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A NEW TECTONIC MODEL FOR THE LATE PALEOZOIC EVOLUTION OF THE LORRAINE-SAAR COAL-BEARING BASIN (FRANCE/GERMANY)

The extensive database of published geologic information, structural maps and sections, combined with results of seismic surveys have been used to elaborate a new tectonic model of evolution for both French and German parts of the entire Lorraine-Saar Basin (LSB). In our interpretation the LSB is a thin-skinned asymmetrical *parallelogram-shaped* pull-apart basin. It has been settled and developed on the basal detachment of the listric Metz Fault within megablock on junction of two overlapping sublatitudinal master wrench faults. Our model implies that styles of sedimentation, further deformation and magmatic patterns in the LSB were governed by interplay of local extension-compression environments resulted from translational and rotational responses of the megablock to multiple dextral-sinistral strike-slip reactivations of master wrench faults. The strata in basin lie within a regional scale domain of present-day tensile stress state where cleat systems should be open and we expect that coal seams here must possess higher permeability and hence higher potential for coalbed methane production.

Keywords: Variscan Belt, strike-slip faults, blocks rotation, local extension and compression domains, sedimentation, folding, magmatism, cleat systems, coalbed methane.

Introduction. The Lorraine-Saar Basin (LSB) is one of the largest geologically and commercially important Carboniferous-Permian infill sedimentary basins in the Central Europe. The LSB is one of the major and the mature coalfields in the Western Europe, which contains a number of conventional hydrocarbon accumulations and has the potential to host significant quantities of unconventional plays including coalbed methane gas.

Tectonic setting and contradictions in existing tectonic scenarios for French and German parts of the LSB. In gross structural terms the Basin is a result of the late evolution of the Variscan Belt of the Europe, which had been formed during the convergence of the Laurussia with the Gondwana continents by a closure of different oceans and produced several suture zones including the Rheno-Hercynian and the Saxo-Thuringian zones. The Lorraine Basin was settled and developed since Namurian-Westphalian time upon southern-western portion of the Saxo-Thuringian zone bounded on the south by Bray-Vittel transcrustal fault and bordered with Rheno-Hercynian foldbelt zone along scarp line of continuous deep-seated listric Metz – South Hunsrück fault. Geologically, the LSB stands out by its up to 5 km sedimentary column (Saar 1 borehole [16]; Gironville borehole [14]) and its inversion resulting in Paleozoic low-amplitude erosion in range of 750 m [13] (French part of the basin) and pre-Mesozoic (Permian) erosion between 1800 and 3000 m [12] (German part of the basin). The petroleum systems of the Lorraine basin's sedimentary carapace and superimposed on it the Paris Basin in Lorraine province are mostly associated with the Carboniferous source rocks and historic parametric deep wells have shown hydrocarbon shows throughout the Carboniferous Westphalian and Stephanian sequences in interval 1.0-5.0 km.

As it was mentioned by Korsch and Schäfer [17] non-marine sediments in the basin were deposited in a narrow, structurally controlled basin, which sedimentary infill has been built for two stages of sedimentation: the Late Paleozoic one, when the Lorraine was simply a limnic coal-bearing basin within the framework of units of the Variscan chain [14], and the Early Mesozoic one, when Lorraine become a part of the newly-born Paris Basin.

Using mine-scale and general geologic prospecting datasets Donsimoni [7] proposed a pretty sophisticated geodynamic synthesis for the Lorraine Basin, but Korsch and Schäfer [17] did the same for the Saar Basin. However, there is a proper misfit in these models. Moreover, there is no consensus in tectonic scenario for the entire LSB. What is a difference?

The classical interpretation of geologic history of the basin after Donsimoni [7] considers an extensional control of the sedimentary sequences during the Carboniferous since Namurian [7]. Meanwhile Schäfer et al. [28] cited two compression episodes, the first during Viséan (340 Ma) and the second one corresponding to folding-and-thrusting event in the Lorraine coal basin during

Moscovian (Westphalian C, 310 Ma). More specifically, there is principal contradiction in the age of the principal compressive deformation in the Lorraine and the Saar-Nahe subbasins. From Averbuch et al. [3], a folding associated with reverses faulting in the Merlebach and the Morhange anticline (i.e. the Lorraine segment, Fig. 1) occurred during the deposition of the Westphalian D and can be related to the Asturian tectonic phase, meanwhile normal faults in distension occurred during the sedimentation of Stephanian and Autunian between the anticlines.

