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# Examples of Recently Discovered Oil and Gas Fields in the Carpathian Foredeep and in the European Foreland Plate underneath the Carpathian Thrust Belt, Czech Republic

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## ABSTRACT

Several oil and gas fields have been discovered recently in the Neogene foredeep, in the European foreland plate, which underlies the foredeep and the thin-skinned Carpathian thrust belt. The fields are reservoired in the Neogene strata of the foredeep plate and in the crystalline basement rocks and the Jurassic, Paleogene, and Neogene strata of the European platform. The most significant accumulations of hydrocarbons in the subthrust plate have been found in the erosional relicts (buried hills) of the Jurassic rocks on the northern side of the Nesvacilka graben and paleovalley and in the fractured and weathered surface of the Precambrian granite massifs of the Chriby and Zdanice elevations. The thickness of the saturated parts of these reservoirs typically ranges from several tenths of a meter to as much as 200 m (660 ft). The geological reserves of the discovered fields are in a range of hundreds of thousands to a few million cubic meters (less than 1 million bbl to several million barrels) of crude oil and hundreds of millions to billions of cubic meters (several to tens of billions cubic feet) of gas. They represent a significant economical potential for petroleum companies operating in the territory of the Czech Republic.

## INTRODUCTION

The main objective of this chapter is to present examples of oil and gas fields found recently in the Neogene foredeep and in various reservoirs of the European foreland plate underneath the thin-skinned Carpathian thrust belt. A systematic exploration of the sub-Carpathian potential began only in the early 1960s, although several shallow gas fields had been found previously in the Neogene foredeep below the thrust


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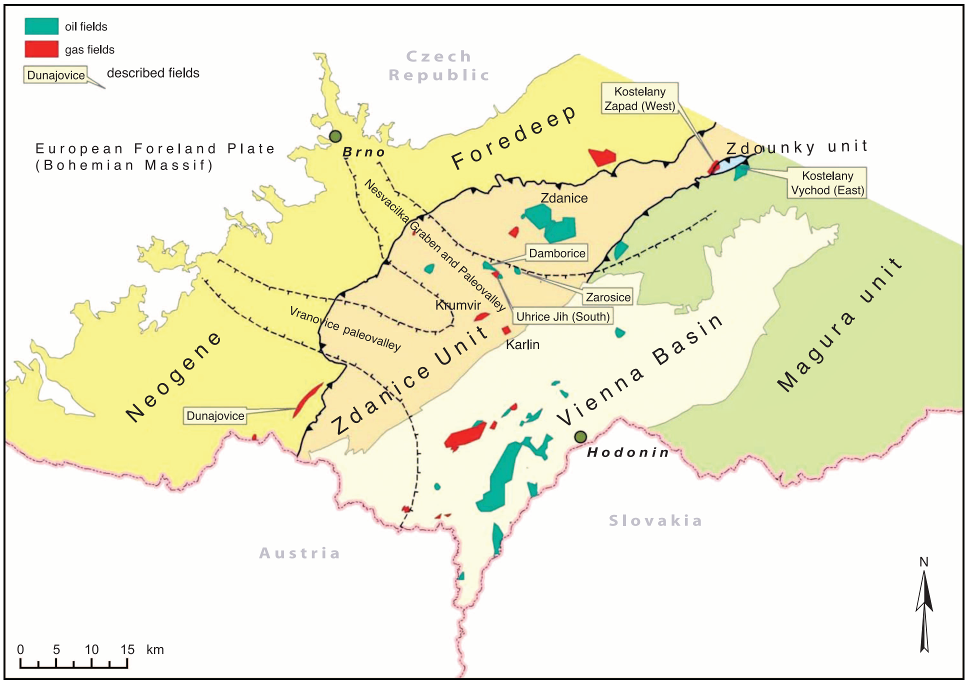


**Figure 1.** Index map showing the main tectonic units and major oil and gas fields in the territory of southeastern Moravia (Czech Republic).

belt in northern Moravia. The early studies and deep drilling, done mainly by the Czechoslovak Geological Survey, led to an initial stratigraphic reconstruction of the subthrust plate and to a discovery of the first commercial oil field Kostelany Vychod (East) (Lubna-1 well) in 1966. Further detailed exploration work was conducted by the Moravske Naftove Doly (Moravian Oil Company; MND) state oil company. The systematic exploration of the hydrocarbon potential of the subthrust plate began in the late 1970s. Several oil and gas fields in various subthrust stratigraphic and structural settings have been found: the Zdanice oil fields in the granitic basements rocks; the Uhrice gas and oil field in the Devonian and Jurassic carbonates and Jurassic and Paleogene clastics; the Korycany oil and gas field in the lower Miocene clastics; the Uhrice gas field and the largest oil field Damborice in the Jurassic clastics; and the Karlin and Krumvir gas fields in the autochthonous Paleogene. In addition, the largest gas field Dolni Dunajovice was found in the Neogene foredeep just in front of the Carpathian thrust belt.

In 1992–1998, the former state company was gradually privatized under the original name MND. The string of successes has continued with recent discoveries of the Uhrice Jih (South) and Zarosice fields in the erosional relicts of the Jurassic strata with reserves in the range of 1–3 million $m^3$ crude oil in place. The exploration work has been greatly improved by the application of three-dimensional (3-D) seismic acquisition, which considerably decreased the risk of exploratory drilling. Exploration works have concentrated on reservoirs in the Jurassic clastic and carbonate sequences and the Paleogene sandstones in the Nesvacilka graben and paleovalley in depths ranging from 1000 to 3500 m (3300 to 11,500 ft). Several typical examples of the subthrust fields and one example of a field found in the foredeep in front of the thrust belt are discussed in the following sections.

## GEOLOGICAL SETTING

The area considered by this chapter covers the contact zone between the west European foreland plate and the Western Carpathian thrust belt in the territory of southern Moravia (southeastern part of the Czech Republic) (Figure 1). The European foreland plate in southern Moravia is represented by the Bohemian Massif, which consists of the Hercynian orogenic system of Western Europe and its late Precambrian (Cadomian) foreland terrain called the Brunovistulicum that extends far below the Carpathian belt. The Brunovistulicum underlies the entire exploration area of southern Moravia. Since the Middle Devonian, the Brunovistulicum passed through two full plate-tectonic cycles, the Hercynian and the Tethyan–Alpine cycles (Picha, 1996). The Paleozoic Hercynian cycle in the area began with rifting and deposition of the late Early to Middle Devonian clastics. In the Late Devonian to Early

Carboniferous, carbonate platforms and basins evolved on passive continental margins. At the onset of the Hercynian orogeny in the Early Carboniferous, the carbonate sedimentation was replaced by synorogenic flysch (Culm) facies, which, in the Late Carboniferous, was followed by the late orogenic and postorogenic molasse of the upper Silesian coal basin. During the Hercynian orogeny, these Paleozoic deposits were folded and thrust over the foreland of the Brunovistulicum.

The Mesozoic to Cenozoic Alpine cycle in southern Moravia began with continental rifting in the Early Jurassic and deposition of synrift detrital deposits, followed by marine transgression and deposition of mixed carbonate and siliciclastic rocks of the passive margins. The carbonate platforms occupied the shallow marginal zone and uplifted rift blocks, whereas the organic-rich marly facies (Mikulov marls) formed in a deeper basinal environment.

During the Late Cretaceous to early Paleogene, the European foreland in Moravia was uplifted and deeply eroded. Rivers cut the deep Nesvacilka and Vranovice valleys that turned into submarine canyons more than 1500 m (5000 ft) deep, which were gradually filled with the Paleogene detrital organic-rich deposits (Picha, 1979, 1996; Jiricek, 1987) (Figure 1).

In the early Late Cretaceous, the Carpathian passive margins were converted into a foreland-type synorogenic basin marked by deep-water turbiditic flysch sedimentation, followed by a late orogenic and post-orogenic shallow-marine and continental molasse sedimentation. During the late phases of the Alpine orogeny, in the late Paleogene and early Miocene, the flysch sequences were deformed and thrust over the European foreland, including the inner zone of the Neogene foredeep. The Carpathian thrust belt in Moravia is composed of Late Jurassic to early Miocene synorogenic sequences of the flysch belt, with several rootless tectonostratigraphical units, including the marginal Pouzdrany, the Zdanice–Subsilesian, the Silesian, and the Magura units. The Neogene foredeep (Figure 1), with the exception of the innermost zones adjacent to the front of the thrust belt, remained undeformed. The thickness of the sedimentary fill of the Neogene foredeep in Moravia typically does not exceed a few hundred meters. Superimposed on the thrust belt is the Vienna basin. For more information on the geology of the region, we refer to the account by Picha et al. (2006).

During this complex geological history, conditions for deposition of organic-rich source rocks occurred in the Middle Devonian, Late Carboniferous, Late Jurassic, and early Oligocene (Francu et al., 1996; Krejci et al., 1996). After rock burial below the thin-skinned Carpathian thrust belt, hydrocarbons were generated from some of these source rocks. They migrated into potential reservoirs in the foreland plate and in the Neogene foredeep. Oil and gas accumulations have been found in the weathered and fractured surface of basement granitic rocks, in the Devonian carbonates, in the Jurassic clastics and carbonates, and in the Paleogene and Neogene clastics. Early accounts of petroleum systems and characteristics of some of the fields were published by Krejci (1993) and Ciprys et al. (1995).

In the following sections, we present examples of three typical subthrust fields: Kostelany Vychod (East) and Kostelany Zapad (West), which were reservoired in the crystalline basement, and the newly discovered Uhrice Jih (South) and Zarosice fields, with reservoirs in Jurassic clastics and carbonates, respectively. We also describe here Dolni Dunajovice, which is, by far, the largest gas field found in the Neogene foredeep.

## Kostelany Oil and Gas Fields

Kostelany Vychod (East) oil and gas field and Kostelany Zapad (West) gas field are situated on the northeastern part of the Chriby Height in central Moravia (Figures 1–3). The fields are reservoired mainly in the weathered and fractured surface of the basement granitic rocks, which form two elevations (buried hills) with relicts of metamorphosed Proterozoic shales and Paleozoic carbonate rocks on the slopes of the elevations and in the surrounding depressions. The strongly weathered surface zone of granites commonly has a character of sandstones with very high permeability. The basement rocks are covered by transgressive deposits of the Karpatian (lower Miocene), which are composed predominantly of shales with some sandstones that occur on the eastern side of the elevation. The Miocene strata make a good cap rock. Superimposed on these autochthonous deposits are the Carpathian nappes represented by four distinctive tectonic units: the Magura flysch unit, the Zdounky unit, the Zdanice–Subsilesian unit, and the Pouzdrany unit, which may actually be a tectonically transported slice of the autochthonous Paleogene (Figure 3). The Pouzdrany unit is composed predominantly of shales and mudstones with a few enclosed discontinuous sandstone beds that represent additional reservoirs. The shaly deposits of the Zdanice and Pouzdrany units are considered to be an excellent regional seal.

Biomarker studies (Picha and Peters, 1998) indicate that the hydrocarbons in the Kostelany fields were sourced from organic-rich Paleogene rocks. The autochthonous Paleogene and detached slices of it, such as the Pouzdrany unit and/or the Menilitic shales of the Zdanice unit, are the most likely sources of these hydrocarbons.

