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SEDIMENTARY RECORDS of INTRA-OLIGOCENE DEFORMATION within the OUTER CARPATHIAN THRUST BELT

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Most of the Oligocene (including the Lowermost Miocene) sequences preserved in the highly shortened Outer Carpathians belt were interpreted as deep water, dominantly clastic turbidites organized in various assemblages that interfinger with basinal fine sediments shed into an euxinic foredeep basin. The importance of the Oligocene sedimentary units for the petroleum industry arises from the fact that they act as both source and reservoir for most of the known hydrocarbon reserves in this basin. However, the Oligocene facieses correlation and spatial distribution within the South and especially the East Carpathians have been subject to a long debate. The main causes for lacking consensus are related to the inherent complicated architecture of such depositional systems, severe thrusting, no regionally correlable marker or scarcity of index fossil groups. Consequently, various correlation schemes were proposed by many scholars as well as contrasting transport directions of the detritus, although the geometry and initial location of the basin remains widely unknown.

The overall structural architecture of the East-Carpathians thin-skinned belt is generally seen as resulting from a progressive shortening which began as early as Mid-Cretaceous. The innermost thin-skinned nappe, namely Ceahlau, had been deformed and emplaced during the Cretaceous (forming the External Dacides, sensu Sandulescu, 1984), whereas the Outer Carpathians nappes (Curbicortical Flysch, Audia, Tarcau, Marginal Folds and Subcarpathian) were grouped altogether as Moldavides by Sandulescu (1984) meaning units that underwent Miocene shortening. Importantly, no deformation has been considered so far as taking place during the Oligocene times in the East Carpathians.

Further developments of the theories dealing with the fold-and-thrust belts would rather account for a more continuous process of shortening, with climaxes in the strain rates which can correspond with those already identified in Miocene times. The reconstructions of the Tertiary tectonic transport of the Carpathian units along the Cerna/Timok fault system towards the final docking to the East European/Moesia foreland plate (e.g. Fugenschuh and Schmid, 2005) pointed out to the presence of a marine embayment that closed progressively rather than in sudden steps. Furthermore, the documentation of tens of kilometers of displacement along the Cerna wrench fault during the Oligocene (e.g. Fugenschuh and Schmid, 2005) requires a corresponding shortening in front of the advancing plate.

We have looked for the effects that this tectonic transport should have had upon the sedimentary depositional systems in the Oligocene. We have studied a few relatively long sections located within the East Carpathians bend zone through the W-most outcropping Oligocene sequences (figure 1). Upon building high resolution sedimentary logs, we have integrated the Oligocene facieses into a consistent sequential framework and linked the observed stratigraphic architecture to kinematic mechanisms.

