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Application of Modern Geomorphological Methods in Theory and Practice: Case Study of the Bohemian Highlands (Czech Republic)

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ABSTRACT: There are a lot of methods used in geomorphological research (Goudie 1992). However, sometimes it is very hard to find their application in practice. This paper deals with an application of geomorphological methods such as morphostructural analysis, detailed geomorphological mapping and computer analysis in the Geographical Information System ARC/INFO, in the field and discusses their application at the building trade, ecology, etc. The author applied them to geomorphological research in the northeastern part of the Hercynian Bohemian Highlands.

Introduction

Nowadays, there is an overall problem in the application of geomorphology in practice. Some people, including geographers or other scientists, say: "Geomorphology is just a theoretical science with limited academic use. I cannot see any practical application of its methods." Why is this so? Therefore, the author has tried to choose those geomorphological research methods whose results can be used in practice; eg in the building trade, ecology etc. For this application geomorphologically uninvestigated region in the northeastern part of the Hercynian Bohemian Highlands was chosen.

Morphostructural Analysis

Morphostructural analysis is the main method of structural geomorphology. Morphostructural analysis includes methods aim at explanations of both direct and indirect relations between the present day relief and the structure of the Earth's interior. There is a tight connection between the evolution of the relief and structures of the Earth's crust. Considering this connection and using morphostructural analysis it is possible to determine the important elements of the geological structure in a study region (Gerasimov 1970 in Demek 1987).

The term "morphostructural analysis" was introduced by I. P. Gerasimov in 1946.

The term of the morphostructure is defined as a structural geological fundament of the relief which includes rocks, influences of older tectonics (fracturing and orogenesis) and the creation of the relief by neotectonics and exogenic processes. It is distinguished between passive and active morphostructure.

The passive morphostructure includes rocks and the influences of older tectonics. The active morphostructure is considered to be a result of either continuous slow or quick undulated deformations influenced by uplift, and subsidence of Earth's crust blocks limited by faults. The blocks can also move in a horizontal direction. During this process tectonic faults of various sizes originate. These deformations are mostly shown in the gradual growth of elevated (highlands) and subsided (lowlands) structural units. The highlands are exposed to surface degradation, the lowlands to accumulation. Morphostructural analysis is significant not only for science and other geomorphological research, ie in detailed geomorphological mapping, but is also useful in the classification of mineral deposits, the forecast of hazards (earthquakes, landslides) and

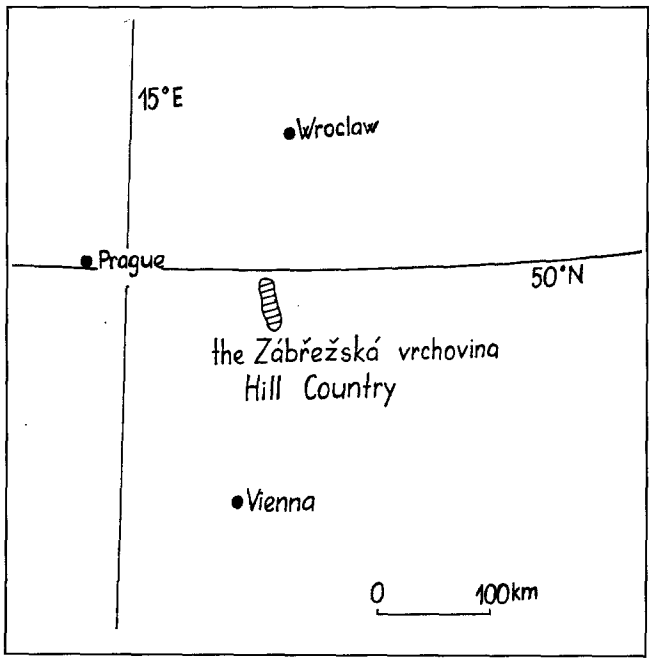


Fig 1 The location of the study area

the construction of highways, nuclear power stations and the like (Demek 1972, 1992).