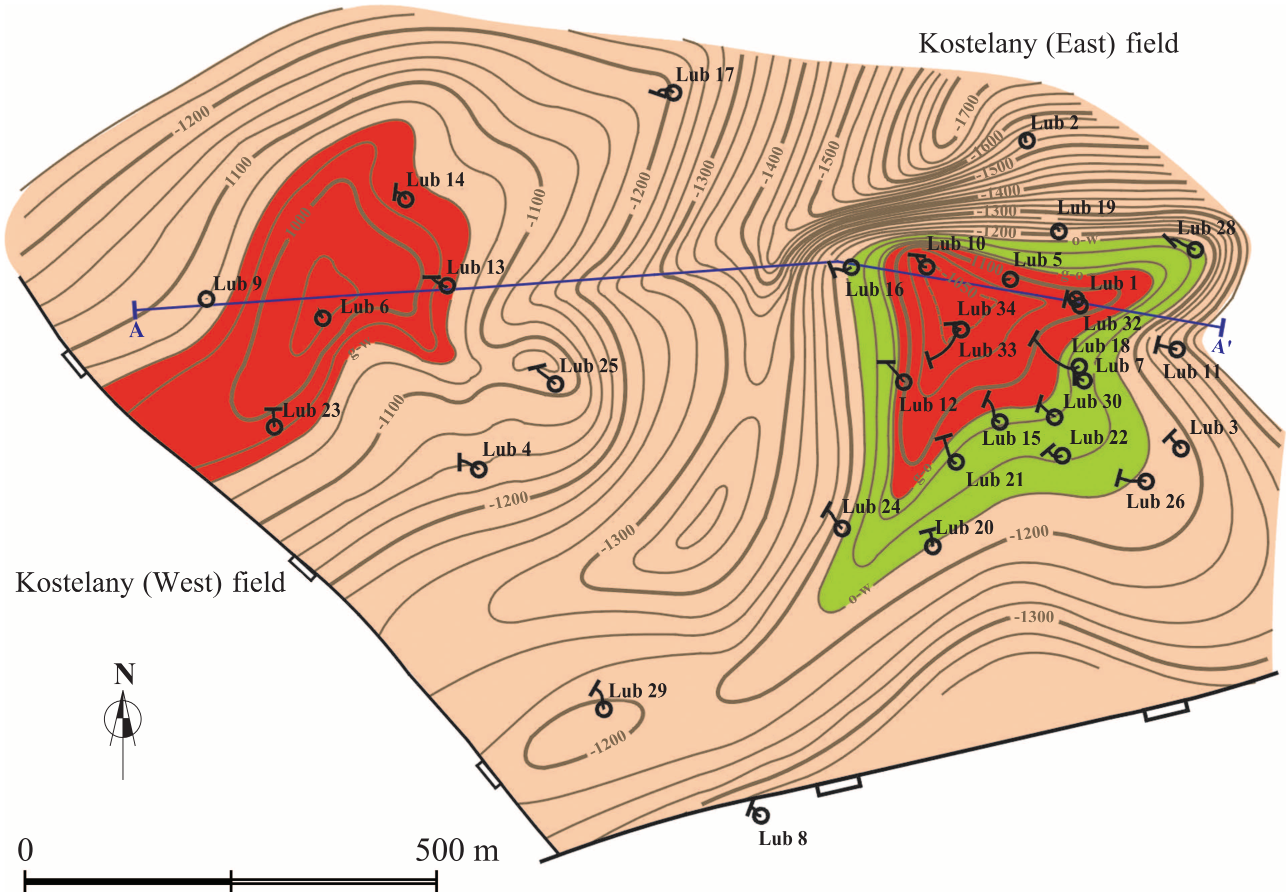


**Figure 2.** Kostelany oil and gas fields. Structure map is on the top of crystalline basement. Hydrocarbons are reservoired in the weathered and fractured surface of granitic rocks. The oil and gas columns reach as much as 75 m (250 ft) in the Kostelany Zapad (West ) field and as much as 175 m (570 ft) in the Kostelany Vychod (East) field.

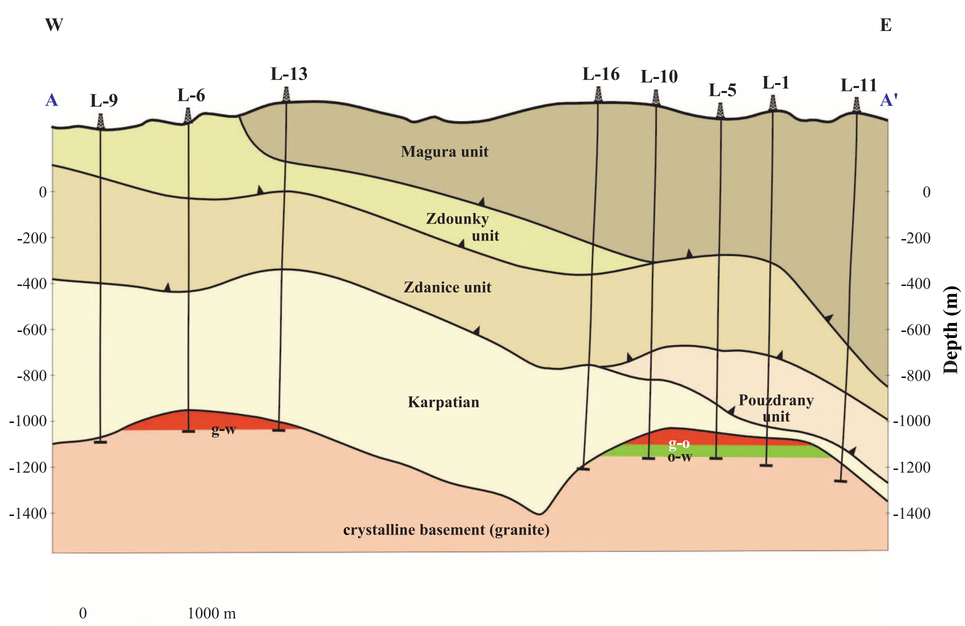


**Figure 3.** Kostelany oil and gas fields. Cross section AA′ is located in Figure 2. Oil and gas accumulations in the surface zone of the crystalline basement are sealed by Karpatian strata of the Neogene foredeep and further overthrust by four tectonic units of the Carpathian thrust belt. g-w = gas-water contact; g-o = gas-oil contact; o-w = oil-water contact.

**Table 1.** The characteristics of significant deposits.

| Parameters / Fields | | Kostelany Zapad (West) | Kostelany Vychod (East) | Dunajovice | Zarosice | Uhrice Jih (South) |
|---|---|---|---|---|---|---|
| Discovery | | 1971 | 1966 | 1973 | 2001 | 2001 |
| Exploration Period | | 1971–1975 | 1966–1975 | 1973–1977 | 2001–present | 2001–2003 |
| Production Period | | 1976–2000 | 1968–present | 1977–1984* | 2001–present | 2001–present |
| Oil in place | | --- | 1,4 MM $m^3$ | --- | 2,9 MM $m^3$ | 1,1 MM $m^3$ |
| Total oil exploited | | --- | 185 M $m^3$ | --- | 71,4 M $m^3$ | 100,3 M $m^3$ |
| Gas in place | | 840 MM $m^3$ | | 1600 MM $m^3$ | 140 MM $m^3$ | 98 MM $m^3$ |
| Total gas exploited | | 579 MM $m^3$ | | 811 MM $m^3$ | cca 5 MM $m^3$ | 5,5 MM $m^3$ |
| Field area | | 2,3 $km^2$ | 3,1 $km^2$ | 5,4 $km^2$ | 0,8 $km^2$ | 0,6 $km^2$ |
| Geological unit | | crystalline basement | crystalline basement | Eggenburgian | Jurassic-Vranovice carbonates formation | Jurassic-Gresten formation |
| Reservoir rocks | | granite | granite,sandstones | transgressive basal sandstones | dolomites | beach sandstones |
| Sealing | | Karpatian shales | Karpatian shales | Eggenburgian shales and the Vestonice fault | Mikulov marls and Paleogene shales | Paleogene shales |
| Source rocks | | Paleogene | Paleogene | assumed Jurassic marlstones | Paleogene, Jurassic | Paleogene, Jurassic |
| Depth of the reservoir | | 1270–1350 m | 1450–1550 m | 1050–1120 m | 1600–1850 m | 1850–1950 m |
| Effective thickness of the reservoir | | max. 83 m, average 55 m | max. 107 m, average 75 m | 11–37 m | max. 250 m, average 150 m | max. 90 m, average 50 m |
| Porosity | | 3–10 % | 3–15 % | 23–35 % | average 10% | 21% |
| Permeability | | 5–15 mD | 5–20 mD | 15–1300 mD | min. 500 mD | 300–400 mD |
| Gas saturation | | 65% | 65% | 67% | 65–70 % | 60–70 % |
| Reservoir pressure | | 13,2 MPa | 13,5 MPa | 10,966 MPa | 18,038 MPa | 17,336 MPa |
| Reservoir temperature | | 54°C | 60°C | 42°C | 51,4°C | 55,5°C |
| Oil API gravity | | --- | 26.2 | --- | 23.5 | 24.4 |
| Gas composition | methane | 65.9% | 87.1% | 98% | 85% | 94% |
| | higher hydrocarbones | 2.2% | 6.2% | 0.8% | 8% | 4.9% |
| | $CO_2$ + $N_2$ | 31.9% | 6.7% | 1.20% | 7% | 1.1% |
| | $H_2s$ | 0 | 0 | 0 | 0 | 0 |

*Converted to the gas storage.

The Kostelany Vychod (East) field, which was discovered in 1966, was the first commercial field found in the subthrust foreland plate below the Carpathian thrust belt in Moravia. Although in production for more than 30 yr and despite the high stage of reservoir flooding, production is still commercial.

Basic parameters of these fields as well as further fields are shown in Table 1.

## The Zarosice and Uhrice Jih (South) Subthrust Oil and Gas Fields

The Zarosice and Uhrice Jih (South) fields are located in the Nesvacilka graben (Figures 1, 4), an asymmetrical northwest–southeast-trending depression whose southwestern side is bounded by a steep fault, whereas the northeastern side is stepping down gradually. The Cadomian crystalline basement of the graben area is covered by depositional sequences of Paleozoic to Miocene age. They include the late Lower Devonian basal clastics, the Middle Devonian to Lower Carboniferous carbonates, the Lower Carboniferous flysch, the Upper Carboniferous coal-bearing molasse, and the Middle–Upper Jurassic synrift clastics and carbonates. In the Late Cretaceous to early Paleogene, the foreland area was uplifted and deeply eroded. A large, as much as 1500-m (5000-ft)-deep, paleovalley and submarine canyon was cut within the confines of the Nesvacilka graben and filled with Paleogene organic-rich deep-water deposits. Finally, the lower Miocene clastic deposits of the Carpathian foredeep were laid down in the northwestern part of the graben. During the latest phases of Alpine orogeny, the Nesvacilka graben, including the paleovalley fill, was buried below the Zdanice–Subsilesian nappe, which thus formed a regional seal. The most promising exploration targets proved to be the basal sandstones and the carbonates of Jurassic, occurring as isolated erosional relicts on the northern slope of the graben (Damborice, Uhrice, and Zarosice fields) (Figure 4). These relicts (buried hills) are sealed by impermeable shales and mudstones of the paleovalley fill. Thanks to differences in velocities between the Jurassic and the overlying Paleogene rocks, these erosional relicts can be recognized and outlined on the 3-D seismic survey. Also small in their areal extent, the saturated reservoirs of these relicts are relatively thick (several tens of meters to 200 m [660 ft]) and typically have very good reservoir properties. The largest discovery so far is the Damborice field with more than

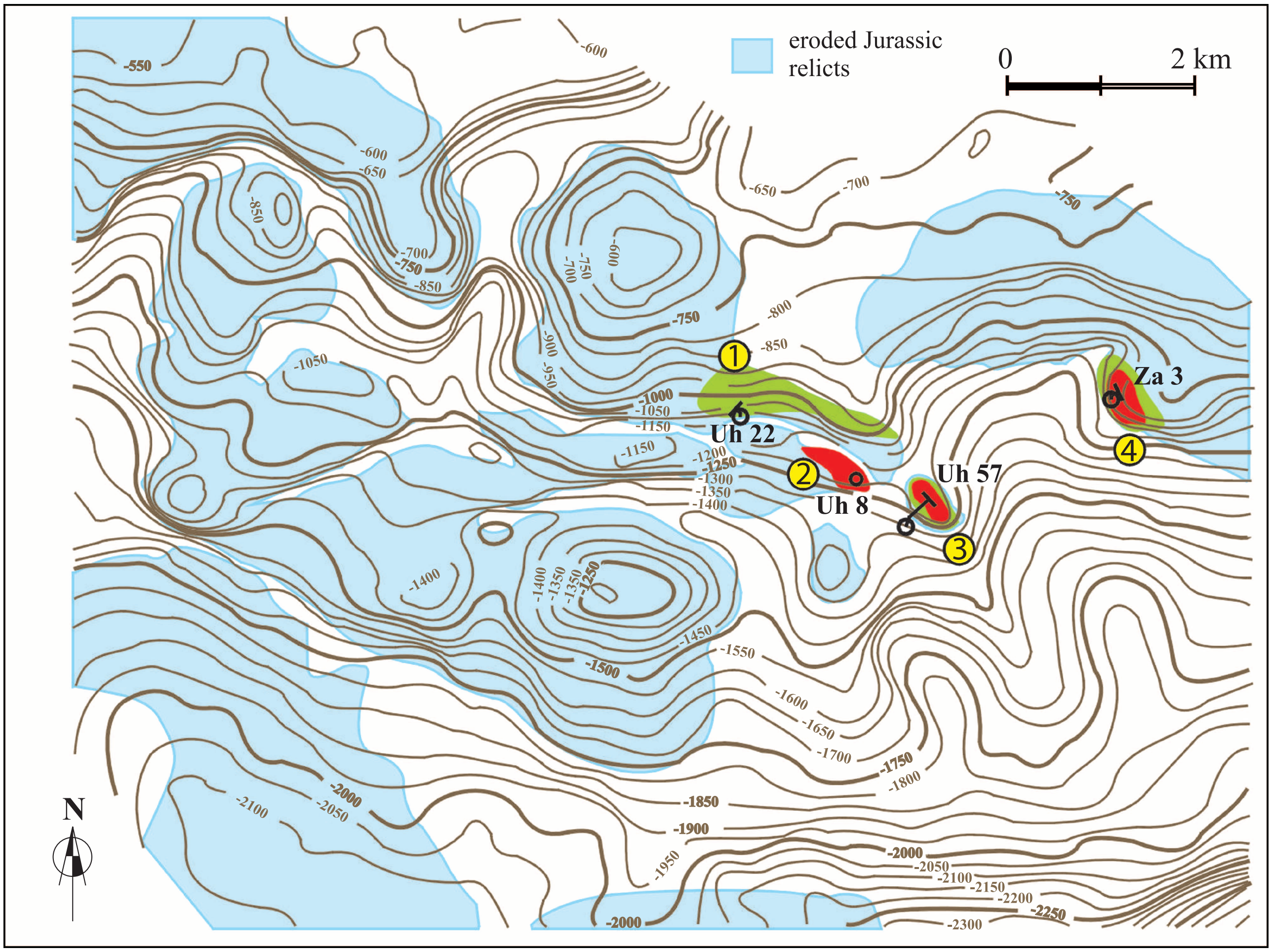


**Figure 4.** Time map of the pre-Tertiary relief of the northeastern slope of the Nesvacilka graben with delimited erosional relicts of Jurassic strata and proved oil and gas fields: (1) Damborice oil field; (2) Uhrice gas field; (3) Uhrice Jih (South) oil and gas field; and (4) Zarosice oil and gas field.

