The link between tectonics and sedimentation in asymmetric extensional basins: inferences from the study of the Sarajevo-Zenica Basin

Andrić, N.[1,2], Sant, K.[1], Matenco, L.[1], Mandic, O.[3], Tomljenović, B.[4], Pavelić, D.[4], Hrvatović, H.[5], Demir, V.[5]

[1]*Utrecht University, Faculty of Geosciences, Utrecht, The Netherlands*
[2]*University of Belgrade, Faculty of Mining and Geology, Belgrade, Serbia*
[3]*Geological-Paleontological Department, Natural History Museum Vienna, Burgring 7, 1010 Wien, Austria*
[4]*University of Zagreb, Institute of Geology and Geological Engineering, Zagreb, Croatia*
[5]*Federal Institute for Geology - Sarajevo, Ustanička 11, 71210 Ilidža, Bosnia and Herzegovina*

In tectonically active basins, depositional geometry is dominantly controlled by the balance between basin subsidence enhanced by the pulses of fault activity and coeval footwall uplift and erosion influencing sediment supply. In extensional basins, coupled tectonic and depositional history is usually described in terms of stratigraphic sequences linked with the activity of normal faulting. The interplay between deposition and normal faulting stages is less understood in basins bounded by major extensional detachments or normal fault systems associated with significant exhumation of footwalls. The link between sedimentation and tectonic during the spatial and temporal migration of deformation across the basin is especially interesting. The optimal place to study coupled depositional-kinematic history is the Sarajevo-Zenica Basin, located in Bosnia and Hercegovina. This is the largest intramontane basin in the Dinarides. The basin fill overlays pre-existing orogenic fabrics and records Late Oligocene–Miocene lake evolution deposited in an endemic and isolated environment. An integrated study of field kinematics and detailed sedimentological mapping in outcrops correlated with earlier local and regional studies enables us to derive a high-resolution evolutionary model of the basin. The new results suggest a close relation between moments of normal faulting and associated high-order sedimentological cycles. The overall extensional basin was filled by sediments deposited by flows dominantly draining the neighbouring uplifting mountain chain. The temporal and spatial migration of synthetic listric normal faults across the basin created an overall regressive, coarsening upwards depositional cycle with a strong asymmetric depositional geometry. This lower order cycle comprises three higher order transgressive-regressive cycles driven by the individual moments of normal faulting. This Early - Middle Miocene extensional deformation is the most external area in the Dinarides, documented so far, to be affected by extension of the neighbouring Pannonian Basin.

The deformation was predated and postdated by two phases of contraction. The Oligocene - Early Miocene phase of contraction took place during the final stages of the Dinaric collision and was related to the onset of deposition in the basin. The post-Middle Miocene phase of contraction inverted the basin fill by reactivating the earlier basal listric detachment. This event is correlated with the regional indentation of the Adriatic continental unit.

Geodynamic controls of organic matter deposition in lacustrine basins: The case of Miocene pull-apart basins in the Eastern Alps

Groß, D., Sachsenhofer, R.F.

Chair of Petroleum Geology, Montanuniversität Leoben, Peter-Tunner-Str. 5, 8700 Leoben, Austria

The evolution of the Eastern Alps was controlled by large-scale extension and lateral tec-

tonic extrusion in Early to Middle Miocene times. Main eastward movements of the central parts of the Eastern Alps occurred along sinistral NE- and dextral SE-trending strike-slip faults. Consequently, pull-apart basins were formed along the sinistral Mur-Mürz fault system (Noric Depression) at major oversteps. The more than 2 km deep Fohnsdorf Basin, the 1 km deep Trofaiach Basin and the relatively shallow Leoben, Aflenz and Parschlug basins were formed in the central part of the Mur-Mürz fault system. The SSE-trending Pöls-Lavanttal fault system comprises 12 km of accumulated dextral strike-slip movement and vertical offsets of several kilometers since Miocene times. Several basins, including the asymmetric Lavanttal Basin with a > 2 km thick Miocene succession, are aligned along this fault system.

Basin evolution along the Noric Depression started in the Late Karpatian/Early Badenian. Sedimentary sequences are usually similar, comprising coarse-grained alluvial, fluvial and fluvio-deltaic sediments at the base, often followed by coal seams overlain by sapropelic rocks and fine-grained sediments which were deposited in a lacustrine (partly brackish) environment with high subsidence rates. The top of the succession is frequently characterized by a coarsening-upward sequence terminated by coarse-grained fluvial gravels, deposited after the present lakes filled up in times of tectonic quiescence.

The Fohnsdorf and Leoben basins contain more than 10 m of sub-bituminous coal. Although they accumulated in similar ages, similar tectonic settings, and similar stratigraphic position within the sedimentary sequence, variable conditions during peat accumulation resulted in differing coal properties. properties of the coals and therefore peat accumulation differ significantly. Whereas the ash- and sulfur-rich Fohnsdorf coal was deposited in a low-lying mire, the main body of the Leoben coal formed in an ombrotrophic raised mire.

