Fair-Weather versus Storm Influence on Upper Neogene Delta Systems, South Carpathians Foredeep, Romania

Sedimentationsbedingungen unter Berücksichtigung von Sturmereignissen an Deltasystemen im oberen Neogen der Südkarpatischen Vorsenke, Rumänien

by

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with 10 Figures and 1 Table

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Contents

Abstract

Three vertical profiles of Dacian age (late Neogene) from the South Carpathians foredeep (Romania) were investigated in detail from sedimentologic point of view. Fifteen facies types were distinguished on the basis of grain size and primary sedimentary structures. They reflect depositional conditions ranging from low to high energy. Three distinct facies successions were recognized and attributed to depositional environments: wave influenced delta, storm influenced delta and interdistributary bay. The first two successions are both characterized by an overall coarsening and shallowing upward trend, starting with prodelta muds and ending with high energy distributary mouth bar sands. The difference between the two successions is marked by the processes being active at the delta front/shoreface. The first succession was mainly influenced by fair weather, the second was dominated by storms. The interdistubitary bay represents a shallow water and low energy environment, where the background sedimentation is interrupted by catastrophic events (channel crevassing, storms). The facies successions reveal an upward increase of fluvial influence and a basinward progradation of the deltas. Even though, the environments can be characterized as wave (storm) influenced deltas. Thus the delta morphology may have fluctuated between cuspate and slightly lobate.

Kurzfassung

Die vorliegende Arbeit beschreibt die sedimentologische Untersuchung dreier vertikaler Profile in Ablagerungen des Dacicum (oberes Neogen) aus der Süd-Karpatischen Vorsenke Rumäniens. Auf Grund von Korngrössen und sedimentären Gefügen wurden fünfzehn Fazies unterschieden die von unterschiedlichen Ablagerungsenergien abhängig sind. Es wurden drei Faziesassoziationen rekonstruiert, die folgende Faziesräume darstellen: wellenbeeinflusstes Delta, sturmbeeinflusstes Delta und Deltabucht. In den ersten zwei Assoziationen ist ein gradueller Übergang von prodeltaischen Tonen zu groben Ablagerungen der Mündungsbarren zu beobachten. Der Unterschied zwischen den beiden besteht in den Ablagerungsprozessen, die die Deltafront/Vorstrand-Zone beherrschen: Schönwetter-, beziehungsweise Sturmbedingungen. Die Deltabucht ist von niederenergetischer Flachwassersedimentation charakterisiert, die von katastrophischen Ereignissen unterbrochen wurde (Stürme, Hochwasser). Die Faziesassoziationen dokumentieren eine Progradation der Deltas, die von Wellen und Sturm beeinflusst wurden. Als Folge könnte die Form der deltaischen Körper zwischen lobat und kuspat variiert haben.

1. Introduction

In Dacian age (late Neogene) (Tab. 1) deltaic sediments were deposited in the foredeep of the Romanian South Carpathians, in the Dacic Basin, a partially isolated basin of the Central Paratethys (Fig. 1A). The study area is located between the Topolog and Olt river (Fig. 1B).
Because the Dacic Basin represented the connection between the Eastern and Central Paratethys, the Upper Neogene deposits of this region have been investigated in various

Ma	Tethys		Paratethys
	Pliocene	Piacentian	Romanian
5		Zanclean	Dacian
	Miocene	Messinian	Pontian
		Tortonian	Meotian
10			Sarmatian
		Serravalian	
15		Langhian	Badenian
		Burdigalian	
20		Aquitanian	
25	Oligocene	Chattian	

Tab. 1 Stratigraphic overview of the Upper Neogene of the study area, ages corresponding to local nomenclature for the Outer Romanian Carpathians (MATENCO 1997). Tethys-Paratethys correlation after ROEGL (1996).

Tab. 1: Stratigraphische Übersicht des oberen Neogen des untersuchten Areals, die Alter entsprechen der lokalen Nomenklatur der Externen Rumänischen Karpaten (MATENCO 1997). Tethys-Paratethys Korrelation nach ROEGL (1996).