6 million m$^3$ (42 million bbl) of oil in place reservoired in the as much as 100-m (330-ft)-thick basal Jurassic clastics (Gresten Formation).

The isolated bodies of turbiditic and channelized sandstones enclosed within the Paleogene fill of the Nesvacilka paleovalley represent the secondary exploration play (Ciprys and Kostelnicek, 1990). The 3-D seismic survey enables us to see these isolated bodies of sandstones and, thus, lower the exploration risk. Interesting accumulations of gas and condensate have been found in these sandstones in the deeper parts of the Nesvacilka paleovalley (Krumvir and Karlin gas fields) (Figure 1). The reservoir pressure in the Karlin field is extremely high; it doubles the hydrostatic pressure.

Thus far, only small uneconomic accumulations of hydrocarbons have been found in the deeper Paleozoic sequences, namely, in the Devonian carbonates.

Geochemical studies (Francu et al., 1996; Krejci et al., 1996; Picha and Peters, 1998) suggest that the hydrocarbons in the Nesvacilka graben area were predominantly sourced from Jurassic, organic-rich Mikulov marls. The Paleogene shales and mudstones may be considered as additional source rocks, especially for gas.

## ZAROSICE FIELD

Zarosice field (Figures 1, 5–8) is located in an erosional relict of Jurassic rocks (buried hill) on the northern slope of the Nesvacilka graben. It is reservoired in the Jurassic Vranovice carbonates (mostly dolomites with some limestones and sandstones) and sealed by the mudstones of the Paleogene valley fill and the overlying Zdanice nappe.

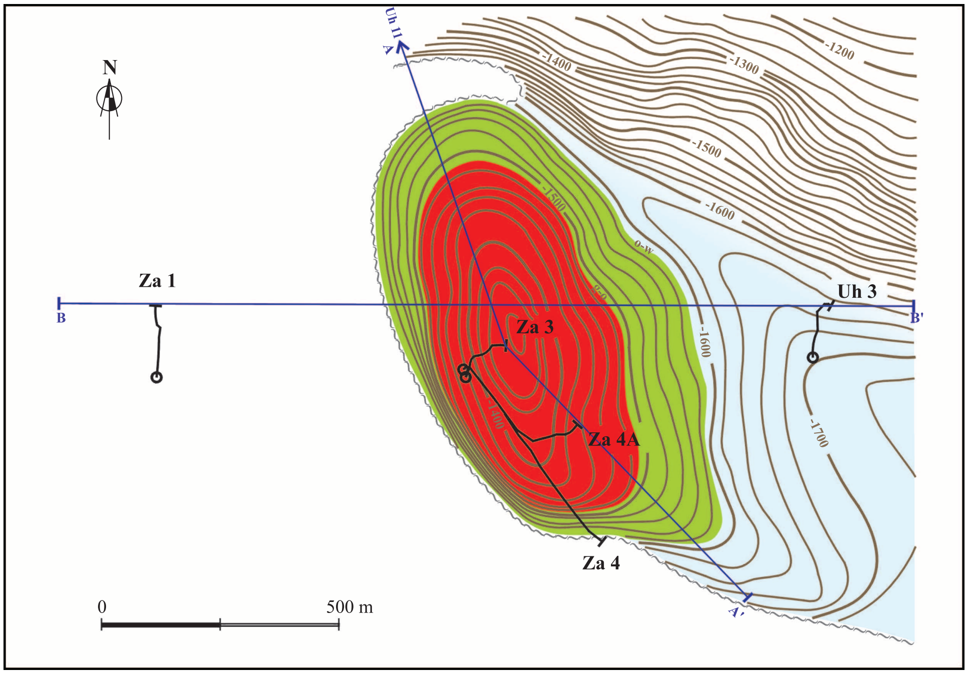


**Figure 5.** Zarosice oil and gas field. Structure map is on the top of the Vranovice carbonates in an erosional relict of the Jurassic rocks sealed by the Paleogene valley fill and overthrust by the Zdanice nappe. Combined oil and gas column reaches as much as 250 m (820 ft). o-w = oil-water contact.

## UHRICE JIH (SOUTH) FIELD

The Uhrice Jih (South) field is located in an erosional relict of Jurassic rocks (buried hill) on the northern slope of the Nesvacilka graben, southeast of the major Damborice field (Figure 4). It is reservoired in the basal Jurassic clastics (quartzose sandstones) of the Gresten Formation and sealed by the mudstones of the Paleogene valley fill and the overlying Zdanice nappe (Figures 9–12).

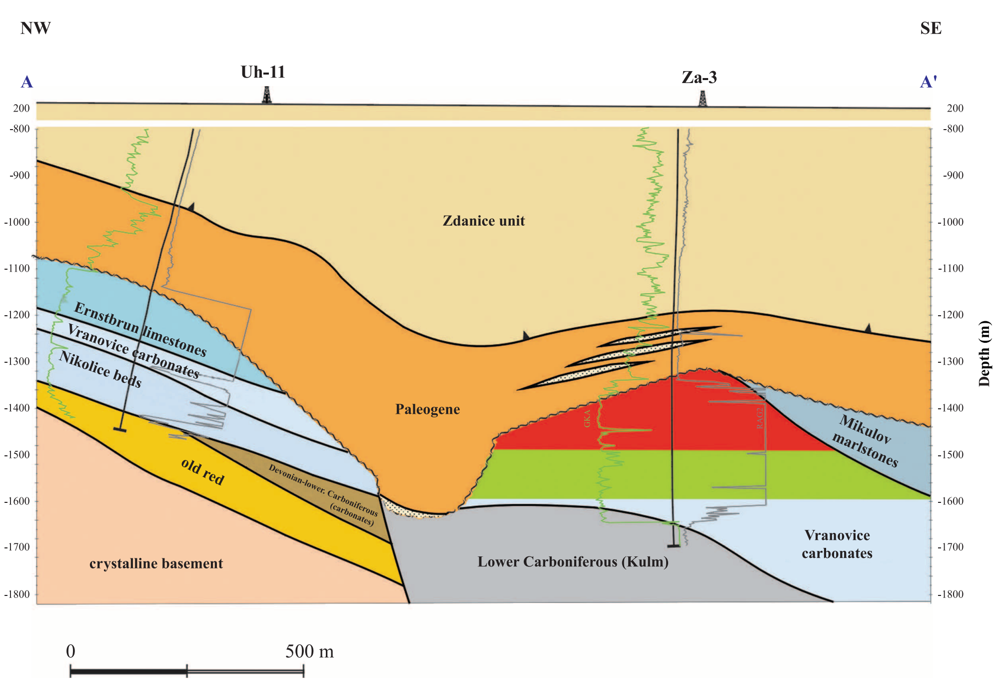


**Figure 6.** Zarosice oil and gas field. Cross section AA′ is located in Figure 5.

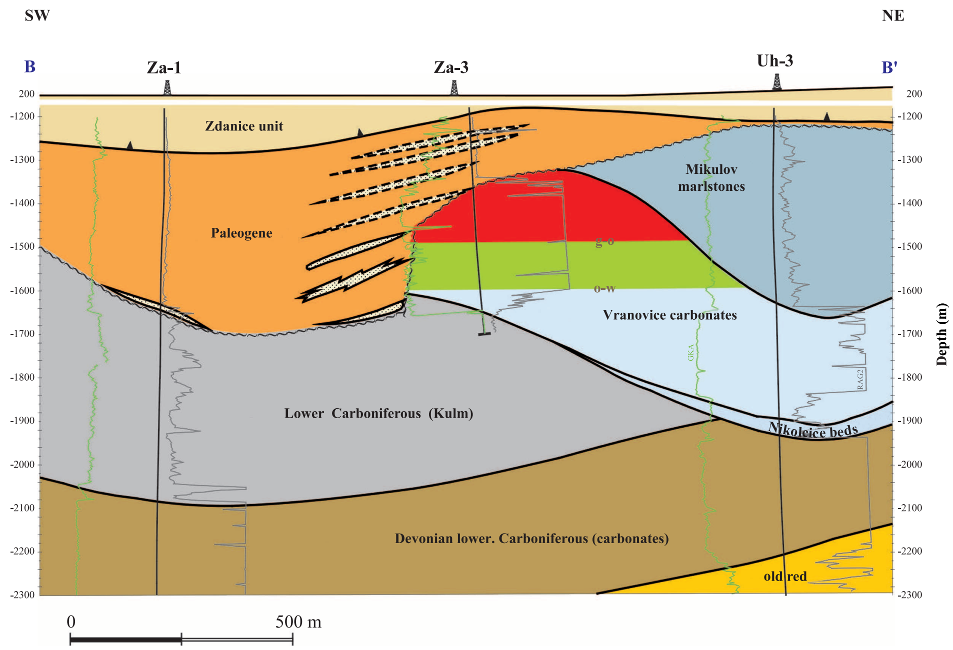


**Figure 7.** Zarosice oil and gas field. Cross section BB′ is located in Figure 5. g-o = gas-oil contact; o-w = oil-water contact.

## DOLNI DUNAJOVICE GAS FIELD

The gas field Dolni Dunajovice, which was discovered in 1973 in the Neogene foredeep in front of the Carpathian thrust belt in southern Moravia (Figure 1), is one of the largest gas fields found in the territory of the Czech Republic. The field is reservoired in the Eggenburgian sandstones draping over a southwest–northeast-trending upthrown block of the foreland plate below the Neogene foredeep (Figures 13–15). On its western side, the block is bounded by the Vestonice fault interpreted in this account as an antithetic normal fault formed during the flexural downbending of the foreland plate during the progression of the Carpathian thrust belt onto the European platform (Adamek, 1979). Some other geologists (Picha et al., 2006) rather interpret this fault as a foreland-type compressional and possibly transpressional structure generated by compressional stresses in the foreland plate during the orogeny. The thinning of Eggenburgian strata over the uplifted block indicates that the block was actively rising during that time. The pre-Miocene basement is represented by the crystalline rocks of the Brunovistulicum, overlain by Jurassic strata; the Paleozoic is not present in this southernmost part of Moravia.

## CONCLUSIONS

Discoveries of several oil and gas fields in a complex depositional and structural setting of the subthrust foreland plate underneath the thin-skinned Carpathian thrust belt at the territory of Moravia (Czech Republic) represent a major accomplishment. They resulted from long-term systematic geological and exploration work conducted by various state organizations and more recently by a private oil company (MND). Although small in size, the territory of Moravia has become one of the most successful exploration provinces in the entire Carpathian region in recent years.

## ACKNOWLEDGMENTS

We gratefully acknowledge the management of the Moravske Naftove Doly, A.S. (MND) for permission to release the data for publication. MND is an owner of the exploration and production permits and is sole investor.

