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Devonian Island Elevations under the Scope: Central Europe, Basement of the Carpathian Mountains in Moravia

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With 7 Text-Figures

Tschechische Republik
Karpaten
Grundgebirge
Devon
Stratigraphie

Contents

Inselartige Aufwölbungen im Devon des Grundgebirges der Karpaten in Mähren

Zusammenfassung

Ein neuer Gegenstand der Erdölprospektion in Mähren sind die inselartigen Erhebungen des Devon. Charakteristisch für die wiederholt auftauchenden Erhebungen ist die Ausdünnung der Karbonatauflage, die bessere Durchlässigkeit aufweist als jede andere Struktur der Karbonat-Plattform, inklusive biohermaler Aggregate oder intralagunärer Riffe.
Das vorgestellte Modell der genau erhobenen inselartigen Erhebungen des Devon von Krasna trägt zum Verständnis der weiterhin geplanten Aufnahmen von inselartigen Erhebungen des Devons bei.

Abstract

Devonian island elevations (DIE) represent a recent subject of oil-survey in Moravia. Repetitiously emerged elevations are characterized by the thinning of the carbonate complex which yields better porosity than any other structures of the carbonate platform including swelling biohermal aggregates or intralagoonal reefs.
The presented model of the intensively surveyed Krásná DIE suggests a clue how the other DIEs in prospect can be understood.

1. Introduction

The final report of the last oil-survey project (MÜLLER et al., 1991) contained, among other topics, also a sequence and space setting of the Devonian carbonate complex. Sixteen maps have been included so that have been illustrating the subsurface outlines of individual sequence units. Both the vertical sequences and facial maps were, in part, based on the previous unpublished data (HLADIL & KALVODA, 1989a, b, 1991; HLADIL , 1991). The serial superimposition of maps indicated two types of elevations: The first ones were cut always in the same place – they are

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young, especially Mesozoic. The second ones displayed a concentric pulsatile submergence/emergence. We called them Devonian island elevations (DIEs).

The DIEs are specific objects of the Devonian Platform. They are characterized by thinning of the carbonate complex above the considerably elevated crystalline basement. These structures differ from thick biohermal aggregates or intralagoonal reefs. On the moderate slopes of DIEs, an intensive fluctuation of pore-water composition took place. The slopes were affected by a fluctuating sea level which reflected as climatic/eustatic oscillations as epeirogenetical pulses. The zone of mixed water along the marginal subsurface of the island was repetitiously changed in configuration and composition. Many rock inhomogenities were formed preferentially here. Core samples of KS-7 Krásná borehole evidenced a good cavern-porosity (10 to 20 %) which is comparable with the best reservoir world standard. No other places of Moravia yield such a high porosity documented in cores.

Within the Sector North, three structures of the DIE type were documented or introduced: Hranice, Krásná and Karolinka. But the actual oil-traps and reservoirs were found only in the Krásná DIE (southeasternly of Ostrava town). Fossil fuels of the Hranice DIE (westernly, in Carpathian foreland) were oxidized and exhausted because the elevation has been repetitiously uplifted and eroded since the late Variscan events. Contrary to the latter one, the Karolinka DIE (southeasternly of Roznov p.R. town) was significantly drowned to a deep position under the Carpathian nappe stack.

The survey of the Krásná DIE was covered by the state budget. Recently, the Krásná field has been released and licenced to Unigeo company that continues the survey and the exploitation of this DIE. The promising Karolinka DIE was indicated by facial and geophysical research. Risks of this deep structure (7 to 8 km) are represented especially by lack of the pioneer wells as well as a necessity to penetrate a thick complex of the flysh nappes. However, the source and migration conditions are probably good (MÜLLER et al., 1991). Neither remaining and only slightly indicated possible DIEs can be totally refused because any conceptual profile drilling was never realized in the large Sector North. Eighty boreholes of this sector were mostly clustered following only the partial survey concepts or promissing structures of the past.

1.1. From Reefs Towards the Non-áeefal Island Elevations: Diagenetical Traps of the DIE Slope Interiors

The standard strategy of Moravian oilers, i.e. the survey of thick reef bodies and their positive undulations at the carbonate surface (1963 to 1988, rarely later) appears to be unsuccessful in the conditions of the Devonian Platform (ramp to back reef). Controversially, the places where carbonates are thinning towards the centres of the structures become to play an important role in the local oil-survey and this is a base of the so-called second strategy. Biostratigraphical core data show that onset of the carbonate complex is always late when the section is close to the DIE centre and the end of the sedimentation is early occurring again at this centre. Sedimentary sequences of distant DIE margins are more continued and thicker in comparison with the central parts. These features can very simply indicate the surveyed DIEs. The inhomogeneity and porosity of carbonate rocks display an increasing even complicated trend towards the centre of the structure.

The second strategy was established as a concurrent approach very late (HLADIL et al., 1990). This study was initiated by former leaders of oil-investigations of the sixties, F. CHMELÍK & D. ĎURICA because the classical strategy was not satisfying enough, although many good geological results were processed in the previous times (long-lasting projects "Oil and gas on the southeastern slope of the Bohemian Massif" or "Uncommon areas of oil-survey in the Bohemian Massif").

Intralagoonal reefs, favoured structures of the past, possess only low porosity. Possible good porosities of the reefs belong to late fault or fissure systems only because the reef bodies consist predominantly of biocementstone. Possible vugs were well cemented in freatic water already in the times when the Devonian carbonate complex was buried under the Carboniferous siliciclastic formations. A comparable lack of important collectors is typical also for dark, thick and well bedded lagoonal sequences. These sediments consist of densely packed algal and amphiporid debris. A high amount of micrite is typical. Depositional environment corresponds to a deeper lagoon within a large carbonate shelf. These rocks were never affected by drastic early diagenetical processes (e.g. emergence, vadose water influence). It is why the resultant pattern is characterized by lack of inhomogenities accompanied by dissoluted horizons enriched in clay. Rocks of this type can be considered rather as a plugging element than a possible collector.

The configuration "low permeable reefs in low permeable surrounding" was essentially wrong and it was the best reason of the triggered DIEs detection. The above mentioned places with thinner carbonate sequences were surveyed with emphasis to wedge-shaped bodies of the moderately inclined DIE-slope interiors. These gently inclined slope parts represent a prominent location of porous, covered and plugged traps while the DIE centre or DIE distant outskirts possess only low porosities. However, this is a well known oiler concept which was developed at Southeast Asia or Northern America carbonate platforms, e.g. the Williston basin in Dakota. The concept was presented in generally understandable form by LONGMAN (1981). In Moravia, the first data relevant to the wedge-shaped porous horizons and DIE slopes have been collected by DVOŘÁK (1982) and ZUKALOVÁ et al. (1983).

