mentary rocks from the north (Teisseyre, 1956). The latter concept is supported by the local presence of rock units termed as cataclasites at the boundary of metamorphic and sedimentary complexes. This ambiguity results from poor exposure of contacts between all the three lithological groups. To overcome this difficulty a geophysical method based on ground resistivity was applied over the area of the Cieszów Unit, where all three rock groups commonly occur.

The Cieszów Unit is composed of metavolcanic and metasedimentary complexes of Early Paleozoic age (Baranowski et al., 1990), which are surrounded at the surface level by Late Devonian to Early Carboniferous sedimentary rocks (fine- to coarse-grain clastic rocks) but separated from them by a rim of cataclasites. The cataclasites have varying texture and structure, however, most commonly they show constant composition: albite, quartz, chlorite, epidote and muscovite (sericite) which are cemented with silica. Both the layering and foliation, respectively for the rock types, are steeply inclined in the studied unit.

The area of the Cieszów Unit was surveyed over with the EM31 Terrain Conductivity Meter (manufactured by Geonics Ltd., Canada) which has an effective depth penetration of about 6 m. As the resistivity of metamorphic, sedimentary and cataclastic rocks varies, the continuous measurements of that physical property allow to interprete the rock boundaries and their general inclination. A set of 50 traverses perpendicular to the lithological boundaries around the Cieszów Unit was made. Their length ranged from 0.2 to 1 km and the conductivity measurements were made every 20 m along the traverses. Soil cover along the analysed traverses was relatively thin, therefore the results of surveying are reliable for the mother-rock boundary interpretation.

The obtained conductivity profiles show very good agreement with the mapped pattern of rock distribution and the outlined faults. Most often slopes of highs or lows appear at the rock boundaries. However, shifts between the highs and lows vary: they rise and drop either abruptly or gradually on lithological boundaries. The first case is interpreted to indicate steeply inclined rock boundaries (usually high-angle faults), the latter contacts at a more gentle angle. Based on the profiles, the supposed high- and low-angle boundaries around the Cieszów Unit were mapped. Generally, steeper contacts are observed on the boundary of sedimentary rocks with cataclasites or metamorphic rocks, while at the border of metamorphic rocks and cataclasites they are both steeply or gently inclined. Additionally, the conductivity profiles show that not only sedimentary complexes are internally not uniform, but also the cataclasites posses spatial variation in composition.

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Vertical Facies Variability of the Building Sandstone (Słupiec Formation, Intrasudetic Basin) on Example of the Selected Fragments of the Profile from the Vicinity of Nowa Ruda

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A 400-m thick Building Sandstone Member forms the lower part of the Słupiec Formation (upper Autunian). It is underlain by fine-grained sediments known as the Upper Anthracosia Shale (Krajanów Formation) and passes upwards into the Walchia Shale, the upper part of the Słupiec Formation. Both shales are regarded to be of lacustrine origin.

The Building Sandstone Member consists predominantly of arkosic or subarkosic arenites and wackes and minor polymictic conglomerates or fine-grained sediments such as arkosic mudstones with various amount of fine-grained sand. Reddish colour is characteristic of all the textural varieties (Nemec et al., 1982).

The deposits form structurally diversified facies set of fluvial origin. Coarse-grained facies (compare Miall, 1985) are represented by matrix-supported conglomerates (Gms), massive conglomerates (Gm), channel pavement horizons (Gc) and, rarely, conglomerates with trough crossbeds (Gt). Among sandstones, which predominate in this part of the Słupiec Formation, massive sandstones (Sm) and horizontally laminated sandstones (Sh) are most abundant. Minor components are sandstones with trough crossbeds (St) or ripple crossbeds (Sr). Fine-grained deposits are usually interbedded sandstones and mudstones (Sr/Fl) with complex cross, wavy, lenticular, flaser lamination and rarely horizontally laminated mudstones (Fl). Short characteristics of the Building Sandstone lithofacies set and the interpretation of the deposition environment are shown in Tab. 1.

