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Gamma-ray and magnetic susceptibility correlation across a Frasnian carbonate platform and the search for "punctata" equivalents in stromatoporoid-coral limestone facies of Moravia

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A comparison of the HV-105 Křtiny γ-ray log (carbonate platform margin and proximal slope, thickness of Frasnian beds ~270 m) with the three times thinner γ-ray spectrometric section from Mokrá (inner platform, Frasnian ~93.5 m) has significantly increased the reliability of stratigraphic correlation between the outer and inner platform areas, i.e. it has allowed strengthening of the detailed links between conodont-bearing and barren sequences. The detailed γ-ray and magnetic susceptibility patterns also provide promising clues which might help trace the "~*punctata* Zone" stratigraphic equivalents, located far in the interior of the platform stromatoporoid-coral facies.

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INTRODUCTION

The moderately segmented relicts of Frasnian carbonate platforms and their proximal slope peripheries cover an area of ~15.000 km^2, along the east Moravian subcrop of Famennian, Tournaisian, or locally also late Viséan/Namurian rocks. Stromatoporoid-coral banks predominate but these are separated by a few deformed zones with slope and deep sea sediments (e.g., near to faults of the Haná Lowland or at the southern end of the Moravian Karst). This Frasnian surface has been nearly continuously detected in a large number of closely spaced wells and reflection seismic sections, over a large area from Southern Poland towards the Slovak and Austrian boundaries (Hladil, 2002). The typical thickness of Frasnian beds is ~0.25 km, but there are several palaeoelevations (e.g., in the southeastern neighbourhood of Ostrava), where this thickness decreases to only several tens of metres; by contrast, lagoonal sequences ENE of Brno (e.g., near the Švábenice-2 borehole) locally show thicknesses exceeding 0.5 km. Moravian Karst (Fig. 1) provides rare outcrops of this shallow-water complex of carbonate banks, lagoons and reefs, as all other parts were covered by Variscan nappes during Namurian and Westphalian times (NW), or Carpathian nappes, during the Miocene (SE; Fig. 1).

A previous survey of 32 natural γ-ray well logs, where the wells were scattered within a broad zone between the towns of Brno–Hodonín (SW) and Ostrava (NE), provided relatively consistent stratigraphical correlation, based on comparison of 3rd- to 5th-order fluctuations and/or successions of distinctively shaped anomalies (Hladil, 2002). However, a link with conodont biostratigraphical markers was principally based on only one intermittently cored section (Jablůnka-1 borehole, near Valašské Meziříčí; Zukalová and Friáková, 1986). A series of strong successive transgressive onlaps developed during the early to middle Frasnian (*sensu* Ziegler and Sandberg, 2001), and this strong transgression caused a rapid retreat of the platform margin toward central highs on separate platform blocks. In particular sections, this corresponds to a gently inclined (although oscillating) shape of the platform margin boundary that "climbs on to the continent". The wells in flanks of the platform blocks are, therefore, biostratigraphically marked mostly by middle to late Frasnian conodonts, whereas early Frasnian conodonts are relatively rare. Pre-Frasnian conodont-bearing deposits were found only along isolated