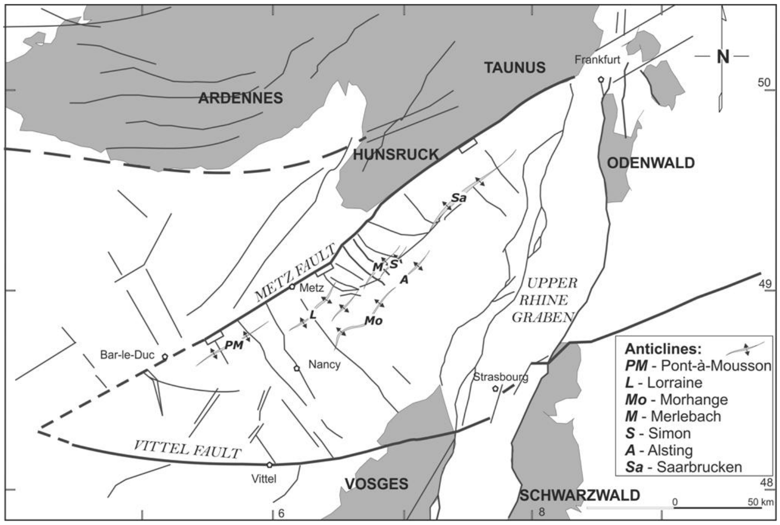

Fig. 1. Structural setting and tectonic elements of the Lorraine-Saar Basin

According Littke et al. [20] there is no doubt that the Saarbrücken anticline - overthrust complex structure (the Saar Basin) was formed during the Saalian tectonic phase, which took place, in fact, from the Stephanian to the Permian. However, from sections presented by Donsimoni [7] it is evident that this tectonic phase has not so dramatically expressed in the Lorraine Basin and it appears to be recorded only in the northernmost part of the French territory of the Basin. According Korsch and Schäfer [17] the most significant Permian deformation patterns are concentrated in the strip between the South Hunsrück-Metz Fault and the Saarbrücken Anticline, and their equivalents to the south-west in France. These conclusions are based on illustrations by Donsimoni [7], which are depicting structural trends from shallow industry seismic reflection data.

The cross-sections of Engel [8] show that the thrust displacement of the Saarbrücken overthrust (in the German part it exceeds 3.6 km) dramatically decreases close to French terrain. Also it is very important to note, that quiet different models of tectonic evolution have been elaborated and proposed for German and French segments of the entire LSB (Fig. 1). A key moment for successful interpretation of all data available is the unique source of information that could be obtained from isopach maps constructed for the Carboniferous units [17]. These isopach maps delineate NE-ward orientated travelling of depocentres of sedimentation along a narrow stripe always located parallel and adjacent to the Metz - South Hunsrück Fault (but not immediately in its damage zone) (Fig. 2).

Strike-slip faulting and deep tectonic framework at the LSB. Stollhofen [30,31] brought sedimentary and tectonic proofs of the presence of strike-slip faults in this basin. According Korsch and Schäfer [17], Schäfer [29] the mentioned above isopach pattern is typical for an internal pull-apart basin at the border between the Rheno-Hercynian and the Saxo-Thuringian Zones of the Variscides. Following this point the Metz - South Hunsrück Fault is interpreted to be a steep, even subvertical dextral strike-slip fault with a considerable transtensional component of movement affected sedimentation within SW- NE trending grain with lateral extent of c. 300 km x 100 km. From the first look this model can explain sedimentation and deformation patterns within the basin. However, because the maxima of thicknesses are not located immediately within the Metz - South

Hunsrück Fault, this fault could not be served a principal displacement zone controlling sedimentation in the basin. The depocentres migrated towards the north-east with time and maintain a consistent moving trend arrangement at some distance from the Fault. However, there is no any evidence prove for existing principal displacement zone's faults parallel to the Metz - South Hunsrück Fault in an area beneath recorded isopach anomalies. Moreover, new structural interpretation proposed recently by Averbuch et al. [3] considers that during the Westphalian D time, at least in the French part of the basin, the compression phase took place and this event was postdated by following regional erosion at the base of Stephanian and weak extension during Stephanian and Permian in the Lorraine. This model contrasts with the classical interpretation of the Lorrain Basin as an extensional intramontane basin structure with related sedimentation throughout the Carboniferous succession since Namurian times [7] and it also has bad connection with ultimate absence of such compression event in the German part of the basin.