Recently, a larger recession of oil-survey has been discernible in Moravia. Beside the world recession valley of the beginning nineties, the main local reasons are small dimensions of visible Moravian reservoirs as well as considerable quality diversification of their fossil fuels. Additionally, new prospective structures are considerably deeper (7–8 km) in comparison with the previous subjects of the survey. The DIEs represent one of the several promising topics, they are still under the scope of Moravian oil survey.

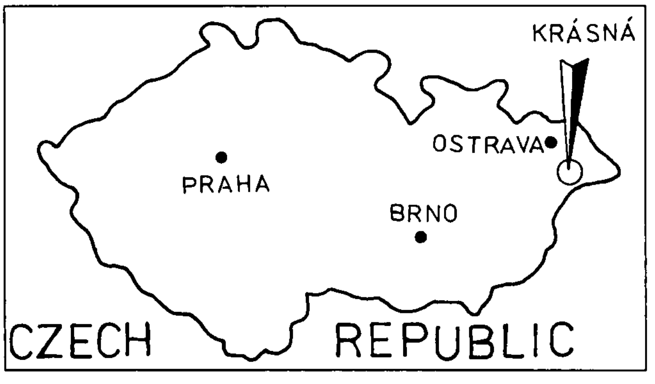
1.2. Structure of the study

1) Revision of sedimentology, lithology, biostratigraphy, completion of rock analyses, new evaluation of the previous data as well as evaluation of new samples which have been officially released from the licenced field by companies. The Czech Geological Survey was responsible for the data processing.

2) New computation of well logs as well as seismic profiles of the previous state projects. This part was financially covered again from the state budget. These case studies were carried out by Geofyzika Co. and Geostas Consult Centre, in Brno and Ostrava consequently.
3) Independent calibration of the facial, diagenetical, and well-log sequences and zones.
4) An interplay of these separately constructed sequences: an introduction of the typical Moravian DIE.

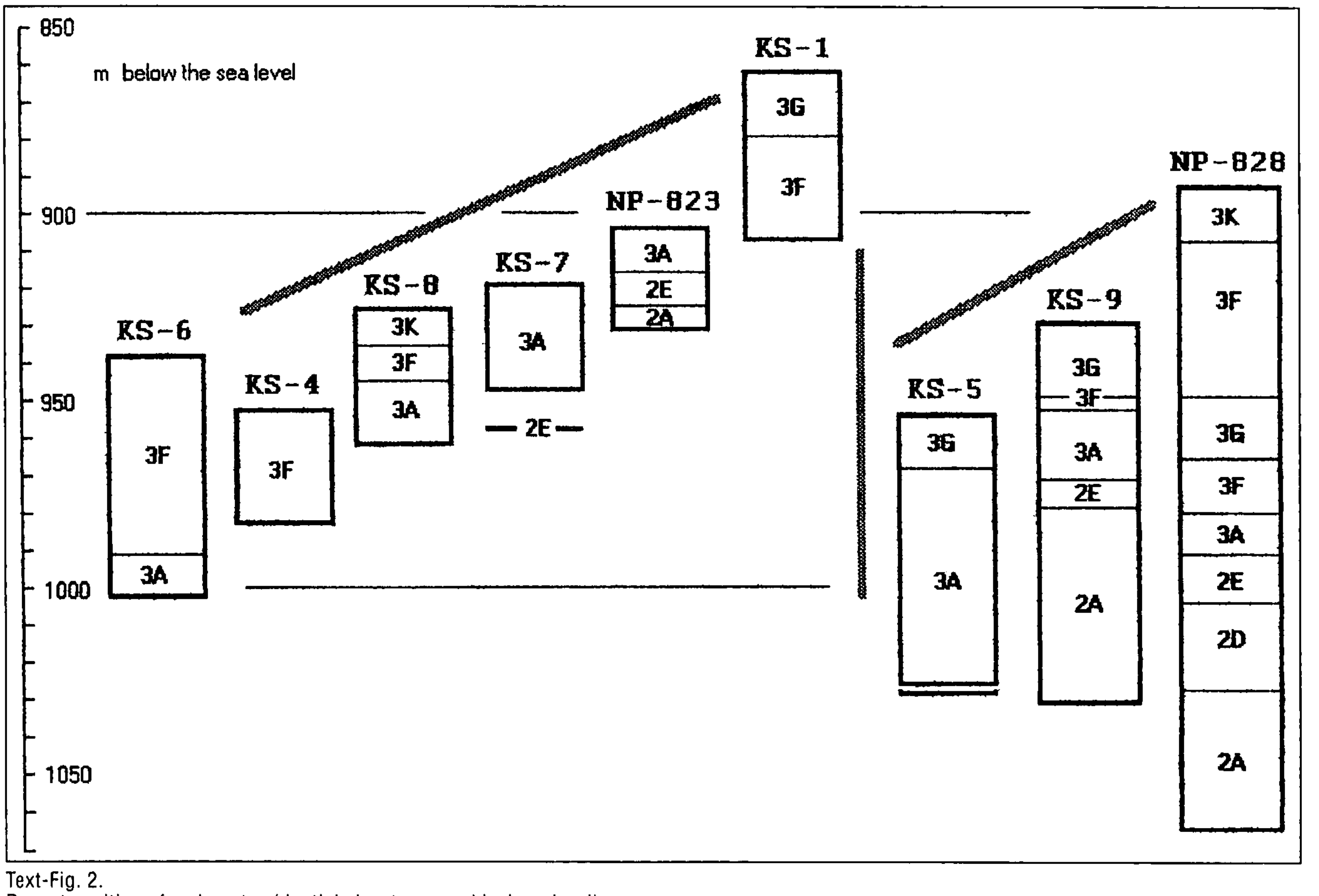
2. Location of the Investigated Structure

The subsurface DIE Krásná is below the Moravskoslezske Beskydy Mountains in the vicinity of Krásná and Moravka villages (Text-Fig. 1). Clustered boreholes documented the Krásná DIE at recent depths of 850 and 1050 m b.s.l., i.e. less than 2 km below the surface (Text-Fig. 2). The boreholes penetrated the overlying nappe stack of the Carpathian flysh (mostly Cretaceous in age). Below the flysh only small and scattered relicts of Neogene foredeep sediments were detected (the Carpathian Neogene stage). The top of the autochthonous Devonian carbonate complex is mostly in touch with the trusted units because the Carboniferous siliciclastic cover rocks were reduced in thickness during the Permian–Triassic periods (and probably also by some earlier and later erosional events, comp. silicified carbonate pebbles in Carpathian flysh). Primary and erosional thinning of the Carboniferous sequence was locally reworked but particularly pronounced by the Carpathian thrust. Nevertheless, there are some relicts of siliciclastic and/or carbonate rocks of the Lower Carboniferous age, e.g. in the NP-828 Moravka borehole. Although a diameter of the DIE was plus or minus 5 km only the character of sedimentation was influenced at least in 15 km-surrounding.