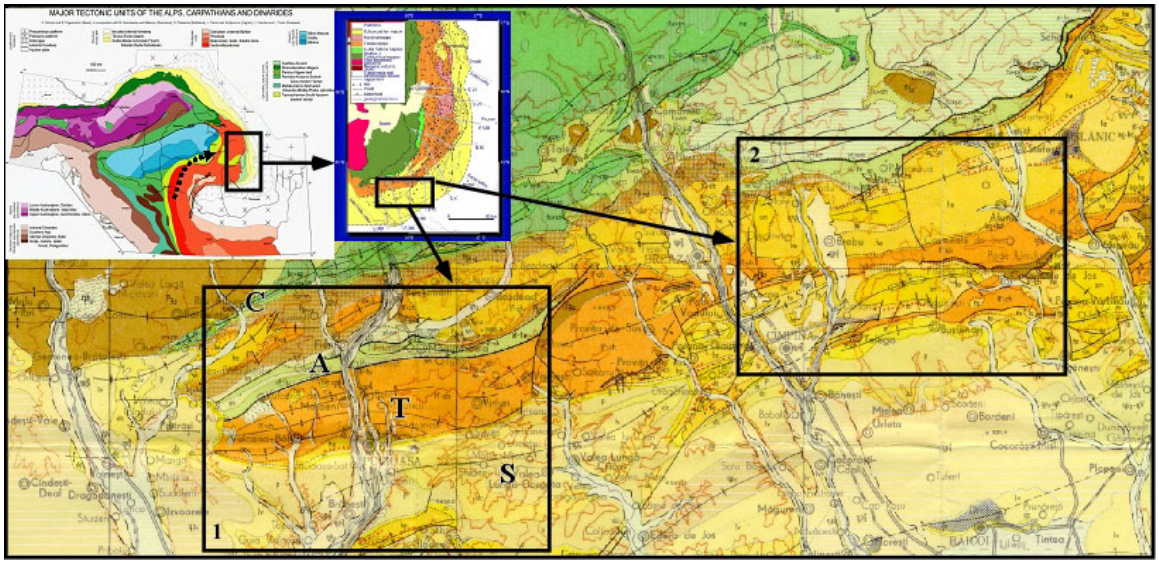

Figure 1 Location of the studied areas (rectangles) within the general tectonic framework (insets from left-up side are from Matenco & Bertotti, 2000, overlying the Romanian Geological Institute's basemap, scanned from the original at 1:200,000 scale). C, A, T and S letters stand for Ceahlau, Audia, Tarcau and Subcarpathian nappes, respectively. Oligocene outcrops (orange) are encountered mainly in the Tarcau nappe.

Figure 2 depicts a synthesis of the most widely accepted correlation for the Oligocene formation and facieses. The Lower and Upper Dysodilic formations are predominantly pelitic (very finely laminated, paper-like shales), distal turbidites or basinal deposits, with high content in kerogen, which include also menilites (siliceous interbeds with organic matter as well). They were encountered throughout the East Carpathians; however, to the bend zone, another pelitic formation made-up of dark marls and subordinate marly limestones or very thin sandstones (Pucioasa) prevails in outcrops. Two coarse turbiditic units were described in the external areas (Lower and Upper Kliwa). The sandstones predominate over the shales and are made-up almost entirely of quartz in both grains and matrix. In the studied area it is not clear whether the quartz-dominated sequences that crop out belong to the Upper or Lower Kliwa. Other deep-water formations were separated as Vinetisu and Podu Morii formed by turbidic facieses whereby the pelites dominate over the arenites.

Within the studied area two coarse sedimentary units crop out: Fusaru Sandstone and Bustenari Sands (fig. 2). Fusaru Formation contains less mature sandstones with higher content in feldspaths and micas whereas the Bustenari one is made-up of almost purely quartzitic sands (like Kliwa facies). The base of the former formation can be observed in the field being obviously represented by an erosional unconformity whereas the contact

of the latter with the underlying sequences (under Kliwa facies, but unknown which of the two formations) remains hidden. An example of a geological profile illustrating the relationships of these coarse units (Fusaru in this case) with the deep marine sequences of the Oligocene is shown in figure 3. The Fusaru Sandstone is mainly made-up of alluvial fans and overlies proximally a well developed angular unconformity eroding the marine lower Pucioasa marls. To the south a normal transition was recognized between the Fusaru formation and the distal upper Pucioasa marls.

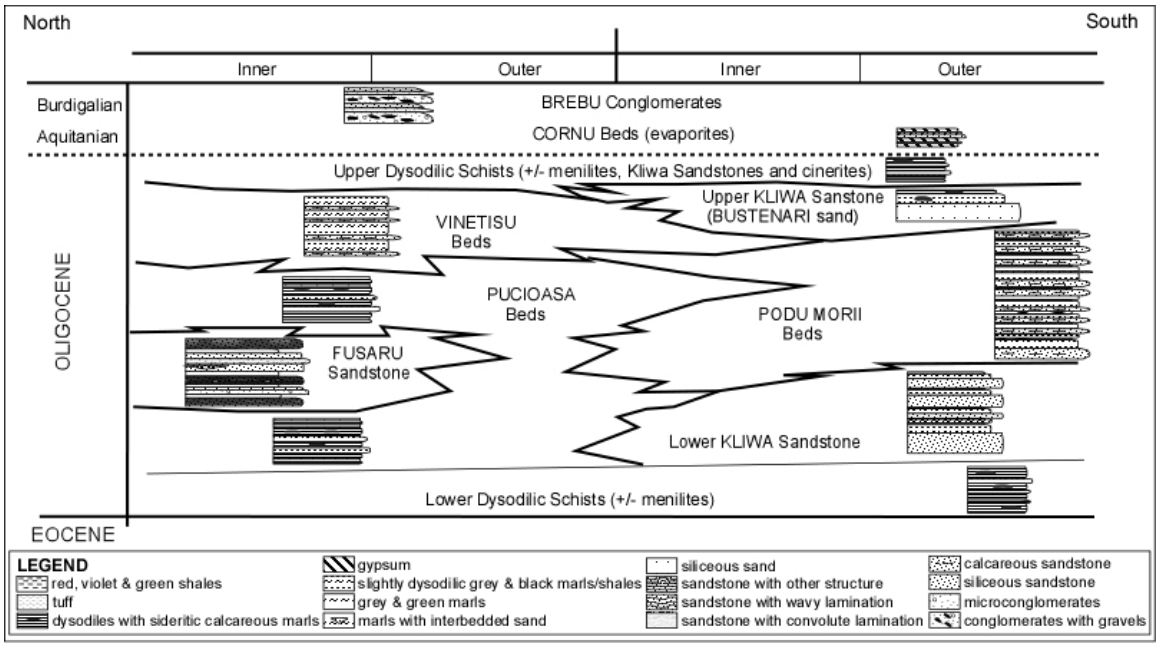

Figure 2 Correlation of the Oligocene units in the south-western part of the East Carpathians (compiled and modified from e.g. Motas et al., 1967; Sandulescu, 1984; Stefanescu et al., 2006)

