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الرمز البريدي : ١٢٣
مسقط – سلطنة عمان

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Review/evaluation of the Doctoral Thesis

*Analysis of depositional controls and provenance of the Upper Paleozoic and Mesozoic deposits and its implication for tectonosedimentary evolution of the northern Bohemian Massif*

By **Roland Nádaskay**

Charles University
Faculty of Science
Institute of Geology and Paleontology
Study program Geology

Praha, 2021

Dear PhD Board/Committee Members,

This is my evaluation of the thesis.

**Abstract**

The abstract informs about what was generally done and also about some of the new findings. It would have been slightly better to shift the balance between these two aspects more towards the novel results.

**Preface**

The Preface informs that the Candidate fulfills the requirement of three published articles in journals with impact factor. In these three publications, the Candidate is two times the lead author, and one time the second author, which is commendable. His curriculum vitae reveals that he has a track record of publishing his research in the form of articles and abstracts (conference attendances) since 2014 which is commendable as well.

**Introduction**

In the Introduction, the reader is at first informed about general aspects of basin evolution covering aspects such as lifespans, inversion, fault reactivation, isostatic and non-isostatic factors as well as tectonic long-distance effects in orogenic forelands. Then some main tectonic and basinal evolutionary trends of Central Europe are summarized.

The aims are listed focusing on specific open questions related to the tectonic and basin evolution of the study area. Table 1 occurs in the Introduction but is not referred to in the Introduction text.

The text continues with a summary of the geology of the study area, especially the Late Paleozoic – Mesozoic basins, beginning with the terrestrial Late Paleozoic (to Triassic) via marine Jurassic to mainly marine Cretaceous basins and successions.

The applied methods are diverse. Sedimentological outcrop and core analyses, emphasizing lithofacies, architectural elements and lateral facies correlations, paleocurrents, utilizing well-logs and gammaspectrometry, microscopy, XRF, Sr isotope geochemistry, biostratigraphy, detrital zircon geochronology and heavy mineral provenance analysis provide substance and prestige to the thesis.

The Introduction ends with an extensive review of the intricate Late Paleozoic and Mesozoic tectonosedimentary development of the study area, covering also paleogeographic aspects.

**Chapter 1**

Similar to the Abstract mentioned above, the Abstract of Chapter 1 stays also a bit too general at times instead of providing more tangible, definite and new information. Here is one example. It is said that the Krkonoše Piedmont Basin displays striking tectonostratigraphic similarities to other early Variscan basins which are left unmentioned. The reader is left wondering which basins are meant.

The first chapter deals with the climatic and tectonic impacts on Permian fluvial depositional systems. The Asselian Vrchlabí Fm. of the Krkonoše Piedmont Basin is identified as a fluvio-deltaic system which grades laterally into lacustrine deposits via microdeltas. The fluvial succession is characterized by sandstone and conglomerate, interpreted to represent channel fills of a braided river system. Floodplain deposits are also present. Intervals of base-level changes and lake expansion were observed, too. The latter is attributed to humid periods. This progress in the understanding of the Vrchlabí Fm. is significant as the respective area exhibits only sparse outcrops. It was in parts achieved by analysis of borehole data and newly acquired outcrop gamma-ray logs. This way, lateral and vertical relationships between the fluvial, the 'transitional' and the lake facies at the basin-scale were possible. The system is controlled in parts by tectonics and partly to climate.

This characterization is convincingly based on the interpretation of lithofacies and architectural elements, outcrop gamma-ray and well well-logs but considers accommodation/supply ratios as well. The identification of architectural elements and their interpretations are nicely listed in the bulk text and also in the convenient Table 1, leading to the establishment of five facies associations (multi-storey and single-storey fluvial channel bodies, floodplain, deltaic and lacustrine), professionally depicted in Figure 6 and exemplarily documented in combined outcrop photographs and line drawings of the Figures 7 to 12, which are professionally designed and executed.