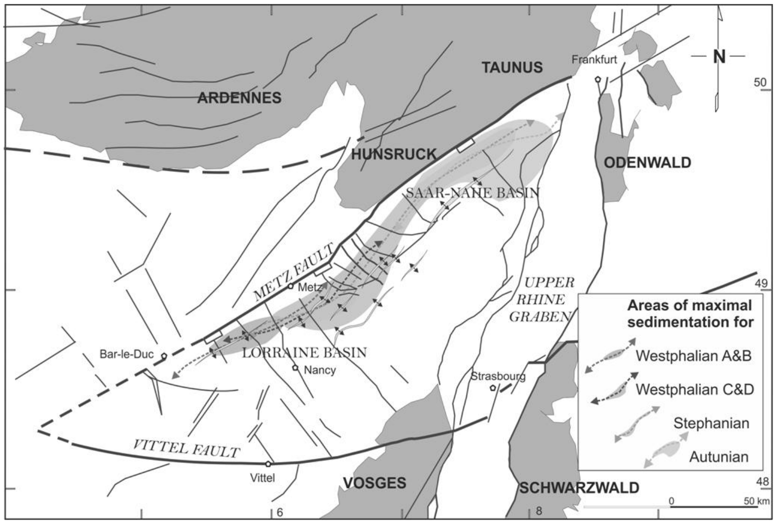

Fig. 2. Distribution of areas of maximal sedimentation in the basin

In this article we are proposing new model for the evolution of the LSB, which could explain the paradox of different interpretations of tectonic history in two parts of the entire and continuous basin. The starting point of our model takes into account that dextral strike-slip component of deformation is widely recognized across the Middle-Late Paleozoic Europe along NW-SE and W-E striking subconcentric wrench faults, e.g. Biscay-Pyrenees, Bristol Channel-Bray-Vittel, North Artois faults [2,19].

In our interpretation the LSB is a thin-skinned pull-apart basin that developed on the basal detachment of the listric Metz Fault between two overlapping transcrustal latitudinal master wrench faults. The first one (the southern master fault) is the Vittel Fault as part of the Wight-Bray-Vittel megashear zone [2,23] extending over 700 km from Bristol Channel to Eastern France and partly concealed beneath Mezozoic sediments of the Paris basin. The Bray-Vittel shear zone has a changing trend from NW-SE in Normandy (Bray segment, wherein a strike-slip regime has been documented by Wyns [32] to E-W in the Lorraine regions (Vittel segment).The second one (the northern master fault) is the North Artois shear zone [6] with dextral strike-slip displacement represented by a bundle of parallel faults recorded from the Weald Basin across English Channel and southern Belgium – northern France boundary [11]. This zone roughly follow the Hercynian front and extend across the Paris Basin southerly from the Southern Ardennes fault zone [24] into the Hunsrück, wherein it can be delineated within the Wittlich-Trier Graben [18] along the sharp gradient zone on the gravimetric map. Schintgen and Förster [30] showed the presence here the set of WSW-ENE striking faults, which could be included in zone of northern master fault, e.g. Lorentzweiler–Bech, Wittlicher Senke and Main Wittlich faults. Murawski et al. [24] have mentioned that in the area of the upper Mosel River at the southern edge of the Ardennes, geological maps and aerial photographs show traces and erosional features of this fault zone very clearly. Also these authors noted that, if the fault zone has a prolongation to the west, it must be below the thick cover of the Paris Basin. Results of deep seismic reflection profile (DFG Geotraverse Rhenohezynikum) demonstrate concave listric faults [1, 24] curving to the south within zone of the Metz - South Hunsrück Fault. In contrast with the interpretation of Korsch and Schafer [17], detailed interpretation of the seismic sections of DEKORP by Henk [10] demonstrated that the Metz - South Hunsrück Fault could not be simply served as a master fault which controlled the Permo-Carboniferous evolution of the basin. Careful examination of the seismic data [10] showed that the Metz - South Hunsrück Fault is not subvertical indeed at deep levels. At ~2 km depth its angle dip is about 65°. The Metz - South Hunsrück Fault flattens rapidly and finally soles out at the subhorizontal position of basal décollement constrained at level of ~4-6 km *depth.* The importance of listric normal faults in the formation of sedimentary basins is becoming increasingly more obvious. *In fact the Metz Fault is well-lubricated listric detachment, which can provide a basis for sedimentation occurring between* its foot and hanging wall blocks when the hanging wall block of a listric fault is pulled away from the foot wall block under extensional forces.

To summarise, the entire LSB possesses all set of distinctive aspects of the of strike-slip tectonics [4,9]. Amongst them are: (i) geological mismatches within and at the boundaries of a basin; (ii) a tendency for lateral basin asymmetry, owing to the migration of depocentres with time; (3) evidence for occurrences of unconformities from one basin to another its part in the same region.

The proposed new model of geodynamic evolution of the LSB considers development of the basin as a thin-skinned asymmetrical pull-apart basin of *parallelogram-like* shape appeared to have settled within megablock bordered by segments of two overlapping master wrench faults: the North Artois-Wittlich Fault at the north and the Vittel Fault at the south. The eastern limit of the megablock was drawn along subsurface trace of listric detachment of the Metz Fault. The western limit of the megablock was drawn roughly at subhorizontal décollement level wherein surface of basal detachment flattens and dies. Our model implies that sedimentation and further deformation patterns in the LSB were caused and governed by multiple responses of the megablock and deposited above them sediments to strike-slip reactivations of master wrench faults. These responses have included acts of rigid body deformations (horizontal and vertical translation, sign-alternative rotation) within the megablock or, more specifically, basement floor of the basin and processes accompanied by effects associated with rigid and non-rigid body deformations (torsion, dilatation, distortion) localised mostly in a sedimentary carapace of the basin.

