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PALINSPASTIC RECONSTRUCTION OF THE EASTERNMOST ALPS BETWEEN UPPER EOCENE AND MIOCENE

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Abstract: During the Paleogene the SE flank of the Variscan Bohemian Massif stayed in a passive margin stage.
In the Late Eocene clastic shelf sedimentation together with coralline-algal reefs were characteristic for this margin area. Coloured clays of deeper environments are comparable with the Helvetic sediments west of Vienna. Sedimentation in the Flysch trough south of it ceased at the end of the Eocene because of the northward progression of the Alpine nappe system.
In the Early Oligocene the separation of the Paratethys began. A regressional phase together with a restricted environment took place. Laminated dark marls and shales were deposited during that period of tectonic inactivity. Beginning with Egerian the flank of the Bohemian Massif was increasingly loaded by the north to northwestward prograding Alps. The former shallow shelf area was turned into an Alpine foreland trough accompanied by a transgression onto the Bohemian Massif. Erosional canyon cuts and block horizons are characteristic for the tectonic unstable condition at the former shelf margin. The direction of nappe progradation and compression turned from N to NNW to the shelf edge.
In the Eggenburgian cyclic Molasse sedimentation was predominant in the NNW prograding foreland trough. Clastic material was derived from the Alpine range. The maximum marine extension and transgression onto the Bohemian Massif occurred at that time. Thrusting changed to a NW direction. From the Ottnangian to Karpatian thrust movement slowed down. Because of the fixing of the Alpine nappes at the Spur of the Bohemian Massif near Vienna and the continuous progression of the Carpathian fold belt, extension occurred in a NE - SW direction. As a result the Vienna Basin was created on top of the stretched Alpine-Carpathian fold belt.
After the nappe progression onto the Bohemian Massif ceased, a new NNE - SSW directed left lateral strike-slip movement dominated. The Vienna Basin turned into a pull apart basin during Badenian to Pannonian. From the Pontian until now, the NW - SE directed extension results in graben-like features along the SE flank of the Vienna Basin.

Key words: palinspastic reconstruction, Eastern Alps, Tertiary.

Introduction

The transition zone between the Alps and the Carpathians has been geologically mapped since the last century. First driven by scientific research, the first hydrocarbon findings attracted much more interest in the Vienna Basin region and its surroundings. In particular the Tertiary filling of the Vienna Basin has been systematically analysed since the early of 20th century. This was strongly supported by an increasing number of exploration bore holes.

First, different formations, their stratigraphic age and areal extent were defined. Their lithology, genetic origin, sedimentological composition and reservoir parameters were analysed later. Comparing the sequences geologists realized that it was difficult to correlate them across the major fault system in the Vienna Basin. Mapping results at the east flank of the basin showed the crystalline formations of the neighbouring Leitha Mts. and Malé Karpaty Mts. were different in facies and stage of metamorphism.

The third observed problem was the identical facies of some Early Miocene formations of the Molasse trough and the Vienna Basin separated by the Waschberg-Ždánice Zone and the Flysch Zone.

From 1980 on new ideas and concepts were developed to explain these observations.

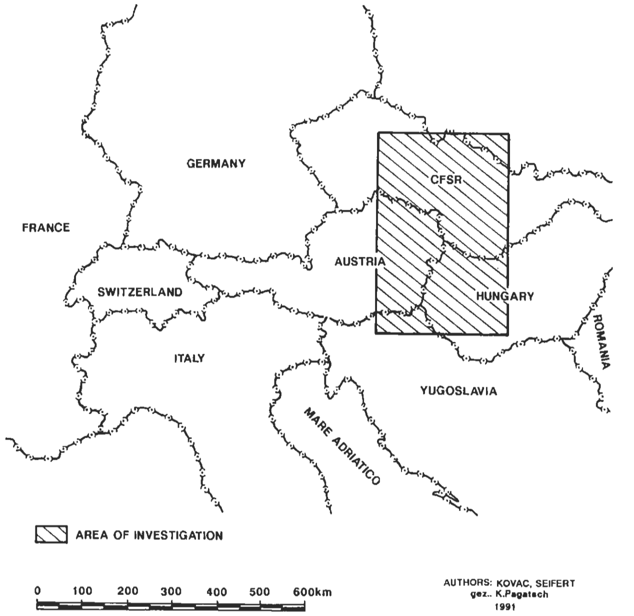

Fig. 1. Situation of the palinspastic reconstructed Alpine-Carpathian junction.