In the discussion, aspects/causes of missing evidence for vegetation are addressed (no rootlets, high water table). On this basis (and also on other grounds), one can rule out that the fluvial system was an anastomosing one.

All Conclusions are sound and reasonable.

Some numbers occur in the text, which seem to stem from the line numbering of the submitted manuscript (212/p. 68; 308/p. 72; 331/p. 75; 379/p. 77; 403/p. 77). They must have been overlooked during the deletion after copying and pasting the manuscript text.

*Note 1*
A braided fluvial system is not only a product of tectonics and climate. It is also a reflection of a relatively steep slope gradient. Thus, the occurrence of floodplain deposits is interesting as among braided river systems, floodplain deposits are usually poorly developed in parts because of the slope gradient which assures rapid and almost linear drainage and because in such settings, well-developed lateral "plains" (as in "floodplains") are often absent, except for the South Sasketchewan-type. I wonder whether the identified system represents this type, but the braided river system was not typified.

*Note 2*
Although the setting is a piedmont basin, there is no discussion on the changing slope gradient and its effect on the style of the river system, except for a brief remark on page 90, referring to a change of color and except for Figure 13 which shows a down-current change in terms of the occurrence of floodplain deposits and scarce vegetation.

The presence of microdeltas (not fan-deltas!), however, may point to a relatively gentle slope gradient in vicinity of the deltas. It is imaginable that a relatively coarse-grained braided system existed in the upper part of the piedmont basin (relatively steep slope gradient; upper longitudinal stream profile) and a finer grained South Sasketchewan-type braided system closer to the microdeltas (relatively gentle slope gradient; lower longitudinal stream profile). I wonder whether the channel fills of the upper stream profile are coarser, and if so, to which degree. Does a tendency towards coarse Scott-type braided river deposits exist?

The distributary/migrating channel system in the floodplain area as depicted in Figure 13 is unusual for a braided river system with the main river splitting up into several branches in down-current direction, unless a delta is meant to be depicted, but this is not indicated, but – on the other hand - at an active delta, the shoreline should advance which is not portrayed either.

**Chapter 2**

This Abstract is more informative than the two previous ones with respect to novel information.

The second chapter is dealing with the stratigraphy and tectonosedimentary development of a Late Cretaceous offshore siliciclastic succession. The succession of the Bohemian Cretaceous Basin was biostratigraphically studied, using inoceramids and nannofossils. The obtained biostratigraphical data were combined with Sr isotope curves (Sr stratigraphy) and geophysical logs for lateral correlations of near-shore to deltaic deposits. Moreover, six sequences were identified and defined, ranging from the latest Turonian to the Early-Middle Coniacian. Accumulation of the sediments ensued partly during increasing water depth and partly by progradation. Progradation is indicated by pronounced siliciclastic influx to the offshore zone, causing changes in the calcareous nannofossil assemblages. Three major transgressive events have been identified, too. These have been controlled by subsidence, and in one case partly also by a rising eustatic sea-level. Accelerated subsidence was tectonically controlled. This subsidence and source area uplift to the NW of the basin fall into the early Ilsede interval of the Late Cretaceous.

After all relevant aspects have been thoroughly introduced, the results are clearly presented. The studied sequence is now characterized by curves of gamma radiation, geochemistry, $\delta^{18}O$, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ (Figures 10 and12), which is a true progress and a precious tool to match/correlate other well cores and outcrops in the future. This may also hold true for the identified sequences and their correlation with the relative and eustatic sea-level curves (Figure 15).

All of the Conclusions are, again, sound and reasonable.

*Note 3*
The interpretation of the detached sandy turbidites as isolated "singled turbidites" *sensu* Vail et al. (1991) is plausible and valid while the interpretation as a Type III system *sensu* Mutti (1985) is not as the latter consists largely of mudstone and actually represents a "system", namely a "channel-levee complex" which is not identified in the study area. Further interpretations (amalgamated turbidites; p. 139-140) are not supported by evidence either. There is no evidence for a distributary system for turbidity currents (Not "turbidites" as I read! Turbidites cannot be distributed in channels, as they are already deposited and consolidated.)

