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SEDIMENTATION AND MICROFAUNA AS KEYS TO THE EVOLUTION OF THE TRANSYLVANIAN BASIN DURING THE MIDDLE MIOCENE

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The Transylvanian Basin is an Upper Cretaceous to Tertiary intra-Carpathian epicratonic sedimentary basin bordered by the Eastern, Southern Carpathians and Apuseni Mountains. Its evolution was strongly related to the Carpathians history.

Major tectonic changes occurred at the beginning of Middle Miocene (Badenian). From this time onward, the Transylvanian Basin continued its evolution in a back-arc setting, squeezed between the extensional back-arc Pannonian Basin and the compressional Carpathian folded and thrust belt. Middle to Upper Miocene basin evolution was evidenced based on sedimentological and micropaleontological data.

The uppermost Lower Miocene sedimentation, with coarse-grained fandeltas representing the lowstand systems tract (LST1), was enhanced by Carpathian tectonics.

The Early Badenian transgression reflected the major tectonic and paleogeographic changes in Paratethys. Carbonate and clastic sedimentation dominated shallow ramp environments mainly in the western part of the basin. Deeper environments with clastic turbidites and pelagic deposition are known in center and east. Several volcanic tuff levels prove the intense volcanic activity.

On the north-western border of the basin, the first sign of the initiation of transgressive conditions (TST1) can be documented by a very important planktonic bloom (*Praeorbulina glomerosa* Biozone – M5a). The transgressive phase of the second sequence (TST2) can be documented by the dominant planktonic assemblages with *Orbulina suturalis* (M5b Zone). Benthic foraminifera colonized the substrate progressively at the transition between the transgressive (TST2) and highstand systems tract (HST2). Foraminifera morphogroups show affinities to offshore and shoreface siliciclastic and carbonate environments.

The uppermost facies of the Lower Badenian, mainly with carbonate sedimentation, indicate progressively shallower facies, ending into the lowstand conditions (LST3).

The following hemipelagic sediments indicate an important early Mid Badenian transgressive event (TST3). Foraminiferal assemblages (*Globoturborotalita druryi* - *Globigerinopsis grilli* Biozone) suggest deeper environments compared to Early Badenian.

A relative sea level fall (LST4) induced progressive restriction of the basin circulation, leading to massive deposition of salt in the deep areas and gypsum at the margins. Salt outcrops follow two major lineaments near the the western and eastern borders of the basin, produced by the Pliocene thrust systems (west), and gravitational gliding processes (east).

The marine flooding event (TST4) produced by the tectonic shortening in the Eastern Carpathians ended the evaporitic sedimentation. The Upper Badenian deposits are represented by deep clastic turbidites (mud and mud-sand dominated fan lobes) and hemipelagics. The deep marine deposits contain almost exclusive planktonic assemblages (*Velapertina* Biozone). Submarine fans were stacked between the proto-diapirs produced by the salt tectonics.

The upper stacked submarine fans (mud-sand to sand dominated, moderate to low efficiency submarine fan systems) have an overall coarsening upward log trend related to the mid Upper Badenian highstand (HST4). The foraminiferal assemblages date precissely the progradation process by *Bogdanowiczia pocutica* assemblages. There were two main sedimentary sources: western part of the Southern Carpathians and north-eastern Eastern Carpathians. The south-eastern corner of the basin represented its deepest part which had wide open marine connections with the foreland area. Upper Badenian sedimentary succession becomes thicker

toward the Eastern Carpathians, but showing well developed onlaps on the salt layer towards west and north-west and condensed sedimentation in north and west. The successive, westward and north-westward onlaps represent prograding submarine fan systems toward the starved western and northwestern area of the basin.
Increased regional compressional stress by the end of Badenian led to relative sea-level fall, which generated a high sediment input, prograding shallow-marine systems and progressive restriction of the connections to the open seas. Ramp settings (submarine heights) close to the end of the Badenian (LST5) were deduced upon the evidence of shallow marine faunas. Submarine channels were incised into the previous highstand slope turbidites in north.
The transgressive character (TST5) of the lowermost Sarmatian deposits continues the process initiated close to the end of Badenian. Important faunal changes occurred during the transgression, reflecting progressive water chemistry changes.
Highstand settings (HST5) are suggested by the diversification of the benthic assemblages. Brackish faunas and reworking processes occur together with prograding sedimentary lobes.
Hypersaline conditions (with miliolids and thin gypsum beds) are common for the lowstand of the following sequence (LST6). The relative sea-level fall produced large scale erosion in the northern part of the basin (submarine channels incised the slope deposits).
The following foraminiferal re-diversification (*Elphidium reginum* Biozone) shows a facies deepening associated to a transgressive event (TST6).
Large scale sandy deltaic progradation (with mysids and reworked foraminifera) produced during the subsequent highstand (HST6) in the north. Large amounts of siliciclastic sediments were deposited as submarine fans in the deep parts of the basin.
Several higher order sequence boundaries were observed in the eastern part of the basin, which correspond to major episodes of turbidite sand deposition (lowstand fans – LST7). One of the most important rising moments of the Apuseni Mountains produced during the Late Sarmatian. Sandstones were deposited in the western part of the basin on a shallow ramp, while coarse grained fandeltas were actively prograding in the east, feeding the central lowstand submarine fans. Increased salt-tectonics generated turtle structures in the east while the structural inversions enhanced submarine erosion and channeled the submarine fans.
A progressive deepening of the basin occurred by the end of Sarmatian. Sediments onlap the previous sequence boundary, forming a large-scale retrogradational geometry (TST7). Microfauna (*Porosononion aragviensis* Biozone) diversified again on shallow and deep shelf.
The new Pannonian fauna associates to a strong transgressive event, recorded by condensed deep-basin marls on the top of Upper Sarmatian fan deltas or submarine fans. The change of water salinity produced the extinction of the foraminiferal faunas, which were replaced by ostracods, better adapted to the particular salinity conditions.
Outer ramp successions with small scale prograding cycles were recognized in the eastern part of the basin. Relative sea level fall during the mid Early Pannonian induced coarse grained fan delta and related submarine fan system progradation in the eastern Transylvanian Basin. The shallow-water to continental Pannonian facies was commonly covered by the Pliocene volcanic products of the Eastern Carpathians.
Transgressive (TST8) and highstand (HST8) systems tracts were interpreted only in a few areas in the east, based on outcrop sedimentology. A large scale coarsening upward tendency (from distal shelf deposits to fan delta sediments) can be observed. The maximum flooding (mfs8 - *Ammonia* acme) seems to be related to the reestablishment, for a very short time, of the connections with the extra Carpathian area. This is supported by the last foraminifera assemblage. The majority of the outcropping Pannonian deposits belong to lacustrine fans.
The Pliocene to Holocene evolution of the Transylvanian Basin was characterized by strong uplift and erosion. The upper part of the basin fill (?Upper Pannonian and newer) was removed from the regions not covered by the younger Eastern Carpathians' volcanics.