The particular position of depositional sites in the basin and their subsidence history was determined by: (i) the type and the configuration of pre-existing tectonic structures; (ii) their kinematic behaviour in relation to external framework of strike-slip movements within principal wrench faults; (ii) variations in an interplay of local extension and compression environments within particular domains as a reaction to translation and rotation of tectonic blocks. In our interpretation we are following ideas of Christie-*Blick and Biddle* [4], Cunningham and Mann [5], who had pointed that the development of fault structural styles may also be influenced by the blocks rotation effects and spatial distribution of restraining and releasing bends. Such approach has been previously implemented for interpretation of existing tectonic patterns and elaborating new geodynamic model for the Donets Basin (Ukraine) [26].

Stages of basin formation. In this section, we focus on processes of basin formation with special stress on setting of depositional sites and certain distinctive characteristics of kinematic fold and fault behaviour as well as formation of principal cleat systems in coal beds of the basin. The principal episodes of Palaeozoic tectonic evolution of the Lorraine Basin are represented below.

Pre-rift Late Viséan stage. The Lorraine coal Basin contains a thick series (8000 m) of sandstones, coals and claystones deposited from Mississippian: Late Viséan and Namurian (Serpukhovian) to Pennsylvanian: Westphalian and Stephanian. After Donsimoni [7], the sedimentation began after the Sudeten phase (Namurian) in the Lorraine coal Basin during a period of distension. Fig. 3 depicts a geological framework of the Late Viséan pre-rift stage or just an initial stage of the basin formation.

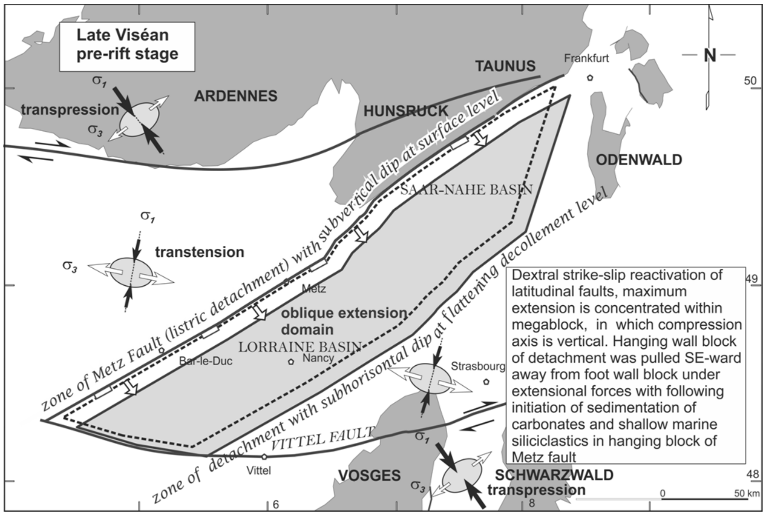

Fig. 3. Geological framework of the basin during the Late Viséan pre-rift stage or just an initial stage of the basin formation

Pre-rift sediments are known here from a few deep parametric wells and these are represented by carbonates and shallow marine siliciclastics. The appearance of dextral strike-slip shear zones of proximate age and strike in the French Variscan belt is proved by monitoring of syn-kinematic plutons [27]. We suggest that during the Late Viséan time the dextral transpressional strike-slip reactivation of latitudinal master faults have took place (principal stresses maximal σ_1 and minimal σ_3 laid in the horizontal plane and the intermediate principal stress σ_2 was vertical) and in this case oblique extension was concentrated within the megablock, in which compression axis σ_1 has become vertical. The hanging wall block of downward-flattened the Metz detachment was pulled SE-ward away (oblique translation) from foot wall block under extensional forces with following initiation of sedimentation of Late Viséan sediments in half-graben structure above collapsed hanging block of the Metz fault.

Syn-rift Namurian stage. Fig. 4 exhibits the kinematic patterns for the Namurian syn-rift stage.

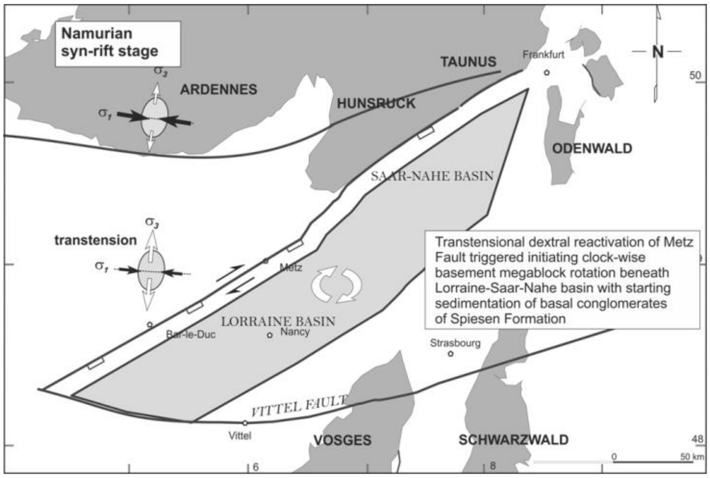

Fig. 4. Geological framework of the basin and the kinematic patterns for the Namurian syn-rift stage

Because of counter-clockwise rotation of compression axis σ_1 to sublatitudinal position in transpressional regime outside of the basin some transtensional dextral reactivation of the Metz Fault has been started. This triggered initiating clockwise basement megablock rotation beneath the LSB with occurring sedimentation of basal conglomerates of the Spiesen Formation that unconformably overlies the pre-rift succession.

