Facies and Architectural Analysis of Low-Sinuosity Fluvial Deposits of the Nýřany Member (Westphalian D – Cantabrian), Kralupy Area, Kladno-Rakovník Basin

Zuzana TASÁRYOVÁ[1], Karel MARTÍNEK[2] and Stanislav OPLUŠTIL[2]

[1] Geophysical Institute, Czech Academy of Sciences, Boční II/1401, 141 31, Praha 4, Czech Republic
[2] Institute of Geology and Palaeontology, Charles University, Albertov 6, 128 43, Praha 2, Czech Republic

Study presented here is performed on outcrops of fluvial deposits of the Nýřany Member in the easternmost part of the Kladno–Rakovník Basin (KRB), namely in Kralupy nad Vltavou area, close to the conventional boundary with the Mšeno–Roudnice Basin (Holub 1997). The Nýřany Member deposits were studied at the Hostibejk Cliff and the Lobeč Cliff, SSE–NNW oriented exposures in Kralupy nad Vltavou. Stratigraphically oldest strata are exposed along the southern margin of the Hostibejk Cliff whereas stratigraphically youngest sediments crop out in the northern part of the Lobeč Cliff. The cumulative thickness of the studied part of the stratigraphic succession exposed in the Hostibejk Cliff is estimated to be about 35 m and that one of the Lobeč Cliff about 45 m.

Six sedimentary facies were recognized: siltstone with plant material content (Fsm), fine-grained horizontally stratified sandstone (Sh), medium to coarse-grained cross stratified sandstone (Sc), fine to medium-grained massive conglomerate (Gm), matrix supported fine to medium-grained cross stratified conglomerate (Gcm) and clast supported coarse-grained cross stratified conglomerate (Gcc).

Architectural elements form the basis for the interpretation of depositional environment, they were defined by geometries and bounding surfaces using the methodology of Miall (1996). Individual elements represent different levels in terms of classification, e.g. sand and gravel bed forms are forming channels, channels are forming downstream accretion macroforms.

Five architectural elements were recognized:

1. Channels (CH), Abandoned channel fill consist of Sc, Gcm and Gcc facies, with sharp erosive base cutting up to few metres into underlying deposits. CH often erode sand bed forms and other channels. Their geometry is of concave-up channel shape occasionally forming multi-storey channel geometry. CH thicknesses are up to 2 m in most cases and rarely up to 3.5 m. CH widths vary between 5 m and 25 m. The average width/thickness ratio is of 14.6 within the whole studied area, of 17.3 at southern margin of Hostibejk Cliff, of 13.3 at northern margin of Hostibejk Cliff and of 12.6 at Lobeč Cliff. High lateral migration of channels is a typical feature. Most channels have multi-storey and multi-lateral nature. Decreasing width/thickness ratio from Hostibejk Cliff to the Lobeč Cliff is the function of exposure orientation.
2. Sand bed forms (SB) consist of Sh and Sc facies, with sharp base. SB have sheet-like geometry and are often eroded by channels. SB are usually about 1.5 m thick but also can reach thicknesses up to 3 m. SB widths vary between 20 and 40 m. The average width/thickness ratio of 19.3 within the whole studied area, of 21.8 at southern margin of Hostibejk Cliff, of 21.2 at northern margin of Hostibejk Cliff and of 20 at Lobeč Cliff.
3. Gravel bars and bed forms (GB) consist of Gcm and Gcc facies, with sharp erosional base. GB often erode sand bed forms and channels and have lobate geometry in some cases and/or sheet-like geometry in other cases. Gravel bar and bed form thicknesses are up to 2 m in most cases and also rarely up to 4 m. Gravel bar and bed form widths are up to 40 m at Hostibejk Cliffs but at Lobeč Cliff they reach up to 135 m. The average width/thickness ratio of gravel bars and bed forms is of 30.6 within the whole studied area, of 24.6 at southern margin of Hostibejk Cliff, of 15 at northern margin of Hostibejk Cliff and of 47.7 at Lobeč Cliff. Erosional relief of gravel bars and bed forms varies between 0.5 m and 4 m.
4. Sediment gravity-flow deposits (SG) consist of Gm facies, with sharp erosional base and geometry of elongate lobes. These deposits occur rarely at the Lobeč Cliff. Sediment gravity-flow deposit widths vary between 5 m and 7 m. The average width/thickness ratio of sediment gravity-flow deposits is up to 1 within the studied area. Erosional relief of sediment gravity-flow deposits is of 0.3 m.
5. Downstream accretion macroforms (DA) consist of Sc, Gcc and Gcm facies, e.g. consist of sand and gravel bed form deposits. Downstream accretion macroform thicknesses are up to 4.5 m and widths vary between 20 m and 40 m. Their geometry is sheet-like and average width/thickness ratio is of 13.8 within the whole studied area, of 16.3 at southern margin of Hostibejk Cliff, of 8.6 at northern margin Hostibejk Cliff. Downstream accretion macroforms were not recognized at Lobeč Cliff.

Palaeocurrent indicators from the Hostibejk Cliff show two major trends: to the NNW and to the NE. Only minor components of palaeoflow directions are to the S and to the SW. Measurements of the Lobeč Cliff display also two dominating directions striking W and E. Measurements taken from the Hostibejk Cliff are in a good agreement with expected position of the source area to the south (Pešek 1994) and direction of the main drainage, approximately to the north.