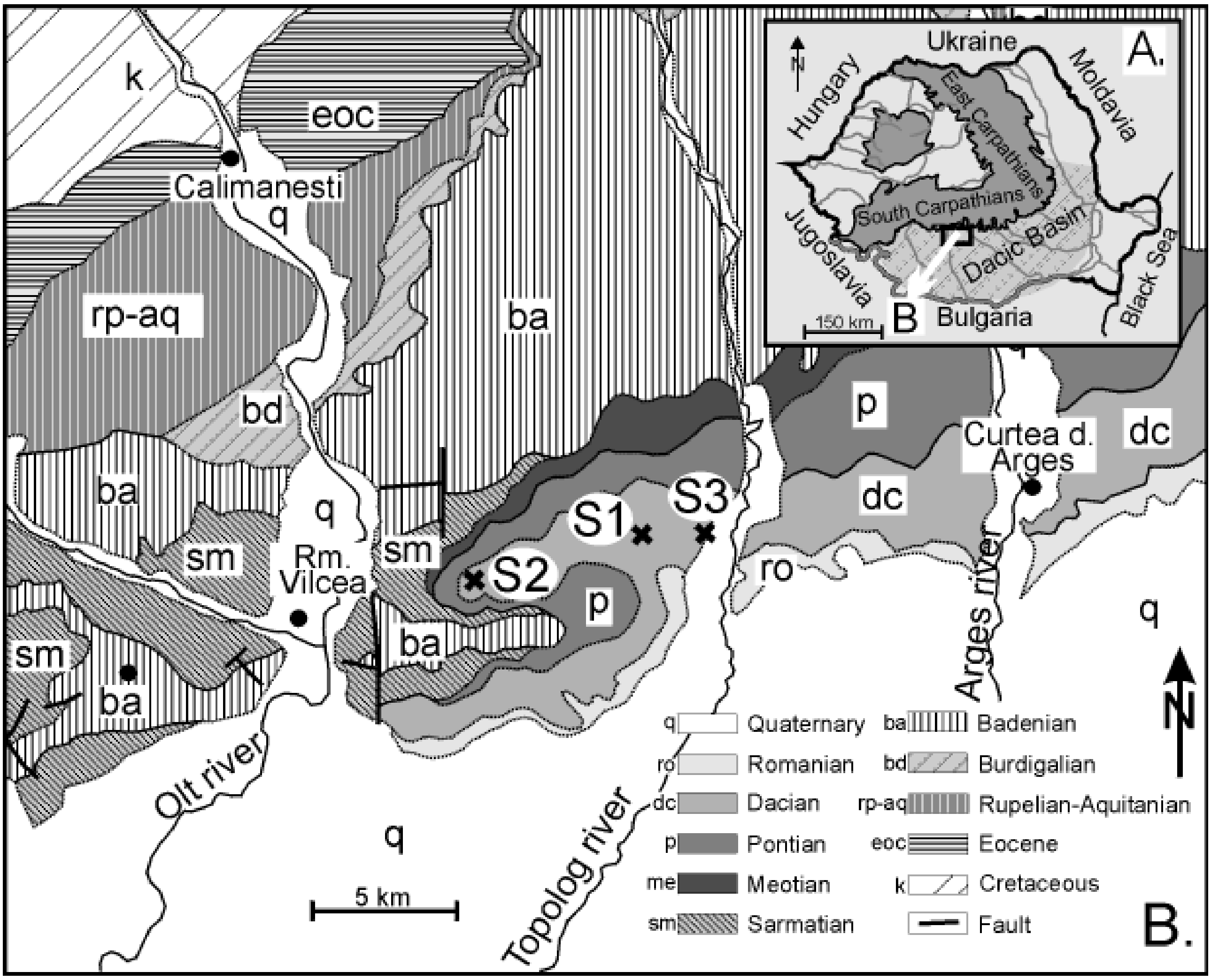

Fig. 1: Location of the study area. S1, S2 and S3 represent the outcrops where the three profiles were investigated.

Abb. 1: Lageübersicht des Studiumgebietes. Die aufgenommenen Profile sind als S1, S2 und S3 markiert.

paleontologic, stratigraphic and paleogeographic studies by other workers (Andreescu 1986, Enciu et al. 1995, Givulescu et al. 1995, Marunteanu & Papaianopol 1995, Papaianopol et al. 1985) . Also some sedimentological work has been carried out by Anastasiu & Iordache (1993), Jipa et al. (1996), Jipa (1997), and recently Derer (1999).
The Dacic Basin was during the Dacian a brackish water basin (with brackish-lacustrine environments) (Andreescu 1986, Marinescu & Papaianopol 1986), which during Romanian age competely changed to fresh water settings (due to isolation and fluvial input). The clastic sediments were derived mainly from the South Carpathians in the North, which at that time suffered an important uplift (Matenco 1997). Even though smaller source areas are believed to have existed to the South (Jipa 1997).
Mainly unconsolidated sandstones and mudstones are exposed, more to the West also coal deposits can be found. Through the whole section brackish to freshwater molluscs are abundant.
For a better understanding of the various sedimentary environments and their relationships, three vertical profiles were investigated by detailed sedimentologic logging and sequence analysis. The profiles consist of Dacian deposits, however their exact stratigraphic correlation was not possible. The three sections reflect different depositional environments, which will be discussed in the following.

2. Facies descriptions

During field work several facies were distinguished by grain size, shale to sand ratio (their nature of interbedding), and primary sedimentary structures. Using these criteria 15 facies types were identified. They are presented in the order of increasing depositional energy.

Facies F1. Massive to poorly laminated mud (thickness 1-100 cm)
Description: Massive or poorly laminated black mudstone, interbedded with almost all other facies.
Interpretation: Subaqueous suspension deposits, low energy. Occurs in most environments, predominates below normal wave base.

Facies F2. Cross-laminated silty mud (thickness 10-20cm)
Description: Silty sets of unidirectional cross laminae interbedded with mud. Sometimes the depositional structure is deformed, small folds and balls and pillows are present.
Interpretation: Predominant low energy environment (below wave base) with mud deposition from suspension, disturbed by low density flows. The deformation may be induced by high pore-water content and/or by the existence of a depositional slope. Occurs only in the prodelta environment.

Facies F3. Mud and Sand with lenticular bedding (thickness 5-70 cm)
Description: Sand lenses imbedded in massive mud. The internal structure of the lenses shows either uni- or bidirectional cross-lamination.
Interpretation: Indicates two energy stages: slack water and higher wave/current energy. The conditions for deposition and preservation of mud dominate.

Facies F4. Sand-mud with flaser or wavy bedding (thickness 5-7 cm)
Description: Cross-bedded sand with mud streaks in the troughs and partially on the crests (Fig. 2). The mud is sometimes bioturbated.
Interpretation: Two energy stages: high wave energy and slack water. Conditions for deposition of sand prevail. Transitions between F3 and F4 are possible.

