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Fluviolacustrine style sedimentation of the lower part of Malužiná Formation from the NE slopes of Nízke Tatry Mts.

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Abstract. The middle stage basin-fill history of the Malužiná Fm., as a part of Ipoltica Group is described. Ten identified facies, building four facies associations (FA1 to FA4), were interpreted as the deposits of shallow sandy braided system, lacustrine system, gravelly braided - minor debris-flow braided system and sand-bed alluvial system with dominant sheet floods. Facies associations arranged a succession of two cogenetic second-order fluvial depositional sequences. The vertical profile of both sequences displays an overall fining-upwards trend related to the gradual decrease in topographic slope. Fluvial styles can be observed within each sequence, from initial higher to final lower energy systems. The change in fluvial style, combined with the widespread evidence of bioturbation, desiccation and evaporation, suggest an evolution towards a more semi-arid climate in the upper part of the sequence. The controlling mechanisms for this may be autocyclic as well as allocyclic processes, although the tectonic influence on sedimentation was probably significant.

Keywords: Permian, Hronicum Unit, Malužiná Fm, facies associations, fluviolacustrine style

Introduction

The paper deals with depositional environments in investigated lower part of Malužiná Formation (lowermost Permian to lower part of Upper Permian), situated in the northeastern part of the Nízke Tatry Mts. The results of sedimentological analysis are based on outcrop studies. Studied territory is located between villages Liptovská Teplička and Vernár, resp. south of villages Vikartovce, Kravany, Spišské Bystré and Hranovnica.

Studied continental volcanosedimentary sequence of the basal part of superficial nappe of Hronicum Unit represents the complete megasequence of several depositories of Upper Carboniferous to Lower Cretacious age. It belongs to Ipoltica Group (Vozárová & Vozár, 1981, 1988), developed gradually (Biely, 1965; Ďurovič, 1965; Drnzík, 1969; Novotný & Badár, 1971; Vozárová & Vozár, 1981, 1988) from the underlying Nižná Boca Formation of Stephanian B-C age (Sitár & Vozár, 1973). The stratigraphic overlier of the group is built by the Benkovský potok Formation (Biely in Andrusov & Samuel et al., 1984). The Lower Triassic age of this formation was determined by the fauna occurrence at Šuňava village (Roth, 1938). According to this relation and finding of microflora assemblage, the Malužiná Formation covers the age range of Lower-Upper Permian (Planderová in Vozárová & Vozár (edit.), 1979; Planderová & Vozárová, 1982). The important and determining constituent of the formation is the multiphase sedimentary volcanism of continental tholeiites, from geotectonic viewpoint ranked among the non-orogenic volcanism types and connected with the origin of continental rift (Vozár, 1977, 1997; Dostal et al., 2003).

The main petrographic types of sediments are represented with red arkose sandstone, greywacke sandstone,

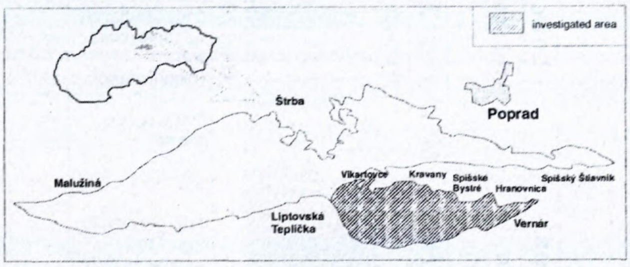

Fig. 1. Location map showing part of investigated area of Ipoltica Group, NE part of the Nízke Tatry Mts.

arkose, greywacke and conglomerate. The anhydrite-gypsum horizons and occurrences of redeposited gypsum were described from boreholes (Novotný & Tulis, 1998). The pyroclastic rocks as tuffs, tuffitic sandstones, tuffitic breccia are present in the vicinity or among particular effusive bodies.

The general assumption allows deriving the clastic detritus from its immediate underlier, rimming the margin of sedimentary basin, eventually from synsedimentary volcanic centres. The petrofacial analysis of clastics indicates the dual provenance: from rejuvenated continental basement and from truncated volcanic arc (Vozárová & Vozár, 1993).

Drnzík (1969) interpreted the sedimentary environment from the Lower Carboniferous as shallow marine (coastal-marine) with alternation of transgressive-regressive cycles with facies from deltaic to bay-lagunary. Drnzík (l.c.) used for the first time the term megacycle for cyclic setting of "melaphyre series"

The works by Novotný (1970, 1972), Novotný & Badár (1971) and Novotný & Jančok (1971) brought first more detail sedimentological knowledge about this forma-

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tion, but allocated relatively complicated names for lithostratigraphic units. Authors suppose, that sedimentation in Lower Permian occurred by traction flows in near-shore zones of shelf sea with ingress of lagoon environment. In Upper Permian they suppose the shallowing of the basin and its diversification into subenvironments of lagoons to continental lakes with increasing salinity. Authors distinguished two Permian cycles. Third cycle was interrupted with intensive volcanism. In later summarizing work (Tulis & Novotný, 1998) authors allocated a new designation for earlier defined lithostratigraphic units (Fig. 2 b)).