Basin evolution in the Lavanttal Basin, also commencing with coarse-grained fluvial sediments in the ENE-WSW striking Granitztal, started slightly earlier (Ottnangian/Karpatian). In comparison to the Noric Depression, no coal seams exist in the transition between fluvial and lacustrine environments in the Badenian. Furthermore, after deposition of the lacustrine to brackish lower part of the Badenian Mühldorf Formation, marine conditions established in the upper part of the Formation (Middle Badenian). Salinity decreased and freshwater conditions prevailed during Late Badenian.

Whereas deposition stopped in the Late Badenian along the Noric Depression, deposition continued after a sea level fall and consequent erosion at the Badenian/Sarmatian boundary. The subsequent transgression is visible in brackish sediments at the base of the Sarmatian succession. The Sarmatian is characterized by brackish and freshwater sediments which host several, partly economic coal seams. Frequent sea level fluctuations and a constant slow subsidence lead to the formation of these seams.

Gas-prone coals and oil-prone sapropelic shales, frequently overlying coal seams, accumulated during initial stages of lacustrine deposition. Sapropelic shales indicate drowning mires, caused by elevated subsidence rates. In the Noric Depression, these shales show hydrogen indices (HI) up to 300 mgHC/gTOC, pointing to a certain oil potential. Brackish conditions in the Fohnsdorf Basin suggest a connection to the Miocene sea which existed in the Lavanttal Basin. Sapropelic shales above Sarmatian coal seams in the Lavanttal Basin reach HI values up to 480 mgHC/gTOC, again suggesting a source potential for oil.

In comparison to the Noric Depression, lacustrine to brackisch sediments of the Mühldorf Formation, deposited in the Early Badenian in the Lavanttal Basin, show high total organic carbon (TOC) contents (up to 10 %) and high HI values (up to 600 mgHC/gTOC), suggesting a kerogen type II resulting from algal blooms. A transgression led to marine conditions in the upper part of the Mühldorf Formation, where

TOC contents around 1–2 % and HI values below 200 mgHC/gTOC occur due to low production rates.

Upper Miocene sedimentation processes in Croatian part of Pannonian basin based on results of 3D seismic interpretation *P*

Jankov, J., Čikeš, K., Marić-Đureković, Ž., Rakarić, D., Krizmanić, K.

INA Oil Industry, Subiceva 29, 10 000 Zagreb, Croatia

The study presents geological data related to sedimentation process which resulted in filling of Croatian part of Pannonian basin (Upper Miocene). Conclusions are based on 3D seismic interpretations for development and exploration purposes in oil industry. Approach used in the interpretation was multidisciplinary and included seismic interpretation and analyses, stratigraphy and petrophysics as well as sedimentological core analyses.

Main target is exploration and development of sandstone reservoirs, in deeper parts of Drava depression, related to existing HC fields and their correlation on broader area between them. The process covered therefore regional to single well approach. Regional approach included seismostratigraphical interpretation on 3D seismic dataset and corresponding well log correlation as well as sedimentological core analyses. The result was regional sedimentological frame which was filled with detailed interpretation of sandstone reservoirs on multiple levels, field scale. Detailed seismic attribute analyses enabled delineation of sedimentological bodies. Together with well log interpretation and sedimentological core analyses it revealed the sedimentation mechanism as a part of broader sedimentation process (frame) which filled the Drava depression.

Since the Upper Miocene (Pannonian and Pontian) represents the majority of sediments in the area of interest its mechanism of sedimentation indicate overall process of Drava depression filling. The result of this work is sedimentological model which is applicable to or at least good starting point for other parts of Pannonian basin. Indeed, very similar experience is also present in Sava depression.

Lake Pannon sedimentation model in the Legrad field area (NW Croatia)

Krizmanić, K.[1], Bigunac, D.[1], Majstorović Bušić, A.[1], Čikeš, K.[2], Sabol, N.[1], Zopf, D.[1], Pecimotika, G.[1], Kranjčec, B.[1]

[1]INA - Industrija nafte, d.d., Exploration Sector, 10 000 Zagreb, Croatia
[2]INA - Industrija nafte, d.d., Field Development Sector, 10 000 Zagreb, Croatia

The Neogene to Quaternary Lake Pannon sedimentary successions of the SW part of the Pannonian Basin are characterized by three 2nd order megacycles divided by major regional unconformities. In here described sediments are related to the transtensional post-rift thermal basin subsidence and belong to the second megacycle between the Base Pannonian to the Base Pliocene unconformity

For the interpretation of the genesis and evolution of the wider depositional area around the recent gas field Legrad in the NW Croatia interdisciplinary approach were used.

Information on lithology, ichnology, sedimentary structures and structural elements were obtained from complete macroscopic examination of cores. Petrophysical and calcimetry measurements, detailed petrographical (and microporosity) and palynological analyses were done. Geochemical evaluations were considered. All available well data were correlated and calibrated with well log and seismic data. Paleorelief features (like channel position and their direction) are visible on coherency time-slices.