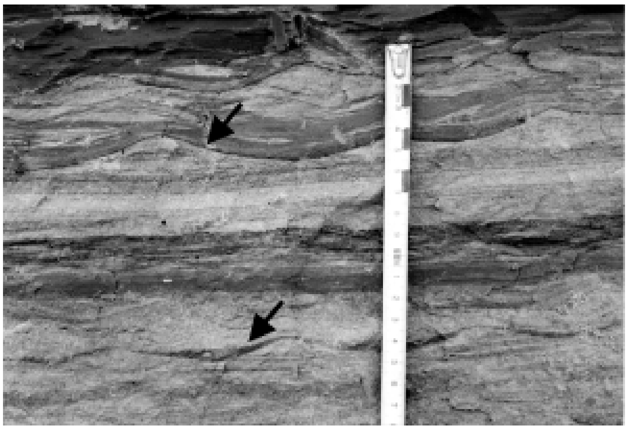

Fig. 2: Facies F7: sand with wave ripples (upper arrow); facies F4: sand and mud with flaser bedding (lower arrow). The scale is divided in cm.

Abb. 2: Fazies F7: Sand mit Wellenrippeln (oberer Pfeil); Fazies F4: Sand und Ton mit Flaserschichtung (unterer Pfeil). Das Messband ist in cm eingeteilt.

Facies F5. Cross-bedded sand (thickness 10-100 cm)
Description: Small and medium scale (foreset laminae less than 50 cm long) unidirectional cross-bedding (trough, planar cross-bedding), sometimes the rippled top is preserved.
Interpretation: Migration and deposition of subaqueous ripples and small dunes from unidirectional currents.

Facies F6. Sand with climbing ripple cross-lamination (thickness 10-20 cm)
Description: Climbing ripple lamination with only the lee side preserved: type 2 in drift lamination (JOPLING & WALKER 1968 fide REINECK & SINGH 1973) (Fig. 3).
Interpretation: Deposition by currents under conditions of high and continuous sediment supply.

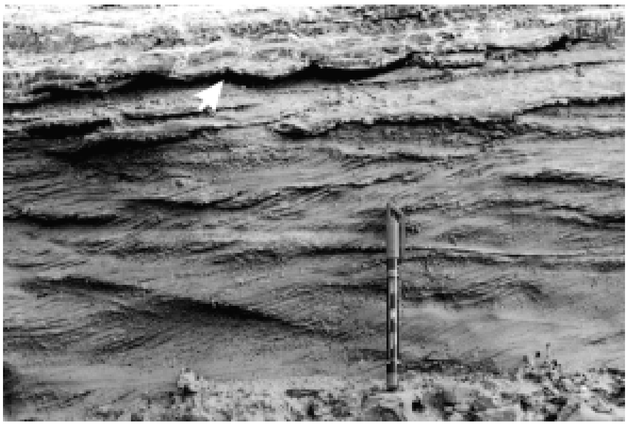

Fig. 3: Facies F6: sand with climbing ripple lamination, the top reworked by waves (arrow). The pencil is 15 cm long.

Abb. 3: Fazies F6: Sand mit „climbing ripple" Lamination, Top von Wellen aufgearbeitet (Pfeil). Stift ist 15 cm lang.

Facies F7. Sand with bipolar (wave) ripples (thickness 3-15 cm)
Description: Ripples with sharp to rounded ripple crests, internal structure shows bidirectional or opposed unidirectional cross-lamination (Fig. 2). Wave length 5-10 cm, ripple height 1-3 cm. Often interbedded with thin mud layers.
Interpretation: Wave generation in shallow water environment, at and above normal wave base (upper shoreface).

Facies F8. Horizontally-laminated sand (thickness 3-30 cm)
Description: Sand with mm-thick horizontal laminae
Interpretation: Subaqueous deposition from unidirectional currents (upper plane beds) or oscillatory movement.

Facies F9. Sand with hummocky cross-stratification (thickness 30-50 cm)
Description: Sets of laminae with convex and concave up curvature. Is part of a more complex tempestite sequence (see further in the text and Fig. 4).
Interpretation: Storm origin, generated by strong oscillatory dominated combined flow (DUKE et al. 1991). Lower shoreface, below fair weather wave base.

Facies F10. Massive sand (thickness 10-100 cm)
Description: Structureless sand, sometimes with pebble-gravel outsized clasts and shell fragments. Plant debris occurs in some cases.
Interpretation: Rapid deposition from turbulent suspension (e.g. storm event), or sediment gravity flow (MIALL 1996). Layers could have lost their internal structure also due to

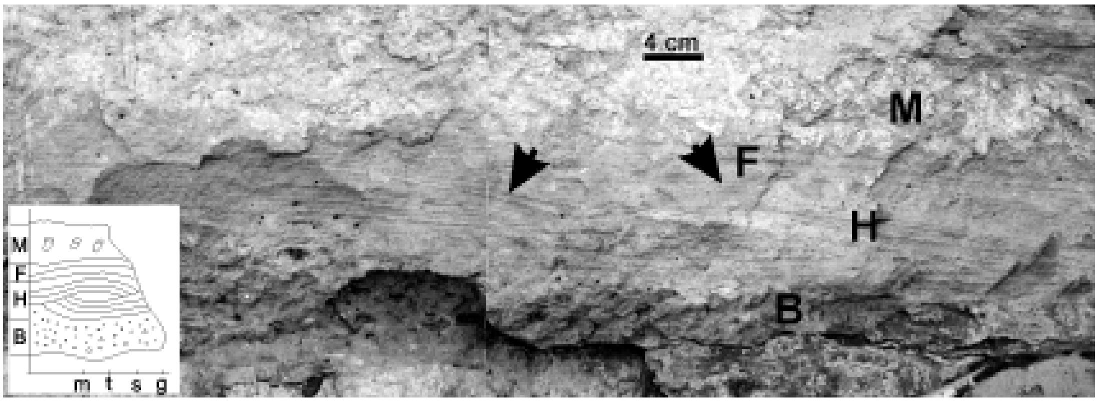

Fig. 4: Tempestite sequence with hummocky cross-stratification compared with the ideal sequence after WALKER et al. (1983). B-base, H-hummocky, F-flat lamination, M-bioturbated sand and mud. Hummocks indicated by arrows.