Syn-rift Westphalian A, B and C stage. Further clockwise rotation of the megablock beneath the entire basin and formation of local environments of compression in the Lorraine Basin and an extension in the Saar basin was typical for the Westphalian A, B and C syn-rift stage (Fig. 5).

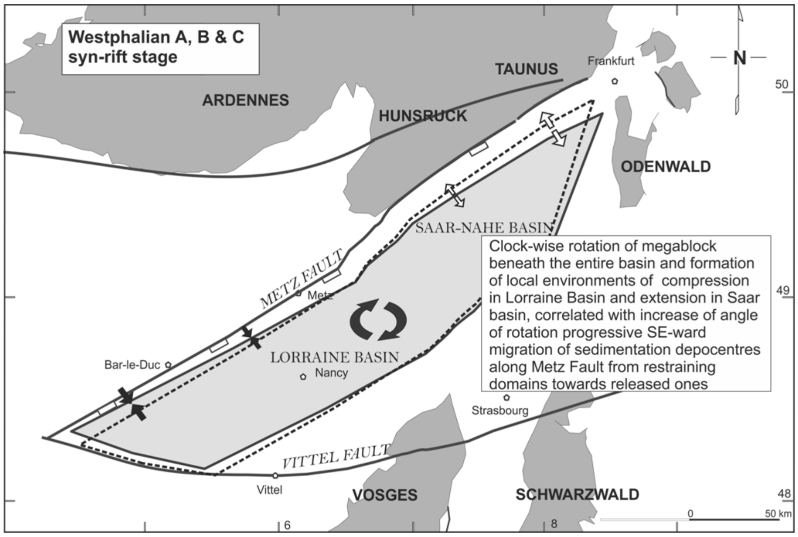

Fig.5. Geological framework of the basin and the kinematic patterns for the Westphalian A, B and C syn-rift stage

Suggested mechanism of deformations caused by rotation of the megablock may provide an explanation of phenomena of generating Westphalian sequences in the Lorraine segment under the compression by faults at the border and inside the basin [3] and depositing synchronous formations in extensional environments in the Saar segment of the basin [12]. Also it is very important to underline that an increase of an angle of rotation triggered progressive NE-ward migration of sedimentation depocentres along Metz Fault from restraining domains towards released ones. This process was accompanied by very specific drainage patterns. In the Westphalian, sediment supply was mainly from the Hunsrück and the Taunus provenance provinces or broadly speaking from the Rhenish Massif, which has been served as an uplifted shoulder of the rift. Izart et al. [14] showed that continental deposits and third to second order sequences of the Lorraine Basin during this stage were mainly controlled by tectonics that generated the accommodation space in the basin during the subsidence and the maximum flooding periods.

Syn-rift Westphalian D stage. The main controls on the development of structural patterns in the LSB during Westphalian D syn-rift stage are shown on Fig. 6. Compressional environment in the Lorraine Basin and southern-western part of the Saar basin were caused by clockwise rotation of the megablock and these resulted here in: (i) folding and thrusting event; (ii) associated formation of primary tensional NW-SE striking cleat system orthogonal to fold axes and after secondary curvilinear NE-SW trending shearing cleat; (iii) uplift and erosion, which provoked formation of Merlebach conglomerates and later Holz conglomerates (Stephanian) that unconformably overlie Westphalian. For example, in the Landroff syncline (region Betting-lès-St-Avold), the Stephanian layers appear to be rested clearly unconformable. In the TOUL 08 seismic line the Westphalian is observed in an anticline that is the continuation of the Pont-à-Mousson anticline, drilled by the Gironville borehole. The contact of Stephanian on the Westphalian was interpreted by Izart et al. [14] as clear unconformity. In the same time extensional environment and normal faulting took place in the north-eastern part of the Saar Basin, wherein Westphalian-Stephanian transition is conformable [17].