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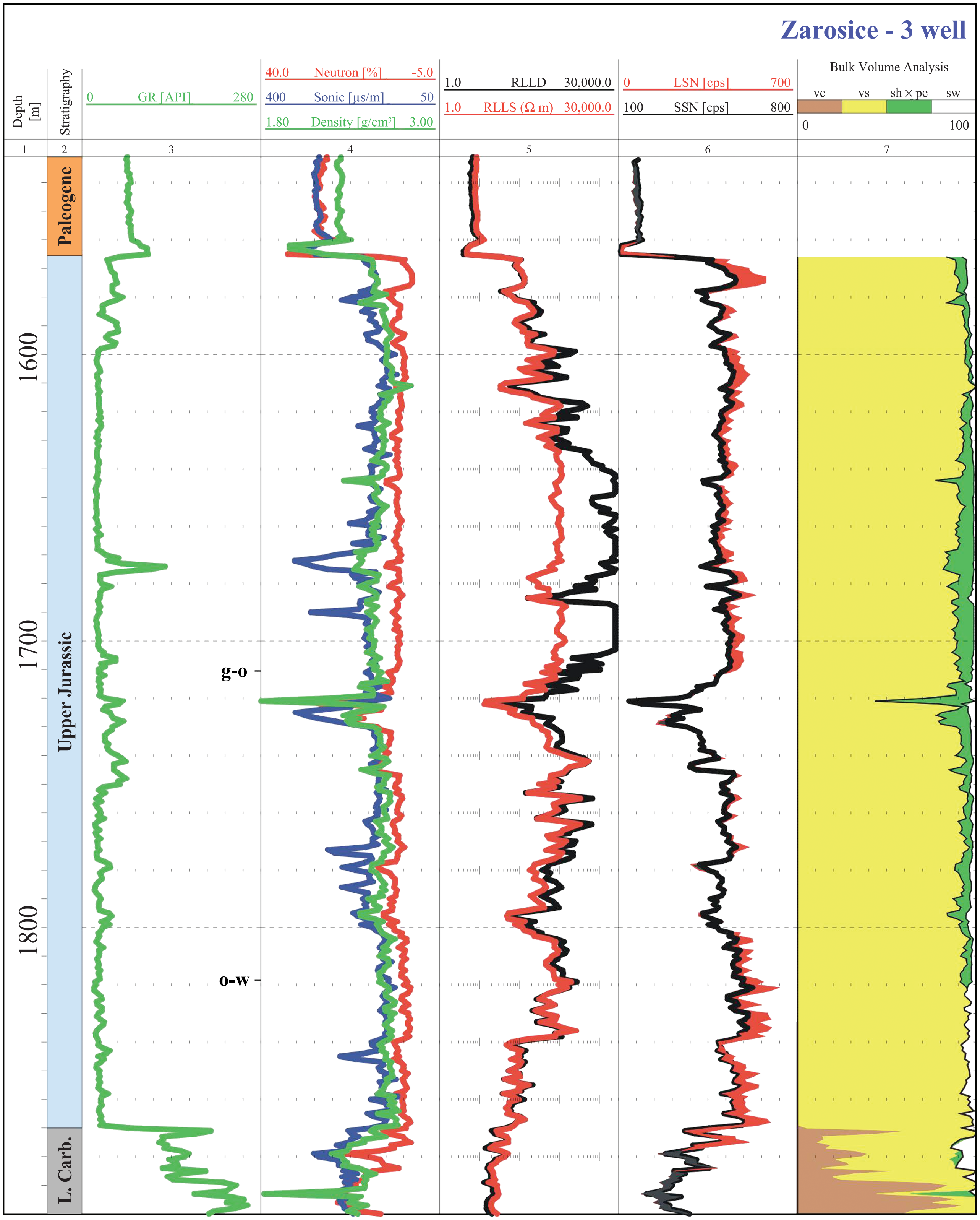


**Figure 8.** Log diagrams and saturation estimation from the Zarosice-3 well. vc = clay volume; vs = sand (matrix) volume; sh × pe = hydrocarbon saturation multiplied by the porosity; sw = water saturation; o-w = oil-water contact; g-o = gas-oil contact; RLLD = resistivity laterolog – deep; RLLS = resistivity laterolog – short; LSN = long-spaced count neutron; SSN = short-spaced count neutron; GR = gamma ray.

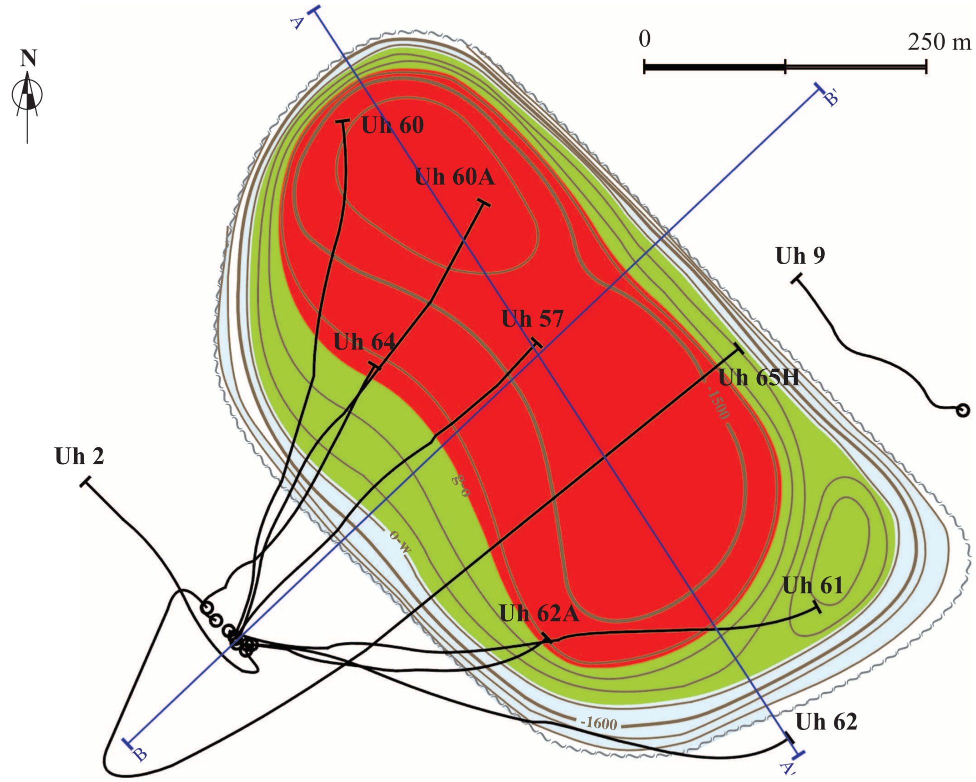


**Figure 9.** Uhrice Jih (South) oil and gas field. Structure map is on the top of the Gresten Formation (sandstones) in an erosional relict of Jurassic rocks. Combined oil and gas column reaches as much as 100 m (330 ft).

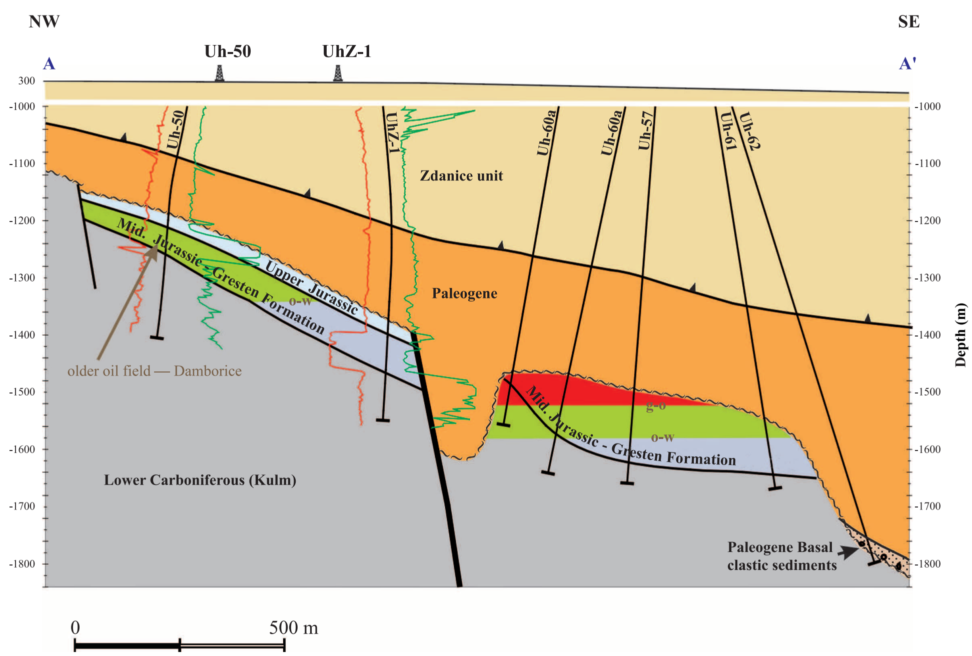


**Figure 10.** Uhrice Jih (South) oil and gas field. Cross section AA′ is located in Figure 9. o-w = oil-water contact; g-o = gas-oil contact.

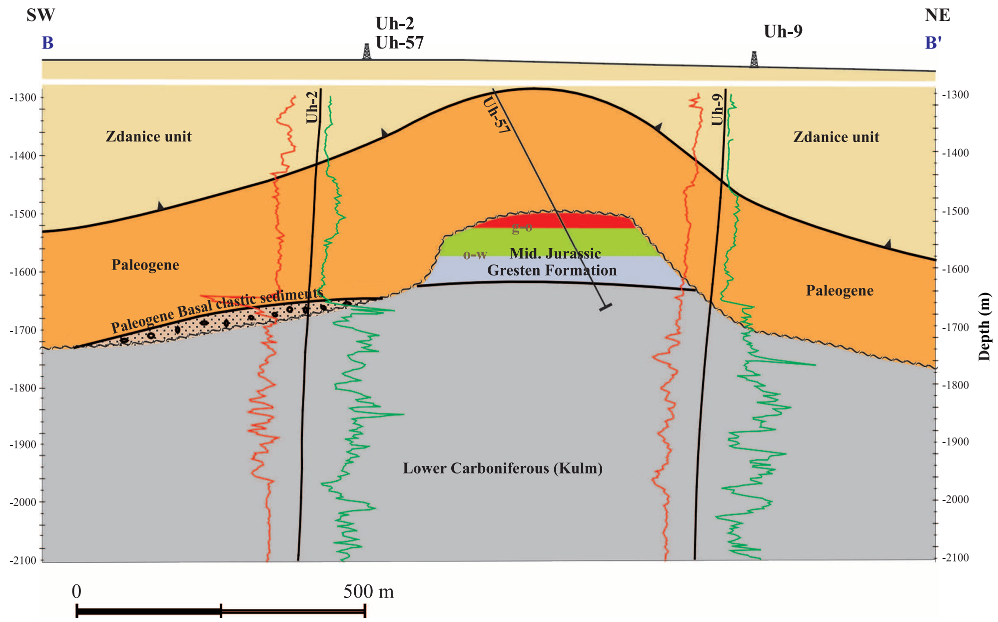


**Figure 11.** Uhrice Jih (South) oil and gas field. Cross section BB′ is located in Figure 9. g-o = gas-oil contact; o-w = oil-water contact.

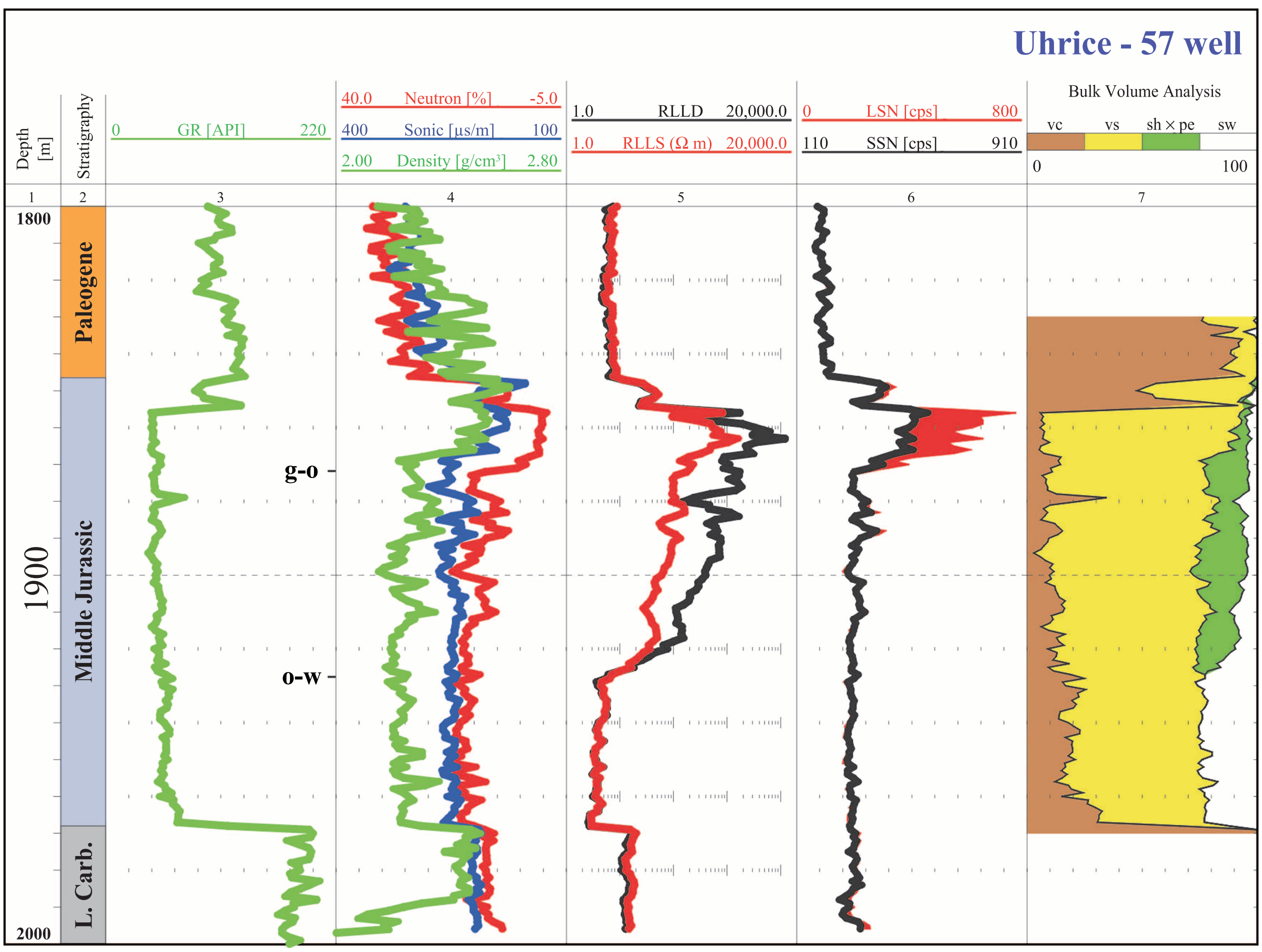


**Figure 12.** Uhrice Jih (South) oil and gas field. Log diagrams and saturation estimation from the Uhrice-57 well. vc = clay volume; vs = sand (matrix) volume; sh × pe = hydrocarbon saturation multiplied by the porosity; sw = water saturation; o-w = oil-water contact; g-o = gas-oil contact; RLLD = resistivity laterolog – deep; RLLS = resistivity laterolog – short; LSN = long-spaced count neutron; SSN = short-spaced count neutron; GR = gamma ray.