Text-Fig. 1.
Location of the study area in the Czech Republic.

2 km-wells took the facility of deep valleys because the oil field is placed in mountains. Mohelnice River and Vlasky Brook formed the straight valleys which are opened to the north having some lateral gorges on both sides. KS-5 was the drilling point of highest altitude being placed between both valleys, on the slope of Mt. Obora. The oil field has been licenced by the state to Unigeo Co. However, all the wells finished in previous years were organized and covered from the state budget. The basic frame of the data, except of some configurations in detail and analyses or field structure and general image of reservoirs, is accessible in the National Information Centre "Geofond".



Text-Fig. 2.
Recent position of carbonates (depth below topographical sea level).

Nine boreholes were selected for our study (KS-6, KS-4, KS-8, KS-7, NP-823, KS-1, KS-5, KS-9 a NP-828). These boreholes form a 4 km-long zig-zag section from the SW toward the NE. Recent roof of carbonates as well as the underlying autochthonous blocks are dissected into several parts, each of them is inclined to the SW. Interpreted fault network is mosaic but arranged in several orders. In our section, from the SW towards the NE, the roof of carbonates is elevating from KS-6 to KS-1, from 940 to 860 m b.s.l., and then again from KS-5 to NP-828, from 950 to 860 m b.s.l. (Text-Fig. 2). The recent morphology was built at the end of the Alpine movements because the thickness of the Paleozoic rocks is increasing diffusively from the centre being independent on younger fault steps.

3. Facies Sequence

Facial setting has been based on microfacial associations (e.g. A, B...) which have been additionally assigned to 4–5 Ma-cycles of the carbonate sedimentation (e.g. 1, 2...). Each of the distinguished units displays a relation to the facial type and cycle. In fact, the units represent time specific shallow water facies groups. An expanded explanation of this approach was introduced by GALLE et al. (1988) and HLADIL (1988). Although the sediments of the Moravian Devonian Platform consist of four of these cycles (sedimented since the Late Eifelian up to the Early Famennian), the carbonates of the Krásná DIE belong only to the medial two of them (Figs. 3 to 5). Especially, the sea level high-stands of the Middle/Upper Givetian and Lower Frasnian times were reflected here by carbonate sedimentation (the Givetian peaks are called 2nd or Býčí skála Cycle; the latter ones belong to the 3rd or Ochoz Cycle. Beginning from the base, the DIE possesses the following sequence of the units:

- 2A) Basal blanket of 2nd cycle. Laminated and spotted micrite with sandy, silty and clayey admixture. Bacteria stromatolites rich in iron oxides occur. Macrofaunal colonization of the sea floor is poor. First carbonate dysoxic lagoons alternated by siliciclastic deltaic plains and bars. Age: Lower/Middle Givetian.
- 2D) Amphipora ramosa-limestone of 2nd cycle. Laminated micrite and Amphipora banks alternated regularly in so-called Kasig cycles. A quiet-water environment flooded onto a huge lagoonal-ramp belt is suggested. *Calcisphaera, Girvanella* and less common coral debris occur. Time specific facies well known around the world. Age: Early Middle Givetian.
- 2E) Coarse bioclastic and lithoclastic rudstones. Stromatoporoids (*Actinostroma, Stachyodes, Stellopora*) and corals (*Caliapora battersbyi, Hexagonaria laxa*) are common. Shallow, segmented platform with patch reefs. Light grey rocks with reddish, brownish or greenish colour hues. Age: Middle/Upper Givetian.
- 3A) Basal blankets of 3rd cycle. Micrite is dominant, lithoclasts and erosional marks are common. Typical is an onset of the facies on emerged and eroded fundament of the 2nd cycle. Beach rocks, algal coatings, worm and gastropod colonizations. Overflood of carbonate shore. Dark colour of rocks in lagoons. Age: Givetian/Frasnian, plus or minus "Fromellenian" cycles of low order.
- 3F) Amphipora laxeperforata-limestone; 3rd cycle. Bioclastic grainstone contains micritized grains. Pellets and peloids are, in places, common components in these medium dark rocks. Numerous shells of *Paraturammina* and *Issinella* tube segments of thalli were dominant in foraminiferal-algal layers. Alternating beds display more irregular pattern in comparison with the older 2D-Amphipora ramosa unit. Lower Frasnian.
- 3G) Mud mounds and flat bioherms. Biocementstone, locally intercalated by coral bafflestone or framestone. Facies markers are namely *Hermatostroma, Scoliopora denticulata* and *Stachyodes lagowiensis*. Medium to light grey colour of the rocks. Age: Middle Frasnian.
- 3K) Lithoclastic rudstone; lack of coeval corals and stromatoporoids. Clastic populations consist of various rock types originated due to large variety of the preburial diagenetical stages. Cannibalization of underlying and nearshore sediments. Variegated colours. Age: predominantly Middle Frasnian.

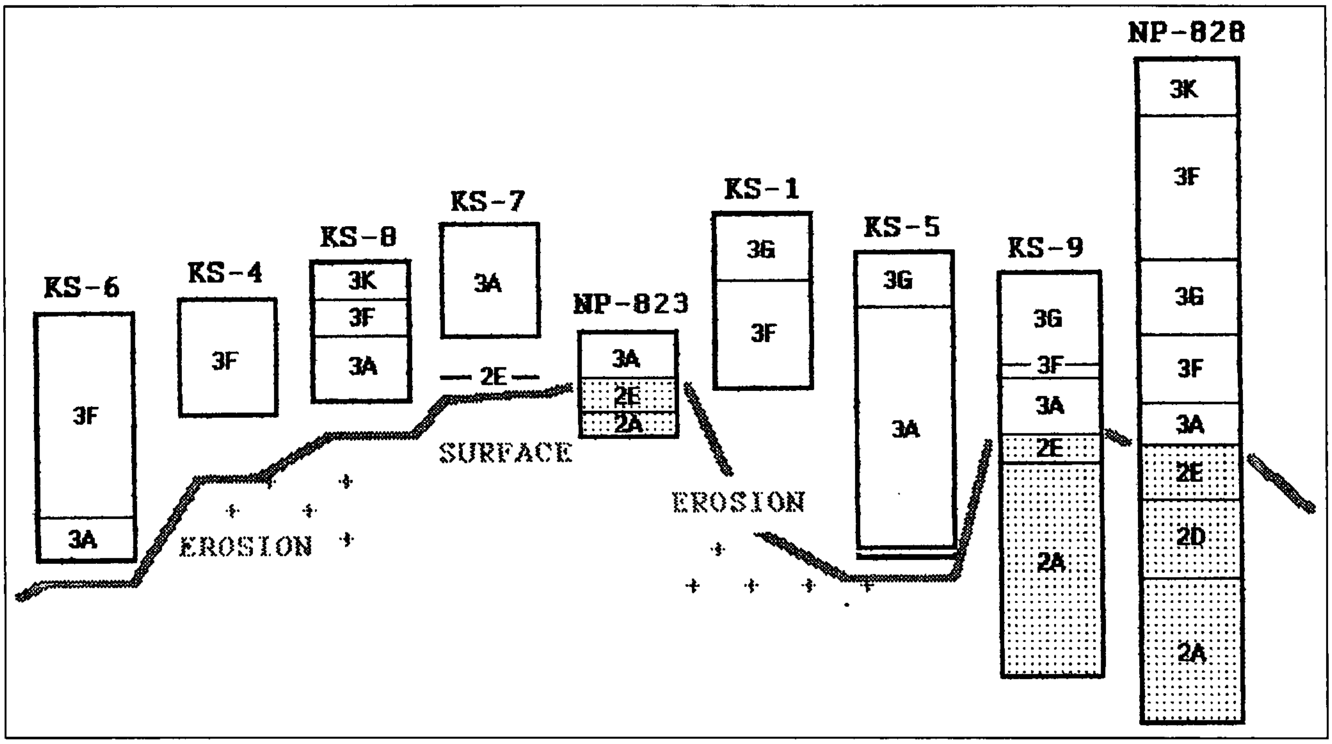
3.1. Sedimentation and Patchways of Consequent Diagenesis