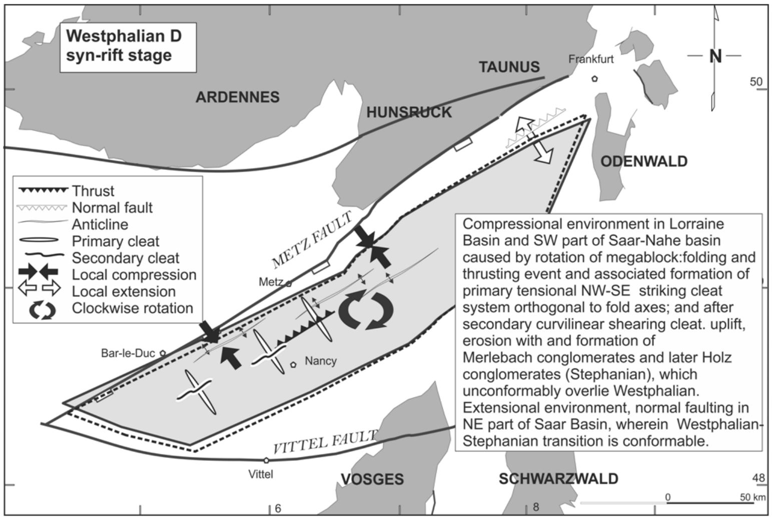

Fig.6. Geological framework of the basin and the kinematic patterns for Westphalian D syn-rift stage

Syn-rift Stephanian-Autunian stage. The Stephanian-Autunian syn-rift stage (Fig. 7) has been characterized by a renewal of dextral strike-slip movements along latitudinal master faults. It caused the conditions of an extension with NE trend of increasing extension magnitude from the Lorraine basin to the Saar basin. We have to conclude that synsedimentary driven normal faults are formed during the sedimentation of Stephanian and Autunian deposits. Subsidence and sedimentation with domination of fluvial depositional environments took place in the entire basin excluding SW part of the Lorraine Basin. At times, particularly during the Kusel and Lebach Group, the Saar-Nahe basin with was covered by large lakes with organic-rich shales, which were subsequently filled by prograding deltas [12]. Definitely, this was a time of maximal burial of sediments and pervasive hydrocarbon generation.

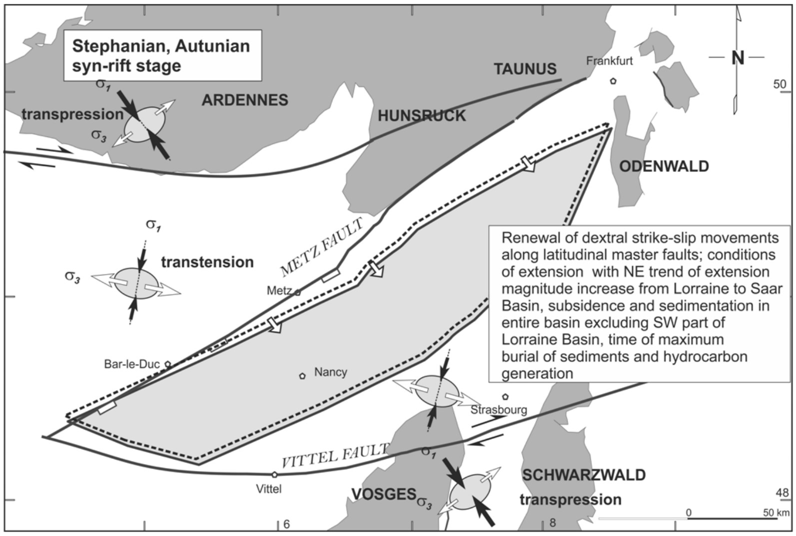

Fig.7. Geological framework of the basin and the kinematic patterns for Stephanian-Autunian syn-rift stage

Syn-rift Early Permian volcanic stage. The Early Permian volcanic syn-rift stage (Fig. 8) has been initiated by sinistral transtensional movements along latitudinal master faults. It caused counter-clockwise torsion of megablock with further triggering local compression in the Saar Basin, wherein Saarbrücken overthrust and anticline were formed. Restraining environment here gave a pulse for initiating formation of primary exogenetic tensile cleat and suborthogonal planes of secondary curvilinear cleat. The Saarbrücken Anticline can be interpreted as a fault-propagation fold developing above the ramp of the thrust fault [17]. Juch [15] proposed an explanation of this anticline as positive flower structure typical for transpressional strike–slip regime. In the Lorraine basin normal NE-SW striking faulting took place. The Metz Fault reactivated as normal fault in which vicinity a number of new NW-dipping and penetrating into pre-Carboniferous basement normal faults appeared. Along the Metz Fault area of release with rhyolitic volcanism was formed. With a compositional range stretching from tholeiitic basalts to rhyolites and alkalifeldspar trachytes, magmas rose from their source levels into the Saar Basin and became involved in intensive volcanic and subvolcanic activities [21]. Because of sinistral reactivation of the Metz listric detachment magmatic camera was allocated within jog of changing a strike of the Metz Fault. Also local releasing jogs appeared because of rotation of the megablock into north-eastern and eastern periphery of Saar-Nahe Basin, and definitively these were facilitated to widespread and various volcanic activity including emplacement of lava flows, domes (e.g. Donnersberg intrusive-extrusive dome), and the formation of maardiatreme volcanoes [21].

