UNIVERSITATEA „ALEXANDRU IOAN CUZA” DIN IAŞI
FACULTATEA DE GEOGRAFIE-GEOLOGIE
ŞCOALA DOCTORALĂ DE CHIMIE ŞI ŞTIINŢE ALE VIEŢII ŞI PĂMÂNTULUI

Sedimentology and Sequence Stratigraphy of the Upper and Midlle Miocene deposits between Moldova and Barlad rivers valleys

DOCTORAL THESIS ABSTRACT

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2013

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Keywords: sedimentary facies, Bessarabian, barrier islands, backshore, parasequence, marine flooding surface

1. INTRODUCTION

The thesis aims to fill the sedimentological model of the Eastern Carpathians Foreland Basins System during Sarmatian developed by Miclăuș (2001) and continued in Grasu et al., (2002), with data obtained from outcrops in the field. Considering that the diploma and dissertation thesis was on the sedimentology and stratigraphy were sequentially from the Sarmatian Corni - Tupilati, I chose to extend the research to a larger area between Moldova and Bârlad rivers valley by identifying the possible points in the field. Such that, the study area was divided into two areas according to the location of the analyzed points and also according to the age of the deposits. The first area is characterized by outcrops identified within Ştefan cel Mare, Corni, Ţibucani Tupilați, Miroslăveşti villages, while the second zone corresponds to Săcăleni, Iucşa and Bozieni outcrops.

2. HISTORY OF THE GEOLOGICAL RESEARCH IN THE STUDY AREA

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In this chapter we make a brief review of the main contributions to the study area between Moldova and Bârlad river valleys, following, from west to east, the most important points of observation. I thought it appropriate to present the main contributions made by the predecessors in the study area under discussion in this paper, in chapters dealing with **stratigraphic and paleontological** studies (Macarovici, 1962,1964, Jeanrenaud and Saraiman, 1995, Ionesi, 1968, Ionesi et al., 2005), **petrographical** studies (Grasu and Ducra, 1996 Grasu et al.,

2002), **paleobotany and palynological** studies (Ţicleanu and Micu, 1978, Ţabără,2006, Ţabără and Chirila, 2012a, 2012b) and **sedimentological studies** (Miclăuş, 2001 Miclăuş and Grasu , 2002 Grasu et al., 2002).

3. GENERAL CONSIDERATIONS ON THE STUDY AREA

The Moldova and Bârlad rivers valleys area, studied in this work belongs to the geomorphological unit: Moldavian Plateau which comprised largely from Bucovina, Moldavia Subcarpathian region, northeastern Romanian Plain, Prut and Danube Valleys (Bacauanu et al., 1980). The Points studied in this paper fall into two subunits of the Moldavian Plateau: Piedmont Plateu Ciungi-Corni and Central Moldavian Plateau.

The deposits studied in this paper belong to Middle Sarmatian, namely Bessarabian. Their dating was based on its faunal content (Corni Tupilati, Miroslăveşti, Săcăleni, Bozieni). Stratigraphic data are taken exclusively from existing literature (Martiniuc, 1948b; Macarovici, 1953, 1954, 1964 Ionesi 1968; Ionesi et al., 1971 Jeanrenaud, 1966, 1971, Ionesi, 1976; Ionesi et al., 1976, 1978 , Saraiman, 1993 Ionesi et al., 2002, 2005).

In the outcrops on the Valea Albă river (right tributary of the Moldova river), in the localities Tupilati and Corni, the deposits are lower Basarabian in age. To Upper Bessarabian belong the analyzed deposits from the Bozieni river valley (in the Săcăleni - Iucşa – Bozieni villages). Their age was determined by Jeanrenaud (1966, 1971) based on the macrofaunistic associations.

The.Sarmatian deposits analyzed in this paper correspond after Ionesi (1994) to last cycle of sedimentation of the Moldavian Platform (Badenian-Meotian).

4. THEORETICAL ASPECTS

This chapter describes the method of analysis discussed in this paper. Sedimentary facies analysis is a primary method in the analysis of sequential, sedimentological and geological deposits. Also, an important aspect is the description of the coastal and shelf sedimentary processes. As many authors often use the terms system and depositional area we attempted to clarify this two terms in specialized terminology. Another important aspect of this chapter was to analyze the studies that describe and define quaternary coastal barriers systems that may show similarities with the reality of the sedimentological analysis. The final part of this chapter analyzes coastal and shelf facies models that can be applied to sedimentary deposits in the study area.

