Ministry of Economic Affairs, Adm. of Mines, Belgian Geological Survey
Annales de la Société géologique de Belgique, T. 109 - 1986, pp. 131-136

Special volume " Aachen 1986"
Avril 1986

THE FAMENNIAN OF MORAVIA (ČSSR) : THE RELATION BETWEEN TECTONICS AND SEDIMENTARY FACIES

by

Jaroslav DVOŘÁK [1]

(3 figures)

ABSTRACT. - The Moravian geosynclinal basin was a small embayment during the Devonian, without intensive tides and generally with quiet sedimentary conditions. The Givetian-Frasnian reefs in this area were killed by the uplift of formerly subsiding blocks. Reef extinction started in the Middle Frasnian (in the North) and ended in the Lower Famennian (elsewhere). Heterochronic inversion of block movements, tilting of blocks and the influx of fine clastic material into the basin were responsible for the diachronic reef extinction. The Famennian lithofacies reflect the overall regression of the sea as a consequence of the increasing compression of the geosynclinal basin. Volcanogenetic sediments are rare in the Famennian deposits since the volcanic and tectonic activities were in their initial phases. (Abstracted by the editors).

RESUME. - Le bassin géosynclinal de Moravie constituait une petite baie pendant le Dévonien, sans marées importantes et avec des conditions sédimentaires généralement tranquilles. Les récifs Givetien-Frasnien de ce Bassin furent tués par la surrection de blocs antérieurement subsidents. L'extinction des récifs a commencé au Frasnien moyen (dans le Nord) et s'est terminé dans le Famennien inférieur (ailleurs). Se produisant à des moments différents, des mouvements d'inversion ou d'inclinaison de blocs et l'apport de matériaux clastiques fins dans le bassin furent responsables de l'arrêt diachronique du phénomène récifal. Le lithofaciès famennien reflète la régression généralisée de la mer, conséquence de la compression croissante du bassin géosynclinal. Les sédiments volcano-génétiques sont rares dans les dépôts du Famennien car les activités volcaniques et tectoniques en étaient encore dans leurs phases initiales.

STRUCTURAL SETTING

Two subbasins can be distinguished in the Moravian geosynclinal basin : the Jeseníky Subbasin to the North and the Drahany Subbasin to the South. These are separated by the Upper Morava depression block. This block was a horst-like structure until the Tertiary when an inversion took place during the Neogene (Dvořák, 1985).

The granitoid Brno Pluton forms the basement of the Drahany Upland. This explains the predominantly miogeosynclinal nature of the Devonian deposits. To the South a brachysynclinal closure of the Drahany Subbasin and a transition into a platform facies exist (Dvořák, 1973, 1978).