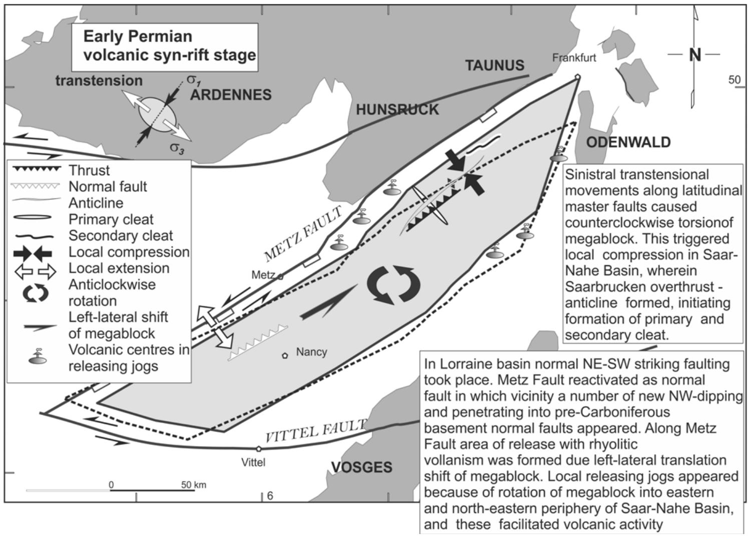

Fig.8. Geological framework of the basin and the kinematic patterns for Early Permian volcanic syn-rift stage

Post-rift intra-Permian inversion and major erosion stage. Fig. 9 depicts patterns of finalization of the Paleozoic evolution of the basin. During transition of the Early-Late Permian times here in the basin was a stage of an inversion and major erosion. Sinistral transpressional movements along latitudinal master faults caused transformation of pull-apart within megablock into push-up structure with prevailing regime of upward movements due to NW-ward sliding of hanging block of the Metz detachment on melt-lubricate fault surface. The uplift of the basin with NW trending and upward movement of the megablock triggered opening of fractures related with secondary shearing curvilinear cleat system in direction perpendicular to NW movement of megablock (i.e. parallel to the Metz Fault). Intensive uplift concentrated mostly in zone adjoining the Metz detachment with following erosion resulted in collapse structures unfilled by thick downfaulted conglomerate-sandstone sediments [22]. During the Rotliegend, large parts of the post-rift and even of the syn-rift basin fill was removed by a major erosional event [17]. Within releasing jog on change of strike of the Metz - South Hunsrück Fault last volcanic activity took place.

Conclusions about present-day stress-state of the basin and its implications for coalbed methane exploitation. In the LSB basin generated gaseous hydrocarbons from deep compartments and low-permeability levels (3.5-5.5 km – dry gas window) may have escaped via several major fault and fracture zones forming structurally related conventional gas accumulations in antiform-type (e.g. Lorraine, Merlebach and Alsting anticlines, wherein strata folded upwards tend to produce internal fracturing due to stretching of the rocks) or associated fault-breached structures. The *Gironville borehole* (Lorraine, France) intersects, at depths between 1000 and

5700 m mainly, Carboniferous coal-bearing formations with progressive increasing diagenetic and catagenetic alterations with depth from subbituminous coals to meta-anthracites.

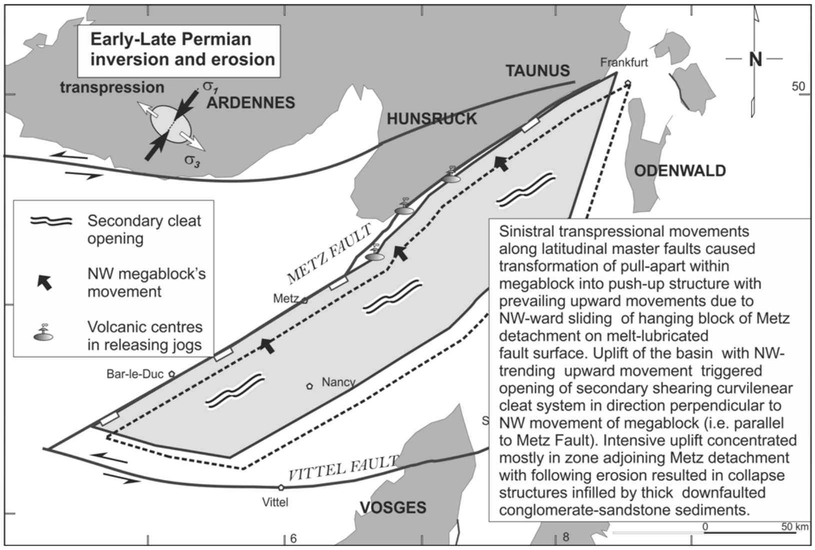

Fig.9. Geological framework of the basin and the kinematic patterns for transition of the Early-Late Permian times - of finalization of the Palaeozoic evolution of the basin