Vozárová & Vozár (1981) defined Malužiná Fm. being composed from three upward fining megacycles (Fig. 2 a). Generally they determined the sedimentary environment as continental, deltaic-lagoonal, eventually complex of bottom lacustrine sediments with wedged deltaic sediments. In later work (Vozárová & Vozár, 1988) the interpretation of the sedimentary environment was as follows: Each megacycle is formed with fluvial channel deposits. In middle parts of megacycles the floodplain deposits tied with levee and temporary riverain pools sedimentary conditions have the main representation. The upper parts of megacy-

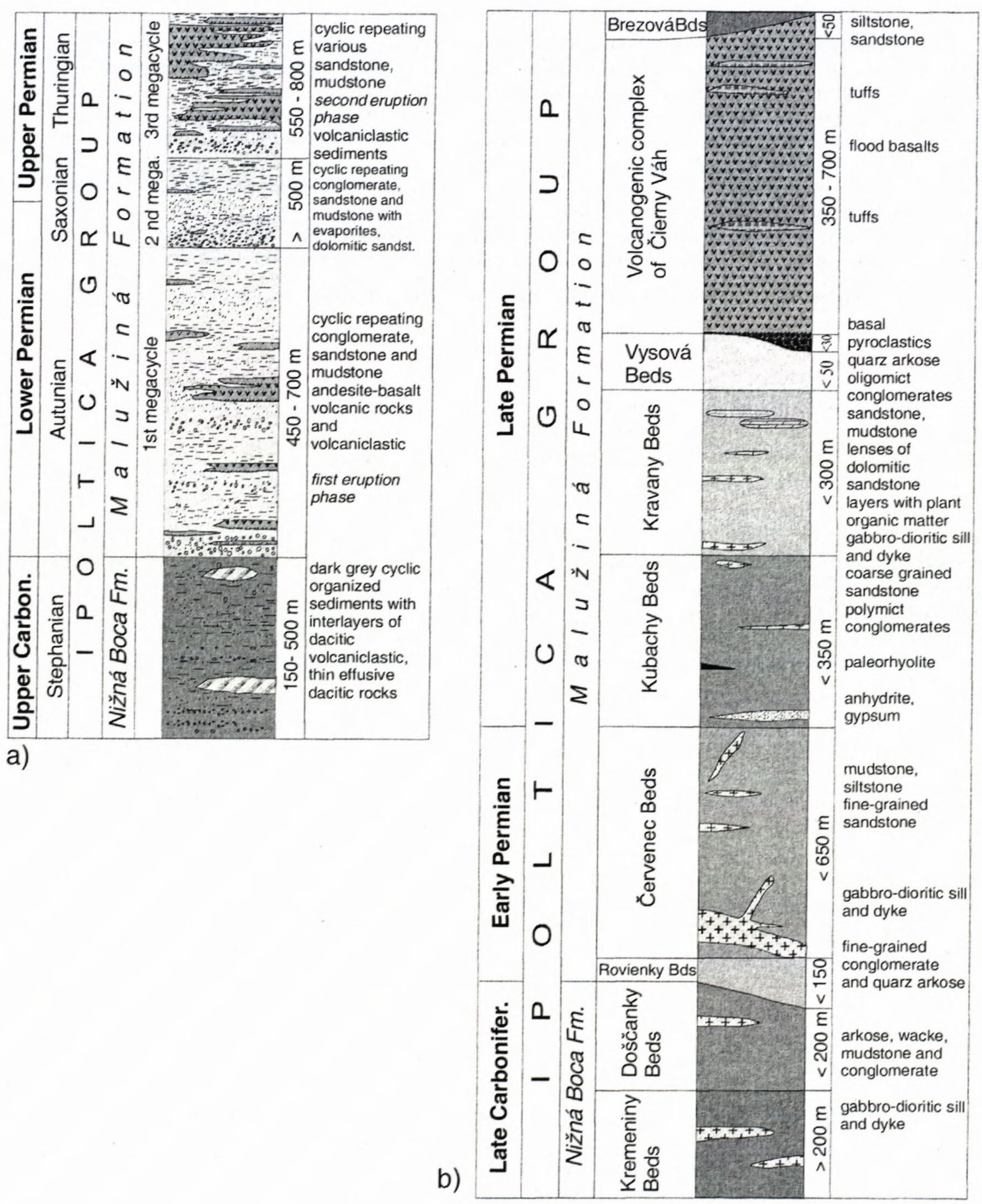


Fig. 2. Lithostratigraphic columns of Upper Palaeozoic of Hronicum Unit after Vozárová & Vozár (1997, a) and Tulis & Novotný (1998, b).

cles are characteristic with sediments deposited in alluvial lowland, where the constant riverain pools, eventually the extended lakes originated. The occurrence of evaporite association the authors connect with the distal facies of intracontinental sedimentary basin.

Lithofacies

The characteristic feature of Malužiná Fm. is the prevalence of repeatedly arranged cycles of fourth- and fifth-orders (parasequences and small cycles) into the third-order depositional sequences. Taking into account the lithological characteristics, primary sedimentary structures and geometry of sedimentary bodies, we distinguish ten lithofacial types. Lithofacies are a part of architectural elements, and their association defines the fluvial style of investigated sediments. The facies codes and terminology of architectural elements were compiled according to Miall (1985, 1996). The Malužiná Fm. is composed by massive bedded bodies 40-50 % *(Gm, Sm, Fm)*, horizontally laminated, eventually cross-bedded 30-40 % *(Gt, Gp, Sm, Sh, Sp, Fl)* and grade-bedded 10-20 % *(Gm, Gt, Gp, Sp, St)*.

