| Bull. Soc. belge Géologie<br>Bull. Belg. Ver. Geologie | T. 84<br>V. 84 | fasc. 1<br>deel 1 | pp. 51-55, 1 fig.<br>blz. 51-55, 1 fig. | Bruxelles 1975<br>Brussel 1975 |
|---|---|---|---|---|

# THE PALEORELIEF OF THE BASEMENT OF THE UPPER CARBONIFEROUS IN THE KLADNO-RAKOVNÍK BASIN

by Jiří KLENER (1)

SUMMARY. — In this paper the tectonic origin of the main depressions of the basement, filled with the sediments of Westphalian C-D, is considered. Furthermore, the geology of the basement of the Upper Carboniferous and the effects of the exogenetic processes having formed the morphology of the basement are discussed. The presumed model of the Westphalian relief of the basement results from the analysis of the thicknesses of the Westphalian sediments and from their paleogeographical distribution.

The area described (about 1 400 km²) covers the central and eastern parts of the Kladno-Rakovník Basin, extending in the north-western part of the Bohemian Massif. The Carboniferous sediments of the Kladno-Rakovník Basin, which form part of the Carboniferous of Central Bohemia, continue from the area studied to the SW into the Rakovník Basin and to the NE into the Mšeno Basin (V. HOLUB, 1970).

## 1. THE CONCISE GEOLOGY OF THE AREA

The basement of the Upper Carboniferous is formed predominantly by the Teplá-Barrandian block of Proterozoic age. The minor part of the basement, chiefly in the west, is composed of granitoid bodies accompanied by hypabyssal differentiates and locally also by basic bodies. The Proterozoic rocks are represented by weakly metamorphosed shales, siltstones and graywackes in the southern and south-eastern part of the area, by phyllites and biotite-phyllites in the central part, and by micaschists in the north. The Proterozoic sequences are intensively folded, displaying tectonic and structural elements of SW-NE trend. The more resistant rocks, spilites, granite, basic igneous rocks and lydites were especially significant in the geomorphological development of the pre-Carboniferous landforms of the basement.

The continental sediments of the Upper Carboniferous of the Kladno-Rakovník lie unconformably on the Proterozoic basement. Their thickness is as much as 1 440 m in the centre of the basin. In the deepest part of the basin the base of the Carboniferous lies at a depth of —1 200 m below sea level. The stratigraphic range of the Carboniferous sediments covers the interval from the Westphalian B/C boundary to Stephanian C inclusively (for the stratigraphy and thickness of the formations see tab. I). Psephites and psammites predominate over pelites. They occur in various facies, having been deposited in proluvial, fluviatile and lacustrine environments. Alternation of grey and red formations is typical. Only the grey formations, in particular the sediments of Westphalian C, are coal-bearing; the red formations are barren. Tuffaceous beds at different stratigraphic levels are rather frequent, many of them representing significant marker-horizons (J. MAŠEK, 1966). Bodies of paleovolcanics, quartz-porphyries and melaphyres have been proved to occur in some places in the lowest part of the Carboniferous sediments. The Carboniferous beds dip gently (7-10°) to the NW in the south-eastern limb of the Kladno-Rakovník Basin, and to the SE in its north-western limb. Faults are abundant, striking mostly to the NW-SE and SW-NE. The throws of the faults are of several tens to two hundred meters, exceptionally more.

(1) Commission for the Classification of Deposits of Mineral Reserves, 11 000 Prague 1, Jungmannova 1, Czechoslovakia.

TABLE I

*Stratigraphy of the Upper Carboniferous of the Kladno-Rakovník Basin.*

| Age | | Lithostratigraphic division | | Thickness in meters | |
|---|---|---|---|---|---|
| | | | | Average | Maximum |
| Stephanian | C | Upper Red Formation | | 270 | 430 |
| | B | Upper Grey Formation | | 170 | 250 |
| | A | Lower Red Formation | | 210 | 280 |
| Westphalian | D | Nýřany Member | Lower Grey Formation | 400 | 630 |
| | C | Radnice Member | | | |

The Upper Carboniferous sediments in the area studied are covered in the north with platform sediments of the Upper Cretaceous (Cenomanian-Upper Turonian), up to 200 m thick. To the south, the Upper Cretaceous cover gradually decreases and changes into discontinuous erosional relics. The Upper Cretaceous sediments are dissected by Saxonian faults.