Abb. 4: Sturmsequenz mit Beulenrippeln. Vergleich mit der idealen Sequenz nach WALKER et al. (1983). B-Basis, H-Beulenrippeln, F-horizontale Lamination, M-Sand und Ton mit Bioturbation. Pfeile zeigen die Beulenrippeln an.

dewatering processes.

Facies F11. Sand with large scale cross-bedding (thickness 70-500 cm)
Description: Sand with sets of unidirectional laminae (50 cm to several m long). Gravel-sized clasts occur as thin lag deposits, or on bedding lee face. Water escape structures are present.
Interpretation: Dune migration and deposition from powerfull currents. Occurs only in the distributary mouth bar and distributary channel.

Facies F12. Cross-stratified gravel (thickness 5-50 cm)
Description: Grain-supported, pebble-gravel sized facies with unidirectional cross bedding. Occurs seldom.
Interpretation: Deposition by single powerfull events (i.e. during river avulsion).

Facies F13. Massive, grain-supported gravel (thickness 20 cm)
Description: Structureless, clast-supported pebble to gravel sized facies.
Interpretation: It occurs below wave base and might be given by a single powerfull current flowing down the delta front (low-strength, pseudoplastic debris flow (MIALL 1996).

Facies F14. Massive, matrix-supported gravel (thickness 10-110 cm)
Description: Structureless, matrix-supported pebble-gravel, with shell fragments and mud clasts.
Interpretation: Strom layers deposited by powerfull currents and rapid deposition. Mainly below fair-weather wave base.

Facies F15. Deformed Sand (thickness 20-60 cm)
Description: Fine to medium-grained sand and subordinated mud, characterized by soft sediment deformations. Primary structure cannot be recognized.
Interpretation: Deformation due to high fluid content in sediment pores (due to rapid deposition), sometimes combined with the presence of a depositional slope.

3. Facies successions

Facies successions represent units which have a process-oriented significance. They are composed of genetically related facies bounded by major surfaces of nondeposition or erosion. Within a succession the depositional characteristics change gradually, exhibiting a certain pattern (shallowing up, etc.).
Three distict facies successions were recognized (represented by the three studied profiles respectively, see Fig. 1B): 1. wave influenced delta, 2. storm influenced delta, (the dominant influence process was established within the delta front sediments) and 3. interdistributary bay. The first two successions belong both to marine influenced deltas. They are differentiated by the dominance of fair-weather and storm conditions respectively. In this context is the wave influenced delta mainly under the impact of fair-weather waves. The distinction between facies succession 1. and 2. will be discussed in the folowing.
Because of the interference between fluvial and receiving basin processes, the equivalence prodelta-offshore, delta front-upper shoreface was considered (BHATTACHARYA & WALKER 1991).

3.1. Facies succession 1 (S1): Wave influenced delta

The succession of a wave influenced delta (Fig. 5) is about 20 m thick and shows a coarsening- and thickening-up trend. From base to top of the section a relative increase in the proportion of sand is observed.
The succession starts with prodelta/offshore mud (facies F1) and cross-laminated silty mud (F2). The deformation structures (balls and pilows and small slumps) certify an instability, probably resulting from the rapid sedimentation of mud and the existence of a palaeo-depositional slope.
Towards up in the section, the facies becomes gradually more sandy, passing into F3, but is still dominated by mud. In between the mud dominated facies types several coarser units occur, which are interpreted as of storm deposits generated on the lower shoreface. They are represented by

