

# **Palynology of Triassic/Jurassic boundary key sections of the NW Tethyan Realm (Hungary and Slovakia)**

Vom Fachbereich Material- und Geowissenschaften  
der Technischen Universität Darmstadt  
zur Erlangung des akademischen Grades eines  
*Dr. rer. nat.*  
genehmigte Dissertation

von

Dipl.-Geol. Katrin Ruckwied  
aus Weiterstadt



Referent: Prof. Dr. Matthias T. Hinderer  
Koreferentin: PD Dr. Annette E. Götz

Tag der Einreichung: 4. Januar 2008  
Tag der mündlichen Prüfung: 4. April 2008

Darmstadt 2009  
D17

# Table of Contents

## Curriculum Vitae

## List of Figures

## Abstract

<b>1. Introduction</b> .....	1
<b>2. Materials and Methods</b> .....	3
2.1 Study areas.....	3
2.2 Sampling procedure .....	6
2.3 Palynofacies analysis .....	6
2.4 Systematic palynology.....	7
2.5 Palaeo-ecogroups .....	7
2.6 Multivariate statistics.....	8
2.7 Geochemistry.....	10
2.8 Clay mineralogy.....	11
<b>3. Geology</b> .....	11
3.1 Palaeogeography.....	11
3.2 Stratigraphy.....	13
3.2.1 Definition of the Rhaetian.....	13
3.2.2 Definition of the Hettangian.....	13
3.2.3 Definition of the Triassic/Jurassic boundary.....	13
3.3 Sediments and lithofacies.....	15
<b>4. Palynofacies</b> .....	24
4.1 Principles of palynofacies analysis.....	24
4.2 Palynofacies Components.....	24
4.2.1 Phytoclasts (plant and wood remains).....	24
4.2.2 Amorphous Organic Matter (AOM).....	25
4.2.3 Degraded Organic Matter (DOM).....	26
4.2.4 Palynomorphs.....	26
4.2.4.1 Phytoplankton Subgroup.....	26
4.2.4.2 Zoomorph Subgroup.....	28
4.2.4.3 Sporomorph Subgroup.....	29
4.3 Percentages and Ratios.....	31
4.4 Palynofacies data.....	31
4.4.1 Tatra Mountains.....	32
4.4.2 N Hungary.....	35
4.4.3 S Hungary.....	39
<b>5. Systematic Palynology</b> .....	39
5.1 Palynology definition.....	39
5.2 Systematic classification of palynomorphs.....	39
5.2.1 Terrestrial Palynomorphs.....	40
5.2.1 Aquatic Palynomorphs.....	53

<b>6. Biostratigraphy</b> .....	54
6.1 Biostratigraphy of the Triassic/Jurassic boundary interval.....	54
6.2 Current palynostratigraphic zonations.....	57
6.3 Microfloral zonation of the studied Rhaetoliassic material.....	58
6.4 Correlation with established zonations.....	62
<b>7. Palaeoclimate reconstruction</b> .....	63
7.1 Palynomorphs and their botanical affinity.....	63
7.2 Taxonomy and ecology of mother plants.....	67
7.3 Sporomorph ecogroups.....	72
7.4 Changes within the palynomorph assemblages and possible causes.....	74
<b>8. Palaeoenvironmental interpretation of the studied areas</b> .....	77
8.1 Tatra Mountains.....	77
8.2 S Hungary.....	79
8.3 N Hungary.....	80
<b>9. Summary</b> .....	82
<b>10. Outlook</b> .....	85
<b>11. References</b> .....	87

**Plates**

**Appendix**

## *Curriculum Vitae*

Name: Katrin Ruckwied

Wohnort: Van Bleyswijkstraat 45  
2613 RR Delft  
Niederlande

Geburtstag: 07.11.1977

Geburtsort: Weiterstadt

### Schulische Ausbildung:

1984 – 1986 Carl-Ulrich Schule Weiterstadt  
1986 – 1994 Albrecht Duerer Gesamtschule Weiterstadt  
1994 – 1997 Eleonorenschule Darmstadt  
1997 Abitur

### Studium:

1997 – 2003 Diplomstudium Geologie und Palaontologie and der  
Technischen Universitaet Darmstadt

2003 Diplom

### Beruflicher Werdegang:

2003 – 2007 Wissenschaftliche Mitarbeiterin an der Martin-Luther  
Universitaet Halle-Wittenberg

seit 2007 Stratigraphin in Shell International Exploration & Production,  
Rijswijk, Niederlande

## List of Figures

**Fig. 1:** Generic-level extinctions of marine organisms during the past 300 m.y., modified from Sepkoski (1996) and Olsen et al. (2002).