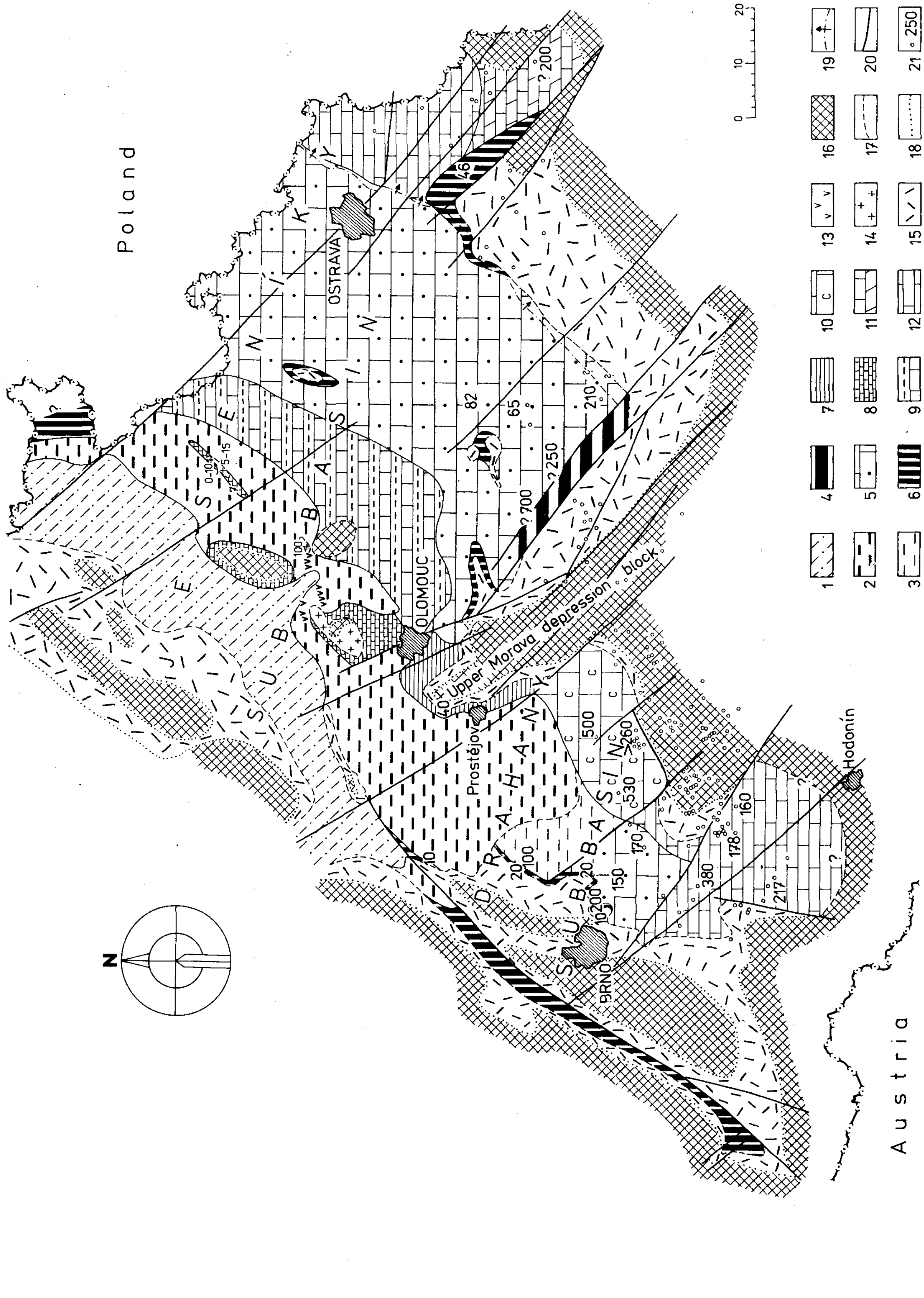
The more mobile basement of the Jeseníky Subbasin consists of gneisses. A stable granitoid mass of Proterozoic age influenced the eastern closure of this subbasin (compare fig. 1 in Dvořák, 1985).

Differential synsedimentary movements of the block-faulted basement have controlled the distribution and thickness of the lithofacies and also the tectonic deformation of the sedimentary fill (Dvořák *et al.,* 1983, 1984, 1986).

GIVETIAN - FRASNIAN

Up to 1000 m thick reefal limestones developed during the Givetian and Frasnian transgressions. An upward decrease of the thicknesses of the individual biostratigraphic units recognized in these limestones suggests a declining rate of subsidence during this timespan (Dvořák *et al.* 1984).

1 *Ustřední Ústav Geologický, Leitnerova 22, 602 00 Brno, ČSSR.*


Poland
Austria
OSTRAVA
OLOMOUC
Prostějov
BRNO
Hodonín
Upper Morava depression block
N

UPPER FRASNIAN - LOWER FAMENNIAN

The reef development came to an end between the Middle Frasnian and Lower Famennian, indicating that subsidence ceased almost completely during this timespan (Dvořák, 1980). However, this gradual change from transgressive to regressive tendencies was not isochronous throughout the basin as suggested by the local differences in the moment of reef extinction.

On some blocks to the North-East and South-East (in the marginal parts of the carbonate platform) the character of the sedimentary facies changed very slowly. There was no change in the lithology; light-grey to grey, massive micritic limestones continued to prevail. Stromatoporoid and coral assemblages disappeared very slowly and were replaced by foraminifer assemblages. Only the thicknesses of the Famennian limestones in these areas are less important than those of the Frasnian ones. In the extreme North-East, in the embayment of the platform, nearly evaporitic environments started to develop. This is indicated by the upward passage from light-grey limestones into whitish-grey dolomites with thin intercalations of green shales (tuffites ?).