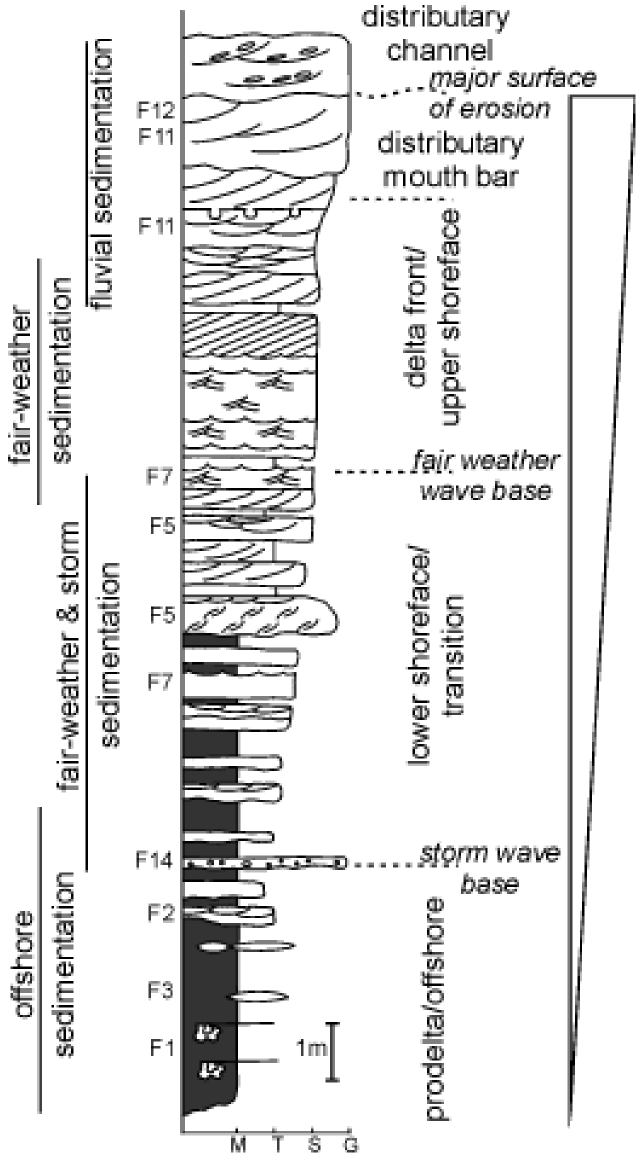

Fig. 5: Facies succession S1, characteristic for a wave influenced prograding delta. The coarsening upward succession is bounded by a surface of low deposition at the base and by a major surface of erosion at the top. Legend in Fig. 6.

Abb. 5: Faziesassoziation S1, ein progradierendes, welleneinflusstes Delta. Die „coarsening-upward“ Sequenz ist an der Basis von einer Fläche geringer Sedimentation und am Top von einer erosionalen Fläche begrenzt. Legende in Abb. 6.

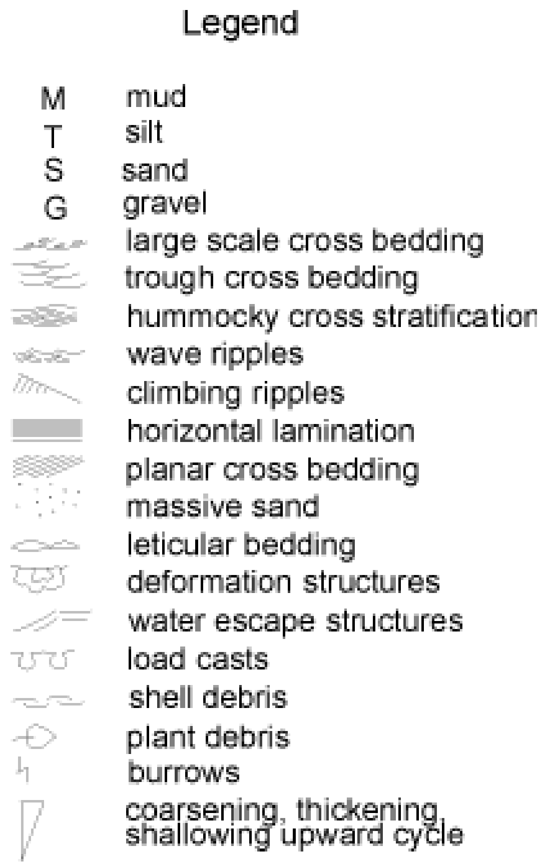

Fig. 6: Legend for Figures 5, 7 and 9.

Abb. 6: Legende zu den Abbildungen 5, 7 und 9.

erosion based facies F13, F14 (structureless grain-, respectively matrix-supported gravel) and F10 (massive sand with shell and plant debris). Beside these more or less single-layer storm deposits, tempestite microsequences were identified. A sequence starts with an erosional base, followed by a massive sand/gravel unit with a high percentage of shell fragments (*Dreyssena* sp.), which has wave ripples on its top. Finally, bioturbated cross-laminated silty mud, covers the top. These microsequences (which are up to 15 cm thick) show a fining upward pattern, reflecting the storm erosion, deposition, and waning. Three of such micro-sequences are present. Nevertheless due to possible amalgamation, it is difficult to point out single storm events.

The occurence of bimodal ripples (F7) marks the fair weather-wave base and the start of the upper shoreface to deltafront sedimentation. It is dominated by wave motion: approximatively 2 m of facies F7, interbedded with thin and often bioturbated mud layers (F1). Transitions to wavy and flaser bedding are present (F4) (Fig. 2). The sandstones gradually pass upward into horizontally-laminated and cross bedded units (F8, F11 respectively), being interpreted as upper shoreface to foreshore deposits. Also massive sandstones (F10) and loading structures are present in this part of the section. These features might result from higher sediment input into the basin during river avulsion.

At the top of the upper shoreface section an important erosional surface occurs which is overlain by several meters of large scale cross-bedded sands (facies F11) with rip-up mudstone clasts. These sands represent probably the fluvial distributary, or its mouth bar prograding basinward.

Conclusion: Facies succession 1 appears as a shallowing upward sequence, which represents the progradation of the wave-influenced deltaic shoreline. From base to top of the section a proximal to distal trend can be observed: from prodelta/offshore muds to upper shoreface/delta front sands and finally to distributary-mouth bar deposits. This sequence also reflect the change in energy acting on the sediment.

Parallel to shoreline progradion (i.e. towards up in the succession, facies becomes more proximal) the lacustrine processes are gradually replaced by the fluvial processes. Even though, the delta front/shoreface deposits were clearly affected by normal weather waves which were capable of reworking the fluvial sediment input. Threrefore, facies succession 1 is interpreted to result from a wave-influenced delta where sedimentation mainly took place under fair weather conditions.

3.2. Facies succession 2 (S2): Storm influenced delta

The facies succession of a storm influenced delta (Fig. 7) measures about 30 m in thickness and exhibits, similar to facies succession 1, an overall coarsening- and thickening upward pattern. Even though several small-scaled fining up sequences (< 1m) are present throughout the section. Compared to the other facies successions, the coarser grain size prevails (highest sand to mud ratio).