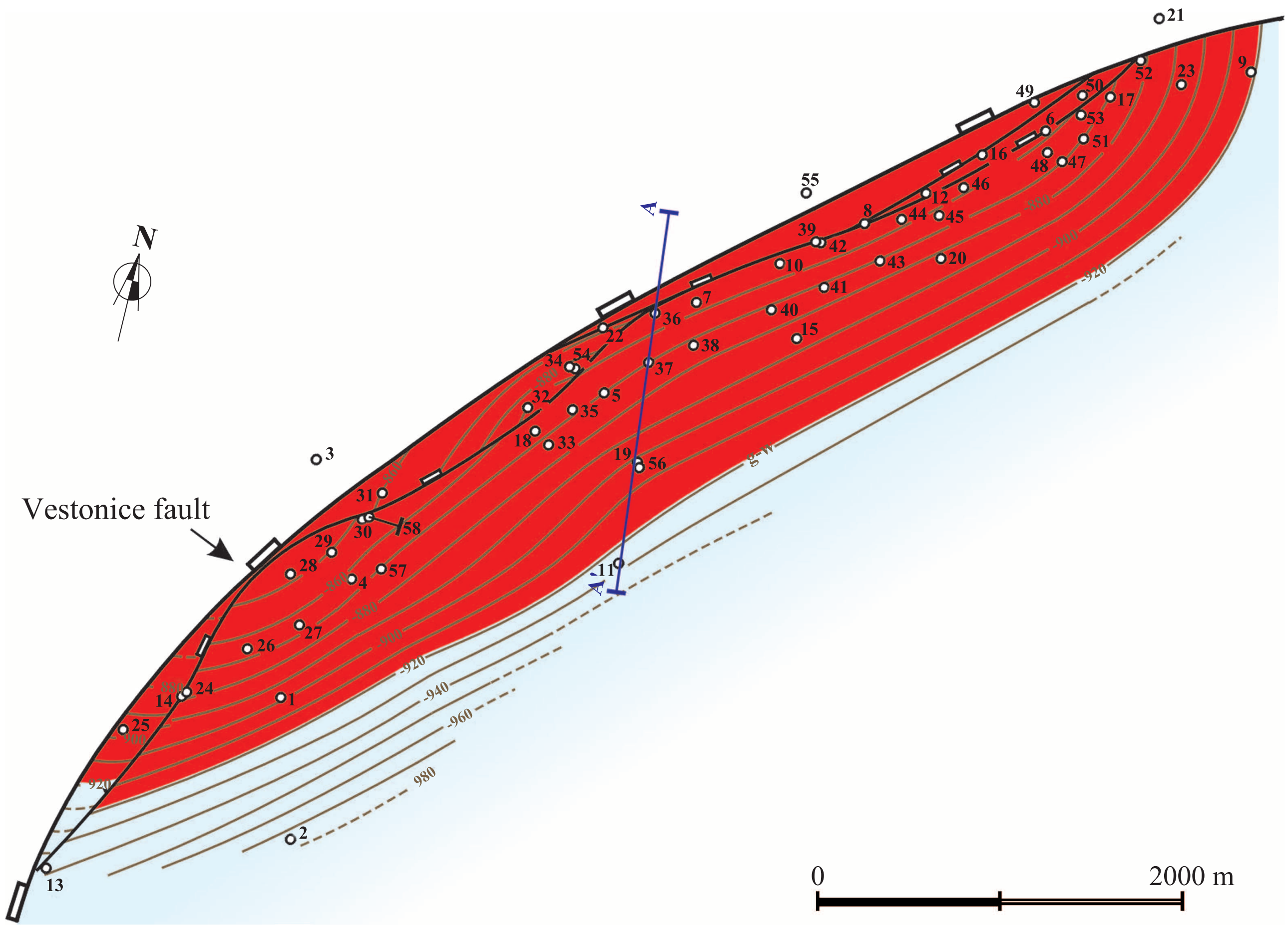


**Figure 13.** Dolni Dunajovice gas field. Structure map is on the top of the Eggenburgian sandstones.

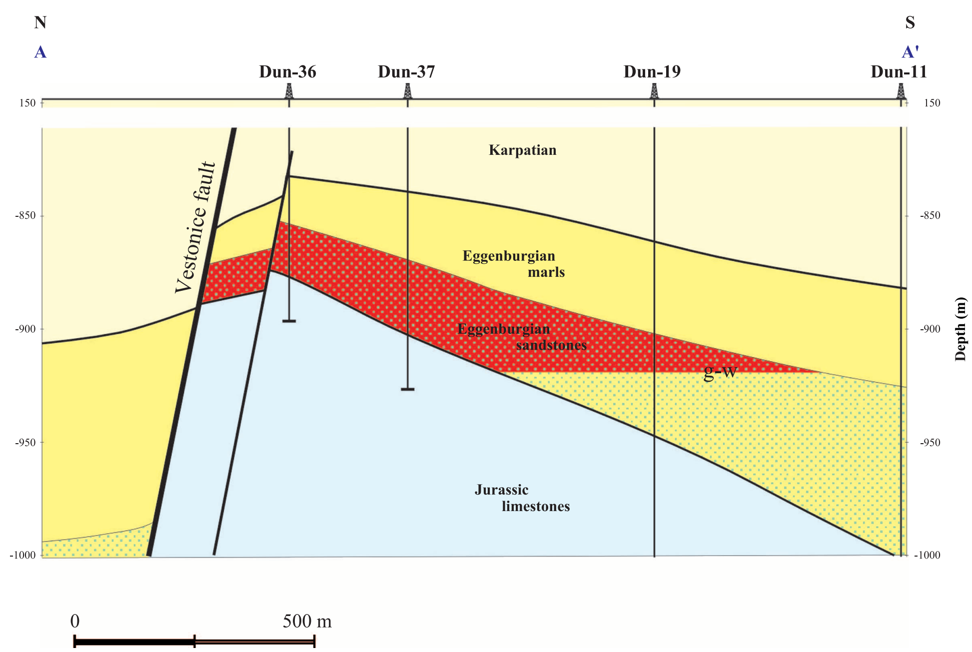


**Figure 14.** Dolni Dunajovice gas field. Cross section AA′ is located in Figure 13. g-w = gas-water contact.

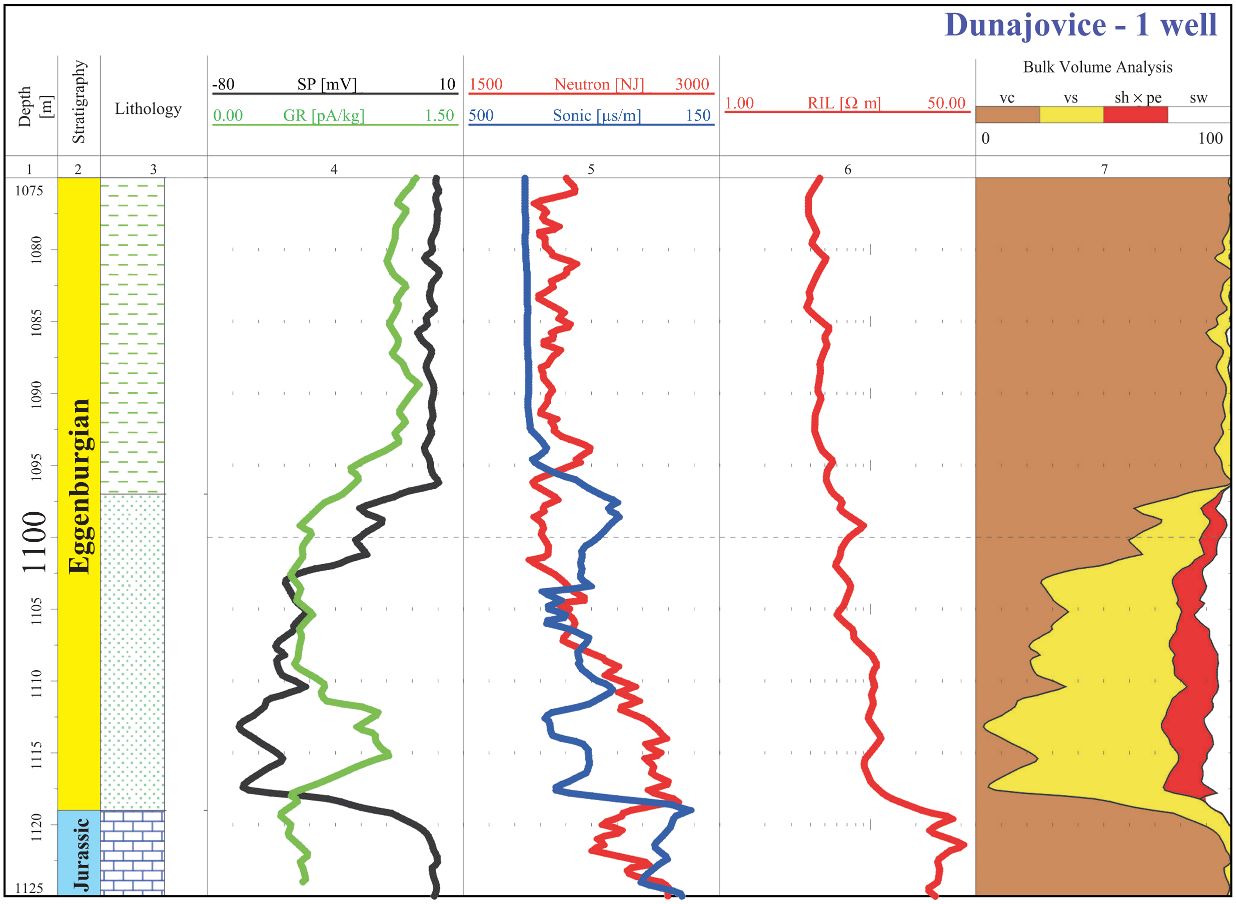


**Figure 15.** Dolni Dunajovice gas field. Log diagrams and saturation estimation from the Dunajovice-1 well. vc = clay volume; vs = sand (matrix) volume; sh × pe = hydrocarbon saturation multiplied by the porosity; sw = water saturation; SP = spontaneous potential; RIL = resistivity induction log; GR = gamma ray.

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# The Vienna Basin

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## ABSTRACT

Through conventional geoscientific research, a fundamental knowledge of the Vienna basin was acquired with the limited data available at the time. Since then, vast exploration programs of the Austrian, Czech, and Slovakian oil industries have contributed significantly to a more detailed understanding of the geological evolution of the basin.

The pull-apart or piggyback nature of the basin at present is well understood and commonly accepted. Basically, it resulted from an easterly directed extrusion of the Central Alpine block alternating with compressional events during the final stages of the Alpine convergent phase.

The basin evolved in several stages that finally resulted in an intricate arrangement of prominent highs and partly deeper subsided depocenters. The basin was filled by Miocene to Pleistocene sediments that can be subdivided into sequences separated by unconformities; the most pronounced are between the early and the middle Miocene.