The diachronous progression of the Alpine-Carpathian nappe system onto the foreland was published in 1979 by Jiříček.

Royden et al. (1983) defined the Vienna Basin as a pull apart basin. Steininger et al. (1986) demonstrated that the Vienna Basin during its early stage (Lower Miocene) was a so called piggy back basin on top of the Alpine-Carpathian belt, connected with the Molasse Basin.

Kováč (1986), Nemčok et al. (1989) and Marko et al.(1990) analysed the tectonic evolution and the change of stress fields during the Miocene in the NE part of the Vienna Basin and the adjacent Malé Karpaty Mts.

Wessely (1987) proved this concept by analysing the fault pattern and the different stages of its tectonic evolution.

Jiříček & Seifert (1990) created thickness maps of different Neogene formations which reflect the tectonic development of the Vienna Basin and its frame.

In 1984 Kováč created a palinspastic sketch map of the Alpine-Carpathian junction from the Eggenburgian to the Badenian. This was first time the prograding nappe system and the expanding Vienna Basin on top of it were integrated into one model. In 1988 Kováč started with a group of Central European geoscientists with the palinspastic reconstruction of the whole Carpatho-Pannonian region beginning with the Late Eocene stage until now. The whole region between Vienna, Brno, Bratislava, Hungary, southern Poland, Romania and northern Yugoslavia was included. This paper deals with the geological development of the Vienna Basin region at the Alpine-Carpathian junction. Six maps beginning with the Late Eocene were created.

Todays outline of the exposed Variscan Bohemian Massif is marked on each map (Figs. 2 - 7). The cities of Graz, Vienna, Bratislava and Brno are situated in todays geographic position marked on the maps.

Stages of geodynamics

Upper Eocene

Sedimentation in the Rheno-Danubian Flysch trough ceased during this period. The Flysch sequence started to get internally thrusted. The Calcareous Alps turned predominantly into mainland. Both geological units moved fast northwards. Towards the east, Flysch sedimentation continued in the Carpathian trough at that time, connected to the Pannonian sedimentation area to the south.

The sea between the Alpine-Carpathian belt and the Bohemian Massif remained some hundred meters to 2000 *m* deep. Coloured clay sedimentation was typical for this so called Late Helvetic and Subsilesian zone.

Transgression onto the foreland continued in Upper Austria west of the Bohemian Massif spur. Nummulitic sandstones and coralline algal limestones were deposited on a broad shallow shelf.

Regression continued along the southeast flank of the Bohemian Massif. Upper Cretaceous, Paleocene and Eocene formations were eroded. Shallow marine clastics (Reingruber Serie) and coralline algal limestones appeared on a narrow shelf. Two interesting features occurred at that time. The Moosbierbaum Conglomerate west of Vienna represents an alluvial terrestric fan in a semiaride climate. The Nesvačilka and Vranovice ca-