The lower part of the section (about 20 m) is dominated by sediments which are interpreted as storm deposits. Several types of tempestites are identified. Type 1 tempestite is represented by single or amalgamated massive, matrix-supported pebbles (facies F14) with a high amount of disarticulated shells and shell fragments. Sometimes the lower part of the layers show normal grading. The geometry of this type varies from sheet to scour-fill. Type 2 tempestites starts with an erosional base which is overlain by a basal shell lag or rip-up mud clasts, low angle cross-bedding, small scale trough cross-bedding and sometimes at the top fine sand with deformation structures. Type 3. tempestite is a fining upward micro-sequence, containing hummocky cross-stratification: the erosional base is overlain by a basal lag of pebbles, followed by hummocky cross-stratification and flat to slight undulatory lamination. At the top bioturbated sand or mud occurs. Type 2 and 3 appear complete or with missing members. The most complete type 3 tempestite is similar to the ideal sequence described by Walker et al. (1983) (Fig. 4).

Even though three different tempestite types were described, they all exhibit common features: a sharp erosional base (scours, gutters, etc.) and a fining upward pattern. Their deposition took place below normal wave base (lower shoreface) under high energy conditions in a waning storm regime (Aigner 1982). The background sedimentation (reflected by massive mud, F1 and in mud imbedded sand lenses, F3) is almost competely overprinted by storm conditions. Due to erosion and amalgamation which led to composite beds, it is difficult to resolve single storm events. Towards the top of the facies succession 2, cross-bedded sand (facies F5) becomes dominant, sometimes interbedded with mud. Some of the sandy units represent costal bars, as

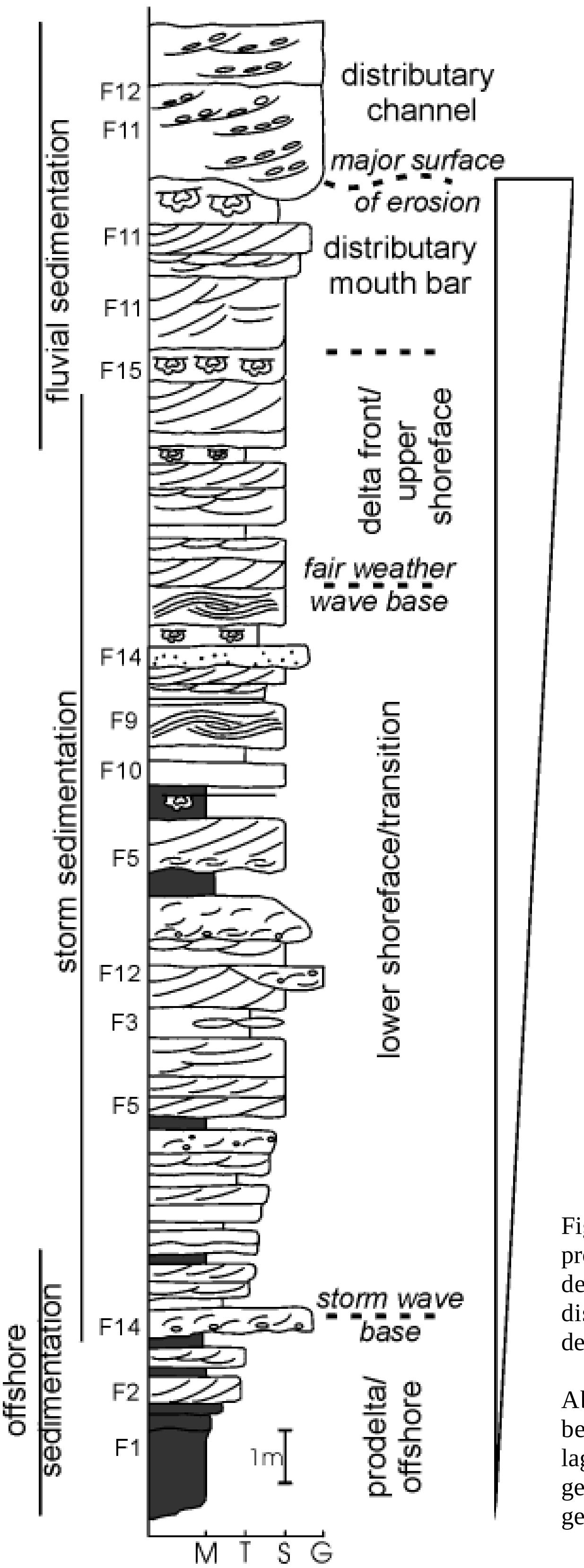

Fig. 7: Facies succession S2, characteristic for a storm influenced prograding delta. The succession contains a high amount of storm deposits. It is capped by a surface of erosion, followed by distributary channels and underlain by a surface of reduced deposition. Legend in Fig. 6.

Abb. 7: Faziesassoziation S2, ein progradierendes, sturm-beeinflusstes Delta. Enthält einen hohen Anteil an Sturmab-lagerungen. Die Assoziation ist von einer Erosionsfläche gekappt, gefolgt von Mündungsrinnen. An der Basis ist sie von einer Fläche geringer Sedimentation begrenzt. Legende in Abb. 6.

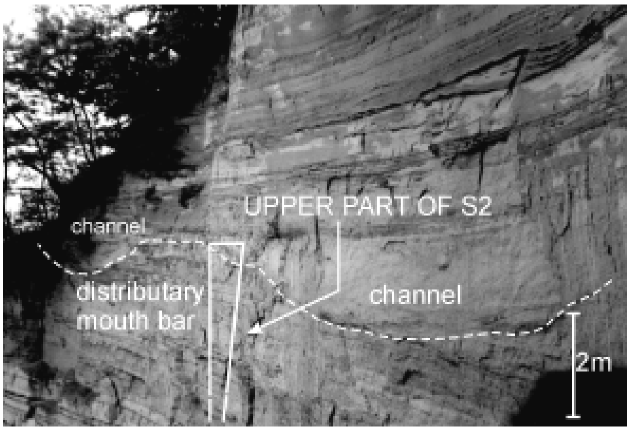

Fig. 8: Picture representig the upper part of facies succession S2 (Fig. 6). The incized channels underlain by the surface of erosion are visible.

