów oraz osuwaniem: 1 — stałe (punkt 59 w stosunku do punktu 57), 2 — sporadyczne (punkt 64 w stosunku do punktu 66), 3–4 zmiany wysokości związane ze współczesną morfotektoniką: 3 — punkt 86 (głęboko zastabilizowany) w stosunku do grupy punktów A, 4 — grupa punktów E w stosunku do grupy punktów D. Na rysunku pokazano również ruchy roczne pochodzenia egzogenicznego rzędu 1 mm na 8 lat. Na wykresie 4 pokazano grupę punktów, które nie zarejestrowały żadnych ruchów pochodzenia egzogenicznego, chociaż oczywiste są dla nich tendencje podnoszące pochodzenia tektonicznego

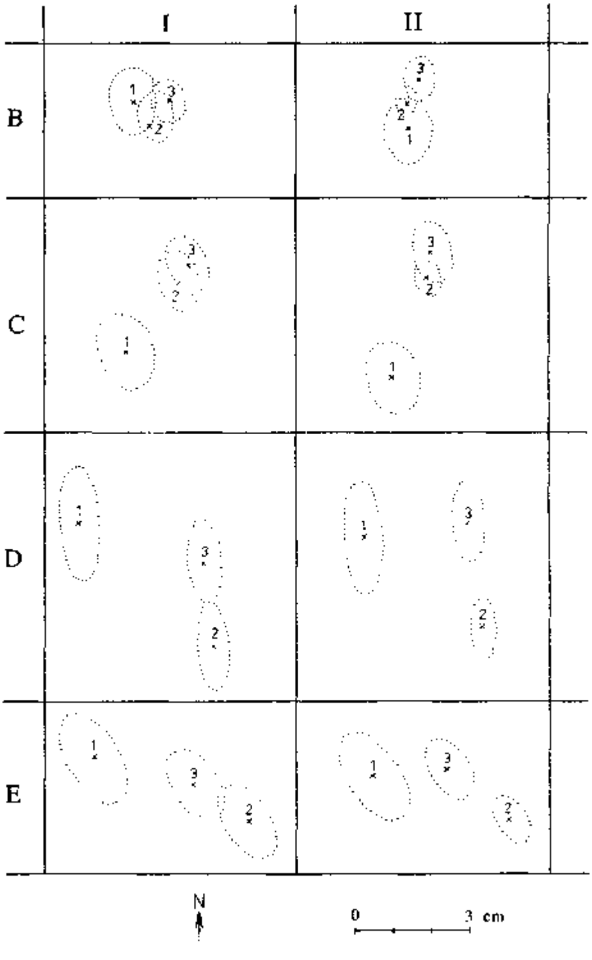

Fig. 4. Sketch of the results of the horizontal component of the Earth's surface movements, in which it is up to now impossible to differentiate the part of natural movements from the geodetical incertitudes of measurements. The N–S oriented base is formed by selected triangulation points (with a lenght of 2 580 m) on ridges above the Bečva valley. Schemes I and II show the positions of the triangulation points located within the groups of levelling points B, C, D and E (see Fig. 1) and at the same time, in dashed lines the areas of measuring incertitudes from the years 1972, 1975 and 1978. The progressive change of the lenght base (a shortening of 2.6 cm after the second measuring and of further 0.6 cm after third one, is not included in scheme I and included in scheme II)

Ryc. 4. Szkic pokazujący wielkości poziomej składowej ruchów powierzchni ziemi, dla których nie jest możliwe odróżnienie ruchów naturalnych od błędów wynikających z dokładności metody pomiarowej. Baza o kierunku N-S jest utworzona przez wybrane punkty triangulacyjne (długość 2580 m) na grzbiecie ponad doliną Bečvy. Schematy I i II pokazują położenie punktów triangulacyjnych zlokalizowanych w obrębie grupy punktów B, C, D i E (por. Ryc. 1). Pokazano również obszary z pomiarami niepewnymi z lat 1972, 1975 i 1978. Postępująca zmiana długości bazy (skrócenie o 2,6 cm po drugim pomiarze i dalsze 0,6 cm po trzecim nie jest zaznaczone na schemacie I, a jest pokazane na schemacie II

CONCLUSION

The geomorphological observation in the region of the Bečva geodynamic polygon in the southern part of the Moravskoslezské Beskydy Mts was aimed at determining the main features of the relief development in the Upper Cainozoic, by landforms analysis and by determination of the causes of the recent Earth's surface movements. A geomorphological mapping enabled us to identify clear evidence of configuration dependence of a set of landforms on the geological structure of the area of tectonic contact of the Silesian and Magura nappes.