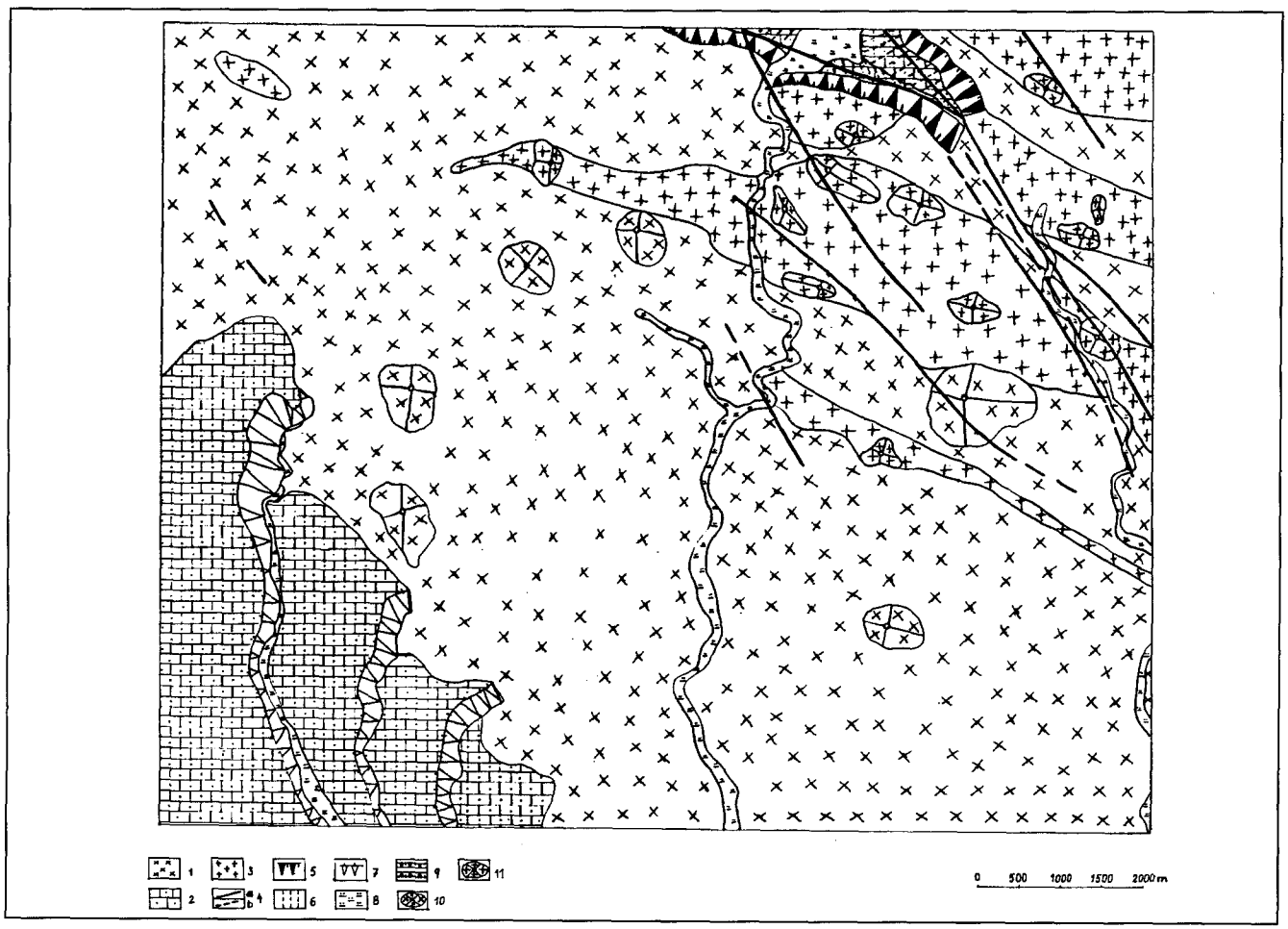
Morphostructural Analysis Applied to a Chosen Region

As a part of the author's doctoral dissertation morphostructural analysis was applied to the northern part of the Zábřežská vrchovina Hill Country which belongs to the Hercynian Bohemian Highlands. The Zábřežská vrchovina Hill Country is a block upland in northwestern Moravia. Opletal's detailed geological map of the Šumperk sheet in the scale of 1:50,000 (in press), some geological profiles, drill wells, boreholes and the author's terrain investigation were used.

Passive Morphostucture in the Studied Region

From the geological point of view the region under study is a monotonous series. Geologists have difficulty explaining tectonic structure, especially faults. In this case the morphostructural analysis helps to solve the problem:

Fig 2 The morphostructural map. Explanations 1 = Proterozoic crystalline rocks (gneiss etc.), 2 = Cretaceous sandstones, 3 = tonalites of unknown age, 4a = obvious faults, 4b = supposed faults, 5 = fault scarps, 6 = a glacis, 7 = cuestas, 8 = flood plains, 9 = grabens (the southern part of the Klodzko Graben), 10 = tectonic domes, 11 - ruwares.