The facies sequence was based on densely spaced cores as well as drilled rock fragments among the cores. The aim of the study was that the all discernible sequences had to be reconstructed on the base of their own data, i.e. the facies sequence – on the exact sedimentology and biostratigraphy, lithological sequence (i.e. the last diagenetical pattern) – on petrography, well-log sequential segmentation – on the geophysical data only. These independent evaluations helped us to understand the DIE structure in its complexity. Boreholes of the Krásná DIE offer a good opportunity for these parallel studies of sequences because the documentation of the wells is relatively very continuous, being comparable only with the exceptional pilot boreholes of Kozlovice or Janovice areas (whole cored boreholes of sixties westernly of Krásná).

From the southwest towards the centre, the boreholes documented a decreasing thickness of carbonates: KS-6 penetrated 64 m, while KS-4, 8, 7 and NP-823 evidence plus or minus 30 m of this decreasing thickness. The opposite side of the DIE displayed an inverse trend: the thickness was step by step increasing towards the NE: 45 m in KS-1, 76 m in KS-5, 104 m in KS-9 and 182 m in NP-828. Eifelian to early Givetian carbonates of 1st cycle as well as the Upper Frasnian to Lower Famennian limestones of 4th cycle are absent. They were probably never deposited in this proper part of the island elevation. On the other hand, the 2nd and 3rd cycle high stands of sea level are usually well recorded in the sediments.

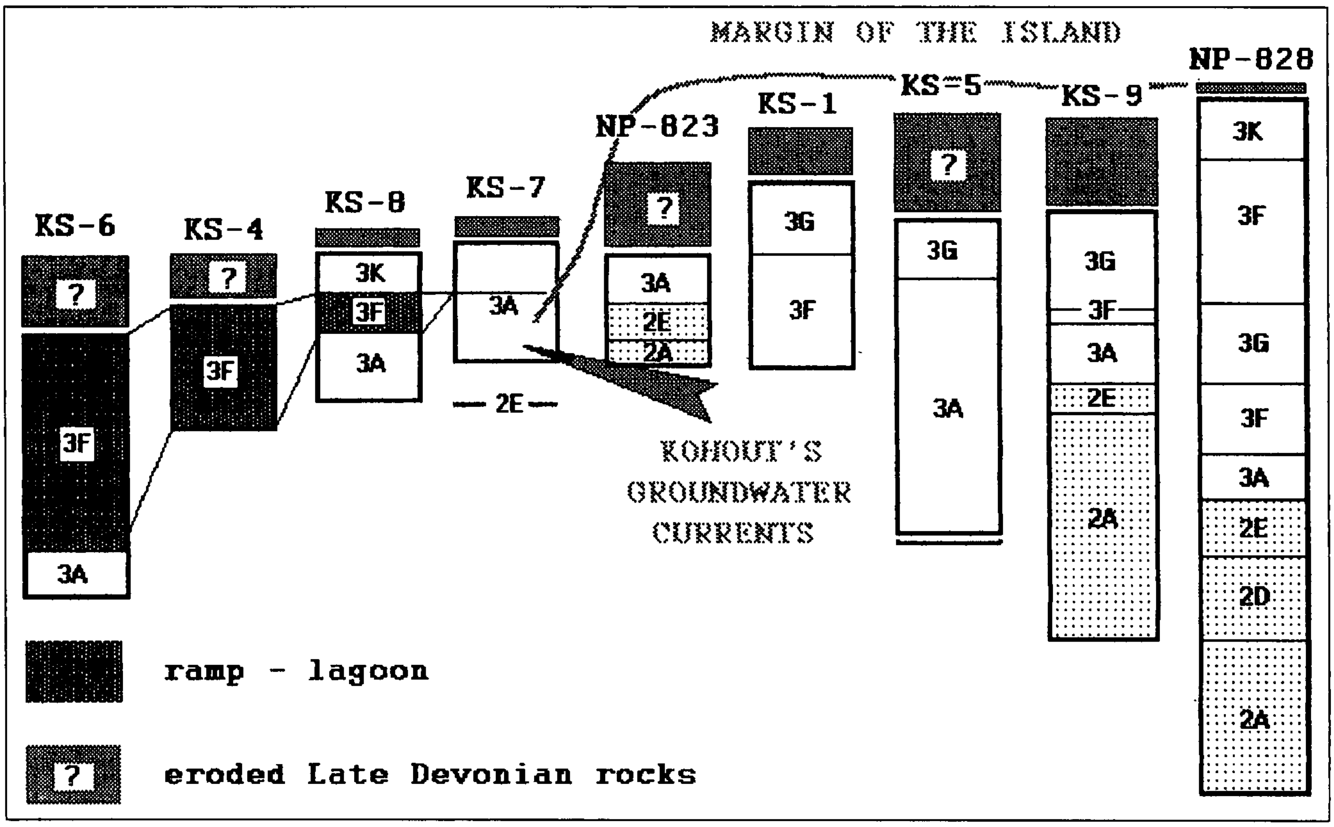
Namely the Givetian rocks of the 2nd cycle are well preserved in the northeastern wing while the soutwestern wing was partly eroded (erosional relict of 2nd cycle in NP-823). Silicified pebbles of the 2nd cycle rocks were redeposited into the siliciclastics of the base of the 3rd cycle (Text-Fig. 3). There are several evidences of the erosion between the 2nd and 3rd cycle: discordant contact of rocks, paleokarst surface, siliciclastic infills of the karst cavities. However, some of these karst cavities were opened, exhausted and filled again during the Late Devonian-Carboniferous (?Permian) karstifications: There are examples of the Famennian and Namurian rocks that were documented inside the underground chambers. Some of them were disturbed additionally by later cave sediments of indistinct age.

