Compositional Variations and Patterns of Conodont Reworking in Late Devonian and Early Carboniferous Calciturbidites (Moravia, Czech Republic)

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Summary

Compositional variations and grain-size properties of both carbonate constituents and conodonts as an alternative component group were used for interpreting the processes governing the deposition of upper Famennian and middle Tournaisian calciturbidites in Moravia, Czech Republic. Both the composition and grain-size properties of conodont element associations showed to be markedly dependent on facies type of their host sediment. Upper Devonian calciturbidite successions deposited on flanks of wide, Moravian - Silesian carbonate platform are composed mainly of echinoderm- and peloid-rich wacke/packstones and intraclastic float/rudstones (fine-grained calciturbidites, “normal” calciturbidites with Tab Bouma sequences, debris-flow breccias) with abundance of shelf- and shelf margin conodont taxa and epipelagic and “mesopelagic” conodonts. Upper Devonian calciturbidites deposited on slopes of volcanic sea-mounts are composed of echinoderm- and peloid-rich wacke/packstones and float/rudstones with increased proportion of intraclasts and volcanogenic lithoclasts (fine-grained calciturbidites, normal calciturbidites), yielding abundant conodont associations with higher proportion of “mesopelagic” taxa compared to the platform-flank examples. Middle Tournaisian calciturbidite succession composed of crinoid-, peloid-, intraclast- and lithoclast-rich lime mudstones, wacke/packstones and float/rudstones (normal calciturbidites and debris-flow breccias) yielded conodont element associations rich in shelf- and shelf-margin taxa, “mesopelagic” conodonts and reworked Middle- and Upper Devonian conodonts.

In general, the ratio of shelf- and shelf margin conodont taxa to “mesopelagic” taxa is distinctly lower in fine-grained calciturbidites than it is in normal calciturbidites and debris-flow breccias. Grain-size properties (mean grain size and sorting) and percentage of fragmented conodont elements, too, are markedly dependent on the facies type: in fine-grained calciturbidites the values of mean grain-size and fragmentation are low and the sorting is good to very good whereas in normal calciturbidites and debris-flow breccias the values of mean grain-size and fragmentation are distinctly higher and the sorting is poorer. The interdependence of facies type and composition and grain-size properties of conodont element associations in gravity-flow deposits is explained as resultant from hydrodynamic sorting during turbidity current flow and final deposition of the bed. Compositional variations observed in our sections may thus be attributed to facies variability (coarsening- and thickening-upward trends) rather than to sea-level fluctuations (highstand shedding of carbonate platforms). On the other hand, significant enrichment in reworked conodont taxa in middle Tournaisian normal calciturbidites compared to scarcity and/or absence of such conodonts in essentially identical facies of upper Famennian age indicate sea-level to be the major control governing such compositional variations, with low relative sea-level stand in middle Tournaisian and high relative sea-level stand in upper Famennian. Thorough analysis of conodont evolution, palaeoecology and taphonomy, with emphasis on understanding the processes of deposition of their host rock, are recommended for any biostratigraphic and biofacies study to be done in carbonate sediments deposited under strong hydrodynamic regimes, such as calciturbidites, tempestites, debris-flow deposits, shelf-edge oolitic sands, tidal-channel facies etc.

1 INTRODUCTION

Variations in grain composition of calciturbidites have shown to be useful markers of stratigraphy and sea-level history of their source carbonate platform areas (Everts 1991, Reijmer and Everaars 1991, Reijmer et al.1991). Careful studies of calciturbidite mineralogy, grain composition and bed-frequency gave rise to the concept of highstand shedding of carbonate platforms as an important tool in carbonate sequence stratigraphy (Droxler and Schlager 1985, Haak and Schlager 1989, Schlager et al. 1994). However, in thick calciturbidite successions of rather uniform grain composition with predominance of environment non-diagnostic grains, such as some Palaeozoic crinoidal turbidites (Tucker 1969, Davies 1977), the carbonate grains may fail to produce traceable compositional variations. In such and some other cases we can often find another fossil group abundantly present in calciturbidites — conodonts which are highly sensitive to various environmental conditions, such as water depth (Seddon and Sweet 1971), distance from the shoreline (Fahreus and
Fig. 1. Representative lithostratigraphic columns of the Moravian-Silesian pre-flysch magnafacies.

Barnes (1975) and physical and chemical parameters of seawater (McCull and Von Bitter 1976). Numerous reports on the relationship between composition of conodont assemblages and depositional environment resulted in definition of the concept of conodont biofacies (Druce 1973, Sandberg 1976). Conodont biofacies are determined on basis of mutual ratio between individual, environment sensitive conodont genera in assemblages deposited “in situ” in their host rock. As a rule, conodont biofacies are named for the one or two predominant conodont genera that must constitute at least 65 per cent of the total population of platform elements (Sandberg 1976, p. 181). The mandatory 65 per cent limit was advocated to be a threshold for “in situ” deposition of conodont elements by Sandberg et al. (1988) (70 per cent according to Ziegler and Sandberg 1990). The same authors reported conodont assemblages with percentage of two predominant genera lower than the limit as originating from downslope movements or erosion. Various other styles of post-mortem mixing of conodont elements were reported by numerous authors. Laboratory experiments by McGoff (1991) showed that hydrodynamic conditions of the ambient water played an important role in conodont element sorting as early as during the fall-out of conodont elements from the water column. Predation on conodonts, mostly by fish (Nicoll 1977), represents another way of mixing and transporting conodont elements before deposition in the host sediment. Further mixing is achieved due to various processes of resedimentation, e.g. by major storms and tsunamies (Dreesen and Thorez 1994), turbidity currents (Bábeck and Kalvoda 1999) and subaerial erosion (Kalvoda et al. 1999).

High sensitivity of certain conodont groups to environmental conditions makes them an ideal tool for interpretation of depositional environments of their host rock. In addition, abundant occurrence of conodonts in resedimented carbonates allows us to use these fossils for environmental interpretations of their source areas. In this paper, we studied quantitatively the relationships between composition of conodont element associations and various facies and microfacies types of their host rocks in selected sections of Upper Devonian and Lower Carboniferous calciturbidites and other gravity-flow deposits of the Moravian – Silesian Basin. The principal aim was to test whether compositional variations of conodont elements in calciturbidites (if any) reflect any sensitivity to facies changes, relative sea-level changes in their source areas and/or whether they can indicate certain stratigraphic trends and processes such as progradation or erosion. In addition, we studied the relationships between grain-size of calciturbidite facies and granulometric patterns of the conodont element associations using a detailed grain-size analysis.

2 GEOLOGICAL SETTING

The Moravian-Silesian basin, located at the eastern margin of the Bohemian Massif, is considered to represent an eastward continuation of the Rheno-Hercynian Zone of the Variscan fold-belt (Engel et al. 1983, Franke 1995). During the Devonian and Lower Carboniferous the basin evolved within an overall extensional regime into a system of halfgrabens with three distinct magnafacies: Moravian...