An analysis of the results of geodetical measurements of the recent Earth's surface movements, effected in the years 1971–1978, showed that: 1) repeated high-precision levelling measurements identified mainly movements of exogenic and anthropogenous origin, 2) only three stages of position measurements are not a sufficient basis for their correct geomorphological interpretation, and 3) relative altitude changes, from the viewpoint of foundation conditions of the most stable points, prove the probable existence of present-day tectonic movements. However, they could by convincingly proved only by further highly specialized geodetic measurements.

As far as present-day geomorphological processes are concerned, mainly slope sediments slidings, limited planar landslides, heat and water influenced volume changes of rocks and soils, rainwash, erosion in brook beds and anthropogenous activities come into play in changes of the landforms in the region of the Bečva geodynamic polygon.

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STRESZCZENIE

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OBSERWACJE GEOMORFOLOGICZNE NA GEODYNAMICZNYM POLIGONIE BEČVA W BESKIDACH MORAWSKO-ŚLĄSKICH

Analiza wieku i genezy rzeźby górnej części dorzecza Rożnowskiej Bečvy była wykonana w celu określenia głównych etapów rozwoju rzeźby w młodszym kenozoiku oraz wyjaśnienia współczesnych ruchów skorupy ziemskiej. Ten ostatni cel realizowano w oparciu o pomiary geodezyjne. Poprzez szczegółowe kartowanie geomorfologiczne zostały określone wyraźne zależności ukształtowania rzeźby od budowy geologicznej na kontakcie jednostki śląskiej i magurskiej. Wyróżniono trzy poziomy równania. Najstarszy poziom jest wieku przedplioceńskiego. Rozwój rzeźby w plejstocenie przebiegał w warunkach modelowania peryglacjalnego oraz umiarkowanych ruchów podnoszących Beskidów Morawsko-Śląskich. Podnoszenie nakładało się na sekularne zmiany egzogenicznych procesów morfogenetycznych, w tym erozji wgłębnej. Względnie cieplejsze i wilgotniejsze warunki klimatyczne w okresach interglacjalnych i w holocenie sprzyjały rozwojowi procesów stokowych, zwłaszcza ruchów masowych.

Praca przedstawia charakterystykę geomorfologiczną oraz wyniki pomiarów współczesnych zmian powierzchni ziemi na poligonie geodynamicznym Bečva. Jest to poligon badawczy położony w strefie kontaktowej płaszczowiny śląskiej i magurskiej w dolinie Bečvy, pomiędzy sztuczną zaporą wodną a wioską Górna Bečva. Obszar objęty badaniami jest położony na wysokości od 540 do 655 m npm a jego długość liczy 4,9 km. Zainstalowano 39 punktów niwelacyjnych, w tym 11 na podłożu skalnym, 4 zastabilizowane głęboko w podłożu, 10 na głazach, 7 na fundamentach piwnic budynków i 7 na budynkach nie posiadających piwnic.

Wyniki pomiarów pokazały, że w latach 1971–1978 wystąpiły przemieszczenia punktów niwelacyjnych. Były one związane z ruchami wywołanymi procesami morfogenetycznymi i przyczynami antropogenicznymi. Względne zmiany położenia głęboko zastabilizowanych punktów świadczą o możliwości występowania współczesnych ruchów tektonicznych. Potwierdzenie tego stwierdzenia wymaga dodatkowych, bardziej precyzyjnych pomiarów. Wśród współczesnych procesów morfogenetycznych na poligonie Bečva najważniejszymi są ruchy osuwiskowe, powierzchniowe spełzywanie oraz przemieszczanie wywołane termicznymi i wilgotnościowymi zmianami w skałach i pokrywach zwietrzelinowych. Ponadto istotne znaczenie ma spłukiwanie i erozja w korytach, związana z działalnością człowieka.

Morphogenetic processes causing recent Earth's surface movements of the Bečva geodynamic polygon points sites, Moravskoslezské Beskydy Mountains
Procesy morfogenetyczne wywołujące współczesne ruchy powierzchniowe na poligonie geodynamicznym Bečva w Beskidach Morawsko-Śląskich