The southeastern border of the Jeseníky Subbasin was occupied by a quickly subsiding, NW-SE trending narrow graben. This was rapidly filled with black clayey limestones and intercalated dark-grey organo-detrital and micritic limestones. Intensive slumping affected the deposits on the northeastward tilted blocks. These sediments grade into black laminated shales with thin laminae of black dolomite and limestones (possibly algal laminites) deposited in a shallow, low-energy and strongly anoxic environment. The shoreline trend was parallel to a synsedimentary dislocation with a throw of more than 2000 m.

Condensed grey, micritic laminated limestones with thin shale intercalations bordered the horst-like structure of the Upper Morava depression block. Periodical changes in the sedimentation rate, the presence of clastic (silt size) quartz (possibly of aeolian origin), and the paucity of the fauna suggest a shallow lagoonal

Figure 1. - Paleofacies map of Upper Famennian deposits in Moravia (ČSSR).

1. Flysch deposits. Alternation of greywackes, siltstones and shales with graded bedding. Local intercalations of pebbly mudstones. Passing into siliceous shales with radiolarites. Thickness : maximum several hundred meters.
2. Siliceous shales with radiolarites. Black or green siliceous shales with intercalations of black or greenish-grey silicites (radiolarites). Basic volcanic activity was not intensive. Conodonts are present. Rather abrupt transition into flysch deposits is marked by the increase of the silty quartz admixture in the siliceous shales. Gradual passage into carbonate facies. Thickness : 20 to 150 m.
3. Presumed occurrence of dark-grey to black shales in the central portion of Drahany Subbasin (East of the Moravian Karst), passing into nodular limestones.
4. Black, clayey limestones with intercalations of dark-grey, biodetrital and biomicritic limestones. Conodonts are present. Transition into black shales through rare laminae of dark-grey, micritic limestone or dolomite without any fauna. Thickness : 150 to 600 m ?
5. Dark-grey, well-bedded, biosparitic to biomicritic limestones with thin shale intercalations. Sorting is good (calcarenites) to very poor. Micritisation. Siliceous nodules. Fossils include crinoids, brachiopods, ostracodes, foraminifera, conodonts, trilobites, sponges, algae and macroflora. Local nearshore facies is marked by ostracodes and lingulids in black shales, and by the influx of silty, terrigenous material. Gradual transition into nodular limestones. Thickness : 100-300 m.
6. Nodular limestones and micritic limestones with admixture of calcareous shale. Nodules are early diagenetic. Intercalations of stromatolites, limestone breccias, slump structures. Red-coloured sediments prevail in places with strong condensation. Basinwards gradual transition into dark-grey shales with nodules of micritic limestones. Conodonts, clymenids, ostracodes and trilobites are present. Thickness : 5 to 100 m.
7. Grey, thin-laminated limestones, locally with thin laminae of variegated shales. Gradual transition into nodular limestones. Thickness : up to 80 m.
8. Grey, thin-bedded micritic limestones, locally with shale laminae. Conodonts are present. Gradual transition into siliceous shales. Thickness : 10 m.
9. Presumed presence of micritic limestones and shales in central portion of Jeseník Subbasin.
10. Light-grey, sugar-like limestones and massive pelbiosparitic limestones with local abundance of authigenic quartz crystals (with zonal coatings and micritic calcite in central part of the crystals). Rare crinoids, foraminifera, stromatoporoids and algae are present. Two intercalations of bimodal, quartzose well-sorted sandstones. Rare intercalations of dark-grey, dolomitic limestones. Gradual transition into dark-grey, organodetrital limestones. Thickness : 280 to 480 m.
11. White dolomites and limestones with thin intercalations of green (tuffitic ?) shales. Very rare foraminifera. Thickness : 100 m?
12. Light-grey to yellowish, massive biomicritic limestones with very gradual transition into underlying reefal limestones. Foraminifera, algae and rare stromatoporoids are present. Thickness : 50 ? to 100 m.
13. Contemporaneous basic volcanism.
14. "Islands" consisting of older basic volcanic rocks.
15. "Islands" and dry land consisting of Frasnian reefal limestones (uplifted areas).
16. "Islands" and dry land consisting of Proterozoic metamorphic and plutonic rocks (mainly gneiss and granitoids).
17. Presumed Famennian shoreline.
18. Presumed Frasnian shoreline.
19. Boundary between folded Variscan foredeep to the West and Variscan Platform to the East.
20. Principal Famennian synsedimentary dislocations.
21. Thickness for total Famennian deposits (circles indicate position of boreholes).

environment. Locally, the limestones display synsedimentary convolute bedding indicating an overall eastward movement of the unlithified mud.