Facies Fm (massive bedding)

Facies Fm are composed of brownred-purple siltstones, claystones, less often fine-grained sandstones. The sandstones can form intercalations of lensoidal shapes, or individual tabular bodies thick app. 1.5 m and long along strike to 10 m. The upper part is usually eroded by new cycle (sharp contact). The erosion intensity is proportional to clast dimensions of eroding overlying bed. This facies type can bear the pseudobed horizons of concretion bodies of mm to dm dimensions, most often there are developed the cavities after these concretions.

Facies Fl (horizontally laminated)

The fine lamination of lighter- and rich-purple thin beds as well as indistinct ripple bedding (Fig. 5a) are observable in this case. Bodies reach thickness of several metres, they can be divided by fine erosion boundaries. The bioturbation are very often, being reflected by chaotic small corridors with diameter from 0.5 to 1.5 cm, coursing perpendicularly, diagonally, or paralelly with bedding.

Facies Sm (massive bedding)

These sandstone bodies reach thickness 2-3 m. They can bear the internal gradations or marks of slight bedding. Sometimes they contain clasts of quartz pebbles and intraclasts of older sediments and volcanites.

Facies St (trough cross-bedding)

Trough cross-bedded sandy sediments are tightly associated with above stated facies of sandy fraction. Material at the base of such body with developed trough cross-bedding is usually more coarse-grained, with developed graded-bedding and often with erosion contact at underlying bed. The trough cross-bedding is developed through whole thickness of the bed, eventually it changes into planparallel, or cross-bedding in upper part. These bodies reach thickness 1-2 m and most often are composed from channel infillings thick 10 - 40 cm (Fig. 5c).

Facies Sp (planar cross-bedding)

The sandy sediments with planar cross-bedding outcrop together with facies Sm, St, Sh and Fm. The cross-bedding either represents the solitary bed (30 cm), or most commonly its basal part (thick to 50 cm) with transition to parallel lamination. It outcrops in small extent also in upper part (20 cm) of positive graded beds thick up to 2 m. The angle of cross-bedding reaches <15° (Fig. 5f). Sedimentary structures include planar cross-stratification with angular contacts and planar parallel to planar non-parallel discontinuous lamination.

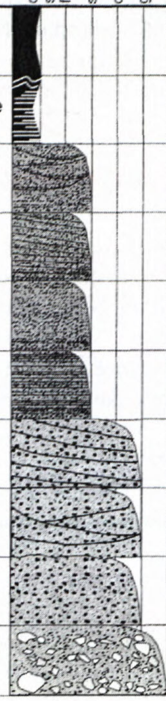
Facies Sh (horizontal stratification)

The current lamination in sandstones represents relatively frequent textural element of upper part of sedimentary bodies of lighter colours, well sorted quartz arkoses, alternating with finer red sandstones. It represents characteristic alternation of lighter and light-pink or red lamina (Fig. 5e)

Coarse-grained conglomeratic facies can be enlisted correspondingly according to the same marks among the massive *(lithofacies Gm)*, planar cross-bedded *(lithofacies Gp)* (Fig. 5g) and trough cross-bedded ones. The positive graded bedding is prevailing. Similarly, the distribution of coarse-grained conglomeratic facies is tied with sandy varieties. Principally they vary from sandy conglomerates to fine-grained conglomerates with the clasts dimensions most often beneath 1 cm. A special kind is represented with coarse-fragment unsorted sediments of red-brown colour with gravel matrix support having higher content of clayey matrix *(lithofacies Gms)*. These coarse-grained conglomeratic bodies with quartzy pebble material of dimensions 5-10 cm and more (max. 30 cm) are present only in this lithofacies (subaquaceous debris flow?). Very often there are the erosion contacts between beds, cutting older horizons, large intraclasts of fine-grained sediments and disproportion in clasts dimension (Fig. 5h).

Architectural elements

By enlarging the scale of observation, lithofacies are combined into architectural elements. In the Malužiná Fm. (in study area) there were identified mainly architectural elements as gravelly bars and bedforms, element **GB** and sandy bedforms, element **SB** comprising from lithofacies: Gm, Gp, Gt, Sm, Sh, Sp, St, filling of small chute channels (element **CH**), representing lithofacies Gt, St. Next there are floodplain deposits (element **FF**), or overbank fines (element **OF**), consisting from lithofacies Fm and Fl. Associations of architectural elements are then used to define the styles of the fluvial systems.



facies		clay / silt / f.s. / sand / c.s. / gravel	sedimentary structures and characteristic of deposits	interpretation	flow regime
Fm	mudstone, fine-grained sandstone, interbed ~ bed		massive bedding, bioturbation, mudcracks	sheet-flood deposit, floodplain	lower flow regime *low energy*
Fl Sr	very fine-laminated mudstone with sand interlaminae		horizontally laminated, loc. ripples, bioturbation	levee and floodplain deposits	lower planar bed condition
St	trough cross-stratified sandstone, loc. gravel		trough cross-bedding	channel fill deposits dunes	lower flow regime
Sp	planar cross-stratified sandstone, loc. gravel		planar cross-bedding (up to 10°)	transverse bars bottom accumulation	rythmic phase of transport
Sm	massive bedding sandstone		slightly graded	longitudinal bars	upper flow regime
Sh	planar horizontally-stratified sandstone		current lamination, planar stratification	large flat bars in active channels, loc. sheetflood	upper flow regime *higher flow velocities*
Gp	stratified gravel		planar cross-bedding	longitudinal bars	upper flow regime
Gt	stratified gravel		trough cross-bedding, erosive base	small chute channel	upper flow regime
Gm	massive or slightly stratified gravel		massive texture	longitudinal bars, sorted gravel, bottom sediments	upper flow regime
Gms	massive unsorted gravel with sand matrix supported		gradation, slight horizontal bedding, imbrication	subaqueaceous debris flow	upper flow regime *high energy*

Tab. 1. Sedimentary facies recognized in the Malužiná Formation and their description and interpretation. Facies codes after Miall (1978).