**Fig. 2:** Geographic map of the Tatra Mountains. Stars are indicating the studied sections.

**Fig. 3:** Geological map of the N-Hungarian Csóvár area.

**Fig. 4:** Geographic map of the Mecsek area in South Hungary

**Fig. 5:** Studied sections in Slovakia and Hungary.

**Fig. 6:** Classification of sedimentary organic matter used in this study (modified after Steffen & Gorin 1993; in Götz et al. 2008).

**Fig. 7:** The Shelf of the Neotethys ocean branch during Upper Rhaetian times (Haas 2001) and location of the study areas (1 – Tatra Mountains, Slovakia; 2 – Csóvár, N Hungary; 3 – Mecsek Mountains; S Hungary).

**Fig. 8:** Geological Units of Central Europe (Haas & Török 2008) and location of the study areas (1 – Tatra Mountains, Slovakia; 2 – Csóvár, N Hungary; 3 – Mecsek Mountains; S Hungary)

**Fig. 9:** Succession of potential marker events for definition of the Triassic/Jurassic (T/J) boundary, primarily based on the New York Canyon area, so exact position of radiolarian turnover is uncertain. The FADs of *P. pacificum* and *P. planorbis* may be equivalent, but this is uncertain (modified after Lukas et al. 2006).

**Fig. 10:** The Furkaska section, field work summer 2005.

**Fig. 11:** Upper Rhaetian basinal deposits with turbidites, Csóvár section (N Hungary).

**Fig. 12:** Half-graben structure of the E Mecsek Mountains with sediments of Triassic and Jurassic age (from Haas 2001)

**Fig. 13:** Overview of the Pécs coal pit, spring 2006 (Mecsek Mountains).

**Fig. 14:** Characteristic small-scale sedimentary cycle (Pécs coal pit, Mecsek Mountains).

**Fig. 15:** Tuff layer within the lowermost Jurassic Middle Seam Group (Vasas coal pit, Mecsek Mountains).

**Fig. 16:** Coal seams within the Karolinavölgy Sandstone, Lampas-völgy

**Fig. 17:** Schematic sketch of the sediments of the Triassic/Jurassic boundary interval (720-780 m), Komló core 176 (after Hönig 1972; internal report in Hungarian).

**Fig. 18:** Schematic sketch of the sediments of the Triassic/Jurassic boundary interval, Komló core 137.

**Fig. 19:** Schematic representation of the life cycle of modern prasinophyte algae (modified after Tyson 1995).

**Fig. 20:** Schematic representation of the life cycle of modern dinoflagellate cysts (modified after Tyson 1995).

**Fig. 21:** Life cycle of a typical gymnosperm plant (modified after Traverse 1988).

**Fig. 22:** Pteridophyte (left) and Bryophyte (right) life cycle (modified after Traverse 1988).

**Fig. 23:** Relative abundance of palynomorphs (marine plankton, pollen grains, spores) of total sedimentary organic matter (palynomorphs, phytoclasts, degraded organic matter),  $\delta^{13}\text{C}$  signature and TOC distribution; Furkaska section (from Michalík et al., submitted). The turnover in bed 408 marks the palaeoenvironmental change within this interval.

**Fig. 24:** Palynofacies of the uppermost Rhaetian of the Hybe section (Tatra Mountains). A continuous increase of spores is observed during the complete interval.

**Fig. 25:** Palynofacies within the Triassic/Jurassic boundary interval of the Kardolína section (Tatra Mountains).

**Fig. 26:** Biostratigraphical data of the Csóvár section (after Pálffy et al. 2007).

**Fig. 27:**  $\delta^{13}\text{C}$  isotope data (Pálffy et al. 2007) and palynofacies data of the Csóvár section. A simultaneous spore and prasinophyte spike occurs in the same interval as a negative isotope excursion.