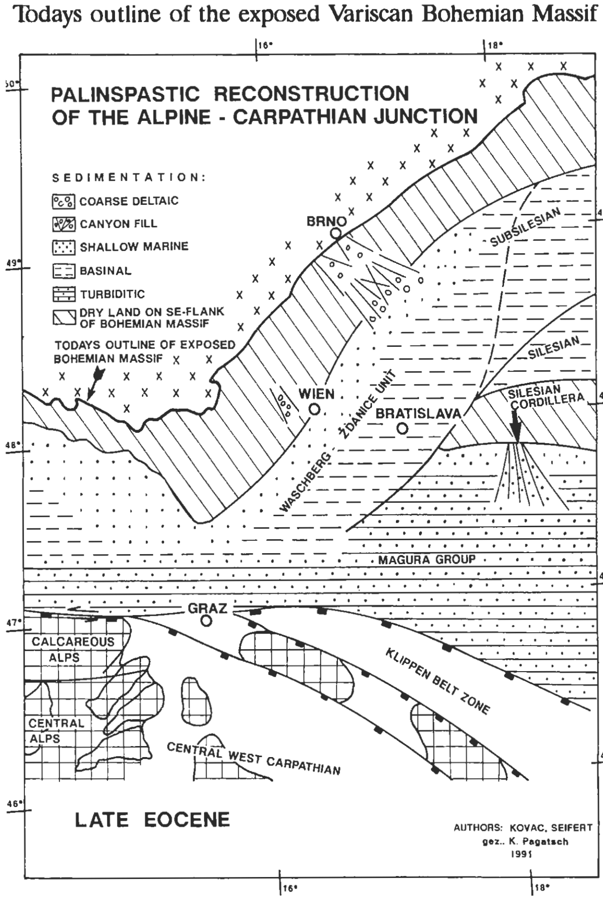

Fig. 2. Palinspastic reconstruction of the Alpine-Carpathian junction. Late Eocene.

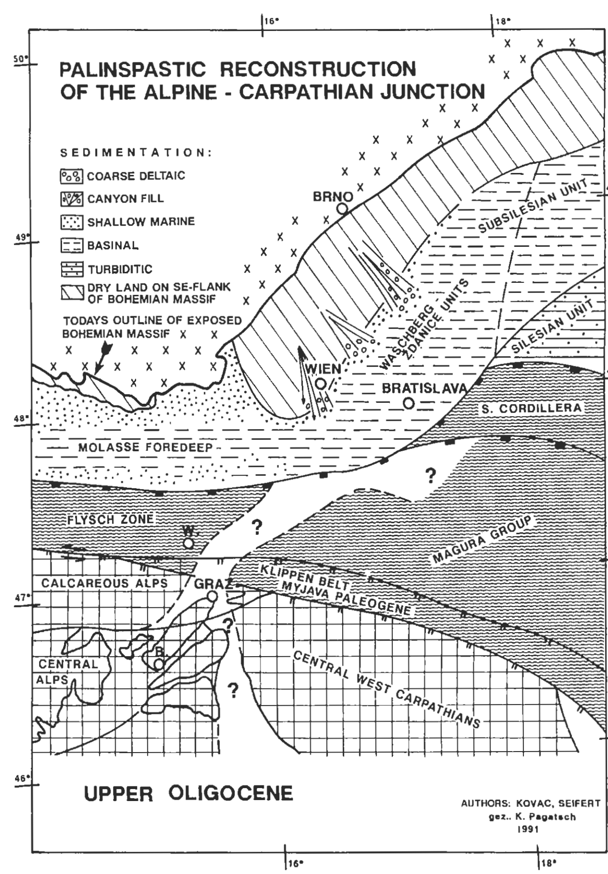

Fig. 3. Palinspastic reconstruction of the Alpine-Carpathian junction. Upper Oligocene.

nyons, deep cuts into the Bohemian Platform, derived material from Tertiary, Mesozoic and Paleozoic formations. The sedimentary development is partly flysch-like.

Upper Oligocene

During the Lower Oligocene (Rupelian) the Central Paratethys region was separated from the Mediterranean Sea. The geologic picture changed at the beginning of the Upper Oligocene (Egerian).

The complete Alpine-Carpathian Flysch belt moved northwards. In front of it a foreland trough developed with some hundred to 1500 meters depth. Light grey and some coloured shales and claystones were deposited. A residual flysch trough remained only north of the Silesian cordillera. The front of the Calcareous Alps reached probably todays position of Graz.

More canyon cuts through the shelf platform appeared NW of Vienna and NE of Vienna near Zistersdorf. This was the result of the continuous uplift of the southeast flank of the Bohemian Massif in connection with eustatic sea level changes.

Later during the Egerian, this movement changes into slow subsidence as a reaction to the continuous loading of the prograding Alpine-Carpathian nappes onto the Bohemian Massif margin.

The transgression started with the deposition of shallow marine arkosic sandstones along the southeast flank. At the spur of the Bohemian Massif west of Vienna, a bay-like depression appeared. It was filled by limnic-brackish clastic sediments of the early Melk Formation. This formation continued towards the west in a shallow marine environment on a broad shelf.

During the Egerian a connection to the Pannonian region towards the south was reestablished for some time. The Alpine-Carpathian belt was a shallow marine swell zone in that area.