5. CONTROLS FACTORS ON THE SARMATIAN EXTRACARPATHIAN SEDIMENTATION

The sedimentation in the Carpathian area was controlled by the interaction of the following factors: tectonic, climatic, eustatic and sediment supply. Teconic factor is the movement of Carpathians uplifting reflected in the Eastern Carpathian foreland basins system. Grasu et al. (1999) distinguished in the evolution of the Carpathians foreland basin two stages, namely one old foreland and one the young foreland basin system. The first is a consequence of the dacidic convergence events (Cretaceous), while the second, is a consequence to moldavic tectogenesis (Miocene). The second phase was analyzed in a monographic work by Grasu et al. (2002) who recognized the

presence of four distinctive depozone: the wedge-top, the Foredeep, the forebulge and the backbulge.

From the paleobotanical and palynological point of view showed by Micu and Țicleanu (1978) and by Țabără and Chirilă (2012a) the climate in the Bessarabian was warm-temperate type to humid subtropical while the rainfall regime was the largest one of all the Sarmatian periode.

Popov et al. (2010), based on seismic profiles and field data from the northern shelf of the Black Sea shows that with the Sarmatian transgression occurs a raising sea level by about +35, +45 m. Middle Sarmatian is characterized also by a raising of the sea level with 80 m, while the beginning of the Kersonian is characterized by major regression (a decrease of the sea-level with 150 m)

Miclăuş (2001) demonstrates the consequences of the longitudinal and axial sediment supply in the foreland basins of the Eastern Carpathians.

6.1. GRAVEL BARRIER FROM CORNI-TUPILAȚI AREA

6.1.1. Sedimentary facies and Facies Associations

Following the sedimentay facies analysis on the outcrops from: Corni, Țibucani, Ștefan cel Mare, Miroslăvești and Tupilați were identified 20 sedimentary facies:

- Mudstone with horizontal lamination – *Ml;*
- Pelite with flame structures - *Mf*
- Shell lag with decimeter thick– *Pb*;
- Fine to very fine sand with parallel stratification - *Npp*;
- Fine to very fine sand with ripple cross lamination - *Nr*;
- Fine to very fine sand with hummocky cross-stratification - *Nhcs*;
- Fine to very fine sand with swaley cross-stratification - *Nscs*;

- Fine to very fine sand with through cross stratification - *Nt*;
- Fine to very fine sand with convolute lamination - *Nc*;
- Medium to coarse sand with herringbone structures – *Nhb;*
- Medium to coarse sand with planar cross-stratification – *Np*
- Fine to medium sand with low angle cross stratification– *Nl*
- Sandstone concretions with various shapes *(beachrock*) - *Br*
- Fine to medium gravel with parallel stratification - *Ppp*
- Medium gravel with trough cross-stratification at small to medium scale - *Pt*;
- Spherical boulders with pronounced bimodality - *As*;
- Fine to medium gravel with good sorting - *Aso*;
- Fine gravel with parallel stratification and coarse sand with trough cross-stratification - *Anp*
- Medium to coarse gravel with good morfological sorting - *Af*;
- Coarse gravel with discoidal clasts and pronounced imbrication– *Ad.*

This 20 sedimentary facies were grouped into 11 facies associations characterizing each one a depositional subdomain.:

1. Facies Association A (facies association with horizontal mudstone) –offshore;
2. Facies Association B (association with heterolitic facies) – transition between *offshore-shoreface* deposits;
3. Facies Association C (sandy facies association with HCS and SCS) – upper shoreface deposits;
4. Facies Association D (sandy facies association with SCS and PP) – middle shoreface deposits;
5. Facies Association E (sandy facies association with TCS) – upper shoreface deposits;
6. Facies Association F (gravelly facies association with PP) – gravelly beach deposits;

7. Facies Association G sandy-gravelly facies association with PP) – mixed beach deposits;
8. Facies Association H (heterolitic facies association) – backbarrier deposits.
9. Facies Association H1 (sandy facies association with LACS) – washover fan deposits;
10. Facies Association I (sandy-gravelly facies association with TCS) – tidal inlets deposits;
11. Facies Association J (facies association with striped mudstone) – fine lagoon deposits.