Many of the foreland blocks in the East and in the South were tilted towards the basin center (Dvořák *et al.,* 1976). Thin sequences of nodular, well-bedded micritic limestones were deposited on the border of these blocks, Purple lateritic clay material (Al_2O_3/Na_2O ratio : 80 to 130; Fe_2O_3/FeO ratio : 50) was washed down from the slowly rising ridges of Proterozoic crystalline rocks into the basin and deposited in a shallow oxic environment. Intercalations of redeposited limestone nodules (the clay matrix had been washed out), limestone breccias and slumping occur locally. Condensed variegated sediments interfinger with the dark-grey nodular limestones. The amount of the dark-coloured shale matrix of these nodular limestones increases basinwards where these pass into shales with rare limestone nodules. The dark-coloured nodular limestones suggest sedimentation in an anoxic, slightly deeper environment (Dvořák, 1972; Dvořák *et al.,* 1976).

UPPER FAMENNIAN

Following a condensed sedimentation of black, sandy nodular limestones and sandstones during the Lower Famennian, some blocks of the platform to the East started to subside again during the Upper Famennian. Light-grey sugar-like, massive pelbiosparitic limestones were deposited in a shallow-water, oxic environment on the carbonate flats and in subaqueous bars or dunes. Dolomite intercalations and locally abundant authigenic quartz crystals (maximum length 1.5 mm) indicate that sedimentation occurred in almost evaporitic conditions in between the shore-line and calcareous sand bars (Skoček, 1979). These rather thick deposits suggest a relatively rapid subsidence.

In the more mobile zones (at some distance from the platform within the basin) some small blocks started to subside again since the Middle Famennian. This is indicated by the fact that the thickness of the dark-grey, well-bedded organodetrital limestones on these blocks is about ten times the thickness of the nodular limestones on neighbouring blocks. The boundaries between these blocks are relatively sharp and marked by steep flexures and rapid changes in the thickness and facies of the Famennian sediments. Rich foraminifer assemblages associated with conodonts of the *Palmatolepis* biofacies occur in these calcareous sands and muds. Icriodids and other conodonts characterizing a turbulent water facies are absent in Moravia. Intensive micritisation of bioclasts in residual shell beds is very common, although no important sorting by waves or rounding of bioclasts is observed. The limestones were deposited in a turbulent, shallow environment that repeatedly became more quiet as shown by the

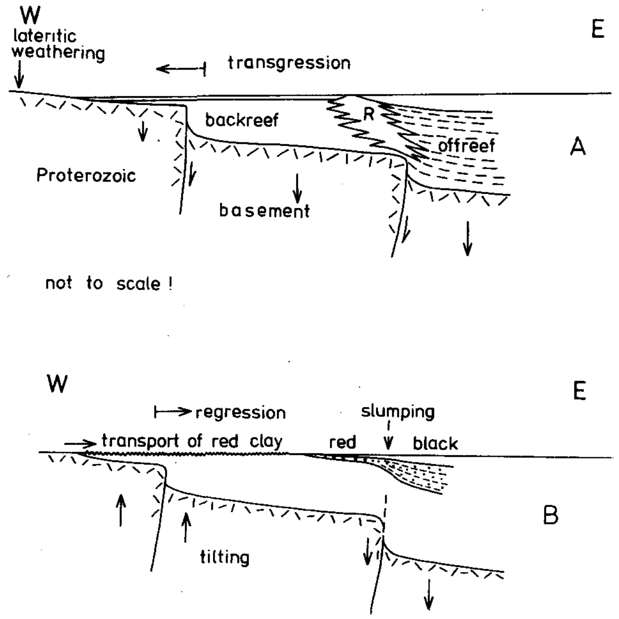


Figure 2
Schematic sections through the Moravian Karst, showing facies and thickness of Frasnian (2A) and Famennian (2B) deposits controlled by synsedimentary tectonics of Proterozoic basement.

micritisation of bioclasts or by the deposition of biomicrites (Kukal, intern. report).

Very condensed sequences of grey, micritic limestones occur on volcanic elevations. Frequently, these are followed by a sedimentary gap of uppermost Famennian or Tournaisian age. Often, a gradual transition of these limestones into siliceous shales is observed.