Frasnian sedimentation of the southwestern wing significantly differs from the sedimentation of the opposite

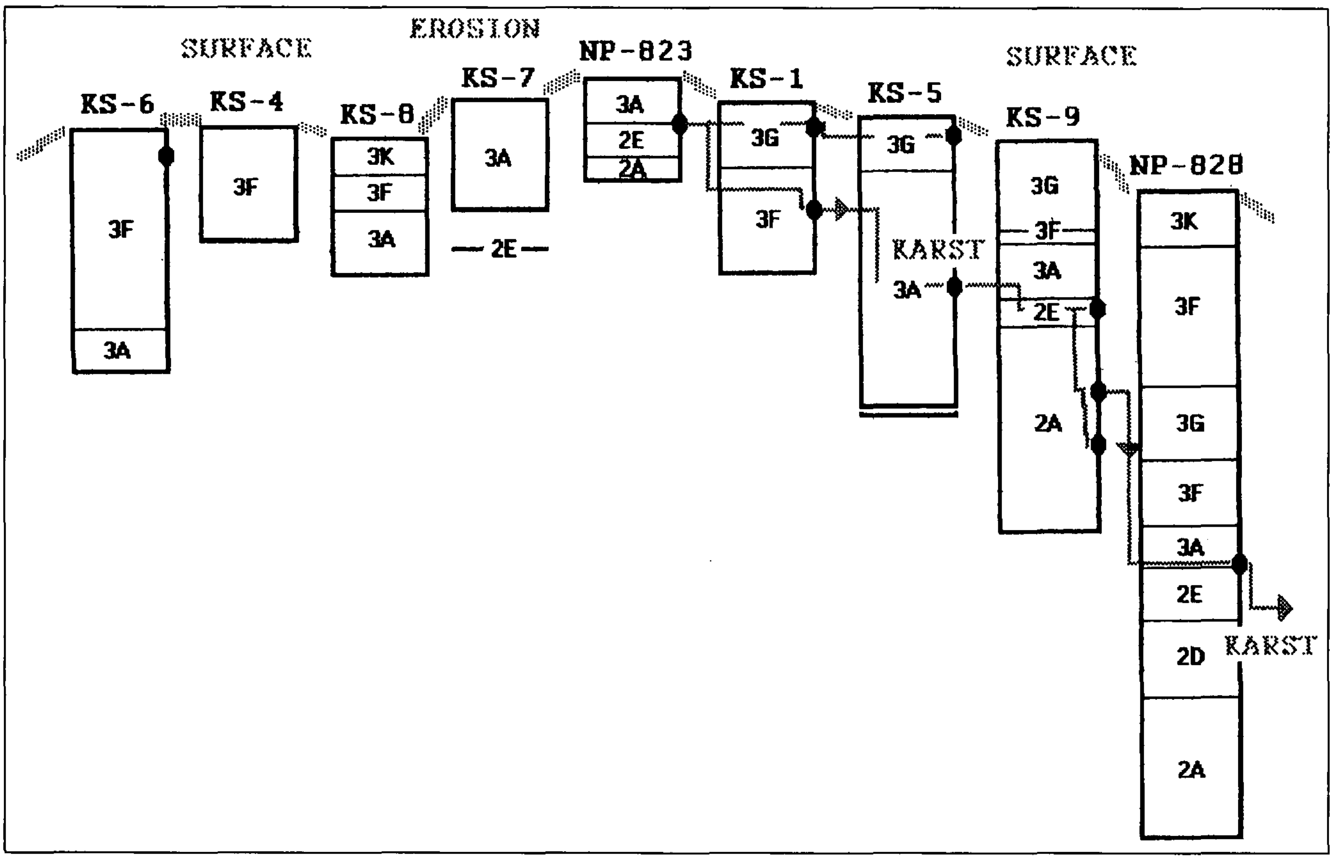


Text-Fig. 3.
Reconstructed configuration at the end of the Givetian, at the boundary between 2nd/3rd cycle.
There were no 3rd cycle sediments in this time. Surface of the islet elevation was eroded.

side. In the SW a transitional, lagoonal to moderately open-ramp environment was indicated in KS-6, 4, and partly 8. An influx of clastic material derived from cliffs of turbulent zone was accompanied by numerous resedimentation events. Nevertheless, these 3F-sediments are absent in KS-7 and NP-823, i.e. higher on the slope. What is significant, the first borehole documented a maximum porosity of the older sediments while the latter one shows a maximum diagenetical damage of primary textures which was strikingly joined to an extreme tightness



Text-Fig. 4.
Diagram of the island slope with springs of the island groundwater.
Middle Frasnian.



Text-Fig. 5.
Tentative position during Tournaisian times.
The former DIE structure was strongly emerged. Dominant drainage toward the NE (right).

(an up-slope plugging). In this part of the DIE slope, we suggest an existence of the Lower–Middle Frasnian rocky bottom (Text-Fig. 3).

The Springs of Kohout currents (groundwater of island interior) built probably the first generation of KS-7 porosity (in lower part of rocky slopes, similarly to the model redescribed by TUCKER, 1990). On the other hand, the sediments of the opposite DIE wing, in the NE, differ in several characters. Micrite is common here while the reworked material is apparently less contained. Dark Amphipora layers alternate with flat algal-stromatoporoid bioherms of light colour. The boreholes KS-9 and NP-828 found relatively complete sequences. Neither the rocky bottoms nor the Kohout currents were indicated in the NE of this DIE (Text-Fig. 4). The zone of mixed pore water was probably quietly fluctuating in the northeastern wing, having simultaneously only low gradients of the composition. These data indicate that the southwestern slopes of DIEs may provide the best textures for prospective traps (MÜLLER et al., 1991). Exploitation of the Krásná DIE seems to confirm generally this assumption.