6.1.2. Depositional environment

The succession of the facies associations in the Miroslăveşti-Tupilati area is: offshore, transition offshore-lower shoreface, lower shoreface, upper shoreface. The existence of these depositional subdomains on the internal shelf may be evidence that they belong to the distal part of a barrier system, if we refer to the depositional environment diagnosed in the outcrops of Corni.

The sediment supply occurred in the region studied was made by orthogonal and longitudinal basin processes. As a possible source of sediment in the studied area we consider to be Boiștea fandelta. For this gravel barrier, the tidal inlet identified in the Șerbești outcrop was due to action of the storms that have broken the barrier achieving a connection between the sea and the lagoon.

In this part of the barrier system, the breking could occur duet o the sand deposits in the foreshore. Due to the positioning further south, the Serbesti area received a less coarse sediment input by littoral drift of northern source. In conclusion, we consider the deposits in the Serbesti-Corni-Țibucani-Tupilati-Miroslăveşti area was accumulated in nondeltaic coastal area characterized by a gravel barrier system.

6.1.3. Sequence Stratigraphy

In terms of sequence stratigraphy in the study area have identified a number of discontinuity surfaces:

- wave ravinement surface (WRS)
- tidal ravinement surface (TRS);
- marine flooding surface (FS)

These discontinuity surfaces separates parasequencese ,some of which we have identified: three progradational parasequences in the Miroslăveşti and Stefan cel Mare area, 6 progradational parasequences in the Tupilati area and 4 such parasequences in the Corni outcrops.

6.2. SANDY BARRIER FROM BOZIENI – SĂCĂLENI AREA

6.2.1. Petrography

Were collected 7 samples (6 from the sandy deposits of the Săcăleni - Bozieni area and one from the outcrop on the Bârnova area) to determine the grain size. The results of the grain size of the samples from Săcăleni – Bozieni area shows that the sands are fine to very fine with a relatively good to good sorting.

6.2.2. Fossils vertebrates

Within the sandy deposits from Bozieni area was collected a rhino fragment, respectively a *Aceratherium* like. In the following it will be described and classified taxonomically.

Systematic Order: Perissodactyla Owen, 1848
Family: Gill Rhinocerotidae 1872
Subfamily: Aceratheriinae Dollo, 1885
Tribe: Aceratherini Dollo, 1885
Genre: Aceratherium Kaup, 1832
Species: Aceratherium incisivum Kaup, 1832

Description: The rhino from Bozieni is documented by a fragment of left mandible horizontal branch that preserves the full range of jugal. Before burial in sediments, the horizontal branch was broken in the diastema. After the death of the animal, the bone was exposed on the lip and, therefore, of all tooth enamel labial wall has been removed by the action of atmospheric agents.

Comparisons and discussions. The piece of the Bozieni outcrop is rare in Romania, where the juvenile forms of fossil rhinos are rather rare (Codrea, 2000).

Consequently comparative materials are absent, which is why we refer to published data for other European regions.

6.2.3. Sedimentary facies and Facies Associations

Using sedimentary facies analysis we identified 16 sedimentary facies:

- Mudstone with horizontal lamination – *Ml – Ml*;
- Shell lag with decimeter thick – *Bl;*
- Fine to very fine sand with hummocky cross-stratification – *Nhcs;*
- Fine to very fine sand with parallel stratification – *Npp*;
- Fine to very fine sand with ripple cross lamination form by oscillatory currents action - *Nwr*

- Fine to very fine sand with swaley cross-stratification (SCS) – *Nscs*;
- Fine to very fine sand with combined ripple cross-lamination- *Nwcr;*
- Fine to very fine sand with convolute lamination– *Nc*;
- Fine sand with low angle cross lamination - *Nl;*
- Fine sand to very fine sand with herringbone structures – *Nhb*;
- Fine to very fine sand with flaser heterolitic stratification– *Nf*;
- Fine sand with tabular cross stratification– *Ntb*;
- Fine sand with through cross-stratification – *Ntc;*
- Fine to very fine sand with current ripple cross lamination – *Ncr;*
- Fine to very fine sand with planar cross-stratification– *Np;*
- Sand in the form of vertical prisme in mudstone layers– dessication cracks – *Dm;*