Abb. 8: Der obere Teil der Faziesassoziation S2 (Abb. 6). Die erosionale Oberfläche und die Mündungsrinnen sind sichtbar.

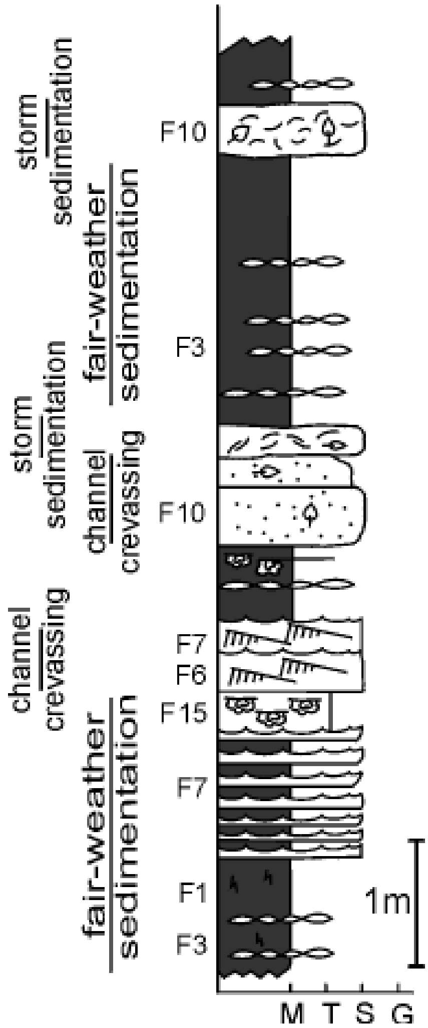

Fig. 9: Facies succession S3: representing deposits of an interdistributary bay. Background sedimentation is interrupted by storms and channel crevassing. Legend in Fig. 6.

Abb. 9: Faziesassoziation S3: Ablagerungen einer Deltabucht. Die Grundsedimentation ist von Stürmen und Uferwalldurchbrüche unterbrochen. Legende in Abb. 6.

they exhibit erosive base and lens-shaped geometries, their tops sometimes are reworked by waves. Parallel to the increase in grain size and to the individual bed thickness, a higher frequency of deformation and water escape structures (F15) is observed. The top of the section is marked by channel incision (channel filled with facies F11). This upper part was interpreted as being deposited on the upper shoreface/deltafront where a distributary mouth bar is developed. The channels erode the top of the mouth bar and probably represent the subaqueous parts of the distributaries which are part of the progradation (READING & COLLISON 1998) (Fig. 8). Due to bad outcrops no information from above or the lateral part of the channels is available.

Conclusion: Facies succession 2 may be interpreted in its lower part as a prograding storm-dominated shoreface. It starts with offshore muds which are invaded by coarser storm deposits. Several lens-shaped bodies (up to 1m thick) with cross-bedded sand occur, which were interpreted as litoral bars. The environment shallows up until river influence occurs and becomes dominant in the upper shoreface/delta front (the high frequency of facies F15 shows an increased sediment input). The entire S2 is a shallowing upward sequence, where storm conditions influence the sedimentation.

3.3. Facies succession 3 (S3): Interdistributary bay

Facies succession 3 (Fig. 9) is up to 8 m thick, no overall pattern could be recognized, though small scale fining upward sequences are present. No particular bounding surfaces were found, because of limited outcrop. The facies succession was defined based on its particular facies assemblage.

Compared to the facies successions 1 and 2, S3 is mostly governed by fine-grained material. The background sedimentation is reflected by facies F7 (fine-grained sand with wave ripples), which is interbedded with massive mud (F1) and also by F3 (mud-sand with lenticular bedding), which becomes more frequent towards the top. This mainly fine-grained nature of the section is interrupted by coarser facies (F6, F10, the latter without and with shell debris). These were interpreted as crevasse channels, splays, or storm deposits respectively. The coarser units exhibit small fining upward trends and usually induce deformation structures in the subjacent layers.

Conclusion: The high mud and silt content together with the above described observations led to the interpretation that S3 represents as a shallow water environment with relatively low energy. Thus, sedimentation was disturbed by more powerfull events as crevassing of the delta distributaries (generating facies F6, F10) and storms (generating F10 with shell and plant debris). It probably represents an area nearby yet outside the direct influence of the active distributaries.

4. Depositional systems: discussion

The coarsening and shallowing upward sequences presented above (S1, S2), reveal a basinward progradation of the shoreline. This shoreline is influenced by two major processes: fluvial discharge and basinal influence (fair-weather wave action and storm activity). Tidal activity was not encountered.

The fluvial influence on the facies successions S1 and S2 seems to have been more or less equal. The process which differs them, is the proportion of fair- to storm-weather sedimentation. In both successions the river discharge must have been considerable (documented by the thickness and grain size of the deltaic sediments and by the abundant deformation structures) but affected by fluctuations, that are indicated by the alternation of coarse- and fine-grained deposits.

In S1 wave power is documented by its typical sedimentary structures (facies F7); it marks the upper shoreface. Here sediment reworking by normal waves keeps pace with fluvial input and storm erosion and deposition.