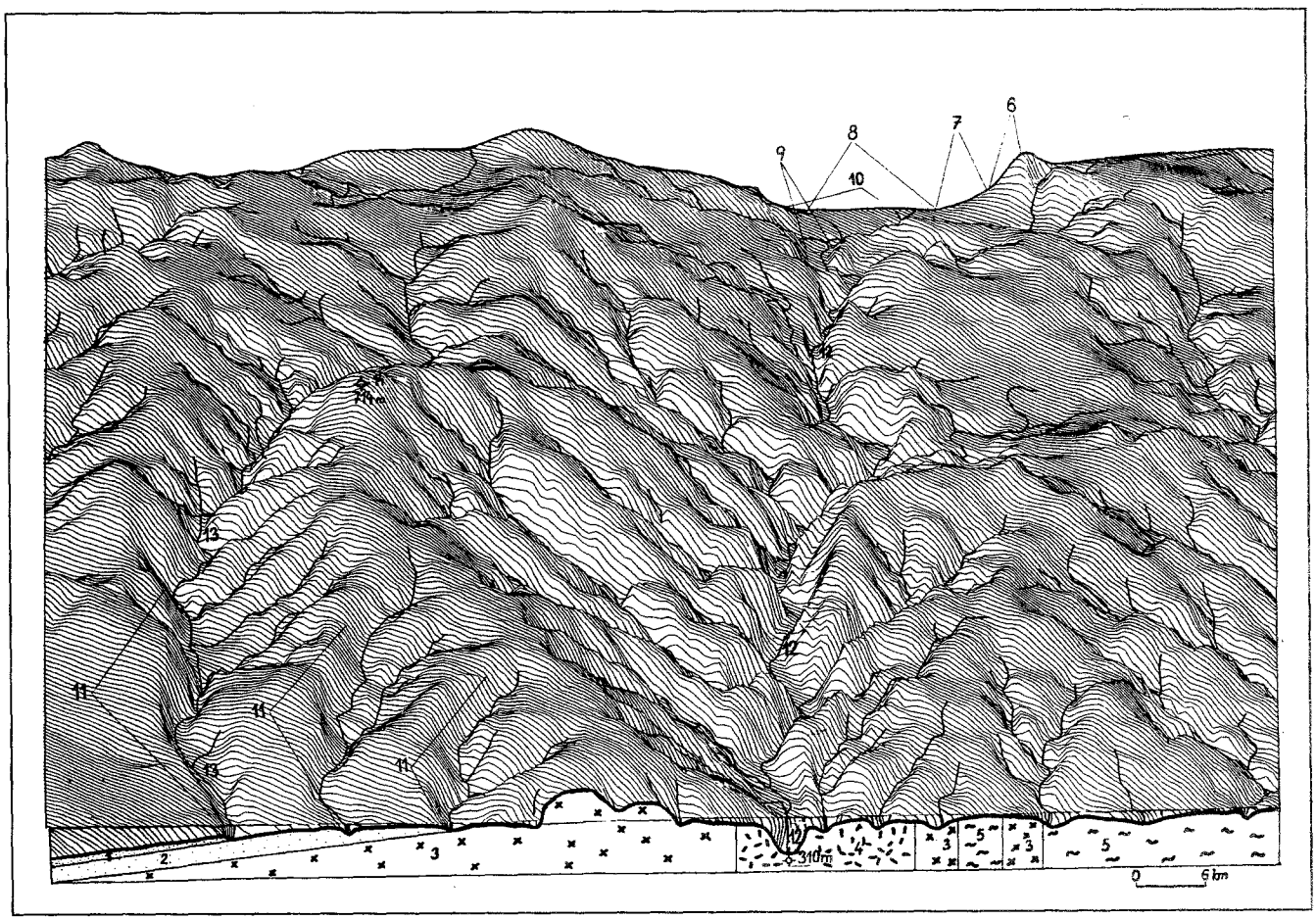


Fig 3 The 3-dimensional model of the northern part of the Zábřežská vrchovina Hill Country (15-times exaggerated). Explanations: 1 = Middle Turonian sandstones, 2 = Lower Turonian sandstones, 3 = gneiss, 4 = phylites, 5 = quartzites, 6 = a fault scarp, 7 = glacis, 8 = the bottom of the Klodzko Graben, 9 = the beginning of the Březná River water gap, 10 = the town of Štíty 440 m, 11 = cuestas, 12 = the Březńa River, 13 = the Hraniční potok stream, 14 = the Lázek Hill (714 m)

Proterozoic rocks

In the southern part of the study area biotic gneiss occurs. In the southeastern part there is gneiss with quartzites. The northern part is formed by the intrusion of tonalites of unknown age. This region was under the influence of old tectonics (Opletal in press).

