trend in foraminiferal strategies indicates a thermal stratification of water columndue to input of cold and oxygenated polar waters into oceanic depths.

The major turn in red marl microfauna in the Tissalo section links with the Cenomanian/Turonian boundary when the rotaliporids disappeared in the planktonic foraminifer spectrum (Fig. 1). The decline of this fauna was caused by general reorganization of the latest Cenomanian oceanic regime, when the thermocline became unstable due to climate warming and subsequent water column homogenization. The rotaliporids settled in deeper part of the water column were exposed to larger ecological stress accompanying the expansion of oxygen minimum zone up to thermocline. Advancing warming at the end of Cenomanian produced general anoxy. This horizon has been determined in the Tissalo section, where three decimeter-scale intervals of black shales like the Bonarelli Beds (OAM 2) occur in the top of the Rotalipora cushmani Zone (Fig. 1). Lower Turonian foraminifer association from red marls above extinction horizon of rotaliporids is characterized by helvetotruncanid opportunistic fauna. Higher up in the Tissalo section, the first representatives of marginotruncanids became to appear in greater amount, which indicates return of meso- to oligotrophic conditions.

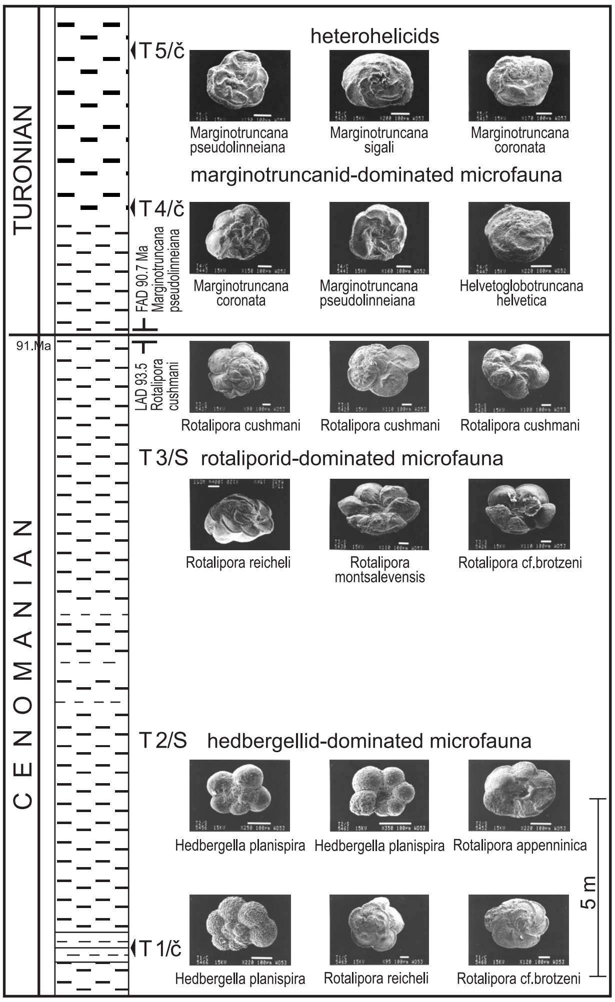

Fig. 1. Distribution of planktic foraminifers in the Tissalo section (Ukraine)

Turbidite Bed Thickness Distributions Applied in Interpretation of Submarine-Fan Depositional Environments of the Kyčera Beds (Rača Unit, Magura Group)

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Introduction

Turbidite bed thickness distribution is considered to be a useful tool for interpretation of submarine-fan depositional environments (e.g. Carlson, 1998, Carlson and Grotzinger, 2001, Talling, 2001). Statistic approach to bed thickness distribution could identify a stacking pattern of data commonly collected by geologists. Understanding on identiffication and interpretation of this patterns could therefore become an usefull cheap and effective complementary procedure in describing sedimentary processes and subenvironments. However, it can´t supply classical interpretations.

An adequate amount of data is required to relevant statistical data processing. Relative sufficient bed thickness data were collected during sedimentary research around Outer Flysch Carpathians in NW Slovakia. This paper provides demonstration how current understanding on statistical distribution was used in intrepretation of sedimentary deposition of Kyčera Beds (Eocene formation of turbiditic sandstones).