FA	dominant lithofacies	minor lithofacies	architectural element	interpretation
FA4	Sm, Sh, Sp	St, Fm	SB: *sandy bedforms* FF: *overbank deposits (floodplains fines)*	sand-bed alluvial system ephemeral sheet-floods
FA3	Gms, Gm	Gp, Gt, Sp	CH: *channel fill* GB: *gravelly bars*	gravelly braided system/ debris-flow-dominated braided system
FA2	Sm, Sh, Sp	Fm, Fl, Sr	FF: *overbank deposits (floodplains fines)*	terminal alluvial plain ephemeral floods
FA1	Gm, Gp, Sm, Sh, Sp	Gt, Fm	SB: *sandy bedforms* CH: *channel fill* GB: *gravelly bars*	shalow sandy braided system on alluvial plain

Tab. 2. Facies associations recognized in the investigated area. Classification from Miall (1978, 1985, 1996).

Facies associations of the Malužiná Formation

Four facies associations have been recognized taking into account the lithology, assemblages of sedimentary structures, and sediment body architectures. These facies associations correspond to individual lithostratigraphic member after Novotný and Tulis (1998) and are summarized in Fig. 4. In investigated area south of Spišské Bystré and Kravany villages four facial association can be distinguished from the bottom upwards:

Facies association 1

The light coloured massive microconglomerates, coarse-grained sandstones (Gm, Sm, 40 %), coarse-grained subarkoses (Sp, Sh, 30 %), with graded-bedding (Gm, Gt, Sp, Sh, 20 %), cross- bedding (Gp, Sp, 5 %), locally with sandy conglomeratic bodies are prevailing. The typical arrangement: At the base the light-coloured microconglomerate with graded transition into sandy light-pink sandstone in upper part with low-angle cross-bedding, eventually the trough cross-bedding are present in the bed. The intercalations of red siltstones (Fm, 5%) thick from 1 to 20 cm are sporadically present in upper part of such graded bed. They are covered with erosive light-red microconglomerate fining upwards. The thickness of this cycle ranges from 50 cm to 3 m. The beds with internal positive gradations, as well as following geometrical and textural elements are present: wedging of the beds, channel load, trough cross-bedding and cross-bedding. Novotný (1972) describes in upper parts of beds the current ripples, rolled bedding, mainly in overlier of