Siliceous shales with radiolarites are generally bound to volcanic areas. Presumably, the massive, non-laminated silicites originated from volcanic exhalations. The silica may have precipitated directly as a gel, or was first bound in organic skeletons. The high amount of organic matter and of bivalent iron in these sediments indicates deposition in a stagnant, anoxic water. Possibly, this environment occurred in partly isolated basins without, intensive bottom currents in between volcanic elevations. The siliceous shales around basic volcanoes are sometimes green (MgO content up to 4 %) and contain greenish-grey silicites, which have been washed down from weathered lavas and tuffs. In this lithofacies small extrusions of basic lavas occur which are associated with iron ores of the Lahn-Dill type (Dvořák *et al.,* 1983).

Clastic material was derived from the quickly rising Proterozoic crystalline blocks in the West. Rapid deposition of unweathered clastic sediments (Al_2O_3/Na_2O ratio of the shales is 8 according to Kukal, 1980) took place in a narrow zone with a high rate of subsidence, and within an anoxic environment. The maximum water depth in this zone exceeded that of the areas where siliceous shales occur. This is suggested

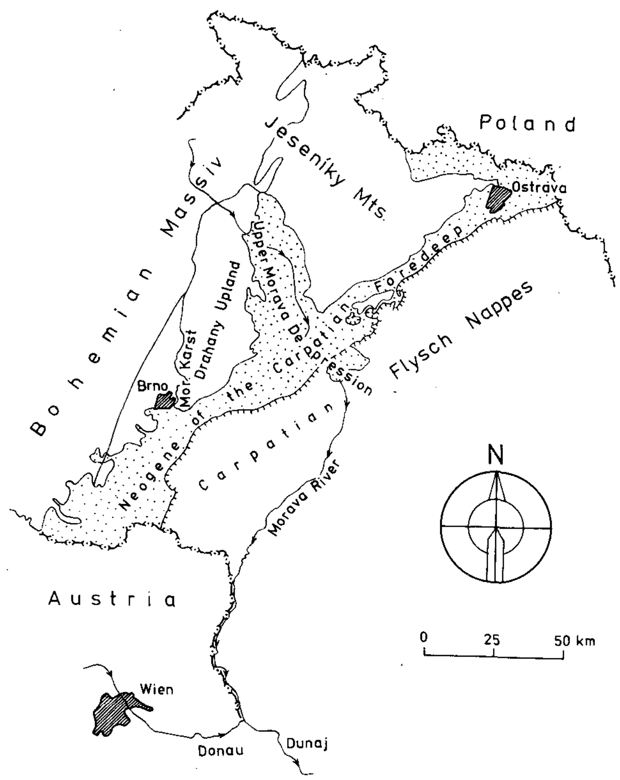


Figure 3. - General geology of Moravia (ČSSR).

by the fact that turbidity currents have not transported the clastic material to the area with condensed siliceous shales. Turbidity currents redistributed clastic material from the clastic deltaic wedges in the South to the inner portions of the basin in the North.

SYNTHESIS

The Moravian geosynclinal basin was a small embayment during the Devonian, without intensive tides and generally with quiet sedimentary conditions. Coarse clastic material is usually limited to the more quickly subsiding parts of the basin, where it occurs in greywackes or in calcareous sands. Marine currents continuously transported the coarser material into synsedimentary developing depressions. In this way, the bottom relief of the basin was continuously levelled.

The Givetian-Frasnian reefs in the Moravian Basin were killed by the uplift of formerly subsiding blocks. This is indicated by the frequent karst features such as fissures filled with younger sediments occurring in the reefal limestones (Franke, 1973; Dvořák & Friáková, 1981). Detailed biostratigraphic investigations based on conodonts (Dvořák & Freyer, 1965; Dvořák *et al.*, 1976, 1984; Dvořák & Friáková, 1978; Dvořák, 1978, 1980) proved that reef extinction started in the Middle Frasnian (in the North) and ended in the Lower Famennian (in the southern part of the Moravian Karst, in boreholes South-East of Brno, in the area around Hradec Králové in the North-West, in the Debnik area near Krakow in southeastern Poland). This emphasizes that reef extinction was not related to a sudden change of the climate or to any "catastrophic" event, but rather to a gradual change of the geotectonic conditions in the basin. Heterochronic inversion of block movements, tilting of blocks and the influx of fine clastic material into the basin were responsible for the diachronic reef killing. And thus reef limestones continued to develop in the South (e.g. near Brno) on the still subsiding Proterozoic basement during the Upper Frasnian and Lower Famennian, when in the North-East (near Hranice na Moravě) the sea retreated and nodular limestones were deposited.