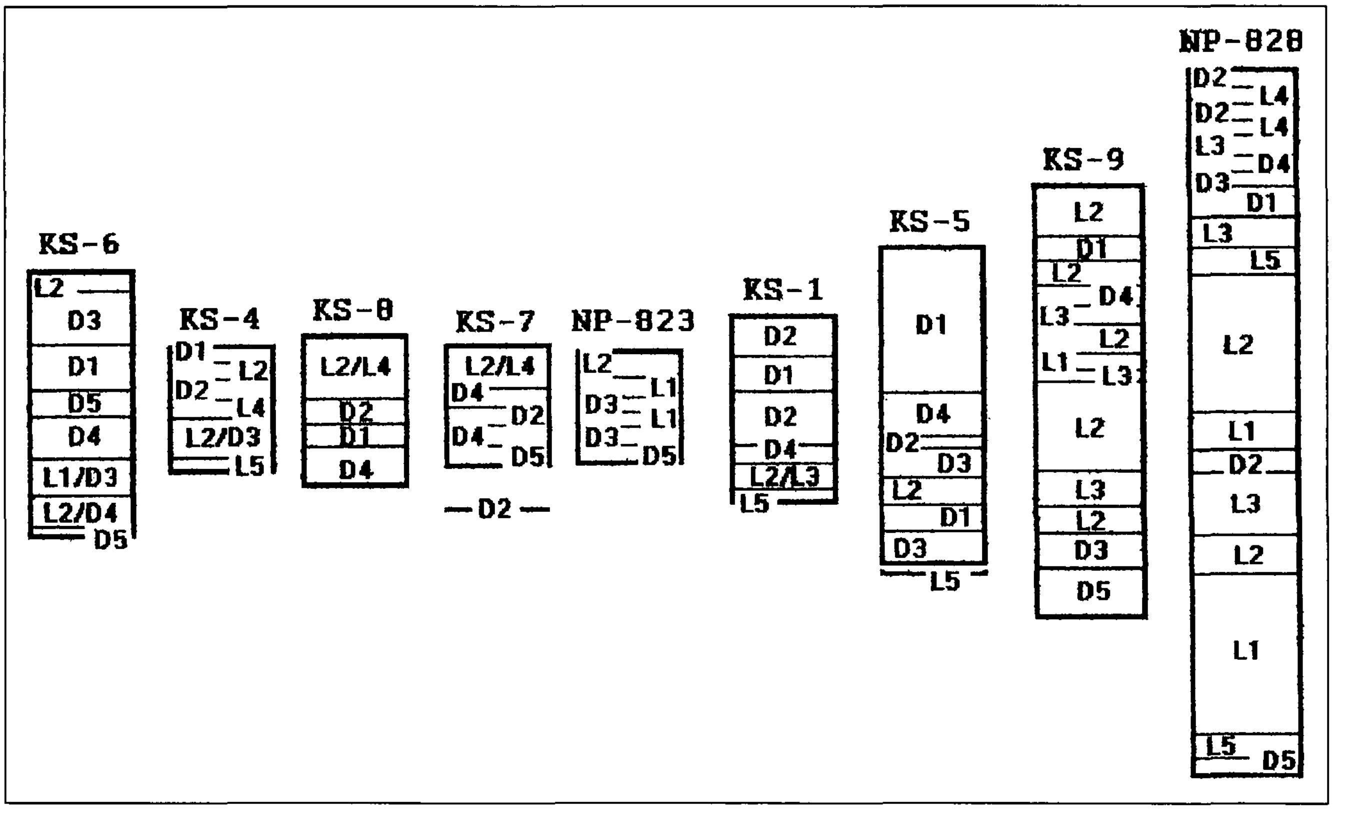
Beginning from the Late Frasnian the DIE was predominantly emerged. The DIE was overflooded only at extremely high stands of sea level which were, however, of very short duration. It may be assumed according to karst as well as neptunian-dyke infills. DIE of the Famennian times was emerged forming only a flat up to slightly domed island while the Tournaisian morphology was probably much more pronounced (an uplift, tilting and climatic sea-level fall simulatenously; Text-Fig. 5). The surface of the DIE was slightly but continuously eroded. Visible karstification continued until the Visean when the DIE was covered by siltstone and graywacke. A rising sea level of the Visean age was recorded also by Visean carbonates with *Dibunophyllum* and *Litostrotion* corals. These carbonates occur at the base of the Carboniferous rocks but they are exclusively bounded to the distant outskirts of the DIE (e.g. NP-824 Ostravice or NP-828 Morávka boreholes).

We have said that the Famennian island morphology had to be low and slightly differentiated. It is because of relative diagenetical timing which suggests an existence of subhorizontal levels of fresh groundwater. These levels were probably stabilized for some long periods because the geophysical data provided visible dissolution and cementation horizons which were situated several metres or, rarely, several first tens of metres below the DIE surface (HELEŠICOVÁ & HRUBANOVÁ, 1991; sequence units 1.1. and 1.2. in Text-Fig. 7).

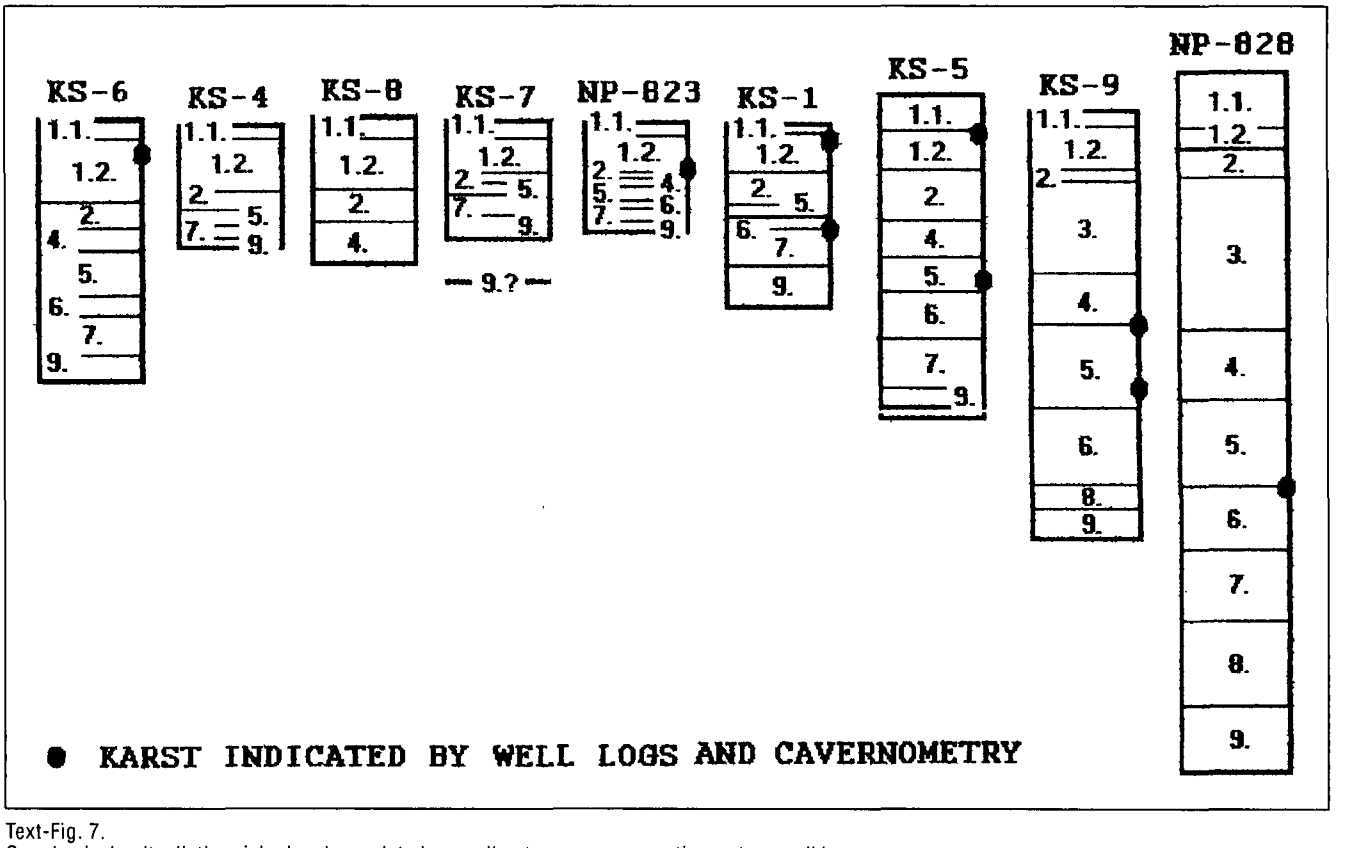
Older diagenetical structures (arranged in a dish-like shapes below the DIE) were usually strongly overprinted by these horizons. The petrogenetograms based on image-analysis seem to confirm these conclusions.