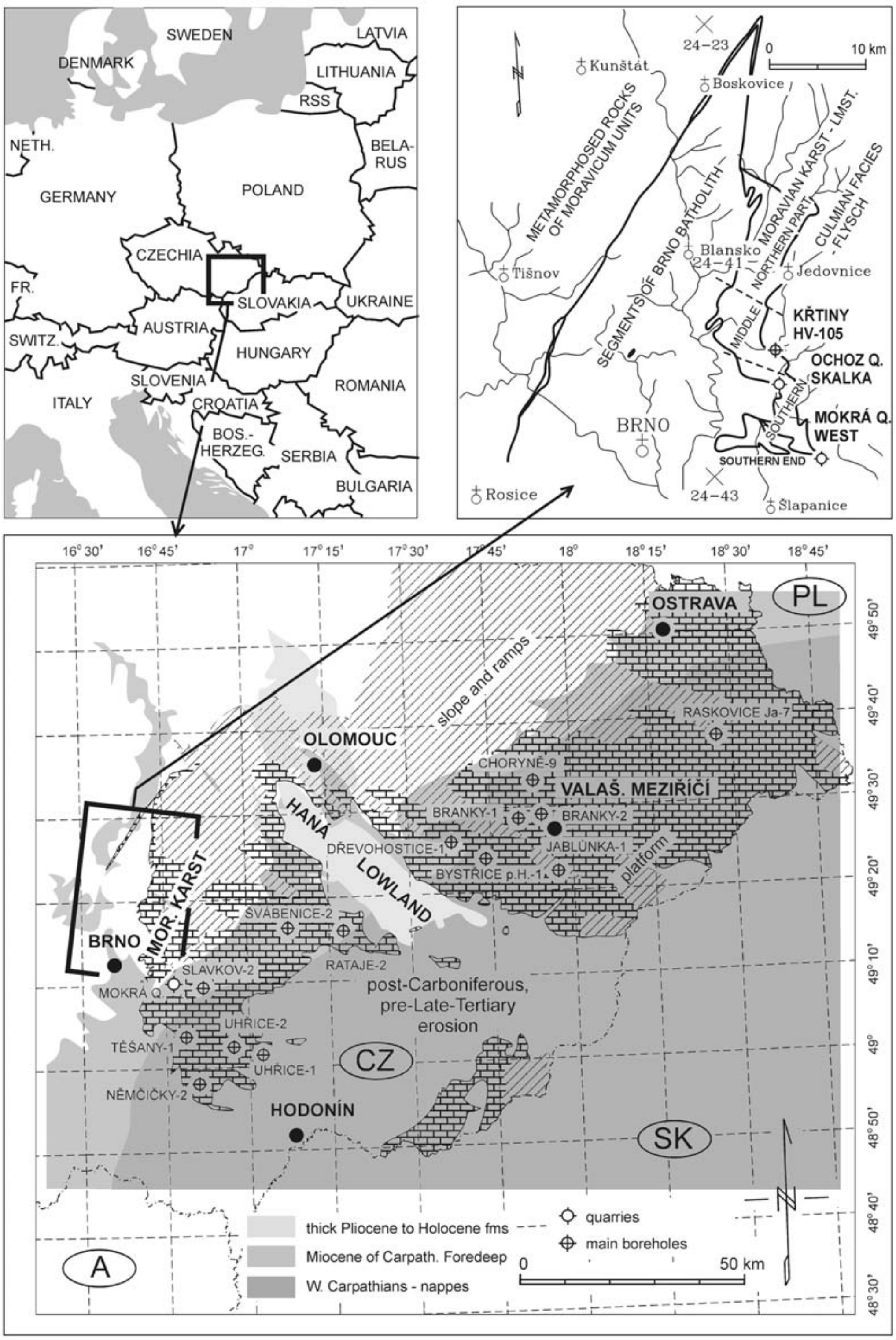

Fig. 1. Location of sections studied in Moravia, E part of the Czech Republic.

reefs in deep basins (tectonic slices stretching from Olomouc towards the northeast) but never directly on the platform reef slopes (Galle *et al.*, 1995; Hladil *et al.*, 1999).

These uncertain links with early Frasnian biozones have stimulated a search for other methods of correlation. In this context, the currently released, technically corrected and digitized natural γ-ray log from the Křtiny HV-105 borehole (E margin of the Moravian Karst) is important. In addition a recent review of data indicated insufficient or misleading formal descriptions in earliest papers and suggested the necessity for a new synthesis.

REASSESMENT OF THE HV-105 BOREHOLE PRIMARY DATA

The Křtiny HV-105 borehole was drilled by the Geotest enterprise in 1974 close to the eastern part of the Moravian Karst (in its central part, W of Křtiny village; Fig. 1). The top of the Frasnian was reached at 160 m, after drilling through a small relict of Culm flysch facies and a relatively thin Famennian–Tournaisian carbonate wedge (Dvořák *et al*., 1984; Hladíková *et al*., 1997).

FACIES AND BIOSTRATIGRAPHY

The cored section of the Křtiny borehole, particularly if combined with the reported distribution of facies along the eastern margin of the Moravian Karst (Hladil, 1983; Dvořák *et al*., 1984), has provided one of the best Moravian examples documenting large-scale onlapping of carbonate facies towards the inner parts of a reef plateau (locally to the west, Fig. 1), with only late Frasnian deposits displaying a progradationaly offlapping pattern. The borehole initially encountered the prograding late Frasnian biohermal deposits, then the mid and late early Frasnian slope deposits related to periods of the highest sea level stands and finally the early Frasnian platform (reef) margin with early Frasnian to late Givetian amphiporid lagoonal banks beneath.

The Givetian-Frasnian boundary in the borehole corresponds approximately to the final decline of *Amphipora pinguis*, and it is probably close to the base of the *falsiovalis* zones as observed on slopes of isolated reefs. This age assessment is substantiated by the conodont data from Leskovec, Horní Benešov and Ludmírov, as very roughly generalized by Galle *et al*. (1988 and 1995), and more accurately by Dzbel (in: Bábek, 2001). The listed sites are scattered along the contact of two Culmian nappes, west of the carbonate platform area depicted in Figure 1.

There is insufficiently accurate characteristization of the Givetian-Frasnian boundary by the GSSP (Global Boundary Stratotype Section and Point) (Col du Puech de la Suque) in the Montagne Noire of France (Klapper *et al*., 1987) according to the standard conodont scale, where this boundary can occur inside Early *falsiovalis* Zone (e.g., Ziegler and Sandberg, 1990; Rzhonsnitskaya, 2001). Therefore, we have used a simplified approach to this GSSP, assuming that it corresponds to the boundary between the *disparilis* and *falsiovalis* zones. A similar approximation was also used by Kaufmann (2003). The late Givetian, here, embraces the beds deposited since the end-late *Polygnathus varcus* sea level drop, more or less corresponding to the first strong decline of *Caliapora battersbyi*, until its extinction close to the Givetian–Frasnian boundary. The early Frasnian, accordingly, embraces the time equivalents of the ~*falsiovalis* and ~*transitans* Zones.

The most typical reef-margin facies with stromatoporoid-coral reef builders, high-energy rubble, and multi-generation cracks, cavities and fills were found between 330–340 m. The facies found immediately beneath (to ~370 m) are different and correspond to back-reef rubble and sediments which usually originate on sand ridges, bioherms or in moats behind the reef-margin. The content of lime mud gradually increased and conodonts disappeared with the transition from the backreef stachyodid to the amphiporid facies.

The lowest significant conodont samples at 325–334 m were reinterpreted by J. Zusková (in Hladíková *et al*., 1997) as indicating the *transitans* Zone. This material, which contains common late forms of *Ancyrodella rotundiloba*, *A. alata* with uncommon and fragmentarily preserved *Angulodus, Polygnathus* and *Palmatolepis* elements, may in reality correspond to this time determination. However, Friáková in Dvořák *et al*. (1984) emphasized the dominance of *A. alata* much higher in this section, at ~224 m, together with the disappearance of *A. rotundiloba* at ~253 m. This is not in agreement with the possible first entries of *A. gigas* at ~285 m (single specimens), their gradually increased abundance to ~210 m and their disappearance rapidly after this (Friáková, *op. cit*.). The entry of *A. gigas* significantly below 200 m likely indicates *punctata* Zone (the first appearance of *A. gigas* provides the commonly used proxy for determining the base of the *punctata* Zone, corresponding more or less to the "Montagne Noire Zone 5", or "Middlesex sea level rise", *cf.* Klapper, 1997; Over *et al*., 2003). The basic problem of the Friáková concept was in probably underrating the significance of the first *A. gigas* entries and, in addition, attributing this taxon entirely to the "upper *asymmetricus* Zone". (~ *hassi–jamiae*). In addition, J. Zusková (in Hladíková *et al*., 1997), in our view erroneously, further deduced that the *punctata* Zone was not present in the section (the *punctata* Zone was not involved in the zonal scheme of Hladíková *et al*., 1997, p. 4).