Cretaceous sediments

Cretaceous sediments occur in two parts of the region under study:
A) In the southwestern part near the village of Tatenice Proterozoic gneiss is covered by Cretaceous sandstones of the Upper, Middle and Lower Turonian. Sandstones tilted to the southwest reflect synclinal buried relief of the crystalline fundament. The geological profile of Rejchrt (1967) shows three cuestas developed gradually from the west to the east in the Upper, Middle and Lower Turonian sandstones (Fig 2, 3, 3).
B) In the northern part near the town of Štíty as a filling of the Klodzko Graben. Horizontal sandstones reflect the flat buried relief of the crystalline fundament (Opletal in press).

Cretaceous sediments which once covered a larger area have been degraded and transported (Malkovsky 1974). However, remnants of these sediments were not found in the higher parts of the study area.

Quaternary sediments

These are situated mainly in the following regions:
A) In the narrow flood plains of the Březná river, the Cotkytelský potok stream and the Nemilka river with smaller proluvial cones in the confluences of the three water courses and their tributaries.
B) As debris at slope foots.
C) In the bottom of the Klodzko Graben is loess.

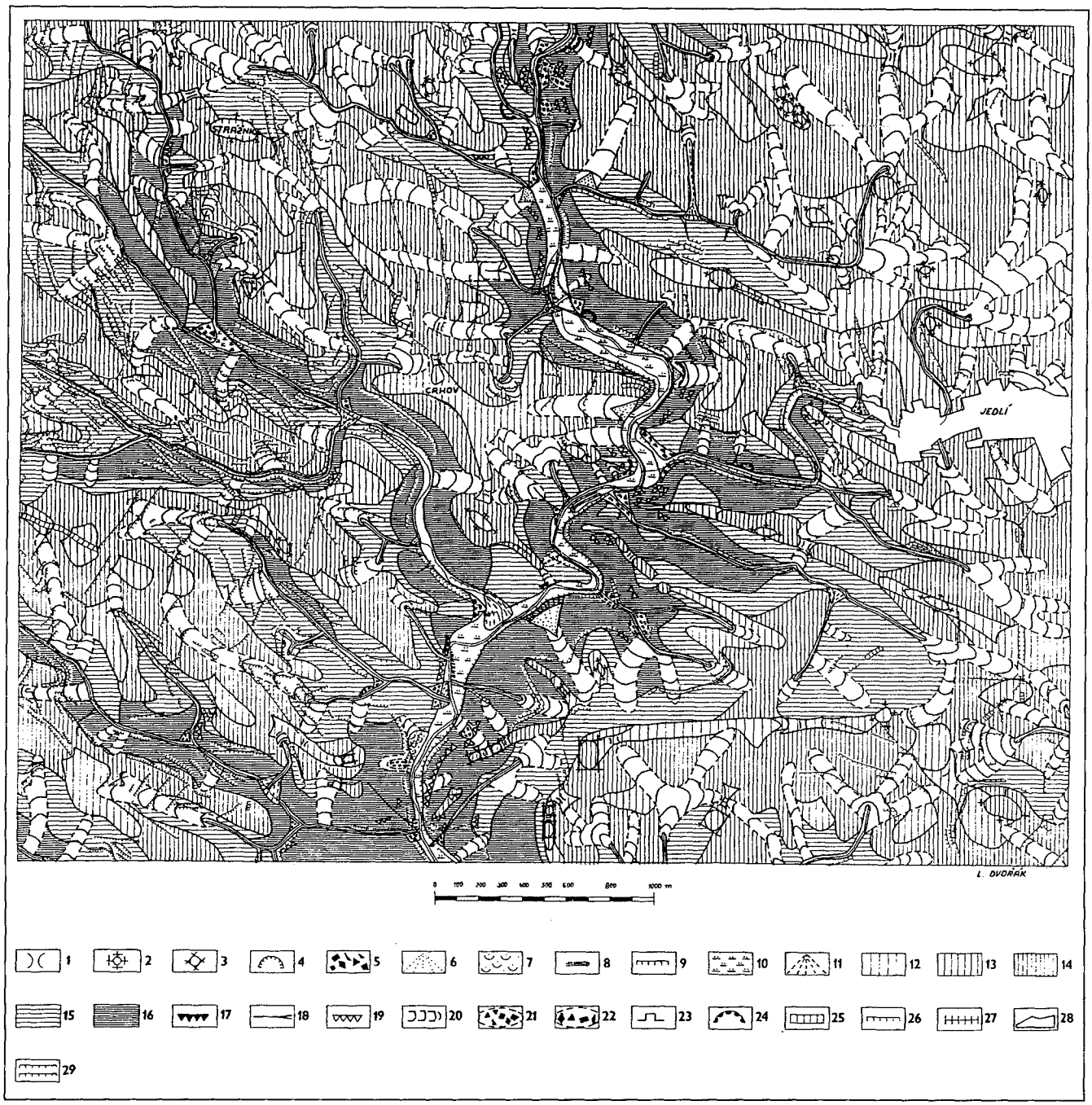


Fig 4 The Detailed Geomorphological Map Explanations (according to Demek ed. 1972): 1 = passes, 2 = ruwares, 3 = monadnocks formed by crystalline rocks, 4 = upper parts of landslides, 5 = talus, 6 = deluvial cones, 7 = accumulated parts of landslides, 8 = valley bottoms, 9 = cliffs in unconsolidated sediments of proluvial fans, 10 = flood plains, 11 = proluvial fans, 12 = flat plains at 0-2°, 13 = slopes inclined at 2-5°, 14 = slopes inclined at 5-15°, 15 = slopes inclined at 15-35°, 16 = slopes inclined at 35-55°, 17 = slopes inclined more than 55°, 18 = gullies, 19 = frost-riven cliffs, 20 = dells, 21 = block fields, 22 = block streams, 23 = pits, 24 = quarries, 25 = sunken roads, 26 = anthropogeneous cliffs, 27 = anthropogeneous banks, 28 = surfaces with significant anthropogeneous influence, 29 = agricultural terraces.

Active Morphostructure of the Studied Region

In the northern part there are a few older faults revived during the neotectonic period (Opletal in press). They belong to the Bušín Fault System which passes through the study area in a northwest-southeast direction.

In the Klodzko Graben fault scarps reflect this dislocation. Their foots are formed by Cretaceous sandstones and their upper and steeper parts by Proterozoic crystalline rocks. Therefore, the author classifies this foot surface as glacis d'erosion. Some valleys of water courses (ie the spring part of the Nemilka river,