Otherwise in S2, storm sedimentation completely dominates the shoreface, until the fluvial influence becomes more important. The relatively humble presence of fair weather waves could be explained by the domination of storm and fluvial influence. Thus, a direct change from tempestite to fluvial sedimentation took place.

The fair-weather, respectively storm influence on successions S1 and S2 may have an possible explanantion in their location on the palaeocoast. Whereas facies succession S1 laid relatively isolated, was succession S2 positioned on an exposed part of the shoreline where storm conditions were dominant.

In the interdistributary bay sedimentation is characterized by medium to low lacustrine energy, interrupted by catastrophic events of fluvial and basinal nature (channel crevassing, respectively storms).

The morphological characterization of a delta can be derived from the ratio between fluvial and lacustrine (normal waves and storms) influence. The depositional systems in S1 and S2 show a clear increase upward of fluvial dominance. This means that the reworking capability of the lacustrine processes, relatively decreased in time due to a progressive progradation of the fluvial systems. This relationship also dictates the inferred delta shape: the studied Dacian deltas may have fluctuated between cuspate and a slightly lobate geometry (Coleman & Wright 1975 fide Bhattacharya & Walker 1992).

Even though the three successions probably belong to different stratigraphic positions within the Dacian, they may represent lateral equivalents on an ideal section parallel to the palaeocoast (Fig. 10). The distributary channels represent the axis of sediment deposition, whereas their absence represent a lateral position. In this sense facies succession S1 was located not far from a distributary channel, in an area influenced by fair weather conditions. Succession S2 was also close to a distributary, but in an exposed area of the coast where storm energy played an important role. Otherwise succession S3 was more isolated, outside the direct influence of the distributary.

In agreement with Anastasiu & Iordache (1993) the presented examples show, that the studied Dacian deposits cannot be regarded as a single depositional system. Several stacked environments are present which reflect different

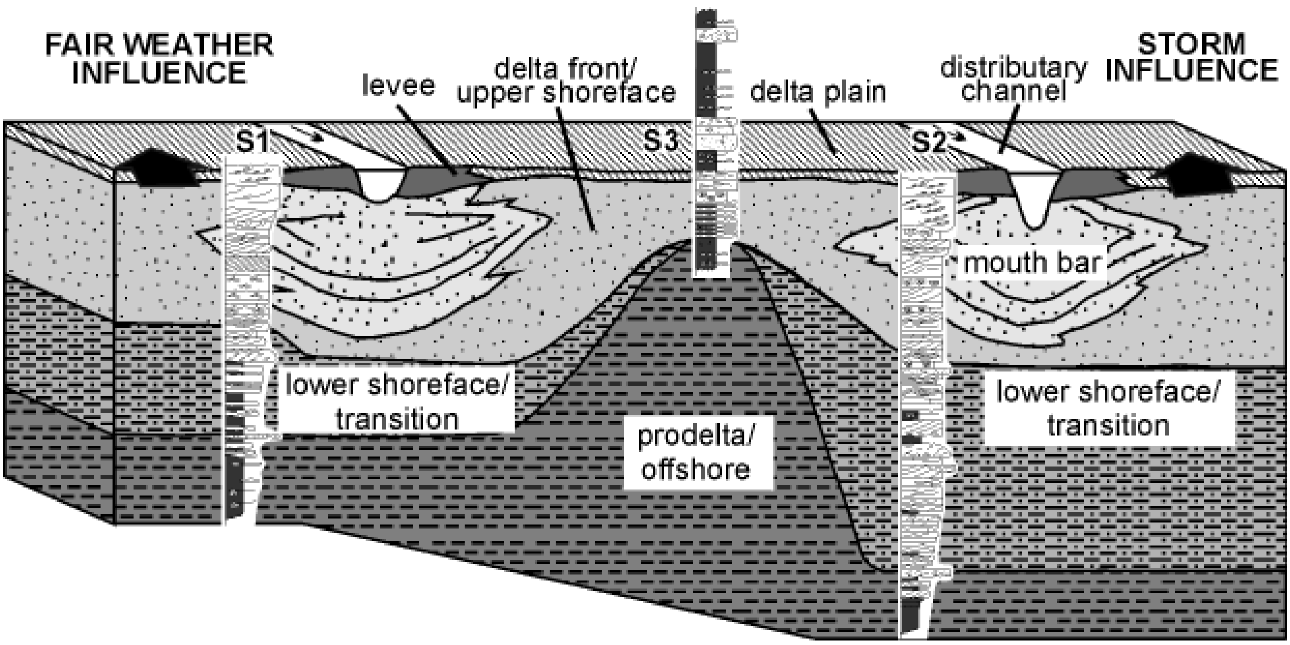

Fig. 10: The facies successions S1, S2 and S3 are arranged into a possible scheme. Succession S2 is the most exposed one, leeding to a dominance of storm conditions. The distributary channels indicate the axis of sediment deposition within a delta.

Abb. 10: Faziesassoziationen S1, S2 und S3 in einem möglichen Modell eingeordnet. Assoziation S2 ist am meisten den Sturmbedingungen ausgesetzt. Die Flussrinnen zeigen die axiale Sedimentablagerung innerhalb eines Deltas an.

types of processes (offshore, two types of a delta, interdistributary bay). However, as shown above, the general trend is an upward increase of fluvial influence.

In accordance with paleogeographic data (Papaianopol 1985, Jipa 1997) these environments are part of a series of relatively small deltaic bodies and their basinal correspondents that prograded into the Dacic Basin. Similar facies types and sequences are present in synchronous deposits of the outer margin of the Carpathians bending area, in the Southeast (Vlad 1997, also personal observations). Their drainage area was situated not far to the North in the Carpathians.

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