In the Bozieni - Săcăleni outcrops we have identified seven facies associations characterizing each a depositional subdomain:

1. Facies Association A (facies association with horizontal lamination) – *offshore deposits*;
2. Facies Association B (heterolitic facies association) – *transition offshore-shore deposits;*
3. Facies Association C (sandy facies association with RCL and SCS) – *lower shoreface deposits;*
4. Facies Association D (sandy facies association with small and medium scale TCS) – *upper shoreface deposits*;
5. Facies Association E (facies association with LACS) – *foreshore deposits*;
6. Facies Association F (sandy facies association with flat lamination) – *backshore deposits;*
7. Facies Association G (sandy-silty facies association– *backbarrier deposits.*

6.2.4. Depositional environment of the sarmatian deposits from the Săcăleni –Bozieni area

Facies associations described above indicate for the Săcăleni - Bozieni area a coastal environment characterized by following subdomains: *offshore* → *transition* → *shoreface* → *foreshore* → *backshore* → *backbarrier* . The high thickness of the ripple cross-lamination structures may indicate a low ambiental energy, with a great sandy supply. Sporadically, SCS type structures indicates the incidence of storms in the sedimentary basin. The presence of good weather structures in the Bozieni- Săcăleni area can be interpreted as the high rate of creation of accommodation space accompanied by a small contribution of sediment.

The Paleocurrents measurements performed on TCS structures of facies association D revealed SW senses, so that we can consider that the longshore current had NE-SW directions. Possibly in the NE part of our study area (somewhere in the Monastery – Mădârjac) it was a sediments supply carried by a paleo-delta (possibly Siret paleo-delta). So the sediments were redistributed by littoral drift in the basin edges.

As we can see, with the Upper Bessarbian the grain size of the sediments is changing to finer and the ambiantal energy is lower in the sedimentary basin. In the Lower Bessarabian the shoreline is on the alignment Serbesti-Corni-Ţibucani-Paşcani-Vlădeni, but with the Upper Bessarabian the shoreline would have moved to the alignment Icusesti-Averesti-Săcăleni-Monastery-Bârnova-Bălăneşti-Chisinau.

Based on the results obtained by applying sedimentary facies method we consider that Bessarabian deposits outcropping in the Săcăleni-Bozieni are were accumulated in a coastal sandy barrier system.

6.2.5. Sequence Stratigraphy

In terms of sequence stratigraphy we have identified a number of stratigraphic surfacse such as:

- marine flooding surfaces;
- subaerial unconformity;

Regressive surface of marine erosion.

These stratigraphic surfaces separate three progradational parasequences. Based on field data there was elaborated a Fence diagram for the Săcăleni outcrops, Iucşa and Bozieni.

CONCLUSIONS

- Identification of 20 sedimentary facies grouped in 11 facies associations characteristic of a coastal gravel barrier system in the Corni-Tupilați.
- Depending on the existing literature we have integrated in the paleogeographic map the deposits analyzed from the new outcrops identified in the field
- In terms of sequence stratigraphy in the study area we have identified a number of stratigraphic surfaces that separates many progradational parasequences.
- In the Săcăleni-Bozieni we have identified 16 fsedimentary grouped on 7 facies associations characteristics of a sandy coastal barrier.
- In terms of particle size were analyzed a number of samples from different sedimentary facies identified in this area, so it predominate fine to very fine sands.
- In the F facies association was identified a mandible belonging to a juvenile specimen of *Aceratherium incissivum.* This piece is the oldest identification of this species in the Sarmatian deposits of Romania.
- Depending on the data in the field and on the existing literature we attempted to develop a paleogeographic map for the situation during the sedimentation of Bârnova Formation.
- In terms of sequence stratigraphy we have identified 3stratigraphic surfaces that separates the 3 progradational parasequences.
- Based on field data was performed a Fence diagram for for the Săcăleni,Iucşa and Bozieni outcrops.

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