If the condensed deposits at ~300 m (Dvořák *et al*., 1984) possessed the characteristics of sedimentary starvation during a large sea level rise, such an idea about the thin to missing record of the *punctata* Zone might be possible. But the Al_2O_3/Na_2O values are within the boundary interval of immature and mature compositions, and the rocks contain also small lithoclasts of weathered sedimentary as well as crystalline rocks. In addition, the directly overlying deposits (the sequence fines and thins upwards) contain also many fore-reef breccia layers at their base (Dvořák *et al*., 1984). The change of lithology, as described above, corresponds more likely to partial sea level drop and subsequent sea level rise, and there is no serious physical or geochemical reason for the absence of the ~*P. punctata* deposits from these proximal forereef conditions.

The critical review of primary data and interpretations in both previous papers led to the approximate assignment of a ~*P. transitans* "age" to depths several tens of metres below the borehole depth of 300 m, and a ~ *punctata* "age" several tens of metres above this level (Fig. 2).

PATTERNS IN NATURAL γ-RAY WELL LOG (NGR)

The original analog graph of downhole NGR (Natural gamma-ray activity) (J. Dolák, Geotest, November 1974) was found in the Geofond state archive and was on loan for our purposes in 2003. The measurements on the trajectory of 500 m were made using the RARK-type probe calibrated with a 42μR initial dose by ^{60}Co in cobalt nitrate, with a speed of 400 m/hr. The records were scaled in μR/hr (= 7.166×10^{-5} C kg^{-1} s^{-1}). The

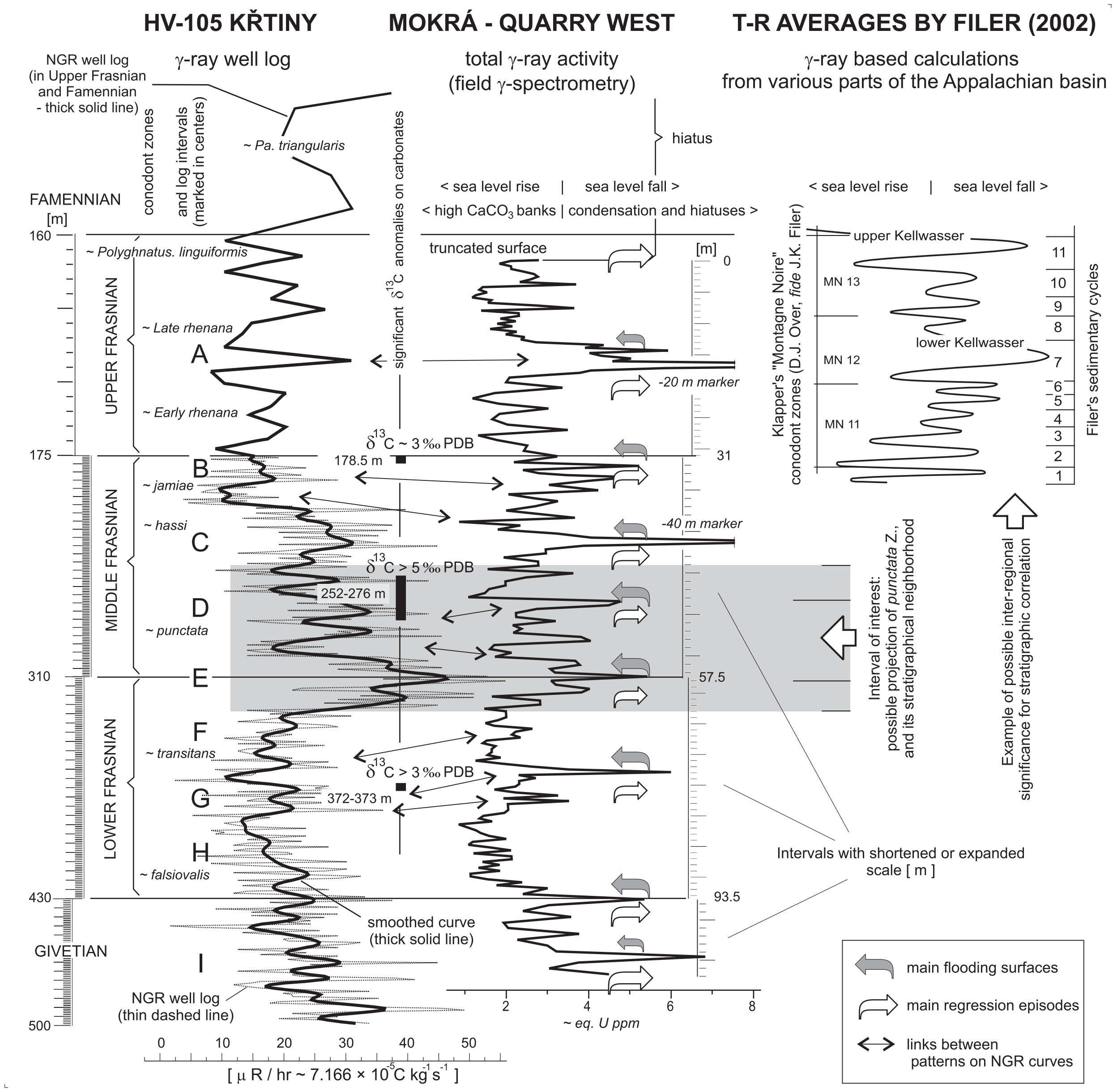

Fig. 2. Comparison of the Křtiny HV-105 borehole and Mokrá — quarry west; natural γ-ray records

Note the great similarity of the patterns developed on the curve from the reef-margin and the forereef zone (left) with those representing very shallow environments (right), and note the same for the similarity between the upper Frasnian γ-ray records from Moravia (Czech Republic) and the γ-based T-R averages published from the Appalachian Basin (upper right); note the variable vertical scale of the sections compared

log was digitized with 1 m resolution avoiding possible bias from technique, caverns or fluids (contracted work, checked against 5 parallel well-logging methods, A. Těžký, Brno Well-Logging Team) and the data were qualified for definition of the main patterns or conspicuous valleys and peaks on the curves (only some parts display reliable NGR information with 0.15 m resolution). The well log interpretation methods provide various subdivisions, but nine depth intervals provide the most varied characteristics (Fig. 3A–I).