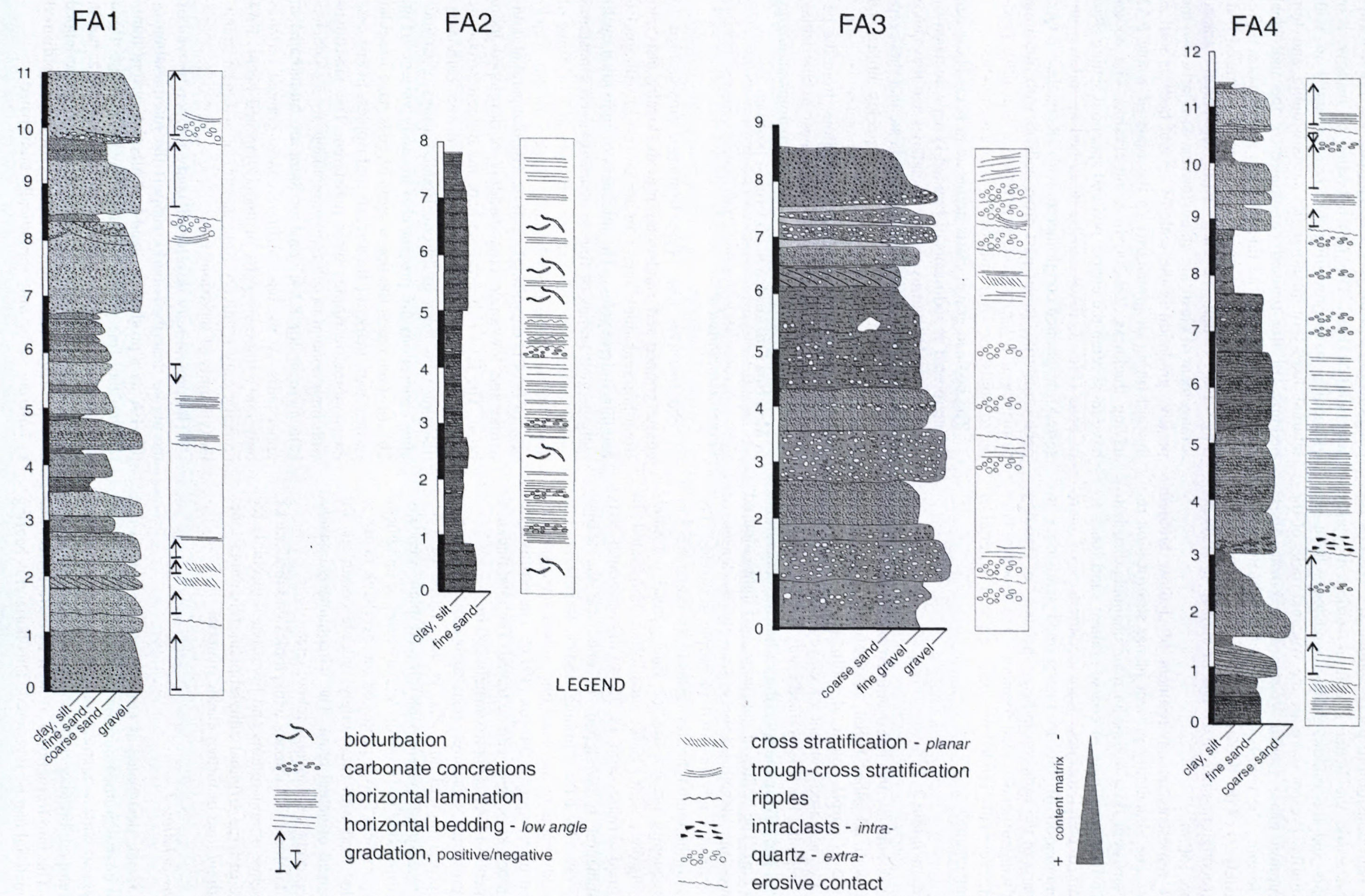


Fig. 3. Characteristic logs of the facial associations from Malužiná Fm. mapped in the study area. FA1 - Bystrá valley, Grúň. FA2 - Mokrá valley, Grúň. FA3 - Bystrá valley, Karabinovo mokré. FA4 - Bystrá valley, Palesák.

ripples with transition to planar lamination. For this FA is characteristic the better structural sorting of clastic sediments and the middle-grained sandstones have the best maturity. Present there are the volcanic rocks of the first eruption phase (sensu Vozárová & Vozár, 1981; 1988), forming the vein bodies, as well as effusions (approximately 2) of the thickness 1–2 m. They are covered by microconglomerates. FA1 has in studied area thickness app. 150 m.

FA1 represents an environment of shallow braided systems. The abundantly present planar stratification reflects consistent flow regime in main channels distributing material prevailingly of coarse-grained sandstones to fine-grained conglomerates. Rare occurrences of more often alternation of silts to fine-grained sandstones in upper parts of the beds can indicate the states of flooding periods with suspended load forming levee deposits, later covered, eventually eroded by coarse-grained material of migrating channel.

Facies association 2

FA2 is built by the finest-grained sediments in comparison with all other facial associations. The typical brown-red to purple colour of sediments in this FA is caused by increased content of clayey matrix in sediments containing the fine-grained sandy fraction (Sm, Sh, Sp, 70 %) and having the sporadic carbonatic concretions (ca to 5 cm). The bodies of coarse-grained light-coloured sandstones are developed only scarcely as lenses of coarse-grained sandy material in purple siltstones. The thickness of individual bodies varies in the range 0.5-3 m. Most frequently present are the fine-grained red sandstones/siltstones with clastic mica, often bioturbated. In fine-grained varieties (Fm, Fl, 30 %) the horizontal, very fine lamination is developed. In one case the texture strongly resembled the climbing ripples. Relatively common muddy fractures and local fine slide deformations are described by Novotný & Jančok (1971). The positive gradation in bed association can be traced. The total thickness of sediments of FA2 is approximately 250 m.

All presented signatures, resp. their combination support interpretation of this FA as association of fine–graided lacustrine system with alluvial plain deposits, which correspond to facies of "playa" type, or ephemeral lakes. Sporadical floods produced the overbank facies as suspended load with exceedingly suitable conditions for development of actual biota. The ichnofauna is considered to represent the Scoyenia ichnofacies.

The laminated claystones with ripples and mudcracks, the presence of concretions and bioturbates resemble the presence of large terminal alluvial plain, remaining long-time without load of further clastic material.

Facies association 3

The facies, designated as Gms, is present only in this FA. The coarse-grained horizon of red-brown to red colour is typical with its textural non-maturity. Locally there are developed brighter horizons with relatively better sorting. The intraformational as well as extraformational pebble material can be registered. This horizon is bearing conglomerates with gravel supported, less often matrix supported texture. The bench bodies of massive conglomerates have prevailing thickness around 1 m, with internal marks of plan-parallel cross-bedding and thin bedding. In fine-grained conglomerates the individual beds of pebble material thick 4-6 cm and composed prevailingly of quartz are present. The positive graded bedding and trough bedding with sporadical graded arrangement of clasts are characteristic. Similarly also the positive gradation in the scale of several beds as well as upward-fining of granularity in the scale of whole FA3 having thickness 200-300 m is observable. The bodies have most often the coarse-bed and sphenoid setting. Part of beds (Fig. 3, FA3) can be described as follows: unsorted fine-grained conglomerate with 28 cm clast of Qtz, pebble material, lower part cross-bedded with transition to planparallel lamination, erosive basis – positive grading to sandstone, overlying bed is in erosive relation.

The bedload gravel clasts dominate in FA3. These can be interpreted as sediments of braided systems initiated by flood events. Numerous erosive boundaries and prevalence of channel arranged conglomerates indicate that these represent the system of relatively shallow quickly infilled and non-stable channels. Though the Gm's facies we cannot directly characterize as typical debris flow, from the genetic viewpoint it is genetically very near to this facies. This FA is in hierarchy of deposition environment energy of Malužiná Fm. located in uppermost position.