The Famennian lithofacies reflect the overall regression (or stable conditions in a small part of the basin) of the sea as a consequence of the increasing compression of the geosynclinal basin. The foreland blocks to the East were underthrusted below the geosyncline and below the Variscan Median Mass (core of the Bohemian Massiv). Because of the steep temperature paleogradient (70-200°C/km) the underthrusted Proterozoic granitic layer was melted, migrated below the rising Median Mass Blocks and intruded herein as granitoid intrusions. Acid volcanites built up high mountains on the border of this Median Mass. Ashes from these volcanoes have been blown into the basin. Nevertheless, volcanogenic sediments are rare in the Famennian deposits since the volcanic and tectonic activities were in their initial phases.

REFERENCES

DVOŘÁK, J., 1972. Shallow-water character of the nodular limestones and their paleogeographic interpretation. N. Jb. Geol. Paläont. Mh.,: 509-511, Stuttgart.

DVOŘÁK, J., 1973. Synsedimentary tectonics of the Paleozoic of the Drahany Upland/Sudeticum, Moravia, Czechoslovakia. Tectonophysics, 17 : 359-391, Amsterdam.

DVOŘÁK, J., 1978. Proterozoischer Untergrund der variszischen Geosynklinale in Mähren (ČSSR) und ihre Entwicklung. Z. Dtsch. geol. Gesell., 129 : 383-390, Hannover.

DVOŘÁK, J., 1980. Geotectonic conditions of the forming and extinction of the reef complex, notably in the Devonian of Moravia. Věst. Ústř. Úst. Geol., 55 : 203-208, Praha.

DVOŘÁK, J., 1985. Horizontal Movements on Deep Faults in the Proterozoic Basement of Moravia (Czechoslovakia). Jb. Geol. B. A., 127 : 551-556, Wien.

DVOŘÁK, J., FRIÁKOVÁ, O., 1981. Paleogeografie famenu a tournai v severní části Moravskéno krasu (na základě konodontových faun) Čas. Geol. Miner., 26 : 301-306, Praha,

DVOŘÁK, J., FRIÁKOVÁ, O., GALLE, A., HLADIL, J. & SKOČEK, O., 1984. Correlation of the reef and basin facies of Frasnian age in the Křtiny HV - 105 borehole in the Moravian Karst. Sbor. Geol. Věd, Geologie, 39 : 71-98. Praha.

DVOŘÁK, J., FRIÁKOVÁ, O., HLADIL, J., KALDOVA, J., & KUKAL, Z., 1986. Geology of Paleozoic in the vicinity of quarries of Mokrá Cement Factory. Sbor. Geol. Věd. Geologie (in print), Praha.

DVOŘÁK, J., FRIÁKOVÁ, O., KUKAL, Z. & OTAVA, J., 1983. Stratigrafie a faciální vývoj paleozoika v okolí Šternberka na Moravě. Čas. Min. Geol., 28 : 397-414, Praha.

DVOŘÁK, J., FRIÁKOVÁ, O & LANG, L., 1976. Block structure of the Old Basement as indicated by the Facies Development of the Devonian and the Carboniferous in the Moravian Karst (Sudeticum, Moravia, ČSSR). Geologica et Palaeontologica, 10 : 153-160, Marburg/Lahn.

FRANKE, W., 1973. Fazies, Bau und Entwicklungsgeschichte des Iberger Riffes (Mitteldevon bis Unterkarbon III., NW-Harz, W-Deutschland). Geol. Jb., A,11, 1275, Hannover.

KUKAL, Z., 1980. The sedimentology of Devonian and Lower Carboniferous deposits in the western part of the Nízký Jeseník Mountains, Czechoslovakia. Sbor. Geol. Věd. Geologie, 34 : 131-207, Praha.

SKOČEK, V., 1979. Litologie paleozoika v karpatské předhlubni (úsek střed). Sbor. Geol. Věd, Geologie, 33 : 7-46, Praha.