The interval A was defined using the entire combination of well log methods, together with lithological and biostratigraphical data. This part reflects condensed sedimentation (15 m only) but represents the nearly complete late Frasnian succession (equivalents of Early *rhenana* to ~ *linguiformis* zones). The condensed sedimentation was caused mainly by a general decrease in reef production, the platform margin prograding towards the basin due to decreased accommodation space, this being accompanied by a development of shorter and more inclined foreslope clinoforms (for analogies with examples in other regions of the world see Chen *et al*., 2002). Although there is no special NGR-based reason to separate this interval from the underlying ~*jamiae* patterns, it was here distinguished

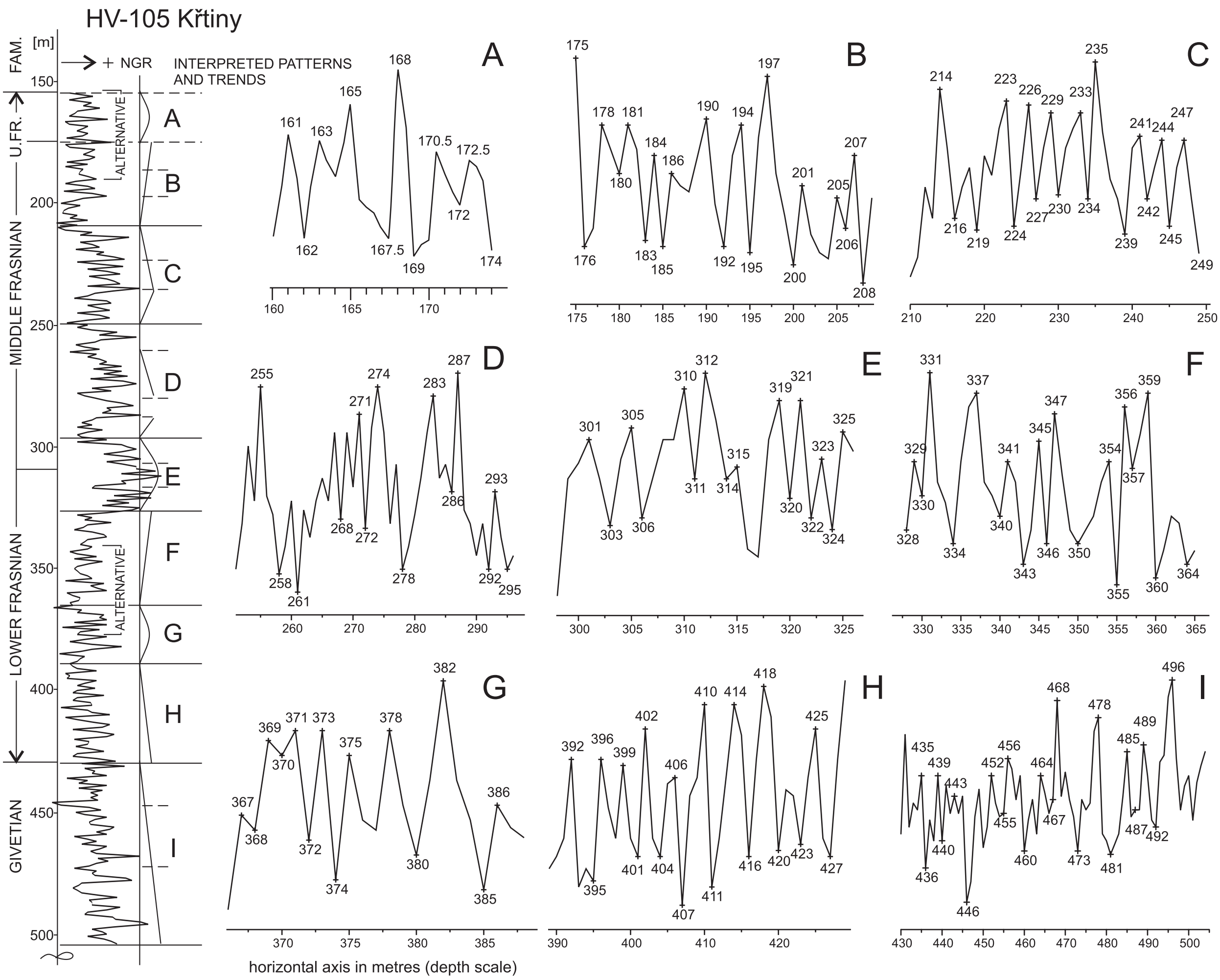

Fig. 3. Discerned NGR log intervals, HV-105 Křtiny borehole

for the purpose of a direct comparison with the Appalachian record (W. Virginia, Ohio, to New York) γ-ray based T-R averages (Filer, 2002; *cf.* Figs. 2 and 3). A great similarity to Filer's curve suggests that:

— the drilled carbonate-platform peripheries have good inter-regional correlation potential;

— increased NGR values mark the HV-105 lowstand sediments both in backreef and proximal forereef conditions. However, the correlation with the Appalachian data cannot be overestimated, because other proxies of eustatic fluctuation from that area displaying mixed sources of sedimentary material (a strong riverine influx) correlate less well with Filer's curve (e.g., Ti/Al ratio vs. TOC, or lithofacies-based sea level curve estimates — Sageman *et al.*, 2003).