and the beginning of the water gap of the Březná river going from the lower Klodzko Graben through the higher Zábřežská vrchovina Hill Country into the Moravská Sázava river) are controlled by faults.

Cretaceous sandstones are faulted in the western part of the studied region (Rejchrt 1967).

No Tertiary sediments were found in the study area. Knowing their locations would have helped to explain the morphostructural evolution of the area. They are presented here as a topic for further research, because Tertiary sediments could be expected here.

Conclusion of the Practical Application of Morphostructural Analysis

1) Generally from the morphostructural point of view the studied region is suitable for any construction except in the northern part because of the influence of the active morphostructure of the Bušín Fault System. The glacis d'erosion gives evidence of relative stability during the neotectonic period. In this part detailed geotechnical measurements are recommended before the beginning of any construction such as highways or power stations etc.

2) Both morphostructural analysis and the morphostructural map (Fig 2) give a basis for other methods of geomorphological research, namely morphosculptural analysis, denudation chronology, computer analysis, and detailed geomorphological mapping. Using these geomorphological research tools it is possible to make a more detailed analysis of the area studied and provide more detailed conclusions for their practical use.

3) Hazard forecasting, ie earthquakes etc.

Computer Analysis

This section shows the application of Geographical Information Systems (GIS) in geomorphology. The region under study was digitized in the GIS of ARC/INFO. At first the coverage called "ISOLINES" was created and each isoline of the Basic Map of Czech Republic No. 14-431 in the scale of 1 : 25,000 was digitized. Then each water course situated on the map was digitized under the coverage called "HYDROLOGY". In the end a 3-dimensional model of the relief was created together with the water courses and the geological structure (Fig 3). Fig 3 confirms the conclusion of the morphostructural analysis. It means that the cuestas, the fault scarp, and the glacis d'erosion are all clearly seen on the 3-dimensional model of the relief.

The digitized isolines were also used to construct 40 valley profiles helping to decide whether the valleys are symmetrical or asymmetrical.

The final use of the digitized isolines was to construct a slope angle map. The slope angle categories were taken from the IGU legend for detailed geomorphological mapping (Demek 1972).