The basin-floor section below the Neogene fill consists of the Alpine–Carpathian imbricated system. From north to south, these individual thrust piles are the Waschberg–Zdanice zone, the Flysch zone, the Calcareous Alps (including its Paleozoic base, the Grauwacken zone), the Central Alps, and the Tatrides. All these units lie on top of the Miocene Molasse, a Mesozoic series, and the crystalline basement. This section is well known from wells drilled in the molasse zone sensu stricto but were also drilled in the Vienna basin. Ultradeep wells targeting the autochthonous basement reached total depths of between 6.3 and 8.5 km (3.9 and 5.3 mi).

Oil and gas are trapped in all units of the basin, from the Neogene fill down to the autochthonous sedimentary cover. Generally, the traps are structural, but recently, stratigraphic traps have also been drilled successfully.

The main source rocks are autochthonous Jurassic marls, which seem to form a substantially thickening package in an easterly direction, according to the sporadic well information available. Although the ultradeep well program was believed to be uneconomic at that time, indications point to an unconventional tight-gas play type in the autochthonous Jurassic marls.


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The contribution of all Vienna basin member countries made it possible to present a comprehensive surface and subsurface compilation. A cross section through the deepest known part of the basin without border limitations was an additional result of this cooperative effort.

## INTRODUCTION

For more than 150 yr, intense research has been done on the Vienna basin. Recent overviews have been written by Sauer et al. (1992), Brix and Schultz (1993), Hlavaty (1996), and Hamilton et al. (2000).

Previous generations of geoscientists have gained fairly good knowledge of the Vienna basin, but it was the oil industry that contributed significantly to understanding the basin evolution. This was achieved by drilling more than 6000 wells (the deepest to a total depth of 8553 m [28,061 ft]) and acquiring a vast coverage of two- and three-dimensional (2-D and 3-D) seismic data.

Early scientific geological investigations in the Vienna basin were done by Hornes, Prevost, Boue, Suss, Schaffer, Friedl, Janoschek, Grill, and Papp in the first half of the 20th century. More recent structural and sedimentological studies were done by Austrian, Slovak, and Czech geoscientists in the second half of the 20th century. This improved geological wisdom, as well as the implementation of 3-D seismic technology, resulted in new discoveries and more effective exploitation of existing reservoirs.

Further success is expected with more extensive use of other modern geoscience methods. These include the application of modern sedimentology, neural network technology, prestack depth migration, seismic inversion, etc.

## BASIN FORMATION

### Tectonic-Paleogeographic Preconditions

The Vienna basin evolved when the Alpine–Carpathian thrust front reached the European forelands during the early Miocene. At the Alpine–Carpathian junction, the Bohemian Promontory forms a recess in which the thrust units could advance progressively, whereas to the west of the reentry, thrust movement stagnated earlier.

Consequently, thrust ages become younger from west to east along the Alpine–Carpathian front. Final thrusting of the easternmost Alpine nappes terminated by the end of Karpatian, whereas the Romanian Carpathians protracted thrusting beyond the Pannonian (Jiricek, 1979) (Figure 1). This resulted in a complex succession of thrusting, wrenching, and normal faulting along the Alpine–Carpathian junction. It was Royden (1985) who first summarized the tectonic features as belonging to a pull-apart basin. Accordingly, the Vienna basin was described as having developed between a system of sinistral transfer faults. More detailed interpretations were done by Wessely (1988), Decker and Perreson (1996), Seifert (1996), and Kovac (2000).

The southern edge of the basin is delimited by a northeast-trending strike-slip fault system with typical transtensional patterns, such as negative flower structures and small pull-apart basins. This lineament still represents a zone of increased seismicity. It encloses a graben-in-graben structure with a considerably thicker Quaternary fill, which is another clear indication for its current activity. However, no evidence exists for this strike-slip zone ever acting as a major fault system throughout the basin evolution.

A structural counterpart north of the basin has not been located so far.

Some faults sole out into individual Alpine thrust sheets or into the main decollement of the whole Alpine thrust complex. The majority of these fault systems follow the strike of the Alpine–Carpathian nappes. Minor lateral offsets occur where the divergent stepover faults deviate from these thrust elements and transect through them.

In summary, the criteria for the pull-apart mechanism are met and are quite obvious. These criteria include the rhombohedral shape of the basin, pronounced depocenters, and en echelon faults. The right-stepping arrangement clearly indicates the left lateral movement. A further controlling element, which has influenced the basin development, is the pre-Alpine morphotectonic features of the subthrust.

### Geodynamics

Three development stages are recognized in the evolution of the Vienna basin: the pre-, the proto-, and the neo-Vienna basin (Figure 2).

#### Pre-Vienna Basin

The area of today's Vienna and Alpine–Carpathian Molasse Basin was a rifting zone during the Middle Jurassic, a passive-margin basin between the Malmian

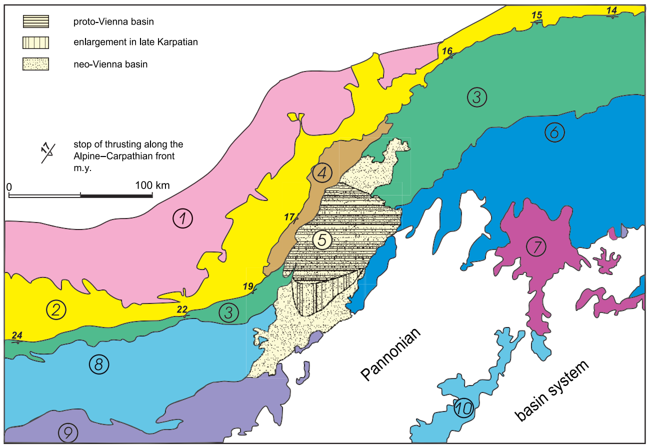


**Figure 1.** The Vienna basin in the Alpine–Carpathian thrust belt.

and the Cretaceous and finally a molasse foredeep basin for the gradually evolving thrust belt in the south up to the Egerian. This foredeep was partly overthrusted by Alpine-Carpathian nappes stratigraphically ranging from the Triassic to the Cretaceous.

Post-collisional thrust activity continued to the Oligocene, as evidenced by the exploration well OMV Berndorf 1, 40 km (25 mi) south of the Alpine thrust front, which encountered Oligocene Molasse sediments below the Alpine nappes at a depth of approximately 6000 m (20,000 ft).

### Proto-Vienna Basin

The first tensional forces initiated during the thrust movement and led to the development of the Proto-Vienna piggyback basin.

Between the Eggenburgian and the Karpatian, the thrust belt advanced into the molasse foredeep. Corresponding series were therefore overthrusted as well as deposited onto the Alpine thrust front. In the Proto-Vienna basin, restricted to the northern part of the present basin, horizontal extension has been illustrated by synsedimentary normal faulting since the early Miocene. Czech as well as Austrian seismic data show synsedimentary faults with considerable offsets in the early Miocene deposits (Ladwein et al., 1991) east of the subsequently evolving Steinbergsystem. To the west, the Korneuburg basin is also genetically related to that period.

Toward the end of the Karpatian, the southwest–northeast-orientated Matzen Flysch ridge separated the marine environments in the north from nonmarine in the south.

The facies boundary was related to an uplift culminating in subaerial exposure of the ridge. Early Miocene sediments were tilted and, along the crest, entirely removed by erosional processes that also substantially affected the flysch itself. Structurally associated subsidence south of the high created an additional accommodation space, which was filled by the limnic Aderklaa Formation. Off the tilted areas, the limnic package is conformably overlain by the Badenian Aderklaa Conglomerate, indicating that the late Karpatian readjustments essentially predefined the geometry of the modern Vienna basin. Only a small rim of pre-Neogene basement, close to the southern margin, was later transgressed by the basal Badenian complex (Weissenback, 1996).

### Neo-Vienna Basin

The thrust movements ceased at the end of the Karpatian period and the basin subsequently subsided into a consolidated substrate. The distribution of the Aderklaa Conglomerate or time-equivalent sediments mirror the established Neo-Vienna basin that retained its northeast–southwest-oriented trough axes throughout the deposition of the Sarmatian and Pannonian series that blanketed the Badenian sequences without major depositional breaks.

## TECTONIC ELEMENTS

The main tectonic elements that occurred as a result of these geodynamic processes are the Steinberg fault, with a vertical displacement of about 6000 m (20,000 ft); the Schrattenberg fault; the Bisamberg fault; the Leopoldsdorf fault (~4000-m [~13,100-ft] displacement); the Markgrafneusiedl fault; the Laksary fault; the Farsky fault; the Lanzhot–Hrusky fault; and other younger elements with offset of several hundred meters (Kroll et al., 1993; Cekan et al., 1990). Remarkably, the regional highs are always up against prominent lows. Examples of this are the Mistelbach (upthrown)

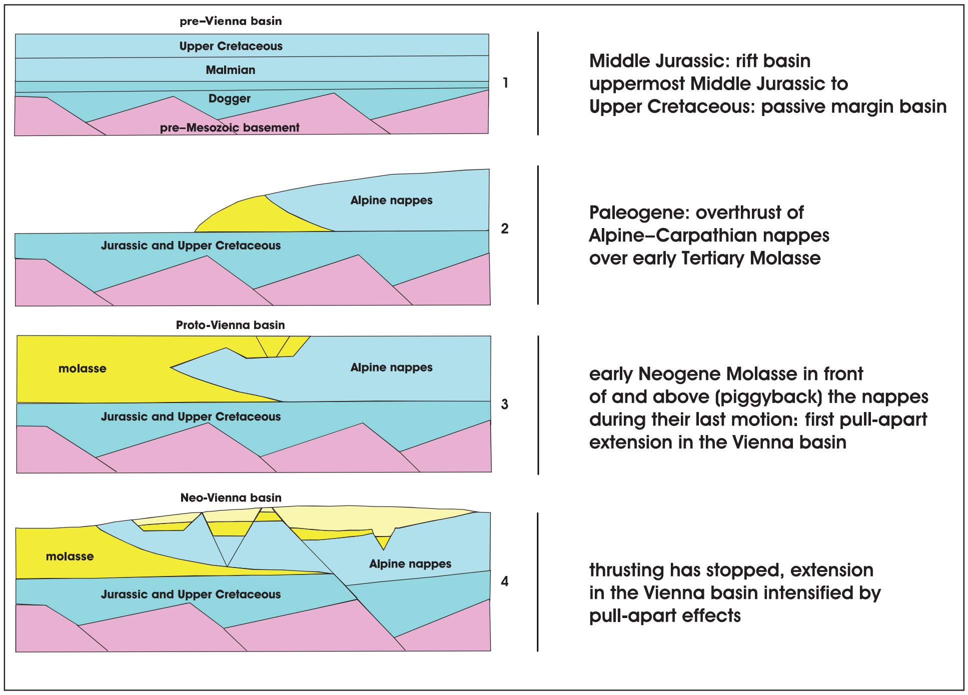


**Figure 2.** Stages of basin development.

block with the Steinberg high vs. the Zistersdorf depression, or the Oberlaa–Laxenburg high on the Modling block against the Schwechat deep (Figure 3).

Further tectonic features similar to small pull-apart basins and grabens, which are related to sinistral transtensional deformation, are preferentially aligned with the southern basin margin and supplement the structural inventory of the Vienna basin. The surface expressions of this active zone are the Wiener Neustadt subbasin, the Mitterndorf depression, the Lassee graben, and its continuation toward Slovakia, the Zohor–Plavecky graben. These are flanked by the northwest-dipping Pottendorf, Kopfstetten, and Engelhardstetten faults. The Hradiste graben is a structural equivalent in the northernmost (Czech) part of the Vienna basin.

The most prominent fault in the northwestern part of the basin is the Steinberg fault, which has been active through almost the entire basin evolution. The syntectonic deposition led to a significant contrast in thicknesses of the Badenian to Pannonian sections on both sides of the fault. Several thousand meters on the downthrown block correspond to an extremely condensed, time-equivalent section of several hundred meters only in the upthrown block. The fault complex has a listric geometry and most likely roots into a detachment plane in the autochthonous, sedimentary cover below the Alpine–Carpathian thrust assembly.

An increased accumulation of sediments could have also been observed in stationary depocenters subsiding through time without contribution of normal faults. In the Schwechat low, for example, isopachs of the lower Badenian Aderklaa Conglomerate indicate an eightfold increase of the interval thickness from the depocenter to the adjoining areas.

The fault block arrangement, as well as tectonic events along the basinal boundary, created a variety of different, areally restricted, facies zones bordering each other. Thus, in-situ banks of Lithothamnia, lumachelles (Badenian), or even oolithic developments (Sarmatian) of elevated areas correlate with silty, shale-dominated layers in the drowning regions.

## BASIN FILL

An overview of the sediments of the Vienna basin has been presented by Tollmann (1985), Jiricek (1988), Kreutzer and Hlavaty (1990), Kreutzer (1993a), and Wessely (2000). Biostratigraphic investigations have been done by people like Grill, Papp, Turnovsky, Senes, Cicha, Steininger, Rogl, Fuchs, Rupp, and others.