The underlying interval B consists of a possible record of the ~late *hassi* transgression (Fig. 3B, right fifth of this diagram) and ~*jamiae* oscillations (left). The highstand (lower) and lowstand (upper) intervals are sharply separated, but each of them seems to be uniformly developed. The upper interval shows a slightly developed transgressive pattern of smoothed NGR curves (Fig. 2) with secondary irregular oscillations.

Interval C, corresponding probably to the *hassi* zones, is characteristic. The mean NGR values are higher in comparison with interval B, and oscillations have high amplitudes with moderately increased frequency. Three sub-intervals of equal thickness (Fig. 3C) can be tentatively distinguished. This interval forms a generally consistent pattern (Fig. 2).

Completely different NGR fluctuations characterize interval D, which is likely correlative with the *punctata* Zone. The complex fluctuations can originate from three or more superimposed cyclicities (with very different magnitudes and frequencies), but were most likely influenced also by undefined disturbances (Fig. 3D).

Another very distinct pattern was defined as the interval E. It can also be subdivided into three sub-intervals, as in interval C above, but massive peaks and broad valleys characterize mainly the 2nd and 3rd sub-intervals on the curve (Fig. 3E, center and left, respectively).

The interval F, corresponding closely to the *transitans* Zone, has a complicated modulation, but the basic trend line indicates nearly linear and continuously decreasing values down the section. Using a model sedimentological approach, the upward increasing NGR signal can correspond to regressional or aggradational trends. However, the sedimentological observations rather point to the opposite concept, because the overall rapid shift of reef margin towards the internal parts of the platform is strong evidence of transgression.

An elevated consistent pattern (node) occurs in the lower part of the approximately distinguished *transitans* Zone. It forms the interval G, which was delimited by visible valleys on its upper and lower boundaries (Figs. 2 and 3). This node separates the inverted long term trend lines of adjacent intervals (Fig. 2).

The earliest Frasnian interval H (Fig. 3H) is characterized by pronounced and apparently regular oscillation, and it shows an overall increasing trend down the section.

The underlying interval I (430 m and below) can be easily distinguished by its multi-component, rapidly evolving up to irregularly developed fluctuations of NGR values. The upper parts of this interval (Fig. 3I, left) display small-amplitude but high-frequency characteristics which are rather chaotic in pattern. The development of the curve downwards (Fig. 3I, right) shows an overall increasing trend but with broader fluctuations having higher amplitudes. This interval likely belongs to the late Givetian, although the direct biostratigraphical information is vague, being based mainly on the dominance of *Amphipora angusta* and the presence of *A. pinguis* (from the *A. ramosa* lineage). The co-occurrence of "Frasnian" stromatoporoids (Zukalová in Dvořák *et al*., 1984) is very problematic and can be mostly explained by various concepts of the Givetian-Frasnian boundary in the 1960–1970's (e.g., Zukalová, 1971, 1980; Hladil, 1980 — thin-sections of stromatoporid fauna from HV-105 and other boreholes are available for study in the Museum of the Geological Survey, Prague). According to these past concepts, the Givetian-Frasnian boundary was kept close above the "Zukalová, 1980 Division II", i.e., within the equivalents of the lower part of the *hermanni–cristatus* zones.

CORRECT JUXTAPOSITION OF THE $\delta^{13}C$ ANOMALIES WITH THE LOG

Unusually high positive $\delta^{13}C$ anomalies were reported from HV-105 borehole depths of 178.5, 252–276 and 372–373 m (Hladíková *et al*., 1997). A particularly strong anomaly consists of positive excursions at 252–276 m (in the upper part of the well-log interval D; ~25 m thickness; $\delta^{13}C > +5$ per mil PDB). However, this anomaly cannot be correlated with the ~*transitans* Zone as argued by Hladíková *et al*. (1997). The present correlation (see above) suggests that its position is most probably within the ~*punctata* Zone, and rather in its middle-upper than its lower part (Fig. 2). Two other positive excursions of $\delta^{13}C$ (~ +3 per mil PDB) are relatively small and stratigraphically well separated. They occur in the upper parts of the G and B intervals, probably equivalent to the ~*transitans* and end-*jamiae* levels (Figs. 2 and 3).

CORRELATION OF HV-105 AND MOKRÁ

The Frasnian facies of Mokrá quarry are mostly shallow-water limestones with quasi-cyclically arranged beds, where stromatoporoids are the most common faunal components. Calcarenitic tempestites have approximately the same proportion as the carbonate-mud supported floatstone and bafflestone deposits. Horizontally laminated units comprise about one-third of the total rock volume and grains on the surfaces of their laminae were fixed by calcified microbial and algal mats of various thickness (0.1–50 mm). Original colonization surfaces were settled by stromatoporoids, corals and other organisms and were occasionally documented during the early stages of quarrying (Čejchan and Hladil, 1996). Inclined and herringbone bedding structures are rare. In the lower and middle part of the section there are also "loferite" fenestral limestones, usually capped by megalodont (uncommon but visible) subtidal facies.

The Mokrá section "quarry west" was characterized using combined γ-ray spectrometric and magnetic susceptibility methods (Hladil, 2002). Albeit in reduced form (total Frasnian thickness ~100 m only), the Mokrá logs roughly correspond to the thick platform sections in Slavkov-2 and many other boreholes over the vast eastern region (Fig. 1). Despite the fact that tens of geophysical, lithological and biostratigraphical links to these boreholes were analysed in comparison with the lower, middle and upper Frasnian boundaries of Mokrá (Hladil, 2002), the whole-log correlations of shallow-water carbonates are always biased by many factors such as hiatuses, weathering and early diagenesis of the rocks, or a lack of short-range biostratigraphical markers. The proposed correlation test using the HV-105 well log was, therefore, awaited with great interest, promising confirmation or falsification of the present stratigraphy of the Frasnian stromatoporoid-coral banks in Moravia.