Facies association 4

The massive, less often laminated fine-grained to coarse-grained red sandstones prevail, locally also siltstone horizons thick app. 1 m are preserved with graded bedding (microcycles). The thickness of individual cyclically bedded bodies of fine to coarse-grained sandstones varies in the range 0.5-2 m, prevailingly to 2 m. Some of these entities have platy bedding thick 7-10 cm. Thickness of FA4 is prevailingly 200 m. The planparallel lamination and low-angle cross-bedding is developed more often. The FA4 is bearing perhaps the biggest carbonatic concretions (up to 30 cm), but also the carbonate-dolomite beds thick to 20 cm. Bedded arrays of cavities after concretions are present also in sandy varieties (Fig. 5b). In some cases the upper parts of beds have irregular surface with marks of flood-casts and ripples. In one case the asymmetric ripples were registered. The sandstones with high content of silt-clay component are a characteristic member for FA4; some of them are bioturbated in upper parts. At the base of more coarse-grained varieties only rarely the clay galls of underlying bed occur. FA4 contains only relatively tight spectra of sediment granularity mainly of sandstone type.

The prevailingly developed sandy fraction as well as the above described marks support the interpretation of this FA as a product of sand-bed alluvial system transporting the fine-grained material with sporadic flood events on alluvial plain. It is similar like in FA2, but in this case the overbank sediments were earlier overlapped by new charges of clastic materials, which is confirmed by horizons being only sporadically bioturbated.

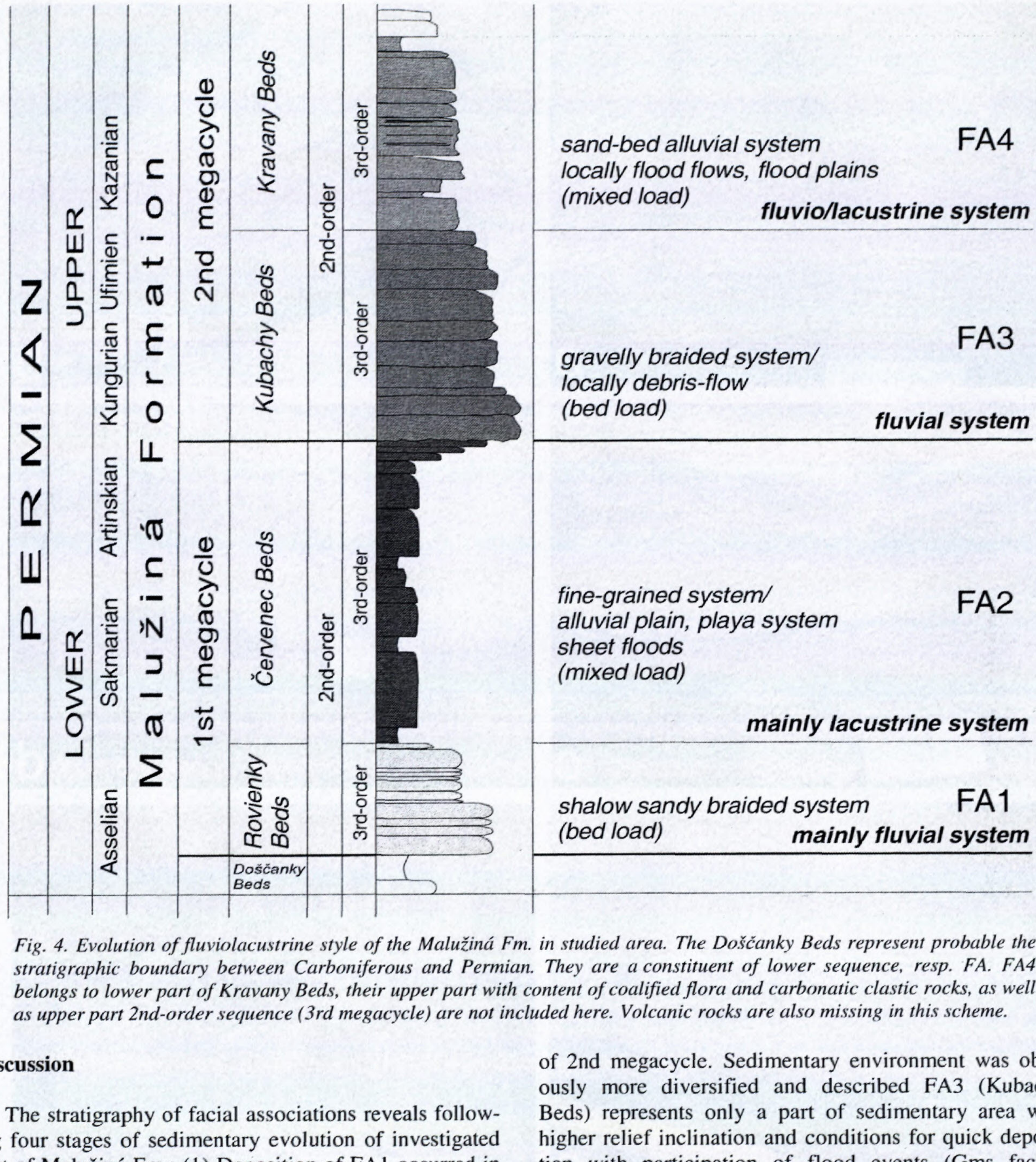


Fig. 4. Evolution of fluviolacustrine style of the Malužiná Fm. in studied area. The Doščanky Beds represent probable the stratigraphic boundary between Carboniferous and Permian. They are a constituent of lower sequence, resp. FA. FA4 belongs to lower part of Kravany Beds, their upper part with content of coalified flora and carbonatic clastic rocks, as well as upper part 2nd-order sequence (3rd megacycle) are not included here. Volcanic rocks are also missing in this scheme.

