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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, nonerosive 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 succession as distal fan-fringe deposits of base-of-slope fan supplied with sediment predominantly from the southern point spot source. Therefore, although less prominent in its basal proximal parts, the second megacycle shows many features similar to the first megacycle and can be interpreted in similar way. It recorded sedimentary evolution from lowstand slope-fan or slope-apron into distal base-of-slope fan as the sea-level gradually rose switching off the western linear source in favour of sedimentation of distal basin-plain deposits of the southern spot source. Both megacycles are separated by a sequence boundary.

Considering its sequence architecture the upper part of the Formation (Vikštejn Member) is poorly understood and requires further study.

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Niemcza Zone Granitoids – Durbachites in the Sudetes

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Durbachites and other ultrapotassic rocks belong to the oldest (340–330 Ma) Variscan magmatites. They have been described from the Moldanubian zone throughout the Variscan belt in the Western and Central Europe. Members of this suite range from K-rich gabbros to syenites and granites. They typically contain K-feldspar megacrysts in the matrix consisting of biotite, actinolite with rare relics of clinopyroxene, K-feldspar, plagioclase with accessory phase's apatite and zircon. The characteristic features for the whole suite are high concentrations of LILE (K, Rb, Ba), radioactive elements (U, Th), and REE, which are associated with high concentrations of Mg, Cr and Ni.

Durbachites form three large plutons on the south-eastern margin of the Bohemian Massif – Rastenberg, Třebíč, Jihlava, and several smaller bodies, cropping out mainly north of the Třebíč pluton.

Syenites and melanogranites from the Niemcza zone (Puziewicz, 1992) at the northern margin of the Bohemian Massif are compared with well-known durbachites from the Moldanubian Zone.

Granitic rocks from the Niemcza zone can be classified as granites, quartz monzonites and syenites. The amphibole-biotite-bearing granitoids contain up-to-3-cm-long phenocrysts of K-feldspar in a medium-grained matrix of granodioritic composition. They are ultrapotassic with a high concentration of MgO (4.0–5.6 wt. %) and K_2O (4.3–5.1 wt. %), and low Na_2O (2.4–2.5 wt. %). LILE are strongly elevated (Rb 138–197 ppm, Sr 506–607 ppm, Ba 1213–1758 ppm) as well as Cr and Ni (40–102 ppm). The REE normalized plot (Fig. 1) resembles durbachites from the Třebíč pluton by their strong enrichment in LREE, week negative Eu anomaly, and low HREE. A normalized plot of the trace elements (Fig. 2) indicates a lower concentration of U and Th in the durbachites from the Niemcza zone when compared with the Třebíč pluton. Such lower concentrations of radioactive elements are more typical for the Jihlava pluton.

The U-Pb dating of the Niemcza Zone syenites define a discordia with a lower intercept age of 338 ±3 Ma and an upper intercept age of about 1.8 Ga (Oliver, 1993). Ar-Ar ages on amphiboles from the Niemcza Zone reveal values of 335 ±5

Fig. 1. Prim normalised REE plot, durbachites from Třebíč pluton and durbachites from Niemcza zone (above). Prim normalised trace elements plot. Durbachites from Trebic pluton and Niemcza Zone (below).