However, the test provided extremely positive results. The juxtaposed logs with adequately adjusted thicknesses of the Frasnian substages (Fig. 2) display a significant match in many NGR diagnostic patterns and their successions. Practically all NGR intervals discerned in the HV-105 well log (A to I, this paper, above) have their equivalents in the curve based on the Mokrá measurements (Hladil, 2002). The small differences in vertical location of comparable patterns and peaks are caused by proportional stretching within each of these three parts of the Frasnian subdivision.

The interval A has the same structure in HV-105 Křtiny, Mokrá and to a large degree corresponds to Appalachian T-R averages (Filer, 2002). This correlation has a partial implication for the projection of the lower Kellwasser level (LKW; see summary of Devonian global events by House, 2002) into the Mokrá section. If the LKW level is compared with the flooding event of Filer's cycle 7, then its appropriate position must be adjusted with marks ~ –15–17 m rather than ~ –5 m at Mokrá. A subordinate faunal event accompanied by hardgrounds, coral sheets and flooding (mentioned at the Mokrá –4 to –5 m marks; Čejchan and Hladil, 1996; Hladil, 2002) may not necessarily be an equivalent of the LKW but perhaps another disturbance between the LKW and UKW (lower and upper Kellwasser events).

The possible ~late *hassi* sea level rise and ~*jamiae* lowstand with many oscillations (interval B) were similarly recorded in HV-105 and Mokrá, the equivalent intervals being thicker in the latter section. However, there is a problem with the accuracy of the conodont zonation and it is difficult to place the relevant flooding episode (HV-105 — 208 m; Mokrá — –38 m) within the *hassi* zones, so that it is not confused with ~earliest *hassi* "lower Rhinestreet transgression pulse" *sensu*

Becker and House (1998). The details of interval C (Fig. 2), clearly seen in HV-105, are reduced in the relevant levels of Mokrá section, where subtidal skeletal wackestone/packstone, tidal laminites and palaeosols compose the lithologic marker "–40 m". This level is associated with stratigraphic condensation and the development of a prominent gap due to subaerial exposure. Increased NGR values with characteristic successions of fluctuations are, however, placed in comparable positions. The range of possible biostratigraphic estimates comprises the late ~*punctata* to ~earliest *hassi* times.

The valleys in the upper part of interval plot D in HV-105 (Figs. 2 and 3) correspond to an extraordinary sharp decrease of NGR values at Mokrá. This level (HV-105 — 261 m; Mokrá — –47 m) lies somewhere in the middle or middle-upper parts of the ~*punctata* Zone equivalents and is also connected with the strongest δ^{13}C anomalies in the Křtiny forereef slope deposits.

There are also similarities in the complicated lower part of interval D, and a massive node with high NGR values lies underneath. Interval E probably involves also the early/middle Frasnian boundary, with emergence of Mokrá carbonate shoals leading to the development of a stratigraphical gap. The tripartite composition of interval E, particularly at Mokrá, implies possible diagenetic control (Fig. 2; –57.5 m). The early Frasnian part is recorded comparably in both the logs, where a wide notch composed of reversely shaped intervals F and H is separated by a node of interval G. Visible valleys above this node are developed in both curves, and there is also a small δ^{13}C excursion found in the HV-105 section (Fig. 2).

CLUES FOR TRACING OF "PUNCTATA" EQUIVALENTS

The investigation of γ-ray spectrometric (GSR), NGR and magnetic susceptibility profiles of the Frasnian, and particularly the above-described "test" of the degree of correctness of these combined methods of stratigraphy, provide a reasonable chance to develop tools for identification of the ~*punctata*-related stratigraphical intervals in shallow-water carbonate facies lacking conodonts.

The active Skalka quarry located N of Ochoz village (currently being extended and deepened) is developed in rocks representing a moderately thick lagoonal sequence of Givetian/Frasnian to middle Frasnian banks, which consist of dark and medium gray bands. They comprise five "dark" bands