## 2. METHOD OF WORK

The thickness of the Lower Grey Formation, the lowest member of the Upper Carboniferous, often varies (105-635 m) especially in its basal part, the so called Radnice Member (0-175 m); the thickness of the upper part of the formation, the Nýřany Member, also differs locally. These differences in the thicknesses of the Lower Grey Formation were influenced by the morphology of the basement. This fact has been known for some decades, but the primary morphology of the basement has not been studied in detail up to now. The author has therefore analysed the thicknesses of the basal members of the above mentioned formation, using the results of 300 deep bores. Special attention has been paid to the changes and variations of the total thickness of the studied members of the formation. In addition, the presumed paleogeographical extent of the Radnice Member was studied so that its contour could be drawn. The relief of the presumed basement has been modelled on the basis of the isolines map showing the thicknesses of the members of the Lower Grey Formation and their paleogeographical extent. This model of the basement should express the geometry of the Westphalian C-D sedimentation basin (P. POTTER & F. J. PETTIJOHN, 1963). This method has made it possible to explain the origin of the depressions of the basement filled with Westphalian sediments, and also has helped to outline the presumed paleogeomorphological development of the relief features during the Westphalian. The term depression has been used in this paper from the geomorphological point of view, implying the low-lying places of the pre-Carboniferous paleorelief; similarly, the term elevation has been used for the high lying areas of the paleorelief (ridges), surrounding the depressions.

## 3. DEVELOPMENT OF THE PRE-CARBONIFEROUS PALEORELIEF OF THE BASEMENT

An intensive denudation is presumed to have taken place in the described part of the Bohemian Massif, from the Upper Devonian to the beginning of the Westphalian C (R. KETTNER, 1948).

Partial exposure of the granitoid massifs furnishes evidence of a long lasting denudation of the pre-Carboniferous land-surface which was considerably peneplained. Major elevations standing out above the terrain were represented only by ridges composed of more resistant rocks, as a result of differential erosion. It was stated some years ago (V. SKOČEK & V. HOLUB, 1968), that the complete weathering mantle of the bedrock of the basement had often not been preserved. A sharp contact of the non-weathered bedrock with the basal sediments of the Carboniferous is most common.

Significant and sudden changes followed the development of the pre-Carboniferous land-surface at the transition of the Westphalian B to the Westphalian C. After a long period of denudation, during which the studied part of the Bohemian Massif had been uplifted, tectonic movements changed the character of the relief. The peneplained relief was tectonically broken and dissected into troughs and horsts. The sedimentation of the basal beds of the lower part of the Radnice Member began in the deepest sectors of the newly developing depressions, covering almost 1/3 of the area studied. The origin of these depressions was probably evoked by the mechanism typical of the final phases of the Variscan orogenic cycle : by tectonic processes active during the postgeosynclinal phase of development of the geosynclinal systems (J. AUBOUIN, 1965; V. HAVLENA, 1971).