Hence depositional environment of the Hostibejk Cliff strata could be characterized by presence of vertically stacked channels forming multi-storey channel fill; downstream accretion; abundant occurrence of gravel bars and absence of overbank fine deposits (alluvial plain and/or floodplain deposits), what indicates that depositional environment of the Hostibejk Cliff could be interpreted as a complex fluvial low sinuosity streams. Depositional environment could be described as a system of probably braided channels, which

cut and eroded themselves and accreted down the stream. These channels are bounded by gravel bars. High dynamics and velocity of depositional current is reflected in grain size of deposits (coarse-grained sandstones and conglomerates), in sedimentary structures (abundant cross stratification) and in geometry of deposits (multi-storey channels, channel bed forms bounded by erosive surfaces, erosional relief of deposits up to 4 m). The absence of alluvial plain deposits could be explained either by their subsequent erosion by braided channels or as that fine alluvial plain deposits had not been developed due to sudden development and deposition of the complex braidplain. Plant and wood material content in Hostibejk Cliff deposits undoubtedly originated in alluvial plain but despite that Hostibejk Cliff streams were erosive, we should see some relicts of alluvial plain deposits exposed at Hostibejk Cliff. Thus, the interpretation is that a distant alluvial plain existed and plant and wood material was transported from there by braided streams, evolved to the braidplain. It must be noted that this interpretation is influenced by limited exposures in the Kralupy nad Vltavou area.

The palaeocurrent measurement analysis show relatively low spread of palaeocurrent vectors, which is characteristic for low sinuosity streams. The major trends of palaeoflows are to the NNW and to the NE and only minor directions of palaeoflows are to the S and to the SW. Therefore, we propose that the main sediment supply was from the SSE and from the SW generally to the N–NE.

On the opposite, the Lobeč Cliff strata should be characterized by different depositional environment than that recorded in the Hostibejk Cliff. Rare occurrence of gravel bars and generally finer grain size of deposits especially in the upper part of the Lobeč Cliff, indicate that depositional environment of the Lobeč Cliff represents complex of fluvial streams with higher sinuosity than streams of the Hostibejk Cliff. Depositional environment could be described as a complex of vertically aggrading channels, which partly cut into underlying ones. Dynamics and velocity of palaeocurrents probably decreased in time as indicated by fining upwards in grain size within the sequence exposed in the Lobeč Cliff (fine- and medium to coarse-grained sandstones), by sedimentary structures (horizontal lamination) and by geometry of deposits (erosional relief of deposits up to 2 m). However, it is not acceptable to interpret that Lobeč Cliff channels represent high sinuosity or meandering streams due to absence of lateral accretion macroforms (e.g. point bars) and presence of coarse-gravel channels and rare gravel bars only at the lower part of the Lobeč Cliff.

Comparison of fluvial styles of the Hostibejk and Lobeč Cliffs

Sedimentary record preserved in the Lobeč Cliff is interpreted as a product of deposition in higher sinuosity and lower dynamics streams in comparison to that of the Hostibejk Cliff. It is indicated by relatively higher spread of palaeocurrent vectors, which is characteristic for high sinuosity streams and by generally finer-grained nature of fluvial sediments.

Change from low sinuosity high dynamic braided river system (Hostibejk Cliffs) to higher sinuosity and less dynamic braided system of the Lobeč Cliff may be explained as a gradual change (in time) from one fluvial style to another one. Deposits exposed at northern margin of the Hostibejk Cliff display distinct vertical stacking pattern than deposits at the lower part of southern margin of the Hostibejk Cliff, where architecture of sedimentary record indicates lateral migration of channels and presence of multi-storey channels. The overlying Lobeč Cliff deposits, representing final depositional environment of higher sinuosity and lower dynamic streams flowing to the E, could record gradual change from vertically stacked channels of the Hostibejk II Cliff to the aggrading channels of the Lobeč Cliff. Thus, the Kralupy nad Vltavou successions represent gradual cessation of the initial high energy depositional conditions (Hostibejk Cliff) to the final lower energy depositional conditions (Lobeč Cliff). The change in palaeocurrent directions could be explained by the gradual change in dip of the basin floor, which could be the primary causation of the gradual change in depositional environments. Gradual change in dip of the basin floor could be related to gradual infilling of the basin with sediments or by changes in tectonic activity.

Another alternative explanation relates an existence of two different sedimentary environments to a short-term hiatus between the deposition of sediments exposed in Hostibejk and Lobeč Cliffs, which could be responsible for changes in tectonic settings and consequently for re-configuration of local palaeogeography / palaeotopography. Possible existence of such short-term hiatuses within the Nýřany Member was already mentioned by Wagner (1977) who studied floristic succession within this unit. In addition, the change in sedimentary environment can also be related to different stratigraphic position of sediments exposed in both cliffs which are separated by fault-bounded valley (Obrhel 1960). This fault can be responsible for juxtaposing of stratigraphically higher parts of the Nýřany Member exposed in the Lobeč Cliff against the basal part of this unit in the Hostibejk Cliff.

References

HOLUB V., 1997. Příspěvek ke stratigrafické interpretaci karbonu u Nelahozevsi. Zprávy o geologických výzkumech v roce 1996: 154-156.

MIALL A.D., 1996. The Geology of Fluvial Deposits. Springer, Italy.

OBRHEL J., 1960. Stratigrafie karbonu mezi Kralupy nad Vlt. a Nelahozevsí. Věst. ÚÚG, XXXV: 19-29.

PEŠEK J., 1994. Carboniferous of Central and Western Bohemia (Czech Republic). Czech Geol. Survey, Prague.

WAGNER R.H., 1997. Floral Palaeoecology of the Carboniferous/Permian. In: E. AGUIRRE, J. MORALES and D. SORIA (Editors), Cursos de verano de el escorial. Registros fósiles e historia de la Sierra, pp. 143-172.