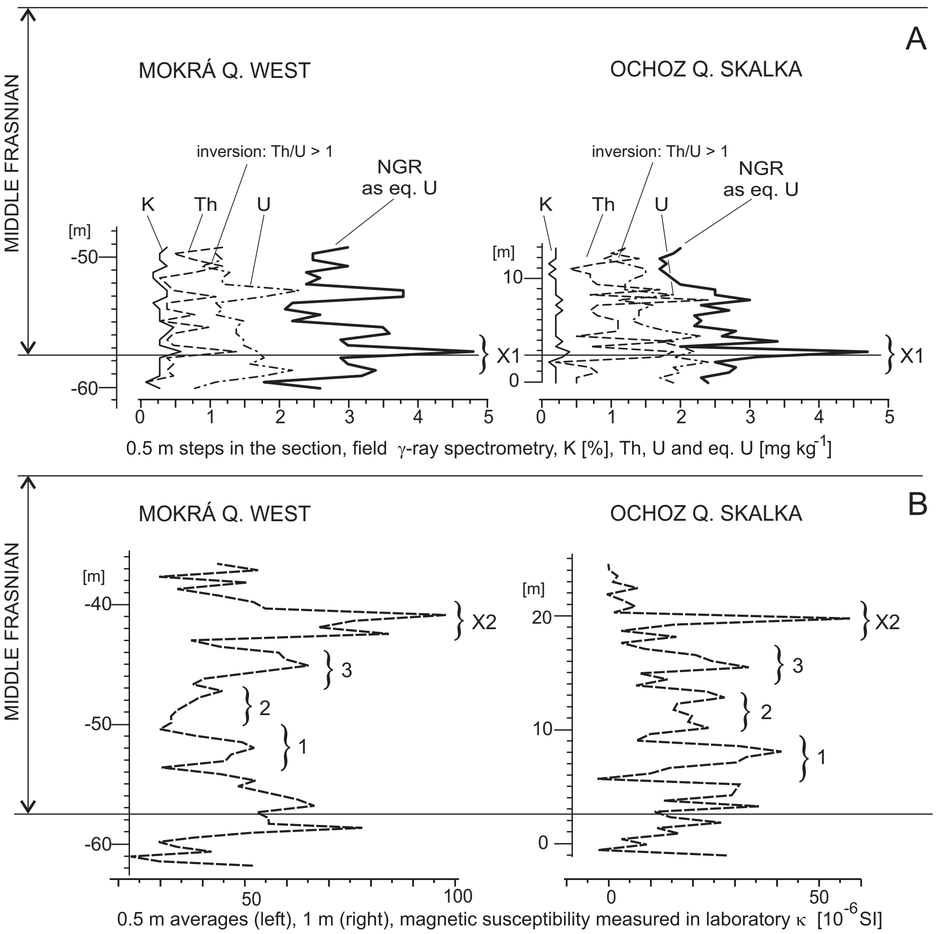

Fig. 4. Diagnostic patterns for search of ~*punctata* stratigraphic equivalents in coral-stromatoporoid limestones of carbonate platforms

A — γ-ray spectrometry; B — magnetic susceptibility; X1 — γ-ray datum horizon for the lower/middle Frasnian boundary; X2 — magnetic susceptibility key level for the ?end-*punctata* level; 1, 2 and 3 — characteristic peaks; K— potassium, Th — thorium, U — uranium

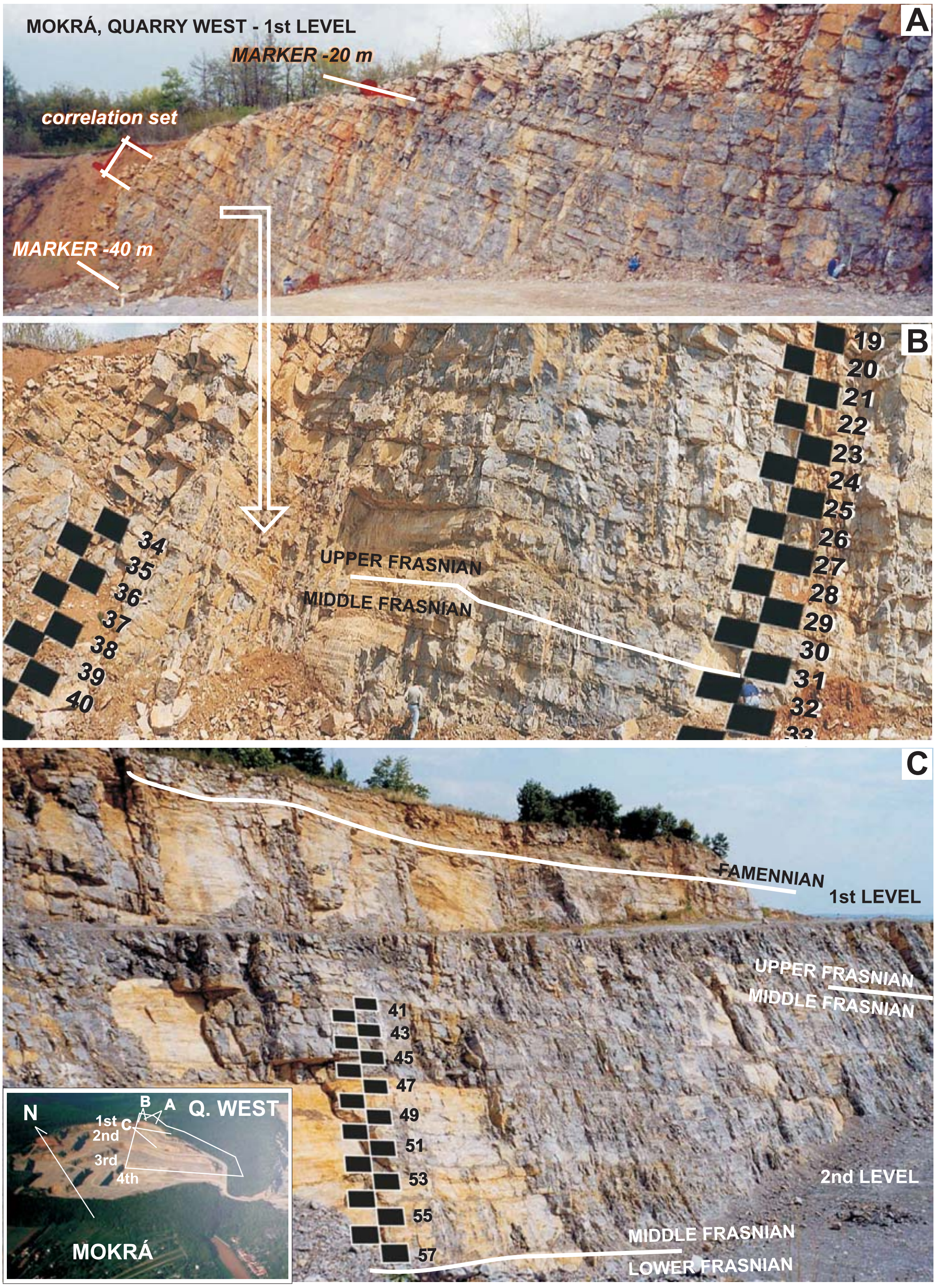

Fig. 5. The eastern upper part of Mokrá — quarry west (field situation)