The aim of the work is to present a model of vertical facies variability of the Building Sandstone based on the analysis of a chosen part of its profile. Out of numerous occurrences of

		Facies association	Facies code after Miall (1985)	Sedimentary structures and textural characteristics of deposits	Interpretation
I	1	G Conglomerates and sandy conglomerates	Gms	Massive or graded conglomerates and sandy conglomerates	Gravity flow deposits
	2		Gm	Massive conglomerates and sandy conglomerates, sometimes with imbrication and pebble lineation	Lag deposits, internal parts of bars (upper flow regime)
	3		Gc	Pebble horizons in conglomeratic sandstones,often with imbrication and pebble lineation	Lag deposits (channel pavement), (upper flow regime)
	4		Gt	Conglomerates with trough crossbeds	Internal parts of bars, minor channel fills
II	5	S Sandstones	Sm	Massive, medium to very coarse-grained sandstones, in places pebbly	Minor channel fills, urgent sedimentation of clastic material, (upper flow regime)
	6		Sh	Fine to coarse-grained horizontally laminated sandstones, often with streaming lineation	Planar bed flow (upper flow regime)
	7		St	Fine to coarse-grained sandstones with trough crossbeds, often with intraclasts and admixture of gravel	Channel deposits at all, dunes, lower flow regime (rhytmical phase of transport)
	8		Sr	Fine-grained sandstones with ripple crossbeds	Minor channel fills, lower domain of rhytmical transport phase (lower flow regime)
III	9	F Fine grained deposits	Sr/Fl	Fine to very fine-grained sandstones and mudstones with ripple cross lamination of all types	Levee and flood plain deposits, lower domain rhytmical phase of transport/lower planar bed
	10		Fl	Horizontally laminated mudstones	Levee and flood plain deposits, lower planar bed condition

Tab. 1. Sedimentary facies of the Słupiec Formation.

the lower part of the Słupiec Formation located in the neighbourhood of Nowa Ruda, the line of outcrops in the cross-cut of the railway line Nowa Ruda - Kłodzko is, in the author's opinion, the most suitable for the purpose of the work. The outcrops are representative for the whole unit, conveniently placed and have a detailed graphic documentation. A 30-m thick continuous and unperturbed fragment of the profile, forming almost 10% of the total thickness of the Building Sandstone Member, was investigated. About 150 facial transitions were noted, a number which is not high for the statistical analysis but is sufficient to observe tendencies in the vertical facies changes.

The investigation of the vertical facies variability was based on the commonly applied method of embedded Markov chains (Nemec, 1981). Reasoning concerning facies variability was based on a difference count matrix. It allows to detect transitions occurring with non-random frequency. "Z" statistics was accepted as a test of a statistical significance (Radomski and Gradziński, 1978). This method eliminates faces transitions insignificant in the process of deposition. Only transitions with the significance level higher than the critical value z = 1,64 (=5%) were taken into account in the interpretation. Such transitions are privileged in the light of depositional processes and, with a positive matrix value, may be used for detection of modal sequence of lithofacies (Radomski and Gradziński, 1978). The results of the analysis are depicted in Fig. 1.

In the "ideal" profile of the Building Sandstone Member there is a very clear inclination to form simple cyclical sequences with grain size fining upwards. There is also a conspicuous asymmetry of the sequences - coarse and medium-grained facies dominate over fine-grained material. Tendency to oscillation is present mainly within fine-grained facies and is far less marked in coarser-grained rocks. These features are unequivocally indicative of alluvial environment, with predominant channel processes. Prevalence of the transitions within the set of coarse and medium-grained deposits suggests rivers with low sinuosity, probably of braided type. Their riverbeds were shallow, unstable and showed tendency for side migration. The initial stage of the sedimentation of each channel cycle was taking place under the conditions of high energy of the environment. The conditions became more stable in the final stage and most probably corresponded with a rhythmic transport phase. Overbank sedimentation was restrained to levees and the adjacent part of a flood plain. Crevasses and crevasses splay are often present within