Karst cavities are large (up to 2 m in diameter) and many of them are younger in comparison with the above mentioned horizons. They can be connected in a cave system typical of the northeastern DIE side (Figs. 5 and 7). The system may indicate the above mentioned Tournaisian inclination of the whole DIE, maybe including some unidentified foreland, towards the NE. High emergence of the DIE enabled a uniform drainage of water in the same direction.

A steplike profound cave system as well as empty holes existing till the Visean/Namurian siliciclastic infiltration (KS-9) suggest a serious fall of the sea level which may be correlated especially with the Lower Tournaisian times.



Text-Fig. 6.
Lithological units.
Superimposed state of all diagenetical stages and influences.



Text-Fig. 7.
Geophysical units distinguished and correlated according to gamma-acoustic-neutron well log.
Wells are ordered at the sequence boundary 1.1./1.2.

3.2. Lithological Sequence Reflecting the Final Diagenetical Superimposition of a Variety of Processes

After reviewing the previous data, we see that the diagenetical complex of the DIE was built in a graded way. The most intensive alterations originated in Famennian and Tournaisian when the DIE was completely emerged. However, these alterations were superimposed on the older Middle Frasnian as well as Late Givetian ones (Figs. 3, 4 and 5). While the Middle Frasnian diagenetical zones of the DIE interior were mostly dish-shaped (a typical zonal shape of the low-emerged sea island interiors), the zones beginning from the Late Frasnian were inverted so that they formed a dome-shaped structure (a typical shape of the upper interiors in high elevated islands). Variegated primary composition of sediments as well as their preservation was in an interplay with the alternating quality and geometry of groundwater bodies. This interplay was more complicated when the consequent diagenetical products were involved in this process. The final result is the complicated lithological mosaic (Text-Fig. 6). The DIE provided us with more than forty rock types which can be distinguished according to the mineral composition, textures and structures. Fourteen of them are of essential importance:

- L1) Compactite. Limestone with small pressure sutures where the small clasts and micrite were dissoluted. Corrosion of quartz grains and redistribution of iron and silica is visible.
- L2) Limestones with less pronounced compaction. The size of the carbonate crystals was several times degraded. Relict structures are dispersed, the rock looks like to be under a veil. Vadose silt and some dripstone cements in vugs were detected.
- L3) Cementite. Limestone with the early cemented porosity. Tight cementation made the rock quite resistant against the diagenetical alteration.
- L4) Limestone breccia and microbreccia. Margins of carbonate clasts were dissoluted: Clasts consist prevailingly of calcite while dolomite and silicified specimens are rare. Outlines of the grains were transformed into contact sutures. Remains of the cement intercalated by micrite are composed of several generations.
- L5) Limestone with large nests of coarse crystalline dolomite. The nests rose from former mosaic sparry calcite of the cemented vugs.
- D1) Mottled dolomite. Crystals of medium size contain many inclusions. Pyrite formed aggregates or coatings on the fractures. Autobreccia reflecting the incidental volume changes.
- D2) Breccia consisting of dolomite, quartz and calcite. This is a primary breccia but increasing diagenetical inhomogenities are common. Dolomitization-dedolomitization as well as silicification-desilicification processes are complicatedly interrelated.
- D3) Fine crystalline dolomite or dolostone. Massive and uniform structure prevails although the possible calcite amount is fluctuating. Fine veins are accompanied by diffusive crystalline silicification.
- D4) Medium crystalline dolomite or dolostone. Fossilmoldic cavities were filled by coarse sparry calcite. This calcite cement is not unaffected by dolomitization. Some of the cavities were not completely filled and there remain empty spaces.
- D5) Coarse crystalline dolomites of irregular structures. Sandy and silty or eventual clay admixture. Mottled and extruded textures were observed.
- K1) Karst cavities filled by siliciclastics or clay. The marine infills dominate over the residual and fresh water sediments.
- K2) Karst cavities filled by marine or fresh water limestone.
- T1) Tectonically crushed zones deficient in calcite cementation. Infiltration of silt and clay is common.
- T2) Tectonically crushed zones sufficiently cemented by coarse crystalline calcite.

The last two types (T1 and T2) were not introduced into the DIE model because their location is probably specific. These tectonic zones are probably young; the oldest of them may be compared with the Late Paleozoic while the youngest ones with the late Tertiary. Ranges of the distinguished lithological intervals (Text-Fig. 6) were based predominantly on cores or drilled rock fragments. Intervals were assigned to the dominant rock type except of very regular alternations (e.g. L2/L4 in Text-Fig. 6). The pattern illustrated here is only a schema because many intercalations and nests can be identified in detail. However, in some places a considerable uncertainty appeared. Then we have used all the accessible indications, especially the models of sequence probability (Hladil, 1985, 1986a, b, 1988) or some similarities to DIEs of other shoals.

Although the final pattern is complicated (Text-Fig. 6), several more or less apparent characters can be traced. Extremely coarse crystalline dolomites of irregular structure occur at the base of the whole carbonate complex. At this base, siliciclastic admixture but also evaporites replaced by carbonates are common. The general pattern of the open platform where the dolomites prevail only at the base of the complex was not validated in the DIE. In the sequences of the proximal DIE outskirts the dolomites occupied only their upper parts while the middle part of the DIE slope was totally transformed to massive dolomites (dish-shape of the mixed zone). The top of the DIE possesses only thin and scattered, horizontal and oblique dolomite bodies. The uppermost carbonate parts consist usually of limestone. They are as conserved in primary calcite composition as dedolomitized when any of the former dolomite bodies occurred (e.g. KS-8, 7 or NP-823). A sedimentary alternating background of the upper 3F-facies was allowed to be interfered with the Famennian dissolution/cementation horizons (e.g. NP-828 in Text-Fig. 6).