The relationships between metre marks (and stratigraphic boundaries) and general appearance of the quarried beds represent additional information to diagrams in Figures 2 and 4; the views A to C are indicated in the small aerial photograph (lower left)

within the "Zukalová, 1980 Division III", spanning approximately the end-*varcus* to end-*jamiae* equivalents. The GSR-based pilot profiles found the boundary pattern relatively easily. Above the tripartite boundary pattern, where the highest U contents are in the lower, and the highest Th levels in the middle segment; the mean GSR values tend to show decreased U contents but increased concentrations of Th. The details of peaks developed stratigraphically upwards are also significant but the most important signal is the occurrence of small local inversions, where the contents of U are lower than those of Th (an abnormal and relatively rare situation in Moravian Karst limestone facies — Figure 4A). The γ-ray marker at the early/middle Frasnian

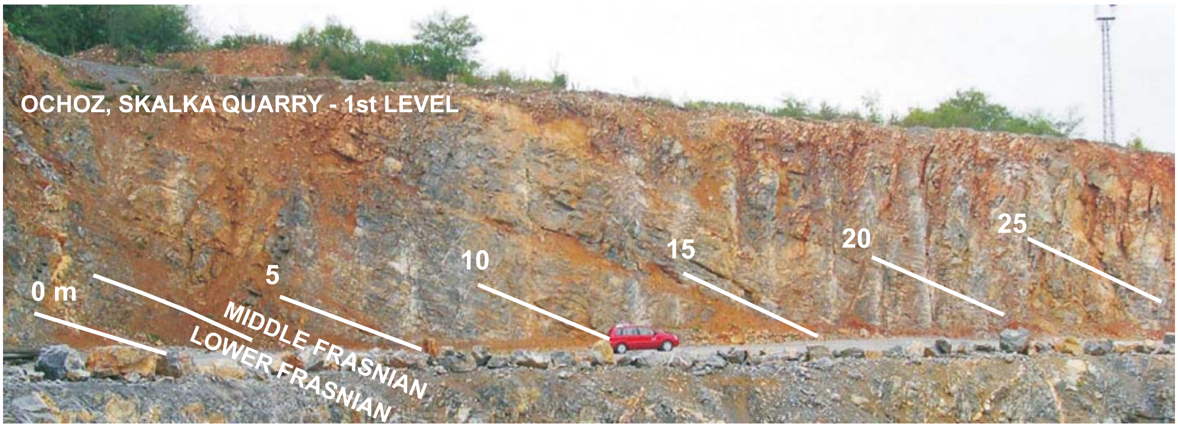

Fig. 6. The northwestern upper part of Ochoz Skalka quarry (field situation)

Middle Frasnian outcrops on the 1st level of the quarry (to be compared with diagrams in Figure 4)

boundary is of primary importance and serves as an indicator of the base of ~*punctata* related intervals (marked as X1).

The magnetic susceptibility profiles serve as another method to improve the correlation results, and certainly are not less significant. Three characteristically-shaped patterns defined on peaks are present between the γ-tag X1 and ?end-*punctata* regressional marker "–40 m". The magnetic susceptibility manifestation of this lithological marker "–40 m" was marked as "X2", and the specific peak patterns in-between them as 1, 2 and 3 (Fig. 4B).

The development of these correlation tools was made with the aim of preparing a framework for "punctata Event" studies in Moravia, but it is possible that these results can be used for carbonate platform stratigraphy worldwide, because comparable major $\delta^{13}C$ shifts are recognized in the Ardennes and the Holy Cross Mts., as well as in China (Yans *et al.,* in press). This hypothesis is substantiated by the fact that much of the γ-ray or magnetic susceptibility information from the relatively pure carbonate sequences correspond principally to trapped atmospheric deposits of the past and these have considerable correlation potential.

Current reviews of the deposition of eolian dust and mineral aerosols (e.g., Duce and Tindale, 1991; Tegen and Fung, 1995; Mahowald *et al*., 1999; Harrison *et al*., 2001) show, that areas with carbonate production have significant contents of such widely dispersed airborne material. The long-term averages of such background deposition fluctuates from $1.5\ 10^{-10}$ to $1.5\ 10^{-9}$ kg $m^{-2}\ s^{-1}$. The small grains of terrestrial dust circulate typically in the lower troposphere, but also at higher levels (grains of dimensions up to 25 μm were also sampled in the stratosphere; Lee *et al*., 2003; Allen, 2004). The relevant flux of particles from the atmosphere is, if recalculated, ~ 5–50 tons per square metre and million of years, and it corresponds, if calculated for 20 m/Ma accumulation rate of pure carbonate, to a maximum hypothetical proportion in carbonate, of ~ 10–50 wt.%. However, this amount is commonly reduced (washed out or dissolved) by as much as l’, i.e., to ~ 2.5–12.5% of limestone mass.

CONCLUSIONS

The main disadvantage of correlation procedures suggested in this paper lies in the slightly "floating" linkage to conodont biozones. These problems are very typical for platform segments not only in Moravia, where most of the transitional and deep-basin sedimentary facies were cut off from the platform mainlands and their slices accumulated in separate piles or completely obliterated by shearing, as well as by extrusion of rigid bodies from the structures and by erosion. Also, the problems with conodont zonal and taxonomic definitions still persist (e.g, *P. punctata* – recent discussions and calls for re-definitions of the morphotype used to define a middle Frasnian substage boundary can be found on http://www.geneseo.edu/~frasnian/) and thus the perspective is seen mainly in terms of mutual international calibration of complex logs.

In spite of all these problems, the combination of γ-ray or magnetic susceptibility stratigraphy provides promising and effective solutions. The additional test of correlation correctness, using the comparison of Křtiny HV-105 and Mokrá — quarry west geophysical log data, has improved basic understanding of the anatomy of whole-Frasnian lithological columns, particularly in carbonate platform and related facies. The great degree of similarity between NGR patterns in relatively pure carbonate sediments of forereef and backreef areas suggests that fixation of these patterns could reflect variations in atmospheric deposition and eustasy. The proposed method of search for the ~*punctata* stratigraphic equivalents in worldwide conodont-barren platform facies (Figs. 5 and 6), based on a combination of γ-ray and magnetic susceptibility techniques, seems to be reliable and practical.

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