Background

The thickness of a turbidite bed at a given point within a sedimentary basin is determined by the shape of the bed and distance to the source, with bed shape depending upon factors such as intial sediment volume, grain size(s) and flow concentration. The frequency distribution of turbidite thickness thus records information on flow dynamics, initial sediment volumes and source migration which are important for reconstructing the evolution of ancient sedimentary basins (Talling, 2001). It has

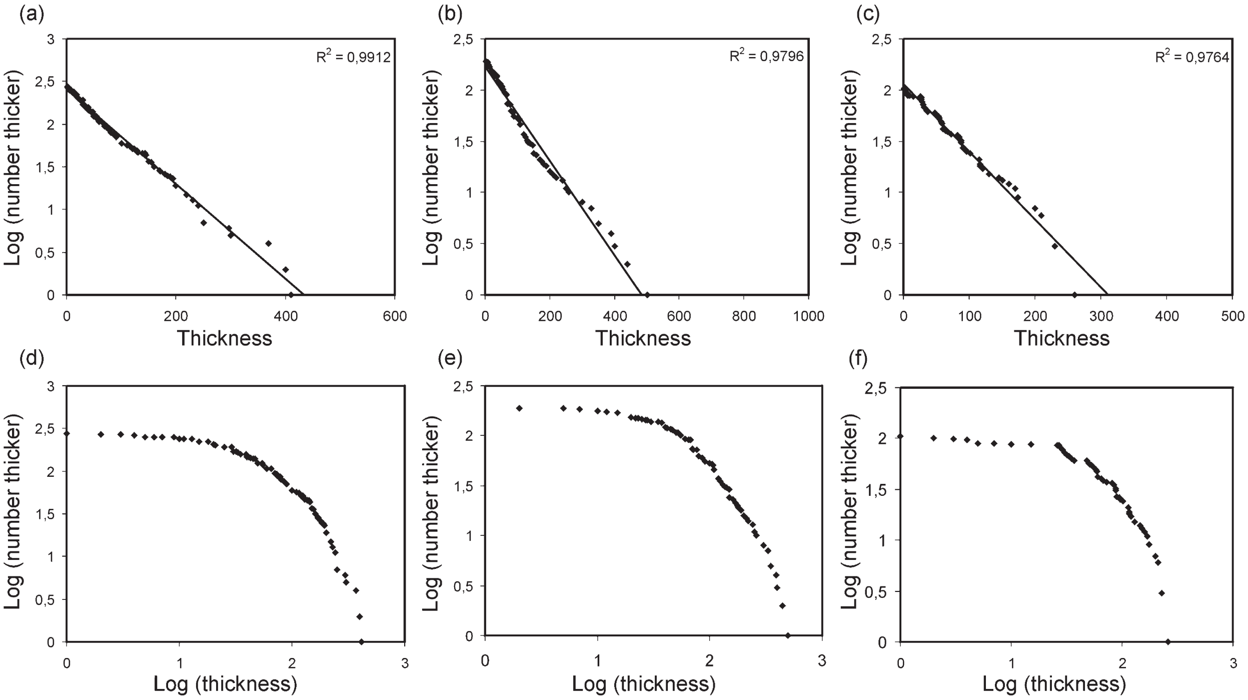

Fig. 1. Log-normal distributions from localities (a) Klubina, (b) Krásno nad Kysucou and (c) Veľké Rovné. The shapes of log-normal distributions from localities (d) Klubina, (e) Krásno nad Kysucou and (f) Veľké Rovné on logarithmic plot.

been proposed that different distributions may reflect different fan processes and environments (Muto, 1995, Carlson and Grotzinger, 2001 and others) and thus could be used as quantitative method to help identify this environments. A number of turbidite bed thickness studies have demonstrated power-law as well as log-normal frequency distributions (see Carlson and Grotzinger, 2001, Talling, 2001 etc.). Log-normal distribution has a linear shape on a plot of log (number of beds thicker) as a function of bed thickness whereas power-law distribution has a linear shape on a logarithmic plot of the cumulative distribution (number of beds thicker) as a function of the logarithm of bed thickness (Carlson, 1998). First simply model of submarine fan which illustrates how such factors as erosion and bed amalgamation can modify the shape of turbidite thickness distributions was established by Carlson and Grotzinger (2001). This model was constructed by testing the geological conditions that might generate a power-law distribution, so it describes the shapes of distributions on logarithmic plot. Moving systematically out into the basin, the shape of the cumulative bed thickness distribution starts with high degree of curvature for "channelized" sections, but gradually straightenss out in the thin-bedded region to obtain the original power-law distribution in more "distal" sections. These shapes qualitatively match the expectations of the shape of the cumulative distribution for upper (deeply channelized), middle (moderately channelized) and lower fan (minimally channelized) subenvironments (Carlson and Grotzinger, 2001).