The base of the Fusaru Sandstone keeps the same erosional character at regional scale. Sylvester and Lowe (2004) encountered farther north from our studied area similar coarse clastics incising tens of meters into dysodilic shales. Same type of facieses separations (although with other local names) and characteristics are documented farther to the west, to the northern part of Getic Depression (Roban and Melinte, 2005). Accordingly, the marine marls deposited by the end of Eocene (Olanesti formation) are separated from another fine sedimentary unit of Oligocene age by coarse units (Cheia and Corbi formations). Apparently, the occurrence of this coarse sedimentary event is diachronous becoming younger from west to east.

As a conclusion it can be stated the existence within the Oligocene of one or more erosional unconformities, developed only in the inner part of the basin. The fine-grained marine sediments (Olanesti marls, Pucioasa marls) or deep-water turbidites (Lower Kliwa? or Podu Morii formation) are incised and then followed by coarse alluvial to shallow marine facieses (Cheia/Corbi, Fusaru, Bustenari formations, respectively). The unconformities are less obvious in the outer part where a more or less continuous marine sedimentation is recorded. These coarse formations are thus interpreted as recording a significant drop in the relative sea-level which can be related to an intra-Oligocene shortening that led to the uplift of the inner areas and development of a widespread

truncation. A west to east time-migrating Oligocene deformation can be thus speculated, this fact being in line with the accepted eastward movement of the intra-Carpathian blocks.

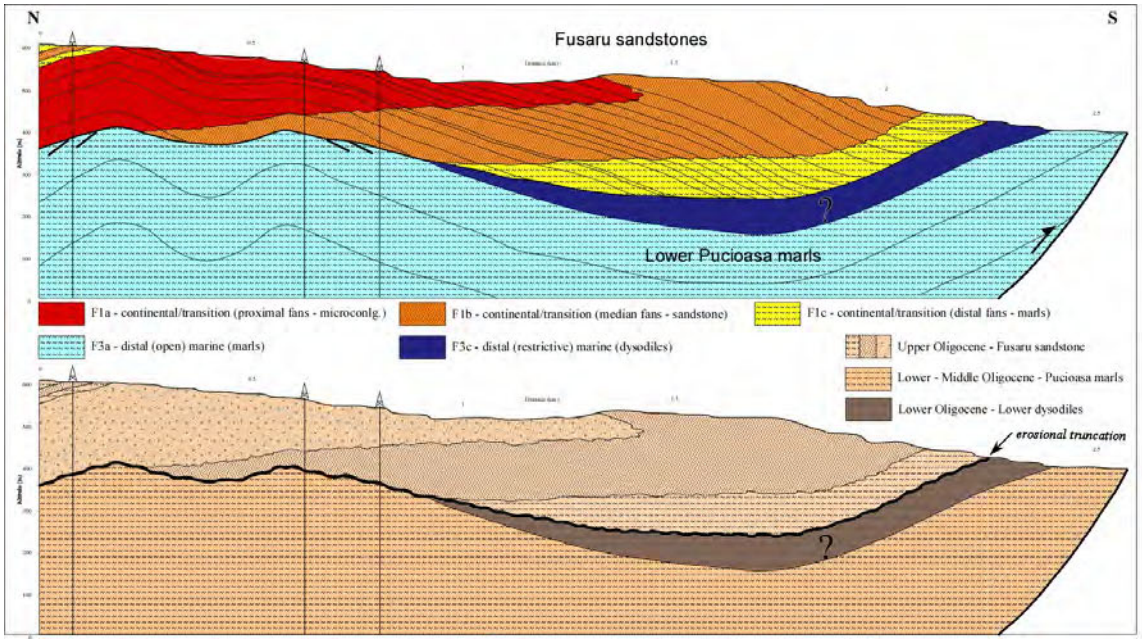

Figure 3 Geological cross-section along the Valea Rea valley (N-S valley from the eastern part of rectangle 1 plot in figure 1) depicting the relation between the Lower Pucioasa marine facieses and the Fusaru alluvial sandstones

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