Stratigraphic Architecture of Cenomanian Palaeovalley Fills, Central Part of the Bohemian Cretaceous Basin: Interplay of Base-Level Change and Tectonic Influences

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The relationship between relative sea level (base-level) changes at the shoreline and the changes in adjacent non-marine depositional systems remains one of the main challenges in sequence stratigraphy. Case studies of coastal-plain fluvial systems correlated to coeval shallow-marine strata are needed for better understanding of the controls on fluvial stratigraphic architecture. We present a study of fluvial to estuarine palaeovalley systems of Cenomanian age from the central part of the Bohemian Cretaceous Basin (Czech Republic). The palaeovalley fills were examined in outcrops and boreholes with the aim to interpret the local and regional (autogenic, allogenic) controls on the temporal and spatial changes in regional depositional geometries of non-marine strata as well as the variability in fluvial styles.

The tectonic framework of the study area was governed by three main structural phenomena: (1) The NW-oriented Labe Fault Zone, reactivated as a broad, dextral strike-slip fault zone during the mid-Cretaceous; (2) the NNE-oriented Blanice- Rodl Fault Zone, forming a conjugate (sinistral) fault zone to the Labe Fault Zone; (3) ENE – oriented fold and fault pattern of the Palaeozoic Barrandian terrane. These structural patterns controlled not only the trends and the topography of a palaeovalley system, characterized by a series of tributaries joining one major, NNE-oriented valley, but, in more tectonically active areas, also the clastic supply.

Understanding the spatial and temporal distribution of individual stratal complexes in the fluvial palaeovalley fills involved correlation between scattered outcrops to the south of the Labe FZ and subsurface (core/well log) data. This was attempted by using a combination of sedimentological analysis and outcrop gamma-ray spectrometry as the bridge between the outcrop and subsurface databases. The correlation between well logs spaced between hundreds of meters to 11 km showed that the fluvial palaeovalley fills contain a number of regionally correlatable surfaces of different genetic-stratigraphic significance, which separate stratal packages showing different lithologies, and, in outcrop, different architectures.

Two prominent types of surfaces were distinguished which could be correlated regionally and stood for key stratigraphic surfaces. The first type, termed an expansion surface, is defined by a pronounced fining in the grain size up to mud in well logs and organic rich lacustrine facies in outcrops, and reflects an expansion of the fine-grained floodplain facies at the expense of the coarse-grained channel facies. The second type, an erosion surface, is characterized by an abrupt coarsening in the grain size in well-logs, associated with erosion.

From the viewpoint of architectural changes across the key surfaces, the strata overlying the erosion surfaces are characterized by the dominance of coarse-grained channel fills, laterally and vertically strongly interconnected, interpreted as braided river deposits. Strata overlying the expansion surfaces are characterized by sheet-like sandbodies encased in floodplain fines, interpreted as meandering river deposits, or by mudstones with isolated channel-fills and local splay sandstones, with sparse occurrence of marine microplancton, which are interpreted as anastomosing river sediments.

Based on regional correlation of the above surfaces from proximal (fluvial) to distal (coastal, estuarine) facies, expansion surfaces are correlated with marine flooding surfaces and are interpreted as a result of a flooding of the palaeovalley, caused by an acceleration of the rate of base-level rise. Erosion surfaces are correlated with sequence boundaries caused by base--level falls with regional incision and slope rejuvenation or are coincident with the bottom of pre-sedimentary palaeovalleys. Expansion surfaces were not always identified. This could be caused by erosion of previously existing expansion surface by channel incision leading to channel facies amalgamation or due to persistence of main channels in the axial parts of the valleys.

The regional slope and the activity of local tectonic elements, such as the Kouřim Fault, were the main controls on the incised channel courses. The style and thickness of incised channel fills show a decrease in grain size in the direction away from the active fault, and a transition from a broad braided-stream valley fill, towards more localized, tidally influenced, heterolithic channel fills, in the same direction.

In general, the observed changes in fluvial facies and stratigraphic architecture are interpreted to reflect allogenic controls (base-level change), with local modification by autogenic factors such as local sediment supply, fault activity or depositional topography.

Syndepositional Geometry and Post-Depositional Deformation of the Krkonoše Piedmont Basin: A Preliminary Model

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The Krkonoše Piedmont Basin (KPB) belongs to a system of post-orogenic extensional / transtensional basins which formed in the Bohemian Massif in the early post-orogenic phase, between the Westphalian and Saxonian times (c. 310–280 Ma). Most of the basins in Western and Central Bohemia are aligned along the NE-striking boundary of the Saxothuringian Zone of the Varsican orogen, with minor modifications of the structural picture caused by NW-oriented fault zones and small basins formed at a later stage (Stephanian) along NNE-oriented faults such as the Rodl / Blanice Fault Zones. The KPB has long been known as an exception to this trend, with its axis in the present-day geological picture having a generally E-W orientation.