An important assignment, which could be used in interpretations is that fan-lobe, channelized turbidites can be statistically differentiated from interfan, thin-bedded turbidites (Carlson, 1998). Log-normal distributions correlate best with fan lobe, channel deposits and power-law correlate best with interfan deposits. Although, Tallig (2001) suggested that turbidite thickness may be characterized by sumation of log-normal rather than power-law distributions, this suggestion do not entirely except previous described assignments. Power-law distributions presented by Talling (2001) may result from convolution of log-normal distributions for separate thin- and thick-bedded turbidites. This would imply that some bed thickness distributions that scale as power-laws result from the input of separate log-normal distributions. However, the same effect can also be accounted for by "finite scaling" effects, in which the thin end of the distribution is simply limited by restricted frequency of beds with small volume (Rothman et al., 1994, Carlson and Grotzinger, 2001), so until an accurate characterization is provided of how modern fan system behave, it is worth proceeding with multiple hypotheses and their assumptions (Carlson and Grotzinger, 2001).

Results

Data sets for this study all represent turbidite bed thicknesses of well exposed flysch sequences of the Kyčera Beds collected from localities Klubina-Zborov, Krásno nad Kysucou and Veľké Rovné (Rača Unit, Magura Group) in NW Slovakia. Data sets from localities Klubina and Veľké Rovné consit of continuously exposed bed thicknesses measured in unoccupied quarries. Data set from locality Krásno nad Kysucou comprise of discontinously exposed beds from road-cut. Kyčera Beds is the topmost lithofacial unit of the Rača sequence (Potfaj, 2002). Around described outcrops it consits of predominantly thick-bedded massive sandstones or positive graded sandstones. Coarse fraction is sometimes dispersed at the bottom part of thicker beds. Small pieces of fossil plants and mudstone rip-up clasts are present in some beds. Turbidite beds arranged from Bouma intervals are frequent.Thicker beds often consit of Bouma divisions A-E while thinner beds consit of D - E Bouma disvisions. Described sediments were deposited mainly from high-density turbidity currents and debris flows (Staňová and Soták, 2002, Starek and Pivko, 2001). Beds deposited from low-density turbidity currents occur less frequent.

In the analysis of the data we need to get an idea of the general shape of the bed thickness. In determining if datasets are well characterized by a log-normal distribution, we plot the cumulative distribution of the data, log (number thicker) as a function of bed thickness. This plot has a linear shape if the data is well characterized by a log-normal distribution (Carlson, 1998). The power-law distribution has a linear shape on a logarithmic plot of the cumulative distribution (number of beds thicker) as a function of the logarithm of bed thickness. It is not clear to identify observed distribution only by visual trend. The goodness-of-fit data to some statistical distribution are expressed through RSquare value obtained using statistical method known as least-squares regression. In other words, we compare predicted distribution with observed distribution.

Studied sedimentary sections consist of predominantly thick-bedded turbidites characterized by log-normal distributions. Goodness-of-fit data to log-normal distribution is expressed by R Square values higher than 0.9 (Fig. 1a, b, c), which means that more than 90% of data match to log-normal distribution. Curved shapes of distributions observed on logarithmic plots (Fig. 1c, d, e) best correlate with more proximal sedimentation where processes such as erosion and bed amalgamation are significant and were also identified in the field during sedimentological research (Potfaj, 2002, Staňová and Soták, 2002, Starek and Pivko, 2001). Carlson (1998) observed several datasets fit well the log-normal distribution, too. These datasets also commonly involved thick bedded facies, consistent with high-density turbidites. There is well-marked step on the shape of distribution observed from locality Veľké Rovné (Fig. 1f). This could be related to occurence of thick-bedded as well as thin-bedded sequences intepreted previously as fan-lobe (alternatively channel) deposits alternating with interchannel deposits (Starek and Pivko, 2001). This could correlate to previously observed “segmented” power-law distributions (Rothman and Grotzinger, 1995, Malinverno, 1997) reffered by Talling (2001) as sumation of a mixture of thin-bedded and thick-bedded turbidites. This produces a step in the trend of the probability plot for entire bed population.

Conclusions

This paper presented how current understanding on turbidite-bed thickness distributions could be useful in intepretations of submarine-fan environments. Observed shapes of turbidite bed thickness distributions together with classical interpretations for studied sequences match to previously interpreted mid-fan depositional subenvironments. It is certain that providing an universal statements for bed thickness distributions corresponding to depositional subenvironments could be therefore able to become an attractive instrument describing a submarine-fan environment in more detail fashion. However, there is still a lot of uncertainities and lack of more general applicable assumptions and more detail research is need to define any specific conditions.

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Pore Space Geometry of the Rock under Investigation by Ultrasonic Pulse Transmission

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The confining pressure-driven closing of the pores in the rock sample results in changes of the effective physical properties of the rock. In order to characterize spatial distribution of pores, the ultrasonic pulse-transmission based method is applied as a tool for the investigation of pore space geometry. With the use of apparatus developed by Z. Pros in Geophysical Institute (e.g. Pros et al., 1998) the measurements of P-wave velocities and amplitudes (V_P and A_P) in 132 independent directions on spherical rock samples are carried out at several steps of confining pressure within pressure-increasing and pressure-decreas-