A	B	C	D			
33	⦶	IV	⁘	(▨)	(↧)	
33.1	●	II	▨	(≋>)		
to	●	II	▨	(≋>)		
33.7	●	II	▨	(≋>)		
50	⊗	IV	⁘	(▨)	≋>	(Δ)
51	⦶	III	⁘	(▨)	(Δ)	
52	⦶	IV	⁘	(▨)	↧	(Δ)
53	⊙	IV	⁘	(▨)	(⇝)	(Δ)
54	⦶	III	⁘	(▨)		
55	✦	I	▨			
56	○	IV	⁘	(▨)	(Δ)	
57	✦	I	▨			
58	⊙	III	⁘	(▨)	(Δ)	
59	◑	IV	⁘	(▨)	(Δ)	
60	◑	IV	⁘	(▨)	(Δ)	(↧)
61	◑	III	⁘	(▨)	(⇝)	(Δ)
62	✦	I	▨			
63	⊙	IV	⁘	(▨)	Δ	(⊡)
64	◑	IV	⁘	(▨)	↧	
65	◑	III	⁘	(▨)	(↧)	
66	●	II	▨	(Δ)		
67	●	I	▨			
68	●	I	▨			
69	●	I	▨			
70	◑	III	⁘	(▨)	(↧)	
71	⦶	IV	⁘	(▨)	(Δ)	(↧)
72	⦶	IV	⁘	(▨)	(Δ)	(↧)
73	●	II	▨	(Δ)		
74	●	II	▨	(Δ)		
75	●	I	▨			
76	●	I	▨			
77	◑	III	(⁘)	(▨)	(↧)	
78	⦶	IV	⁘	(▨)	(↧)	(Δ)
79	●	I	▨			
80	⊙	IV	⁘	(▨)	(Δ)	
81	⊙	III	⁘	(▨)	(Δ)	
82	⊙	IV	⁘	(▨)	⇝	(Δ)
83	⊙	IV	⁘	(▨)	⇝	(Δ)
84	⊙	IV	⁘	(▨)	⇝	(Δ)
85	⊙	IV	⁘	(▨)	⇝	(Δ)
86	✦	II	▨	(⇝)	(⊡)	
87	⊙	IV	⁘	(▨)	(Δ)	(⇝)

●	1	✦	2	◉	3	◑	4	⦶	5
⊗	6	⊙	7	○	8	▨	9	⁘	10
Δ	11	⊡	12	⇝	13	↧	14	≋>	15
( )	16	A	17	B	18	C	19	D	20

1–8 types of levelling points stabilizations: 1 — rock stabilization, 2 — deep stabilization, 3 — bar stabilization, 4 — mark on a cellar-provided house, 5 — mark on a cellarless house or other building, 6 — mark on a rock block or boulder, 7 — levelling stone, 8 — road culvert; 9–16 morphogenetic processes which are the cause of measured Earth's surface movements on the levelling point site: 9 — rock volume changes (mostly seasonal) depending on temperature and groundwater amount, 10 — Quaternary sediments volume changes (mostly seasonal) depending on temperature and especially on groundwater amount, 11 — regelation processes, 12 — creep, 13 — Quaternary sediments sliding, 14 — proper weight subsidence of buildings on Quaternary sediments, 15 — rock blocks or larger near-surface rock massif parts sliding, 16 — a very mild activity of the mentioned type of geological and/or geomorphological process on local Earth's surface movements; 17 — number of the levelling point, 18 — type of stabilization; 19 — class of stability after consideration by Kalvoda and Zeman (1979): I — the point movement is prevailingly influenced by endogenic processes, II — the influence of exogenic processes on the point movement is negligible in a period of about ten years, III — the point movement is influenced by exogenic processes, IV — exogenic processes clearly influence the point movement; 20 — set of morphogenetic processes causing movements of levelling points sites

1–8 typy punktów stabilizacyjnych: 1 — punkt zastabilizowany na skale, 2 — punkt głęboko zastabilizowany, 3 — zastabilizowane kołki, pręty, 4 — znak na piwnicy domu, 5 — znak na budynku nie posiadającym piwnicy, 6 — znak na bloku skalnym, 7 — słupki niwelacyjne, 8 — przepust drogowy; 9–16 morfogenetyczne procesy powodujące przemieszczanie punktów niwelacyjnych: 9 — zmiany objętości skały (najczęściej sezonowe) uwarunkowane ilością wody i warunkami termicznymi, 10 — zmiany objętości osadów czwartorzędowych (najczęściej sezonowe) uwarunkowane termicznie a w szczególności ilością wody gruntowej, 11 — procesy regelacyjne, 12 — spełzywanie, 13 — osuwanie w osadach czwartorzędowych, 14 — osiadanie wywołane zmianami ciężaru właściwego pod budynkami zlokalizowanymi na osadach czwartorzędowych, 15 — bloki skalne lub większe przypowierzchniowe pakiety skalne podlegające osuwaniu, 16 — bardzo niewielka aktywność wspomnianych procesów geologicznych lub geomorfologicznych, 17 — liczba punktów niwelacyjnych, 18 — typ stabilizacji, 19 — klasa stabilizacji wg Kalvoda i Zeman (1979): I — przemieszczenie punktu głównie pod wpływem procesów endogenicznych, II — znikomy wpływ procesów egzogenicznych na przemieszczenie punktu w okresie 10 lat, III — ruch punktu pod wpływem procesów egzogenicznych, IV — ruch punktu wywołany przez wyraźne oddziaływanie procesów egzogenicznych, 20 — zespół procesów morfogenetycznych powodujących przemieszczenie punktów niwelacyjnych