Detailed Geomorphological Mapping

This method of geomorphological research helps to better understand the studied region. The detailed geomorphological maps were drawn during the terrain investigation according to the IGU legend (Demek 1972).

The importance of the detailed geomorphological mapping is the following:

1. The creation of the archives of all geomorphological features in the studied region in a certain time.

2. The creation of a basis for other geographical research as well as for landscape mapping.

4. Studying and forecasting present day geomorphological processes such as soil erosion, underwashing of communications by water courses, landslides etc.

5. To help in making a decision before constructing roads, buildings, power stations etc.

In the studied region 9 detailed geomorphological maps in the scale of 1 : 10,000 were drawn according to the IGU legend (Demek 1972). One of them is presented as Fig 4. It is possible to describe each geomorphological feature of the detailed geomorphological map. These described features help to determine the area's neotectonic stability, hazards etc.

Denudation Chronology

As a final stage in geomorphological research it is possible to provide the denudation chronology of the studied region showing its geomorphological evolution. Using the previous methods the denudation chronology of the region under study is the following:

The north-south axis of the area is the Březná river valley. This river formed a deep antecedent water gap going from the Klodzko Graben through the Zábřežská vrchovina Hill Country into the Moravská Sázava river. The present day relief was probably created mainly in the Neogene with neotectonic influence.

In the Pleistocene the observed territory was situated alternatingly in the periglacial or mild humid climatomorphogenetical zones. Therefore the cryogeny periglacial processes had an influence upon the Tertiary relief features. In that time a few tens of frost-riven cliffs with a height of about 10 m, many dells and sediments of river gravel (with about 5 m thickness) in the flood plains of the Březná river, the Hraniční potok stream and the Nemilka stream originated.

The question of the age of both the water-divide ridges and the planation surfaces is very difficult. They originated in the Tertiary period, however, their contemporary surface is very young. The author takes them to be the etchplain of the Bohemian Highlands. Monadnocks and low exfoliation domes rise from this planation surface.

In the Recent further sedimentation of the flood loams in the flood plain of the Březná river, the Hraniční potok stream and the Nemilka stream has continued. Gullies, alluvial fans and debris have also originated in this period.

The relief shows many anthropogeneous features in the studied region, ie agricultural terraces, communication cliffs and abandoned quarries.

The soil erosion is a current problem in the studied region. Landslides in the Březná river valley are less frequent.

The future evolution of the relief will mainly depend on climatical conditions and human economic activities. It will be necessary to prevent soil erosion, landslides, and the origin of gullies and the underwashing of communications by the Březná river.

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Book Review

Bengtsson, A.M.; Hjort af Ornäs, A.; Lundquist, J.; Rudengren, J. (eds.): The Environment and Free Trade. 135 pp., figs., tabs. EPOS, Uppsala 1994
Report from a workshop held in Linköping, January 18-19 1993. EPOS, Research Programme on Environmental Policy and Society, Department of Social and Economic Geography, Uppsala University.
ISBN 91-506-1036-8

According to trade we are facing a global division into developed and industrialized countries of "the North" and the Less/Least Developed Countries (LDCs) of "the South". The necessity of environmental protection has become an important part of the discussion of trade policies. Especially for LDCs environmental protection is a problem resulting from their dependence on the first world.

The workshop mirrors the recent discussion of trade and environment. In some articles needful definitions of "trade" are given. Obviously the main problem is the question of interaction because each author stresses the conflict between these two subjects. It is pointed out that the interests of free trade often collide with the necessities of nature conservation. The main difficulty seems to be the combination of the development of LDCs and keeping earth's capability of guaranteeing the survival of man. Some authors give overviews of their topics, for example the use of pesticides in agriculture, while others make suggestions for research and for a change in the understanding of the relationship between trade and environment. The question is under which circumstances free trade will be a solution for environmental problems as well as a means for a better distribution of finance and goods. Economic growth should not be allowed to destroy the environment as our resource of life. To find a compromise the standards of first world societies have to be reduced while LDCs standards will have to rise.

Generally speaking, the book shows the most important topics for further research without being able to give any conclusions for recent problems which were well known but now pointed out in a sound and thorough way first.

There should be more international participation in such a workshop. Indeed it is a book worth borrowing and reading.

The undestroyed environment and the commercial trade guarantee the survival of man, while we have to become aware of in how far trade is more or less important than environment.

Ludwig Ellenberg and Michael Kluge, Berlin