Eggenburgian

Progression of the Calcareous Alps continued at that time. Intense internal thrusting of the Flysch belt resulted in shortening in N - S direction. The abbreviations W., G., B. (Fig. 4), mark the position of the cities Vienna, Graz, Bratislava on top of the prograding geological units. The northwards movement of the Alpine nappes slowed down SW of Vienna, because of the resistance of the Bohemian Massif spur. On the contrary the Carpathian nappe system east of Bratislava prograded continuously northwards. This unequal movement caused tension in the nappes at the Alpine-Carpathian transition zone. As a result some lateral movements along the front of the Flysch and Calcareous Alps nappes occurred and thinning of the nappe stack happened. This resulted in subsidence and the creation of a small basin, the Vienna Basin.

It was caused by extension in SW - NE direction. Limnic to brackish deltaic sediments mark the beginning of the transgression onto the north part of the Malé Karpaty Mts. situated at the south end of the basin. At the northeastern end of the basin similar sediments appear north of the Myjava Depression and the Váh river Valley. The Leitha Mts. situated north of todays position of Graz, and the Malé Karpaty Mts. east of it seem to belong to different units of the Unterostalpine. This might explain the different facies and stage of metamorphism of their Paleozoic and Mesozoic formations.

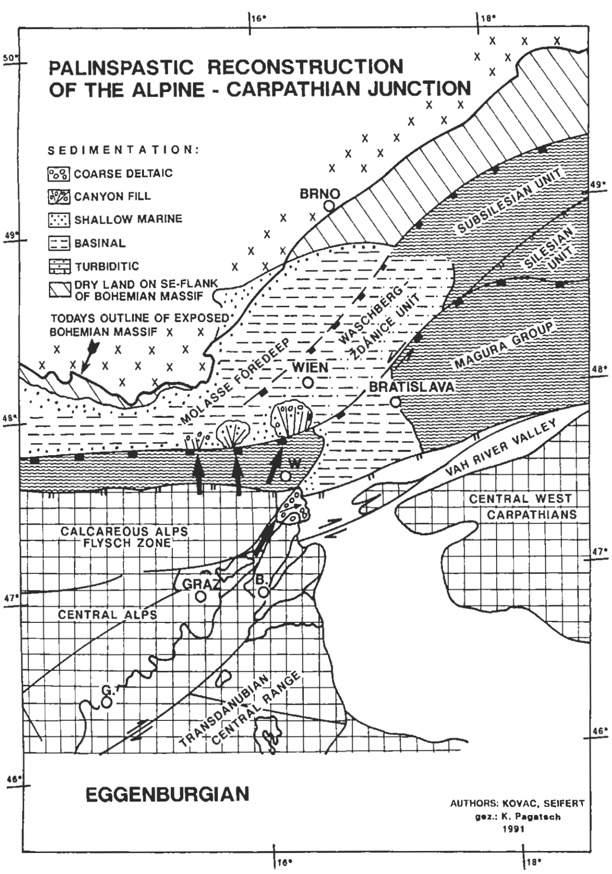

Fig. 4. Palinspastic reconstruction of the Alpine-Carpathian junction. Eggenburgian.

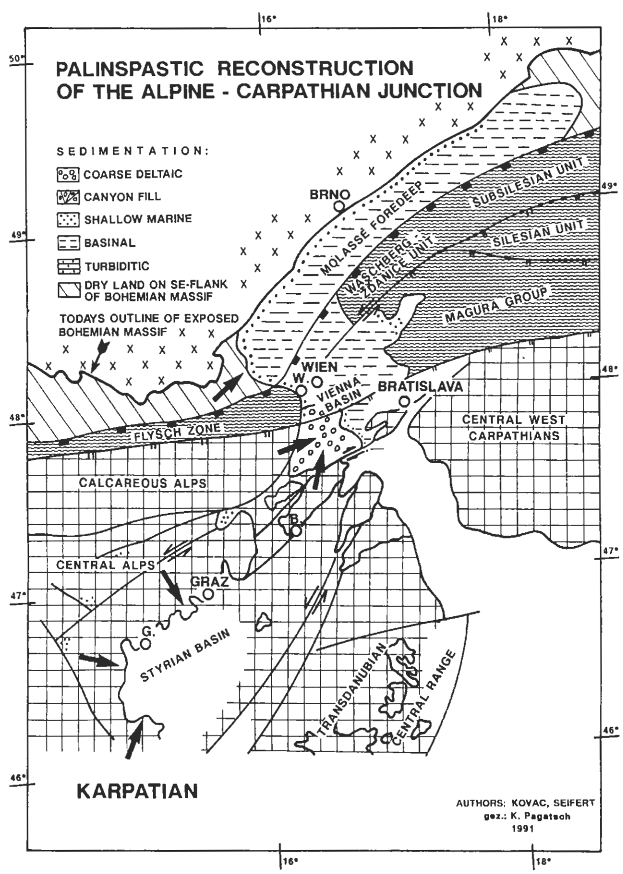

Fig. 5. Palinspastic reconstruction of the Alpine-Carpathian junction. Karpatian.