**Fig. 28:** PCA plot for the Furkaska section. Principle plane for components 1 and 2.

**Fig. 29:** Hierarchical tree plot of the Furkaska data set.

**Fig. 30:** Spore spike within Rhaetian sediments of the Mecsek Mountains as stratigraphic correlation tool.

**Fig. 31:** The “Neves effect”. Transport of different palynomorph morphotypes in different depositional environments (after Chaloner & Muir 1968).

**Fig. 32:** Distribution of clay minerals, T/J boundary interval of the Furkaska section (from Ruckwied et al. 2006).

**Fig. 33:** Palaeoenvironmental reconstruction of the Tatra Mountains during Rhaetian-Hettangian times (from Michalík et al. 2007).

**Fig. 34:** Palaeoenvironment reconstruction of the two vegetation phases detected in the Mecsek Mountains, S Hungary.

**Fig. 35:** Palaeoenvironmental reconstruction of the Transdanubian Range (N Hungary) during late Triassic – early Jurassic times (modified after Galács 1988).

**Fig. 36:** Distribution of Early Jurassic plateau basalts of the Central Atlantic Magmatic Province (CAMP), from McHone (2000).

## **Abstract**

Late Rhaetian/Hettangian microfloras of three depositional environments of the NW Tethyan realm have been studied: platform to basinal limestones of the Csóvár section (N Hungary), shallow marine limestones and marls of the Tatra Mountains (N Slovakia) and terrestrial coal deposits of the Mecsek Mountains (S Hungary). The analysis of the palynological assemblages and palynofacies patterns builds the base for interpretation and comparison of the different depositional environments. Additionally, the sporomorph distribution and diversity are investigated with respect to environmental and climatic change within the Triassic/Jurassic boundary interval and the processes that may have caused these changes. A striking spore spike was detected in all depositional areas studied. Palynological investigations were accompanied by geochemical (stable isotope) and clay mineral analyses. The results of this integrated analysis point to a relatively sudden climatic change most probably caused by the volcanic activity of the Central Atlantic Magmatic Province (CAMP) associated with the onset of rifting of Pangaea during early Mesozoic times. The data obtained in the course of this thesis strongly support this interpretation and depositional series of Hungary and Slovakia proved to be key sections of the NW Tethyan realm.

## **Kurzfassung**

Palynomorphen-Assoziationen und die Zusammensetzung der sedimentären organischen Substanz der Trias/Jura-Grenze wurden in Profilen Ungarns und der Slowakei untersucht, welche drei unterschiedliche Ablagerungsräume der NW Tethys-Schelfregion darstellen: distale Plattform-Beckenablagerungen (Csóvár), proximale Flachwasserablagerungen (Tatra) und fluviatil-lakustrine Kohleablagerungen (Mecsek). Schwerpunkt der Arbeit war die Dokumentation der Palynomorphen und der Palynofazies anhand kompletter Profile von marinen und kontinentalen Ablagerungsserien. Stratigraphische und laterale Variationen in der Zusammensetzung der Palynofazies wurden hinsichtlich eines klimatischen Wechsels innerhalb dieser Zeitscheibe analysiert. Ein charakteristisches Sporen-Signal konnte in allen Regionen nachgewiesen werden. Darüber hinaus zielten die Untersuchungen darauf ab, Veränderungen des Paläoenvirments anhand der unterschiedlichen Palynomorphen-Assoziationen nachzuweisen. Dazu dienten ebenfalls Isotopen- und Tonmineralanalysen. Die Ergebnisse dieser Untersuchungen liefern einen wesentlichen Beitrag zur Klärung der Umweltveränderungen an der Trias/Jura-Grenze, deren Ursache und den globalen Zusammenhängen. Der Einfluss der relativ kurzzeitigen, starken vulkanischen Aktivität der mittelatlantischen Magmen-Provinz (CAMP) im

Zusammenhang mit den plattentektonischen Ereignissen (Pangäa-Rifting) wird als Hauptursache für die Umweltveränderungen im frühen Mesozoikum angesehen. Die neu gewonnenen Daten aus dieser Arbeit liefern dazu wichtige Belege und die untersuchten Ablagerungsserien Ungarns und der Slowakei haben sich als Schlüsselprofile der NW Tethys-Schelfregion erwiesen.