According estimation of European Gas Ltd. experts the coal at depth of 1 km below ground surface is permeable and crumbly, so the gas in the Lorraine will be cheap to extract with no need for expensive stimulation techniques including banned hydraulic fracturing. Some comments regarding relationship of the present day architecture of the LSB, or more specifically, a thin-skinned pull-apart basin, which was largely resulted from the interplay between dextral and sinistral reactivations of master wrench faults: the North Artois- Wittlich Fault at the north and the Vittel Fault at the south, and recent stress field in adjoining regions from seismotectonic reconstructions. Using the inversion method Plenefisch and Bonjer [25] for datasets and following analysis of focal mechanisms of earthquakes in northern Alpine foreland, Upper Rhine Graben, Lower Rhine Graben and Rhenish Massif revealed a stable axis of minimum principal (extensional) stress σ_3, oriented horizontally to subhorizontally and striking in a WSW-ENE to SW-NE direction. The azimuth of σ_1, the maximum principal (compressional) stress, is about 150°. Deflections of modern river courses over the crests of anticlines and around principal fault zone suggest that this deformation is still ongoing at present. These results are in good agreement with the general features for Western Europe in the European Stress Map and could be used as a basis for inferring local extension strain state (because of dextral reactivations of master wrench faults) within the entire Lorraine-Saar Basin. Here the coals lie within a regional scale domain of tensile stress state where cleat systems should be open. To summarise, on the basis of our new model of basin evolution we expect that coal seams here must possess higher permeability and hence higher potential for gas (coalbed methane) production.

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НОВА ТЕКТОНІЧНА МОДЕЛЬ ПІЗНЬОПАЛЕОЗОЙСЬКОЇ ЕВОЛЮЦІЇ ЛОТАРИНЗЬКО-СААРСЬКОГО ВУГЛЕНОСНОГО БАСЕЙНУ (ФРАНЦІЯ / НІМЕЧЧИНА)

Для розробки нової тектонічної моделі еволюції французької та німецької частин єдиного Лотаринзько-Саарського басейну (ЛСБ) було проаналізовано велику базу даних, що включає опубліковану геологічну інформацію, структурні карти і розрізи, результати сейсмічних зйомок. У нашій інтерпретації ЛСБ являє собою тонкопластинчастий асиметричний басейн призсувного розтягу (пул–апарт) паралелограмоподібної форми. Він був закладений і розвивався на базальній поверхні лістричного Мецького розлому в межах мегаблоку на стику двох трансрегіональних зсувних зон, що перекриваються. Наша модель передбачає, що характер осадконагромадження, наступні деформаційні процеси і магматична активність в різних частинах єдиного басейну контролювалися ефектами локального розтягу або стиску, котрі виникали як реакція на поступальні і обертальні рухи мегаблоку за умов знакозмінної зсувної активізації північної і південної зон субширотних розривів. На сучасному етапі розвитку басейну його осадовой чохол знаходиться у стані локального розтягу з відкритими системи кліважу; отже, ми очікуємо, що вугільні пласти тут мають більш високу проникність і, таким чином, більш високий потенціал для промислового видобування вугільного метану.

Ключові слова: герцинський пояс, зсуви, обертання блоків, локальні обстановки розтягу і стиску, осадконагромадження, складкоутворення, магматизм, системи кліважу, метан вугільних пластів.

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НОВАЯ ТЕКТОНИЧЕСКАЯ МОДЕЛЬ ПОЗДНЕПАЛЕОЗОЙСКОЙ ЭВОЛЮЦИИ ЛОТАРИНГСКО-СААРСКОГО УГЛЕНОСНОГО БАССЕЙНА (ФРАНЦИЯ / ГЕРМАНИЯ)

Для разработки новой тектонической модели эволюции французской и немецкой частей единого Лотарингско-Саарского бассейна (ЛСБ) была проанализирована обширная база данных, включающая опубликованную геологическую информацию, структурные карты и разрезы, результаты сейсмических съемок. В нашей интерпретации ЛСБ представляет собой тонкопластинчатый асимметричный бассейн присдвигового растяжения (пулл-апарт) параллелограммной в сечении формы. Он был заложен и развивался на базальной поверхности листрического Мецского разлома в пределах мегаблока на стыке двух перекрывающихся субширотных трансрегиональных сдвиговых зон. Наша модель предполагает, что характер осадконакопления, последующие деформационные процессы и магматическая активность в разных частях единого бассейна контролировались эффектами локального растяжения или сжатия, которые возникали как реакция на поступательные и вращательные движения мегаблока при знакопеременной сдвиговой активизации северной и южной зон субширотных разрывов. На современном этапе развития бассейна его осадочный чехол находится в состоянии локального растяжения с открытыми системами кливажа; следовательно, мы ожидаем, что угольные пласты здесь имеют более высокую проницаемость и, таким образом, более высокий потенциал для промышленной добычи угольного метана.

Ключевые слова: герцинский пояс, сдвиги, вращение блоков, локальные обстановки растяжения и сжатия, осадконакопление, складкообразование, магматизм, системы кливажа, метан угольных пластов.

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