The Vienna Basin reached a depth of a few hundred meters and was connected with the Molasse foredeep towards northwest and probably with the Pannonian region towards southeast. In a few hundred to 1000 meters deep Molasse trough cyclic silty-sandy to shaly sedimentation was predominant. At its southern border talus cones of blocky material occurred at the front of the prograding Alpine belt from the beginning of Eggenburgian on. The marine transgression along the southeast flank of the Bohemian Massif reached the crystalline basement and deposited shallow water sediments far into the Hron subbasin. Southeast of it, near the village of Eggenburg, which named this stage, a broad variety of species of molluscs, fishes, vertebrates, etc. characterized the rich faunal development on the shelf. The northeastern end of the Molasse basin towards southern Poland developed as a bay with halite sedimentation.

Karpatian

The front of the Alpine belt reached its final position. The Carpathian nappe system still prograded northwards. Strong internal thrusting of the Molasse sediments resulted into the development of the outer thrustbelt, the Waschberg-Ždánice Zone. The strike-slip fault line along the Mur-Mürz Valley north of Graz got more prominent. Some small intramontane basins with limnic-terrestric sediments along this and some other lineaments were the results of differential block movement. East of the Leitha Mts. the Malé Karpaty Mts. moved fast northwards along another left lateral strike-slip line. The Vienna Basin opened to the south, where a big fluvial-limnic to brackish delta prograded out from the Alps. Another delta from the north derived material from the uplifting Carpathian belt. In the residual Molasse foredeep, 200 - 300 meters deep, predominantly clayey sediments were deposited. They were identical with those in the connected Central Vienna Basin. The basin got shallower and sedimentation turned into fluvial with deposition of the Anderklaa Conglomerate at the end of the Karpatian.

The Karpatian stage was a regressional phase in the foreland because of the uplift of the Bohemian Massif and the Alps. The Molasse Basin ceased near Vienna.

West of it the former foredeep turned into dry land. At the northeastern end of the Molasse Basin near Ostrava sedimentary conditions turned into brackish.

Badenian and Sarmatian

The Western Carpathian nappe system reached its present position. Some lateral movements occurred along the nappe fronts. More prominent strike-slip movements appeared along new faults, turning partly oblique, and along the nappe boundaries. This happened as a result of the continuous progression of the Eastern Carpathian nappes due to persistent compression.

The most significant features are synsedimentary normal faults with displacements reaching 6000 *m*. En echelon arrangements of faults point to a left lateral displacement.

The Malé Karpaty Mts. reached todays position northeast of the Leitha Mts. The Vienna Basin got a new elongated shape directed NNE - SSW.

Out from the former Molasse Basin, which got dry land as a whole, a big delta system prograded from the west across the