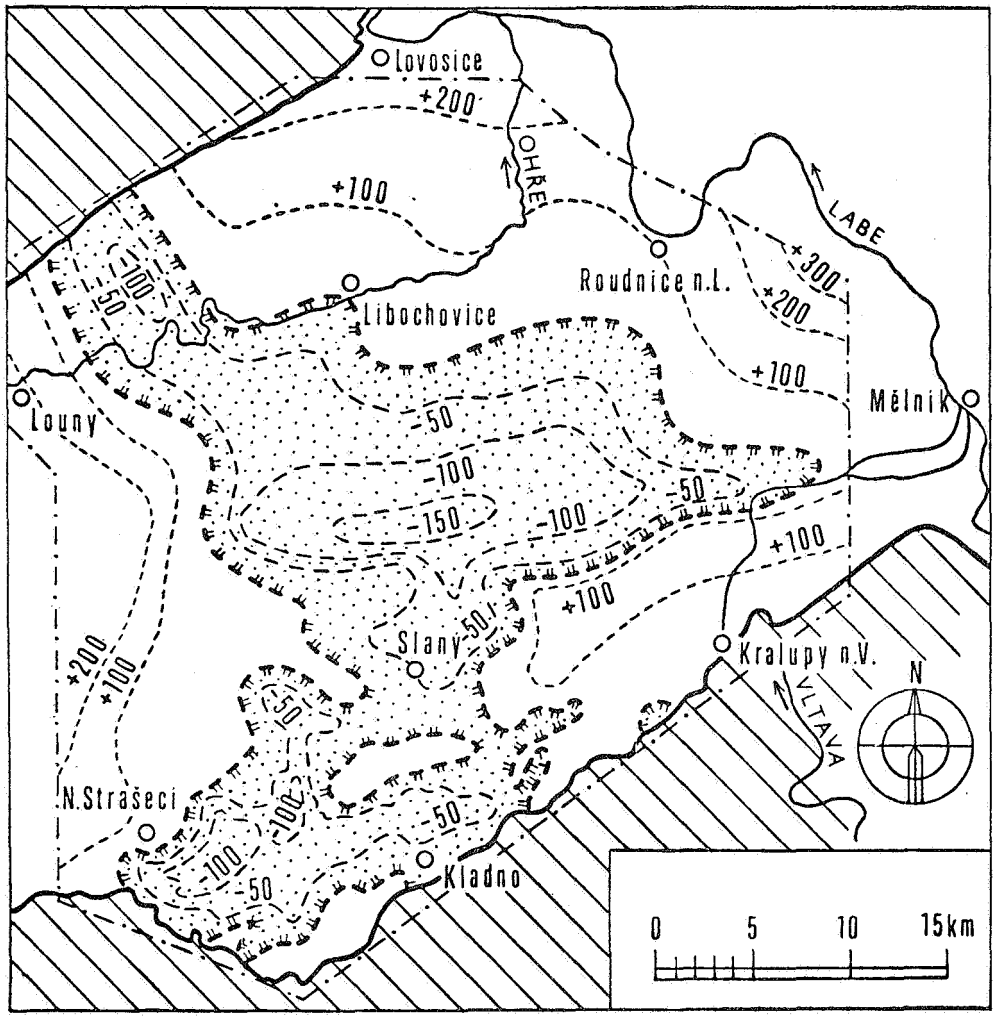
From the paleogeographic map it is evident that the strikes of the faults limiting the depressions of the basement are in accordance with the respective contours of the sediments of the Radnice Member. Two main strikes of these presumed faults (older than Westphalian C) can be followed in the directions : NW-SE and SW-NE. The strikes of these faults coincide with the prevailing strikes of the post-Carboniferous faults (pre-Cretaceous) and even with the strikes of the Saxonian faults. Most probably, the tectonic movements which were responsible for the above mentioned depressions reflected the effects of the beginning Late Asturian orogenic phase. It is also possible that these tectonic movements recurred along the rejuvenated older tectonic zones. This opinion is supported by the coincidence of the strikes of deep tectonic zones (P. RÖHLICH & N. ŠŤOVÍČKOVÁ, 1968) with the younger fault system.

Simultaneously with the lowering of the base level in the newly formed depressions, more intensive denudation and erosion began on the elevations and their hillsides. The destruction of the fault-slopes of the depressions and elevations began most probably during the accumulation of the lower part of the Radnice Member (maximum thickness 110 m). Before being completely covered with younger sediments, the steep slope dips were somewhat moderated by the effects of the landforming factors of the hot and humid climates of that time. This was proved by gradual decrease of the total thickness of the Radnice Member measured in deep bores, in the direction from the deepest sectors of the depressions to their margins, where they thin out on the gentle slopes of the elevations (fig. 1).

The relative approximate differences in meters between the depths of the depressions and the heights of the elevations were reconstructed according to the differences of the sedimentary fills in various parts of the area appearing after covering the depressions and elevations with sediments in the Westphalian D. At that time, the height of the local relief was mostly about 250-300 m, maximally 500 m. These approximate numbers make it possible to estimate in meters the minimum differences, which should be taken into account in reconstructing the basement from the time before its covering with the Carboniferous sediments. The local relief (in meters) was probably rather greater than that at the beginning of Westphalian C. For the time being it is not possible to estimate the denudation range and the total lowering of the elevations during the Westphalian C and the Lower Westphalian D. The question of the range of the subsidence of the bottom, accompanying the sedimentation, was also taken into consideration. The author has analysed the differences in the vertical distances of the two important marker-horizons in a profile about 20 km long. This method shows that the subsidence of the individual sectors of the profile was rather small (30-100 m). The influence of the subsidence was therefore not taken into consideration in reconstructing the paleorelief and in estimating the relative heights of the elevations.

As to the slope dips of the pre-Carboniferous relief the estimated angles were up to 10° in the broad depressions, up to about 20° exceptionally up to 30° in the small and narrow ones.