Discussion

The stratigraphy of facial associations reveals following four stages of sedimentary evolution of investigated part of Malužiná Fm.: (1) Deposition of FA1 occurred in environment of shallow sandy/gravel braided system. The positive graded beds with footwall sharp contact with amalgamation character (Fig. 5d) and through cross-bedded set (Fig. 5c) in FA1 (Rovienky Beds) bear the marks of fluvial deposition. The prevalence of sorted clastics - relatively matured subarkoses is evident. (2) The change of fluvial style is characterized with gradual but quick transition into sediments typical for overbank facies in floodplain area, being represented by FA2 (Červenec Beds). It builds the upper part of 1st megacycle. Its considerable thickness (250-650 m) reflects long-term monotonous development of stable sedimentary area. (3) Abrupt transport of coarse-grained and partially unsorted clastics into the basin indicates the tectonic activity and younging of source area. Such sediments present the basis of 2nd megacycle. Sedimentary environment was obviously more diversified and described FA3 (Kubachy Beds) represents only a part of sedimentary area with higher relief inclination and conditions for quick deposition with participation of flood events (Gms facies, subaqueceous debris flow). The unsorted material prevails over the better sorted coarse-grained sediments. (4) Transition to overlying FA4 (lower part of Kravany Beds) is again gradual and connected with fining of positive graded cycles. The main presence of the sand, connected with the massive, locally planar structures and carbonate concretions, suggests that the main transport was generated by ephemeral sheet floods events (upper flow regime) in alluvial plain conditions.

Despite every effort, there is still not possible satisfactorily explain the character of deposition boundaries between individual FA. The answer would be obtained by analysis of sequence stratigraphy of Malužiná Fm.. accompanied with revision of results of drilling works, located near the boundaries. Although, principal there is

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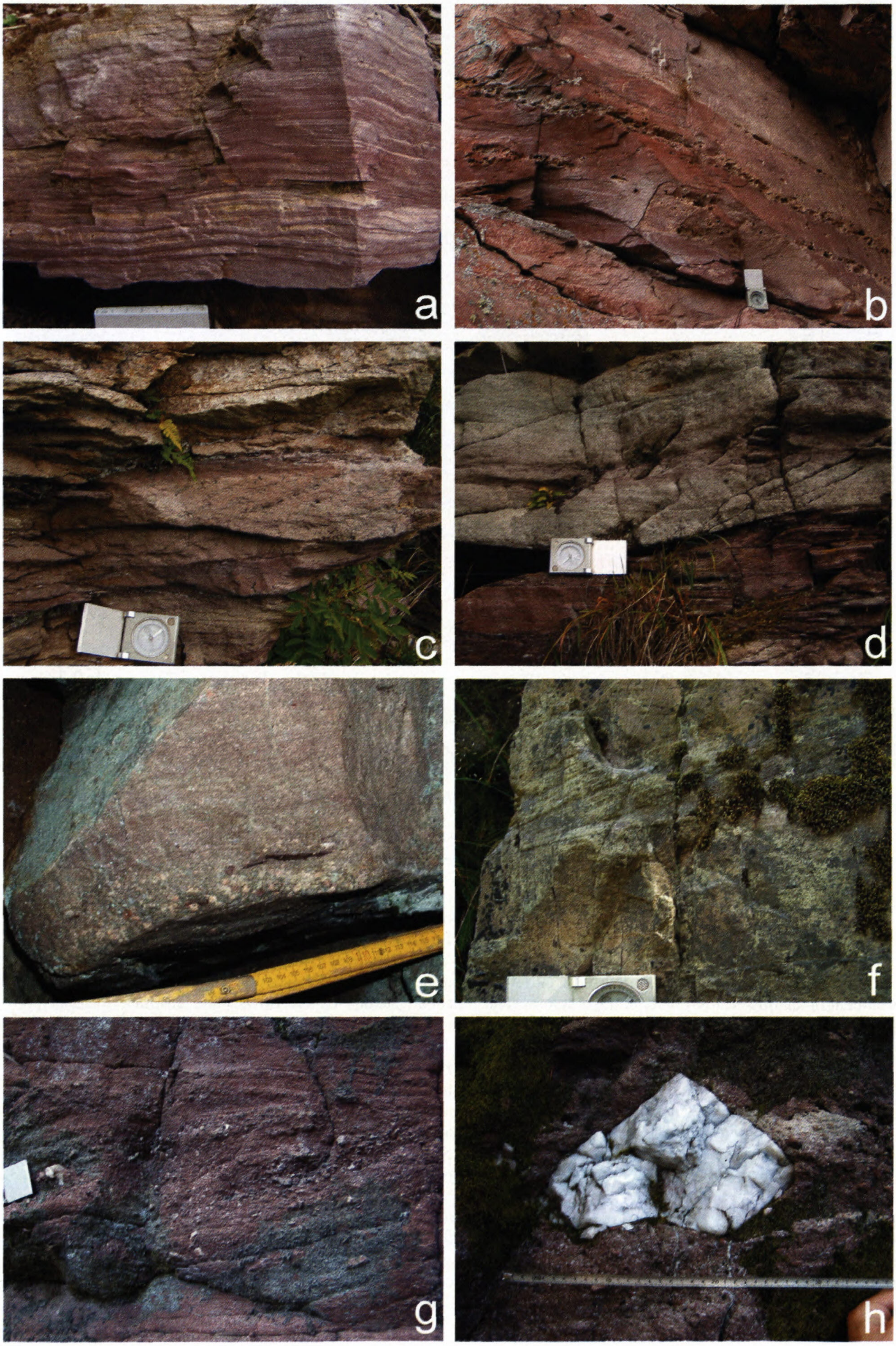