A

Macierz różnic

	Gms	Gm	Gc	Gt	Sm	Sh	St	Sr	Sr/Fl	Fl
Gms					0,293	0,321				
Gm					0,787					
Gc					0,480	0,111				
Gt					0,794					
Sm	0,017		0,049	0,026		0,330				0,049
Sh	0,023	0,029	0,035				0,120			0,075
St			0,065						0,273	0,065
Sr									0,770	
Sr/Fl		0,016					0,083	0,410		
Fl		0,155			0,380	0,011				

B

Z

	Gms	Gm	Gc	Gt	Sm	Sh	St	Sr	Sr/Fl	Fl
Gms										
Gm					4,71					
Gc					3,67					
Gt					1,97					
Sm						4,29				
Sh							1,85			
St									2,44	
Sr									7,32	
Sr/Fl								6,34		
Fl		2,35			2,90					

C

Z%

	Gms	Gm	Gc	Gt	Sm	Sh	St	Sr	Sr/Fl	Fl
Gms										
Gm					14%					
Gc					11%					
Gt					6%					
Sm						13%				
Sh							6%			
St									7%	
Sr									22%	
Sr/Fl								19%		
Fl		7%			9%					

D

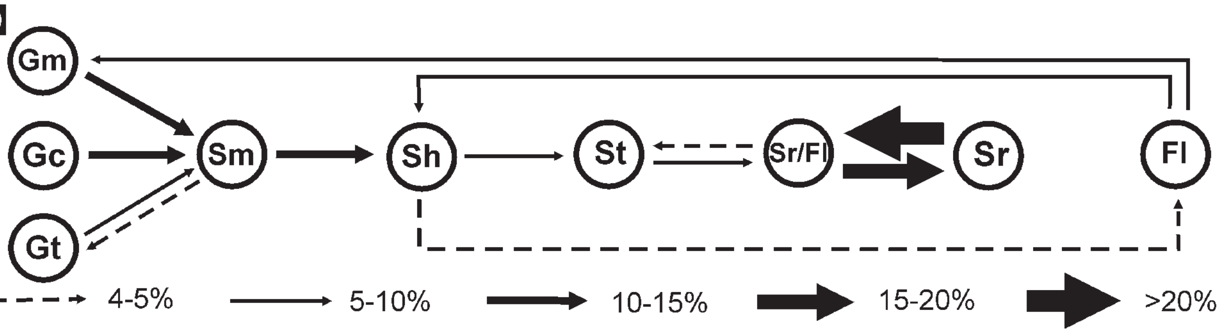

Fig. 1. A - difference count matrix; B - value of "z" statistics; C - value of "z" statistics in [%]; D - graphic model of facial transitions; further explanations in the text.

the deposits. Red colour of the deposits may suggest a significant influence of an arid or semiarid climate on the environment. The features of the presented fluvial system clearly indicate that the sedimentation of the Building Sandstone took place in the environment of terminal fans (Kelly and Olsen, 1992; compare also Kurowski, 2001).

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Trace Fossils as Indicators of Depositional Sequence Boundaries in Lower Carboniferous Deep-Sea Fan Environment, Moravice Formation, Czech Republic

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Sediments of the Moravice Formation (Nízký Jeseník Mts.) contain relatively rich assemblages of trace fossils. The abundance and diversity of these assemblages increase towards the younger parts of the formation. The degree of bioturbation, diversity and abundance of ichnocoenoses and ichnogeneric and ichnospecific variances were taken as a groundwork for determination of two basic trace fossil assemblages and three ichnoceonoses in the Moravice Formation, their distribution being controlled essentially by stratigraphy. Either trace fossil assemblage is then subdivided into one or two separate ichnocoenoses, whose definition is based on ichnogeneric and ichnospecific composition.