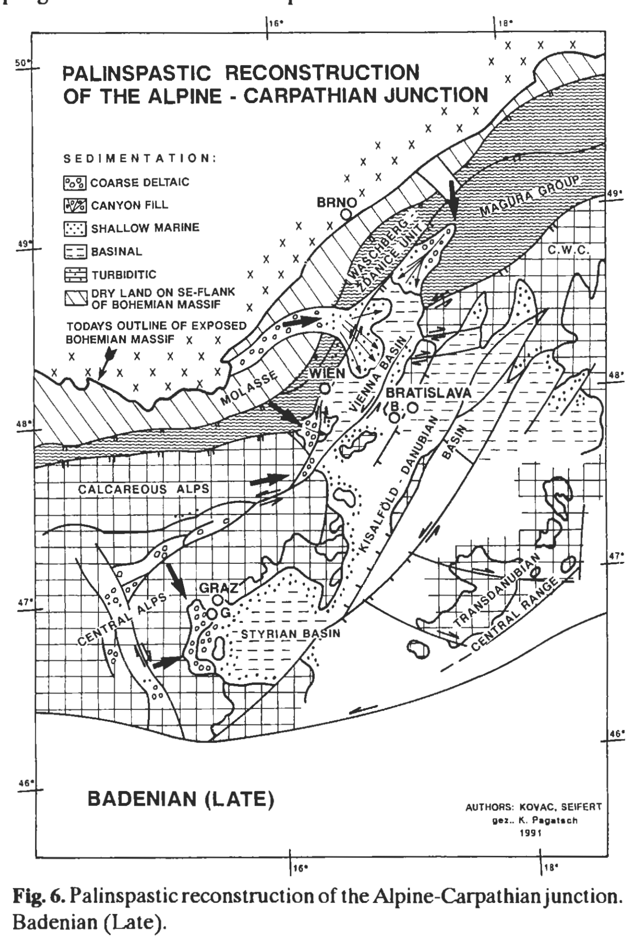

Fig. 6. Palinspastic reconstruction of the Alpine-Carpathian junction. Badenian (Late).

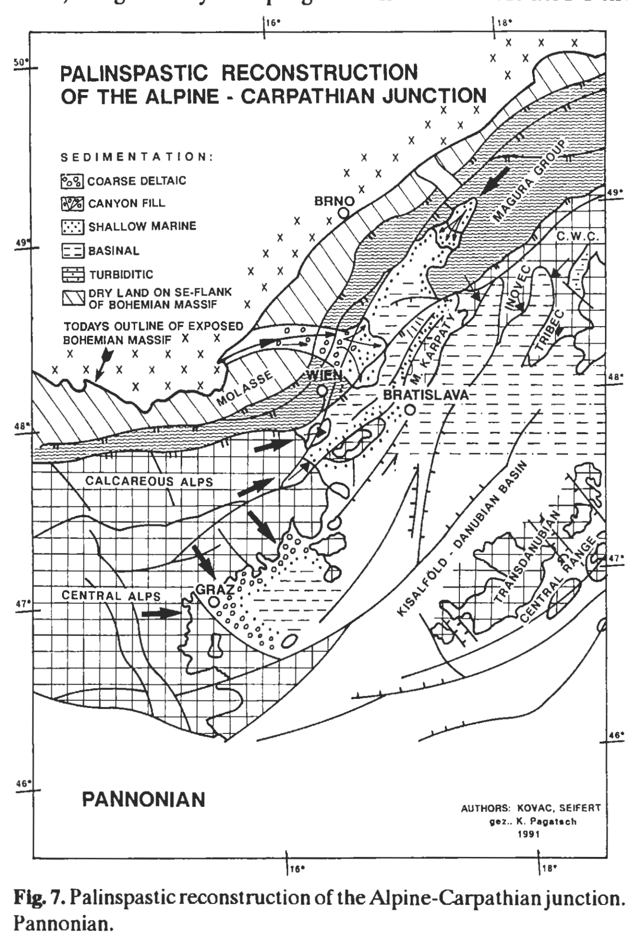

Fig. 7. Palinspastic reconstruction of the Alpine-Carpathian junction. Pannonian.

shallow Mistelbach block into the basin. Smaller deltas from the north and south derived material from the adjacent geological units. Across the Leitha Mts. ridge with its coralline algal reefs the Vienna Basin was connected with the southeastern region. There, in the Little Pannonian and Drava Basins some of the strike-slip movements in the basement turned into normal faulting. Overall, full marine conditions were established across the whole basin system.

Pannonian

The Alpine-Carpathian belt was increasingly uplifted. The central regions were elevated higher. Therefore more intense erosion took place there. The material was transported down to the Vienna Basin. Most of the deltas continued like the big delta of the Paleo-Danube river north of Vienna, carrying material from the Bohemian Massif and the Molasse Basin.

Strike-slip movements ceased and turned into normal faulting. Subsidence of the Vienna Basin slowed down. The water depth amounted up to just some tens of meters. The sedimentary environment was brackish and turned later into a limnic one. A connection to the Little Pannonian Basin was preserved at the southeastern end of the Vienna Basin. The Pannonian Basin system turned also into brackish. Strong subsidence resulted in high sedimentation rates there.

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