At the end of the Westphalian C, after the end of sedimentation of the Radnice Member in the depressions, still more than a half of the basement of the area studied was not covered with Carboniferous sediments. The Radnice Member sediments covered only the lower elevations and ridges of the basement which were composed of more resistant rocks. The higher elevations continued to be denuded and exposed to the effects of exogenous agents. After the depressions had been partially filled with sediments of the Radnice Member (maximum




Boundaries of the area studied.

The present extent of the Upper Carboniferous.

Area not covered with the Upper Carboniferous sediments.

Elevations of the basement.

Depressions filled with sediments of the Radnice Member (beginning of Westphalian D).

+100 Isolines of relative heights of elevations in meters above the top of the Radnice Member.

-50 Isobaths of the depressions in meters (=isolines of the thickness of the Radnice Member).

Fig. 1. — Hypsographic sketch-map of the basement of the Kladno-Rakovník Basin in Westphalian D.

thickness of 175 m), the position of the base level was higher than that at the beginning of the Westphalian C. Simultaneously, the relative differences between the heights of the elevations exceeding the top level of the fill in the depressions were lowered mostly from about 250 m to 100 m, in some cases from 500 m to 350 m. The denudation of the elevations was interrupted only in the Upper Westphalian D at the time when the youngest sediments of the Lower Grey Formation, i.e., those of the Nýřany Member, buried even the highest elevations and thus finished their further geomorphological development.

All the above considered conclusions as far as they concern the development of the paleorelief of the basement and all the factors which influenced it and especially the estimates of the relative heights of the elevations should be restricted to the area in question. There are not sufficient facts justifying similar conclusions in the areas where the Carboniferous sediments were completely denuded.

## 4. CONCLUSION

After the geomorphological development of the relief of the basement had been finished in the Late Westphalian D, the buried paleorelief itself and its landforms were not essentially disturbed during the subsequent sedimentation of the younger Carboniferous formations. During the Stephanian, the basement was subsiding into greater depths simultaneously with the Carboniferous sedimentary cover. The more or less continuous shapes and contours of the buried paleorelief were disturbed by the post-Carboniferous faults only. The primary geomorphological forms and relief features of the basement and the Carboniferous sediments were dissected by two systems of faults into troughs, horsts and step faults. It is always important to differentiate these secondary discontinuous forms, resulting, due to the above mentioned post-Carboniferous tectonic movements, from the primary Westphalian paleorelief of the basement described in this paper. The post-Carboniferous tectonic movements sometimes recurred along the old Westphalian tectonic zones, so that in some cases the post-Carboniferous faults accentuated the Wesphalian depressions. In some parts of the basin the post-Carboniferous tectonic movements were of opposite direction which fact was responsible for the existence of post-Carboniferous tectonic depressions in the areas of primary Westphalian elevations.

## LITERATURE


AUBOUIN, J., 1965, Geosynclines. London.

HAVLENA, V., 1971, Vývojové etapy geosynklinální soustavy a typy jejich sedimentačních depresí. *Čas. Mineral. Geol., 16*, 1, pp. 73-92.

HOLUB, V., 1970, Late Paleozoic deposits underlying the Bohemian Cretaceous basin in the north-eastern part of the Bohemian Massif. *Compte-rendu Congr. Internat. Strat. Géol. Carbon.*, Sheffield, 1967, vol. III, pp. 937-948.

KETTNER, R., 1948, Všeobecná geologie III. Praha.

MAŠEK, J., 1966, Volcanic phenomena in the Upper Carboniferous of the Central Bohemia. *In* Paleovolcanites of the Bohemian Massif. PřF KU Praha, pp. 167-177.

POTTER, P. & PETTIJOHN, F.J., 1963, Paleocurrents and basin analysis. Berlin, Springer.

RÖHLICH, P. & ŠŤOVÍČKOVÁ, N., 1968, Die Tiefenstörungstektonik und deren Entwicklung im zentralen Teil der Böhmischen Masse. *Geologie, 17*, 6/7, pp. 670-674.

SKOČEK, V. & HOLUB, V., 1968, Vznik, stáří a charakteristika fosilních zvětralin mladšího paleozoika v Českém masívu (Origin, age and characteristics of fossil Late Paleozoic weathering residues in the Bohemian Massif. Rés.). *Sbor. geol. Věd*, Ř. G, *14*, pp. 7-46.