knowledge about boundary between Červenec Beds (FA2) and Kubachy Beds (FA3), being described as gradual with coarsening positive grading with transition to overlier (Novotný & Jančok, 1971).

The presented lower (monotonous) part of Kravany Beds is bearing the most probable the fluvial marks. Some authors (e. g. Novotný & Tulis, 1998) suppose, that later (upper part of Kravany Beds) there occurred the basin shallowing and gradual diversification to partial sedimentary areas of fluvial type with local transition to continental lakes with increasing salinity. According to Vozárová and Vozár (1988) the sediments are typical lacustrine ones being deposited in semiarid conditions. The change of sedimentary environment is characterized by change of colours to grey, greygreen and rarely to blackgrey and red. The intercalations bearing the flora fragments in the form of coalified plant detritus are often associated with fine-scale cross-bedding. The carbonate sedimentation represented by dolomite-calcite sandstones and sandy limestones in lensoidal bodies appears here for the first time.

The base of next third-order depositional sequence (3rd megacycle) is built with positive graded Vysová Beds (Fig. 2) prevailingly of light colours and locally with quartzstone beds. Quartzstones represent mineralogically the most mature sediment of Malužiná Fm. (Novotný & Tulis, l. c.).

Significant occurrences of evaporite association indicate the intensive evaporitization in environment of intermittently flooded parts of floodplain with character of continental sebkha or playas (Vozárová & Vozár, 1988). Gypsum in veins, presented as "redeposited", occurring in upper part of FA2 and probable also in lower part of FA3, indicates, that originally it could form cement, or thin beds which could be later resedimented. Also 30 m thick bed, being penetrated by borehole No. 310 (Novotný & Tulis 1998), formed by alternating evaporites (dolomite, anhydrite, gypsum), claystones to microconglomerates (Ďurovič, 1968, 1970), belongs into this stratigraphic horizon. Tightly above the bodies of coalified flora the bodies of carbonatic sandstones are developed. Next similar occurrences of "redeposited" gypsum are located similarly at the boundary between Kravany Beds and Vysová Beds (Novotný & Tulis l. c.).

The setting of Malužiná Fm. was influenced by three allocyclic controls: eustasy, tectonics and climate. From these the global change of sea level (eustasy) principally did not have any effect for development in lower part of Malužiná Fm. Succession of two third-order depositional sequences (FA1–FA4) can be correctly understood as reflection of tectonics in sedimentary area of the basin. The transition from higher energy fluvial regime (braided to meandering streams) towards the regime of calm sedimentary conditions reflects the shifting of facies from proximal to distal part.

Conclusions

Investigated lower part of the Malužiná Fm. consists from four third-order depositional sequences, corresponding to 1st and 2nd megacycle and being divided by sequence boundary of started deposition of coarseclastics. We have distinguished ten principal facies in sediments: massive and finely laminated mud with ripples (Fm, Fl, Sr), massive, trough cross and planar cross-stratified sandstone (Sm, St, Sp, Sh), massive and stratified gravel (Gm, Gp, Gt), unsorted gravel (Gms). Three basic kinds of architectural elements are defined in this study: mainly sandy bedforms (SB), channel (CH) and overbank fines (OF), which are built by four facies associations (FA1-FA4). Described FA mostprobable represent the stratigraphic boundary Lower Permian to lower part of Upper Permian (1st and 2nd megacycle sensu Vozárová & Vozár, 1988). They represent two genetically neighbouring sequences. First of them represent the sediments of shallow braided alluvial system with transition to large terminal alluvial plain. The second sequence characterizes the gravel braided system connected with erosion of underlier, quick sedimentation and repeated origin of floodplain sedimentary environment. Climatic conditions can be characterized as semiarid. Cyclicity of Malužiná Fm. has fluviolacustrine characteristics. The upward-fining cycles of 2nd order reflect the change in topographic gradient and fluvial sedimentation style. Stratigraphic architecture and cyclicity of 2nd order fluvial sequences was controlled by tectonics. The cycles of fourth and fifth order were influenced by fluvial regime in co-influencing climate.

Acknowledgements

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Fig. 5. a) Laminated mudstone facies (Fl) showing finely-laminated mud with very fine sand interlaminae, (FA2). b) Calcretes horizonts in fine-grained red sandstone/mudstone facies (Fm), (FA4). c) Trough cross-bedding in the coarse sandstone facies (St), (FA1). d) Sharp contact between the underlying shale and overlying coarse graded bed, (FA1). e) Graded bed with intraclasts, upper part of the bed is horizontally laminated (Sh), (FA1). f) Planar cross-beds sandstone facies (Sp), (FA1). g) Trough cross-bedded (Gt) gravel, (FA3). h) Almost 30 cm clast of vein quartz in Gms facies (FA3).

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