Our study focused on the question of how much the present-day structural orientation and geometry of the basin reflects its original shape and the syndepositional tectonic regime, and to which extent it was influenced by later, post-depositional deformation. The information on the degree and style of deformation of the KPB is critical for understanding the tectonic regime of the basin inception and the syn-depositional phase of basin evolution. We present a working hypothesis that attempts to put together a simplified picture of the main phases of basin deformation between the Autunian and Late Cenozoic times. It is based on a combination of morphostructural interpretation of the digital elevation model (DEM), compilation of existing geological and geophysical data, Landsat TM imagery, field documentation of meso-scale kinematic indicators, and evidence in the sedimentary / volcanic basin fill.

The dominant deformation within the basin fill occurred as dextral strike-slip along NW-oriented fracture systems, accompanied by sinistral movements on a conjugate system of NNE-oriented structures. This is very similar to the dominant dextral sense of movement along the NW-oriented shear zones documented by many authors from the Variscan orogenic phases in the broad area of the Sudetic and Labe / Lu•ice Fault Zones. In the KPB, the paucity of firm evidence for the timing of the post-sedimentary deformation causes us to rely on a series of indirect lines of evidence if we want to reconstruct the pre-deformational geometry of the basin. The hypothetical model of successive phases of basin deformation which we present is therefore strongly simplistic and the proposed amounts and styles of strike-slip deformation in individual time-slices are rather crude estimates. Furthermore, because of the lack of data we do not consider the possible magnitudes of vertical movements which accompanied the strike-slip deformation.

The restoration of the strike-slip movements along the NW-oriented fracture systems leads us to interpretation of the initial basin shape as an extensional structure formed along originally NE-oriented normal faults, in a way analogous to the Central and Western Bohemian basins parallel to the Saxothuringian/Teplá-Barrandian Zones. Prior to the development of the Autunian/Saxonian unconformity, the basin had a generally half-graben shape, with maximum subsidence located near its NE margin (northern margin in present-day geometry).

A phase of intense, largely brittle, deformation of the basin fill and surrounding crystalline units is interpreted to have occurred between the Autunian and the Saxonian, when the Trutnov–Náchod sub-basin of the KPB formed as a pull-apart structure governed by dextral slip on NW-oriented strike-slip faults. This sub-basin is interpreted as an independent basin structure superimposed on the KPB. During the same time interval, the Orlice Basin opened further southeast, probably at an overstep of the same fault zone which forms the southeastern margin of the Trutnov-Náchod sub-basin. We suggest that the opening of these pull-apart basins was accompanied by the segmentation of the older infill of the KPB along NW-oriented fault zones and the main phase of dextral translation of individual segments. This deformation, with subsequent erosional modification, ultimately led to the current approximately east-west orientation of the basin margins, without a necessary involvement of block rotation about vertical axes. (Very little or no rotation is implied by existing palaeomagnetic data.)

Further reactivations of the same fault systems occurred during the Mesozoic and Cenozoic, and contributed the deformation of the basin fill. In the mid-Cretaceous, opening of the Bohemian Cretaceous Basin system involved dextral reactivation of the Labe / Lu•ice and Sudetic fault zones, with uplift of the areas NW of the KPB, which became source areas (Uličný, 2001 and references therein). Because the subsidence in the main depocenters probably did not exceed 1 km over 11 My of the Bohemian Cretaceous Basin lifetime, the comparison with experimental data (Hempton and Neher, 1986) suggests that the magnitude of displacement of boundary faults such as the Lu•ice Fault Zone did not exceed a maximum of c. 8 km. Most deformation during the Cretaceous was probably accomplished by small amounts of slip at a large number of fractures in the broad areas between the bounding faults.

The last phase of major deformation is attributed to the Palaeogene when several phases of NNE-NNW – oriented compression caused thrusting at the Lu•ice and Hronov-Poříčí Fault Zones and some adjacent structures (Coubal, 1990). No firm evidence is found in the KPB of significant involvement of the later phases of deformation, recorded in the northern part of the Bohemian Massif: the opening of the Ohře Rift during the late Oligocene-early Miocene, and subsequent deformation phases of the Late Cenozoic (Adamovič and Coubal, 1999; Špičáková et al., 2000).

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