Gravity-flow origin for most of its deposits and ichnofacies patterns suggest the Moravice Formation to have been deposited in a deep – water marine setting, which is consistent with the interpretation of other Culm systems elsewhere in Europe. Two principal types of facies associations and their stacking patterns were observed: erosive, slope – related systems and depositional, basin floor systems. These systems are vertically stacked into three megacycles, each about 600 to 800 metres thick.

The first "basal" megacycle, which corresponds with the Cvilín Member, starts with about 200 to 350 m thick succession of erosive facies associations, in which sandstones, conglomerates and exotic blocks suggest high erosional efficiency. The coarse-grained erosive facies and thin-bedded, fine-grained turbidites are assumed to reflect channel-fill and overbank deposits, respectively. Slope-related processes are furthermore supported by the occurrence of trace fossil associations of the Zoophycos ichnofacies, which indicate oxygen-depleted, low-nutrient level and low-energy environment for deposition of the overbank deposits and/or fine-grained channel-fill deposits. Major traces of ichnocoenose include: Dictyodora liebeana, Planolites isp., Planolites beverleyensis, Laevicyclus isp., Chondrites isp., Phycosiphon incertum, Cosmorhaphe timida, Chondrites cf. intricatus, Falcichnites lophoctenoides, Pilichnus isp., Protopalaeodictyon isp, Spinorhaphe rubra, Zoophycos isp. and Rhizocorallium isp. The degree of bioturbation is very low. The abundance and diversity of particular ichnocoenoses vary considerably, but generally they are also relatively low. The channel-fill and overbank deposits are interpreted as a lowstand slope-fan depositional system (Posamentier et al., 1987) or mud-dominated, channelized turbidite depositional system of type II to type III (Mutti, 1992), overlying a sequence boundary in a proximal basin setting. The upper parts of the basal megacycle are assumed to represent basin floor fan in terminology by Posamentier et al. (1987). Rather unusual thickness of the basin-plain deposits and coincident scarcity of depositional sandstone lobes to be genetically linked to the proximal channel-fill system above speak for considerable contribution from the latter. The upper parts of the basal megacycle are assumed to represent basin floor fan in terminology by Posamentier et al. (1987). Distal environment is further supported by trace fossil associations of the Nereites ichnofacies.

Base of the second megacycle is less prominent than that of the megacycle 1 and corresponds with a Brumovice Member. The megacycle 2 starts with about 200 m thick succession, which is composed of erosive sandstones, fine-grained conglomerates and chaotic deposits predominating over non-erosive sandstones and fine-grained deposits. This part of the megacycle 2 is interpreted as a less prominent lowstand slope-fan or linear slope-apron depositional system overlying a sequence boundary. The basal slope-fan deposits grade upward into about 450 to 600 metres thick succession of fine-grained turbidites and minor, non-erosive sandstone bodies, which are interpreted as basin-plain deposits and sandstone-lobe or suprafan-lobe deposits of the classic submarine fan model, respectively (Mutti and Ricci-Lucchi 1972; Bouma et al., 1984). The basin plain deposits contain trace fossils of the Nereites ichnofacies, whereas transitional successions between the basin-plain deposits and sandstone-lobes contain trace fossils of the mixed Cruziana-Nereites ichnofacies. Traces of this ichnocoenose are represented by Nereites isp, Nereites missouriensis, Cosmorhaphe isp., Planolites isp., Planolites montanus, Planolites beverleyensis, Dictyodora liebeana, Chondrites isp. Grazing traces (agrichnia) such as Paleodictyon isp. and dwelling traces represented by Diplocraterion (?Arenicolites) isp. occur in subordinate amounts. Trace fossils of this ichnofacie indicating deep-marine, low-energy, low-nutrient level environments.

By analogy with the previous megacycle we interpret this