The basin fill of the early Miocene is interpreted as foredeep deposits in front and on top of the gradually emerging thrust belt. From Eggenburgian to Ottnangian (Luzice formation), the trough was sourced mainly from the south. In terms of facies, these sediments correspond to the so-called ''Schlier'' of the molasse zone sensu stricto, with which the proto-Vienna basin region still had connection (Steininger et al., 1986). Shales, sands, and conglomerates of open-marine or restricted marine origin in the north were deposited

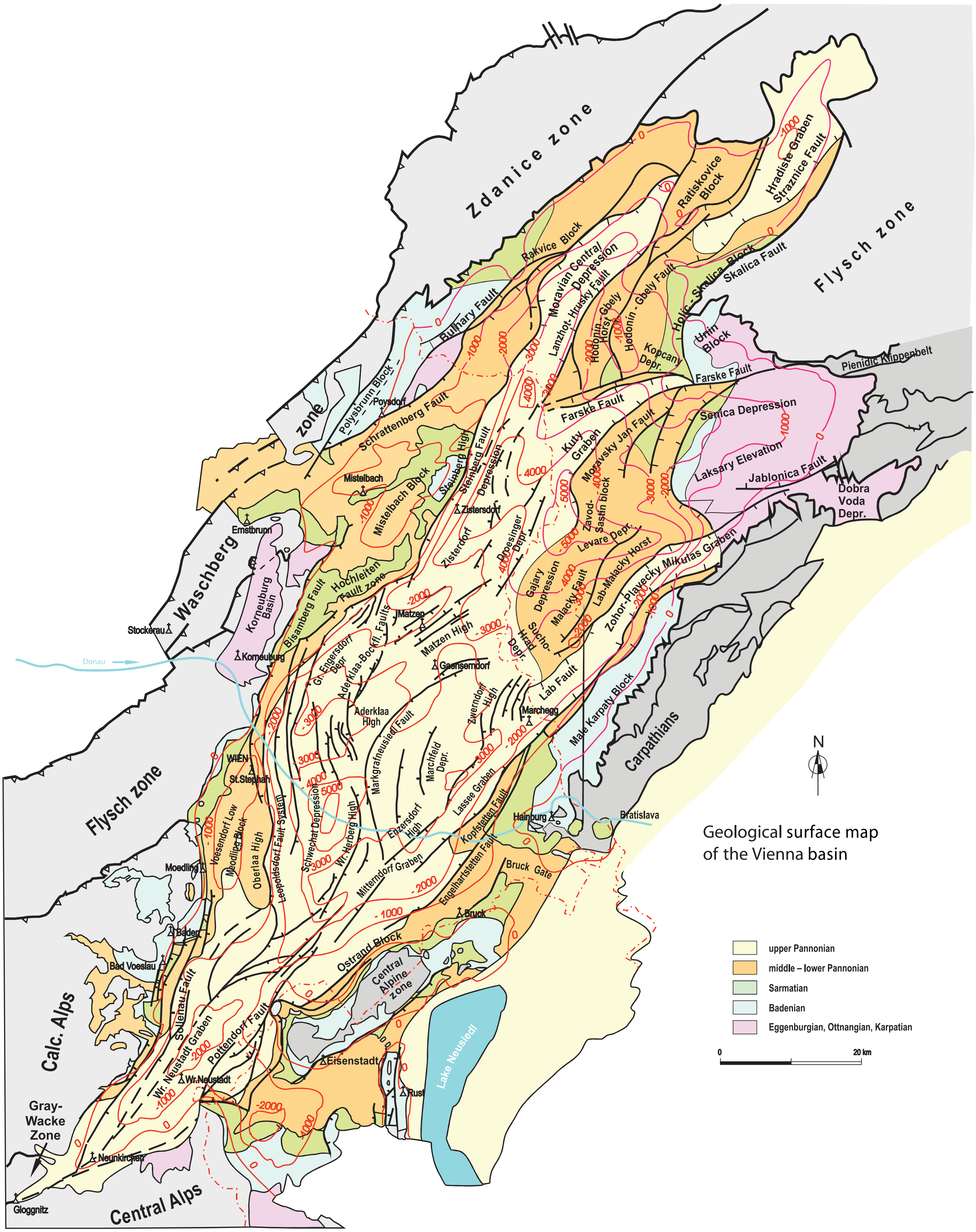


**Figure 3.** Geological surface map of the Vienna basin with contours of the pre-Neogene basin fill.

concurrently with shallow-marine or terrigenous sediments along the southern margin of the trough. Toward the late Eggenburgian, an impoverished faunal variety could be observed.

The areal extent of the Karpatian is still covered by open-marine deposits (Laa Formation) similar to those of the Eggenburgian. At the lower Karpatian, a brachyhyaline, sandy-marly development (Bockfliess Formation) predominated the deposition in the area south of the Matzen ridge and within the Korneuburg (Sub) basin. The Matzen ridge represented a facies boundary, which was effective until the late Karpatian. The Bockfliess Formation was followed by a sequence of coarse-grained layers, sands, and marls containing a limnic, Ostracoda fauna. This group comprises the Ganserndorf conglomerate at the base, variegated marls of the Ganserndorf Formation, and the Aderklaa Formation on top.

The whole Karpatian group underwent an erosional truncation and was subsequently covered by the fluvial Aderklaa Conglomerate (see their figure 2, Fuchs and Hamilton, 2006). Older stratigraphic tables assigned this lithostratigraphic unit to the top Karpatian period. Presently, it is more likely representing a lowstand equivalent at the onset of the open-marine Badenian cycle that progressively affected all parts of the evolving neo-Vienna basin.

During the Badenian, sediments were derived from the northwest and, to a lesser degree, also from the east and south. Isopachs indicate a readjustment of trough axes through time to a northeast–southwest orientation (Jiricek and Seifert, 1990). Simultaneously, the development of the depocenters occurred.

Lithothamnium reefs grew on shoals or along the coast. Partially, they were replaced by other typical shore deposits. The distal realm of the basin, dominated by thick, fine-grained intervals throughout the transgressional phase, was covered afterward by prograding fans fed by river systems emptying into the basin mainly at the western fringe.

Hamilton and Johnson (1999) and Fuchs et al. (2001) reported on a reevaluation of the highly mature Matzen oil field. The comprehensive revision included traditional (core and log analysis) as well as advanced methods like 3-D seismic and areal petrophysical evaluation (based on neural networks). The study came up with a new, detailed sequence-stratigraphic frame for the Badenian interval. Thus, two cycles could be distinguished: a transgressive wedge, followed by a pronounced highstand systems tract.

The 16th horizon in the Badenian, because of its thickness and distribution (still the basin's main producing interval), is seen as a diachronous remnant of the transgressive lag.

Sourced from a large delta located in the northwest, a subsequent series of subfans were deposited in the area of Matzen, Spannberg, Ebenthal, and Gajary. These fans spread out toward the southwest into central parts of the basin, but lobes pinch out rapidly as seen in corresponding deposits of the adjacent areas.

Substantial post-Pannonian uplift of the Alpine–Carpathian foredeep, from the molasse zone to the Western Carpathians, tilted the prograding sequence and created prolific stratigraphic traps (Figure 4).

These formations contain specific faunal associations, and diverse biostratigraphic concepts were developed; a microfaunal subdivision provided the most detailed insight. Although microfaunas are highly dependent on prevailing regional conditions, they provide excellent results wherever a basinwide homogeneous pelitic facies is dominating. The microfaunal evolution of the entire Paratethys bioprovince is preserved, mirroring the continuously decreasing salinity from marine Badenian up to the freshwater facies of the upper Pannonian.

The sand-shale ratio of the Sarmatian is quite similar to the previous period, whereas the contrast of diverse facies zones bordering each other is not that strongly developed. The basin margins still offered good conditions for limestone developments. They were predominantly built up by algae and bryozoans and even locally by ooliths. Ooliths and lumachelles are, furthermore, indicative for deposition on internal paleohighs.

The character of sediment influx did not change essentially throughout the Pannonian stage. The basin, meanwhile, was completely cut off from the open-marine Paratethys, which led to a rapid decrease in salinity and to a stop of carbonate production, as well as a significant change in faunal associations. For the basal part of the lower Pannonian, Kreutzer (1990) recognized mouthbar sand bodies (partly reaching substantial thicknesses in excess of 100 m [330 ft]) that overlap and/or replace each other in a relief-compensating way.

A forerunner of the Danube (Urdonau) flowed across the molasse zone, which was mainly land tied since the end of early Miocene, and left its marks in the form of the giant Hollabrunn–Mistelbach alluvial fan (Roetzel, 1999). The apron gradually prograded toward the east, depositing the majority of the coarse-grained material west of the Steinberg fault. The fluvial systems then built up huge deltaic complexes and distributed sands across the basin in a south-southeasterly direction.

The correlation of the individual units is possible because of the continuous shale intervals, which separate the genetically related packages.

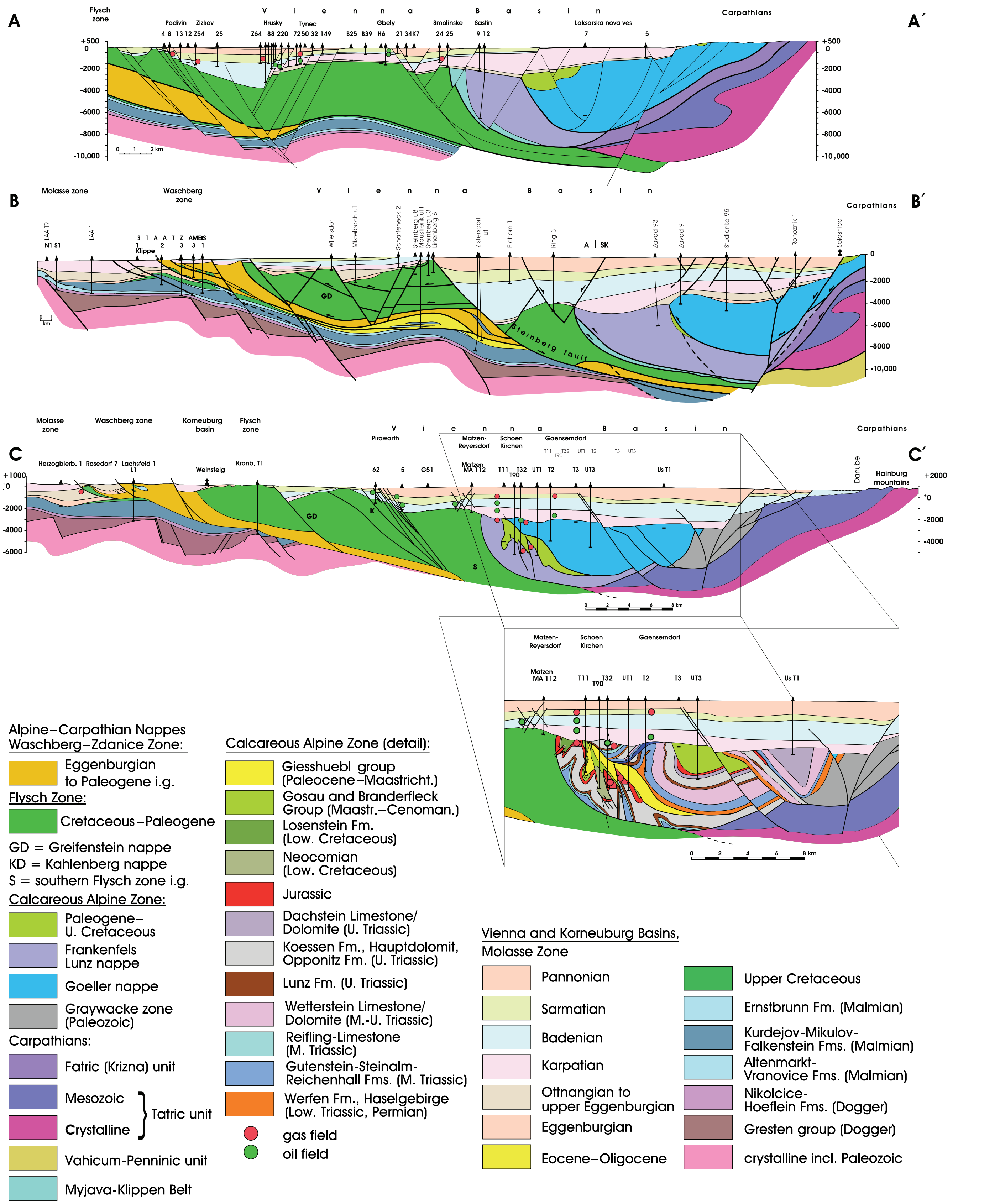


**Figure 4.** Geological sections through the Vienna basin and its pre-Neogene floor.

Within the middle to upper Pannonian section, a broad variety of terrestrial environments, ranging from lacustrine to fluvial, is preserved. Therefore, only a local correlation is possible.