**Chapter 3**

The third chapter is treating the Permo-Mesozoic tectonosedimentary development of the study area from the perspective of detrital zircon geochronology and heavy mineral provenance. The detritus derived not only from the West Sudetic Island. Very interestingly, it is concluded that some material derived from a formerly present Late Jurassic to Early Cretaceous basin that blanketed the Lusatian Block and had been fed with Baltic-derived detritus. This basin was eroded in the course of progressive unroofing of the West Sudetic Island. Much of the eroded material accumulated in the Bohemian Cretaceous Basin. The incomplete depositional record of the study area (gaps during the Middle Triassic–Early Jurassic, mid-Cretaceous, post-Early Campanian) is attributed to reactivation of major NW-SE-striking strike-slip fault zones related to Jurassic to Early Cretaceous rifting of the North Atlantic, and to Late Cretaceous convergence of Iberia, Africa and Europe.

The topic is, again, thoroughly introduced, supported by excellent maps (Figures 1 to 3).

In the Geological Setting, information related to Early Triassic deposits of the study area would have been desirable. There should be rocks of this age as the Early Triassic is not part of a depositional gap. Early Triassic deposits are also not shown on the stratigraphic chart (Figure 4).

On page 163 it reads "dolomitic limestones and dolomites", but it should read "dolomitic limestones and dolostones".

The heavy mineral analysis and the resulting spectra are well and clearly documented in text, in tables (Tables 1 and 2) as well as in Illustrations (Figures 6 and 7). The spectral changes from the Permian to the Jurassic and from the Jurassic to the Cretaceous are significant.

The method of the zircon U-Pb dating is also thoroughly introduced. Coinciding with the changes of the heavy mineral spectra, the results reveal changes in the age spectra between the Permian and Jurassic as well as between the Jurassic and Cretaceous. Other changes in age spectra were detected during the Turonian and between the Coniacian and Santonian Figures 9 and 11). The age spectral groups III and IV are interpreted as representing a distant source from the southern margin of Baltica which has been removed by erosion. The other age spectra represent lithological units or complexes that are still present in the study area or beyond.

The analyses are able to tell when certain source areas were active sediment suppliers and when such source areas became inactive and when certain source areas were important contributors. Figure 13 shows which regions represented source areas and which regions represented basinal domains at different times. Creating Figure 13 reflects a painstaking work and a love to detail. This work enriches and broadens the horizons of the reader. It represents a new and detailed paleogeographic data set.

The Conclusions are justified.

**Decision**

It has been a pleasure to read this thesis. Thank you for the invitation to review it! Please note me as a volunteer to review the Candidate's future Habilitation Thesis!

On 197 pages, this color-illustrated thesis investigates the post-Variscan tectonostratigraphic evolution of the northern Bohemian Massif. The English text is well-written (foreign language) and also well-organized. The literature work is substantial, solid and robust with a list of seemingly more than 300 relevant domestic and international regional as well as general literature references (cumulative in the three chapters).

The thesis is interesting and informative as it contains a wealth of reviewed data and a wealth of novel information in terms of results and interpretations. The thesis is well-written, well-organized and well-illustrated. Modern principles, models and techniques are applied. It represents a significant progress in the understanding of the topic. The thesis amply demonstrates the Candidate's geological and literature knowledge and ability, his methodical and technical-professional skills as well as his dedication to geological research and his methodical flexibility.

My thoughtful/corrective remarks are only of minor importance. What they refer to is by not questioning any of the main findings of the thesis.

The thesis has successfully passed my evaluation and I strongly and wholeheartedly recommend its acceptance.

Frank Mattern

Al-Khodh, March, 12th, 2021

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