Separated evaluations of the petrography and gamma-, neutron- and acoustic well logs show that there is an extremely low correlation between the thin-section petrography and the physical response of the rocks. How can we explain this phenomenon. It was found that rocks of different structures and compositions can be reflected in a similar way, e.g. a similar pattern of crystalline pure calcite and quartzite in gamma logs. On the other hand nearly the same rocks with some small deviations provide different physical responses, e.g. the dry dolomites in neutron logs when a negligible amount of basaltic volcanic ash was contained. Additionally, the rock-fluid-gas system as well as the quality of the borehole substantiated an interplay which provides many specifics and corrections.

When we have an overturned view, we may find that another reason for this low correspondence is properly the common lithological classification. The classification of sediments is based especially on visual features of textures and structures while the chemical features are of less importance. Nevertheless, this approach is not misguiding on the whole because the main subject of the analysis with an emphasis to oil-relevant data remains always the question of porosities.

In our opinion, all the approaches how the traps can be studied yield significant information which can be hardly refused. Only the combined approaches provided a clue how the DIE model can be solved. In complicated Moravian fields, the high resolution of the combined methods can be more effective in comparison with the seemingly saved money in core sampling because the risk of considerable information loss is evident.

4. Sequence Units Interpreted from Well Logs and Physical Anomalies

Gamma, neutron, density and acoustic well-log data were processed in all boreholes. These data were newly plotted. Characteristic superimposition of the curves was evaluated with emphasis to possible subdividing of these composed records into several typical units. Several attributes of peaks and valleys were computed. Although a complete sequence arrangement was only slightly favourized in comparative method the resultant image strikingly displayed an expressive sequence where only some members of the sequence were absent (HELEŠICOVÁ & HRUBANOVÁ, 1992). This result appears to be surprising in comparison with the different arrangement of facies and visible rock types.

Very high reliability of the correlation was confirmed in the uppermost part of the DIE carbonate complex. There were documented four compact (cemented) horizons in a few meters or few ten metres below the roof of the complex. These compact horizons are intercalated by porous (dissoluted) horizons. Correlation of these horizons was clear already in the time when the individual plots were visually compared. Unit 1.1. was characterized by lesser thickness but more pronouncedly developed horizons in comparison with the unit 1.2. (Text-Fig. 7). Nevertheless, even pure geophysical interpretation suggests some changes of rock composition within the same horizon or sequence unit. For example, the well logs suggested the following rocks along the uppermost unit 1.1.: [abbreviations: l-limestone, d-dolomite, cm-claystone/mudstone, s-siliciclastic sand, q-quartz grains, cl-clay, ()-admixture]: KS-6: l+cm(cl); KS-4: l(q); KS-8: l(q); KS-7: l(q); NP-823: l(q); KS-1: l(q+d); KS-5: l; KS-1: l(q+d); KS-5: l; KS-9: l(q); NP-828: l+cm+s(d)+cm. However, the quartz and silicate clasts (q) are weakly distinguished from authigenous populations of quartz, albite, etc.

The base of the carbonate complex is also discernible in the logs. Characteristic features correspond to a higher amount of siliciclastic grains as well as to intensive alterations above the sandstone/limestone boundary (unit 9 in Text-Fig. 7). In the geophysical well logs we may successfully trace the boundary between the 2nd and 3rd cycle because this gap joint with an emergence was strongly marked by silicification. Additionally, this prominent gap was marked by the karst cavities and their siliciclastic infills.

Correlation of the uppermost cemented/dissoluted horizons can be considered as a main achievement of the recent well log studies. These horizons represent a good argument speaking in favour of the Famennian low and flat morphology of the DIE. These expressive zones of cementation/dissolution strongly overprinted the previous diagenetical patterns. They were formed in rocks of different time of sedimentation, composition, etc. (e.g. the facial differences among KS-7: 3A; KS-1: 3G and NP-828: 3K; compare Figs. 2 and 7).

Less intensively are expressed the arch-shaped zones that are visible in well log comparison. The zones are shaped in the same manner as the reconstructed karst systems. It is why they may be assumed as a reflectance of the Tournaisian diageneses in time of them the whole DIE was strongly emerged like a hill.

Comparison of facial, diagenetical and well-log data enable the mutual confirmation of the indicated phenomena as well as the completely new view in the DIE history and arrangement. Neither the lithology nor the physical reaction of the rocks can be understood without the consideration of this interplay.

STAŠ (1992) generalized the results of electric resistance which were carried out in the boreholes. He documented that continuous smoothed maximum values occur in the interior of the carbonate cycles while the minimum ones follow the transitional sets between the cycles. This pattern is a very useful tool for detecting I and II-order cycles. Analysis of seismic records (STAŠ, 1992) confirmed the previous assumption that noise of the overlying 2 km-thickness of intensively disturbed flysh nappes is so intensive that it can be hardly filtered. Despite of this fact, some indistinct limestone bodies were detected within the DIE interior (breccia fan within the 3F-facies, top relief of the 2E-facies and larger aggregates of 3G-bioherms).

5. A Model of the Devonian Island Elevation

(Figs. 2 to 7)

1. The Devonian island elevation (DIE) was covered by carbonates at the maximum sea-level stands of the Givetian (2nd cycle). Older carbonate sediments are absent. The carbonates of the 2nd cycle were partly eroded during the Late Givetian, especially at the southwestern part of the DIE. The surface of this cycle was affected by karstification.
2. The distant southwestern wing of the DIE was covered by ramp/lagoonal sediments in the Middle Frasnian. Higher lying slope was without sediment forming a rocky bottom. At the toe of this slope Kohout current springs had to be located. This parts of the DIE were intensively changed in texture so that bound as the early as the late cavern porosity. Coeval cementation above the springs as well as a consequent cementation of the uppermost part of the complex formed an interesting wedge-shaped diagenetical trap. This feature is of high importance in the trap detection. The idea that the southwestern slopes are promising was confirmed by the KS-7 well.
3. The northeastern wing contains the thick sequences with common micrite. Probable fluctuation of groundwater zones was slow and there were only moderate gradients at their boundaries. Early diagenetical inhomogenities were insufficient in respect to possible later pore-forming attack. Both the wings indicate a dish-shaped arrangement of the diagenetical zones.
4. A significant event was represented by the emergence during the Late Devonian. The groundwater level of the

DIE interior (close below the flat DIE surface) was stabilized in several positions. Flat and very expressive cementation/dissolution horizons were formed at this time. The horizons are a few metres thick.

5 During the Tournaisian age the DIE was highly uplifted and tilted towards the NE. The new arrangement of the fresh-water diagenetical zones was dome-shaped. The cave systems followed the slopes of the elevation in subsurface. A step-like formed drainage is visible chiefly at the northeastern wing. The DIE was slightly eroded and karstificated. This period continued until the Latest Visean drowning marked by onset of the Visean siliciclastics.

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