Thick Pliocene and Quaternary alluvial deposits could be found in depressions like the Mitterndorf Graben, which are associated with the active fault zone at the southeastern basin margin. Presently, the area is undergoing normal faulting, currently superimposed by sinistral strike-slip movement.

As a consequence of the glacial era during the Pleistocene, the Danube (like all Alpine rivers) cut deeply into the underlying sediments and left several generations of terraces. Thick eolic loess deposits were accumulated adjacent to the river-dominated landscapes.

## PRE-NEOGENE FLOOR

### Allochthonous Alpine–Carpathian Floor

From southwest to northeast, the following allochthonous Alpine–Carpathian thrust elements form the floor below the Neogene basin fill (Figure 5): the Central Alpine–Tatride zone, the Grauwacken zone, the Calcareous Alps, the Flysch zone, and the Waschberg zone (Jiricek, 1979; Wessely, 1992, 1993; Kroll et al., 1993). The individual thrust sheets of the Waschberg zone comprise intervals from early Miocene Molasse deposits down to Paleogene and Jurassic sediments, which were originally deposited on the post-Hercynic, consolidated Bohemian Massif. The thrust belt developed during the final stages of the Alpine orogeny, when the main decollement switched down to the Tertiary Molasse, the autochthonous Mesozoic sedimentary cover, or even the crystalline basement.

The Calcareous Alps and a northward-thinning wedge of their former Paleozoic substrate, the Grauwacken zone, represent the highest tectonic unit overlying the Flysch in the north and the Central Alpine–Tatride zone in the south. They were derived from a realm south of the Central Alpine system and were sheared off the Adriatic microplate during the continental collision by the end of the Eocene.

The Flysch zone is made up of the Raca, Greifenstein, Kahlenberg, and the Laab nappe, stratigraphically ranging from upper Lower Cretaceous up to the Eocene. It belongs to the northern, youngest part of the Penninic system, an oceanic province that separated the European continent and the Afro-Adriatic terrane since the Jurassic. The sedimentological composition, as well as the structural imprint of the Flysch zone, reflects the most important stages of the Alpine tectonism. Throughout the convergent phase, the trough sediments were uprooted from their basement and formed an accretionary wedge that was finally thrusted onto the European foreland. Because of the strong internal deformation, the tectonic position of individual units, such as the Kahlenberg–St. Veit system, is currently unknown and under investigation. The oil-bearing thrust sheets (Paleocene–Eocene) of the Steinberg high, which belong to the Greifenstein nappe, are of economic significance.

Among all of the basin-floor units, the Calcareous Alps still offers the greatest potential for prolific reservoirs. They range stratigraphically from Permoskythian to Paleocene; the whole succession is dominated by Middle to Upper Triassic limestones and dolomites, which could reach a primary thickness of several thousand meters. Within the whole suite, the Norian Hauptdolomit proved to be the most important reservoir rock for gas and oil.

The tectonic style and the facies distribution do not differ significantly from the outcrops at the western basin margin.

The intensively deformed Frankenfels–Lunz nappe (Figure 5) represents the frontal and tectonically deepest element along the northwest border and belongs to the Bajuvarikum master unit. Folds and internal secondary thrusts are unconformably overlain by the Giesshubl Gosau, covering a time span from Upper Cretaceous to Paleocene. Whereas the Upper Cretaceous varies from river-dominated facies with conglomerates (>1000 m; >3300 ft) to marine facies with sands and marly limestones, the Paleocene was deposited in a deep-water, flyschoid environment. The latter is of particular relevance for the sealing of internal reservoirs.

The Giesshubl Gosau is overthrusted by the Goller nappe, a member of the Tirolikum assemblage. In addition, this nappe carries as a postdeformational layer group, the Glinzendorf Gosau. In contrast to the Giesshubl series, the stratigraphic range is limited to the Upper Cretaceous and shows a variety of different facial settings from predominantly limnic to shallow-marine and even minor, open-marine deposits.

The tectonically highest structures are a deep-reaching syncline and an isolated body of Lower to Middle Triassic. The syncline consists mainly of Wetterstein (Ladinian) and Dachstein limestone (Norian). The Triassic rocks are piled up against the Glinzendorf Gosau in the area of Tallesbrunn. Accordingly, these structures are equated to the Tirolikum system outside the basin.

In the south (southwest), on the rear side, the Calcareous Alps show a sedimentary contact to their former Paleozoic basement. The wedge-shaped sliver mainly consists of low metamorphic, terrigenous layers and is therefore of minor interest in an exploratory

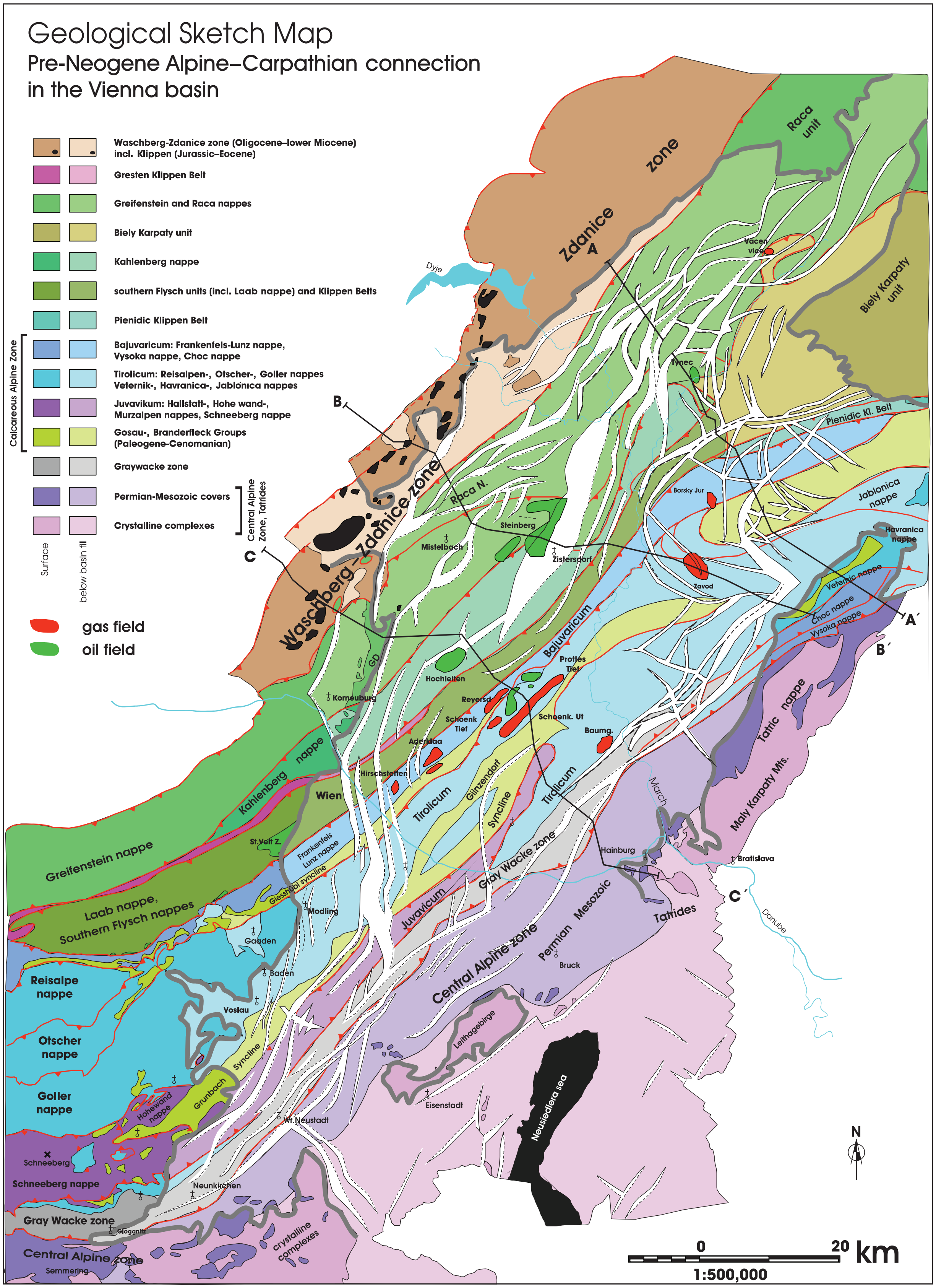


**Figure 5.** Geological sketch map showing the Alpine–Carpathian connection under the Neogene fill of the Vienna basin.

sense. The Grauwacken zone ends at the Slovak part of the basin without any comparable continuation further to the northeast. The relationship between the Calcareous Alps and their equivalents in the Carpathian mountain belt has been discussed several times by previous authors (e.g., Wessely, 1992).

The Central Alpine–Tatride system in the Vienna basin (represented by the Lower Austroalpine complex) was penetrated by only a few wells, which encountered Permian–Triassic strata of the Semmering Mesozoic type. Because of the complex internal structure and a low well density, the individual tectonic features could not be confidently traced across the basin.

The Alpine–Carpathian thrust belt evolved as a consequence of postcollisional north–south shortening between the Afro-Adriatic upper plate and the European lower plate. The climax of the collision is dated by the end of the deposition, and subsequent overthrust of the Helvetic unit, representing the shelf area of the European continent, is dated by the end of the Eocene. Ongoing convergence caused the Penninic–Austroalpine bulge to advance further onto the European foreland. As mentioned, these processes terminated at the end of early Miocene, about 17 m.y. (Figure 1).

## Autochthonous Floor

The autochthonous floor widely extends toward east-southeast below the foreland molasse and the Alpine–Carpathian thrust bulge. It consists of the crystalline basement, an unconformably overlying Mesozoic cover, and the Tertiary autochthonous Molasse (Figure 4).

The Mesozoic succession starts with deltaic sequences of the early Dogger, deposited in half grabens, formed during the Jurassic rifting stage.

The observed strata growth from east to west is a result of active synsedimentary faulting.

Sandy dolomites with lenses of chert were deposited in the uppermost Dogger. Fault activity must have been terminated or at least significantly reduced at that time, as the interval is regionally present with a low variation in thickness. This formation represents the reservoir rock of the gas-condensate field Hoflein below the Flysch zone near Vienna.

A north–south-trending carbonate platform (Altenmarkt Formation) developed in the Malmian. Toward the east, the platform environment interfingers with the basinal marls (the Mikulov Formation), which is, by far, the most important source rock of the Vienna basin hydrocarbon province. The transition between both realms is represented by the slope development of the Falkenstein formation, marly limestones with carbonatic debris. The whole section was covered by a prograding platform complex, the Ernstbrunn Formation, and reefoidal and lagoonal carbonates, which developed during the Upper Jurassic (Tithonian) regression.

Within the basin, only four wells reached the autochthonous Mesozoic: OMV Zistersdorf UT1a (total depth 7544 m [24,750 ft]), OMV Zistersdorf UT2a (total depth 8553 m [28,061 ft]), OMV Maustrenk UT1 (total depth 6563 m [21,532 ft]), and OMV Aderklaa UT1a (total depth 6630 m [21,752 ft]): Wessely (1990), Milan and Sauer (1996).

A gas kick with a considerable flow of overpressured gas in OMV Zistersdorf UeT1a occurred at 7544 m (24,750 ft) and was related to the Ernstbrunn Formation and its cover of basal breccia of Paleogene Molasse. The gas could not be produced because the borehole collapsed, and the replacement well UeT2a did not repenetrate the gas reservoir.

Nearby Zistersdorf, the well OMV Maustrenk UeT1 was drilled into the Jurassic Mikulov marls. Moderate amounts of oil and gas could be produced from a fractured zone close to an internal detachment plane, just above the undisturbed autochthonous interval. It turned out that the Malmian source rock could serve as an example of an unconventional, tight-gas play type.

Next to the border of Vienna, another ultradeep well (OMV Aderklaa UT1) was drilled through the Mesozoic section into the crystalline basement but did not encounter any reservoirs. The reservoir rocks were removed either by a tectonically or an erosional event.

## Oil and Gas Occurrence

The oil and gas provinces of the Vienna basin (Friedl, 1957; Kroll, 1980; Betnarikova and Thon, 1984; Ladwein et al., 1991; Kreutzer, 1993b; Ciprys et al., 1996) coincide with distinct structural features. A concentration occurs along the depocenter of deeply buried autochthonous Malmian marls below the northern Vienna basin. Additional source rocks have been referenced by Francu et al. (1996).

The structural trapping features are the large fault systems of the northern Vienna basin in Austria; in particular, the Steinberg fault system, the median highs of Matzen–Aderklaa–Enzersdorf, including the pre-Neogene Calcareous Alpine floor, and the southern and southeastern fault systems (Figure 6).

The northern and central provinces contain oil and gas of thermocatalytic origin, whereas predominantly biogenic gas was found in the south and southeastern regions.

Lower and middle Miocene transgressive and regressive sandstone cycles resulted in a stack of multiple productive zones (Kreutzer, 1993b).

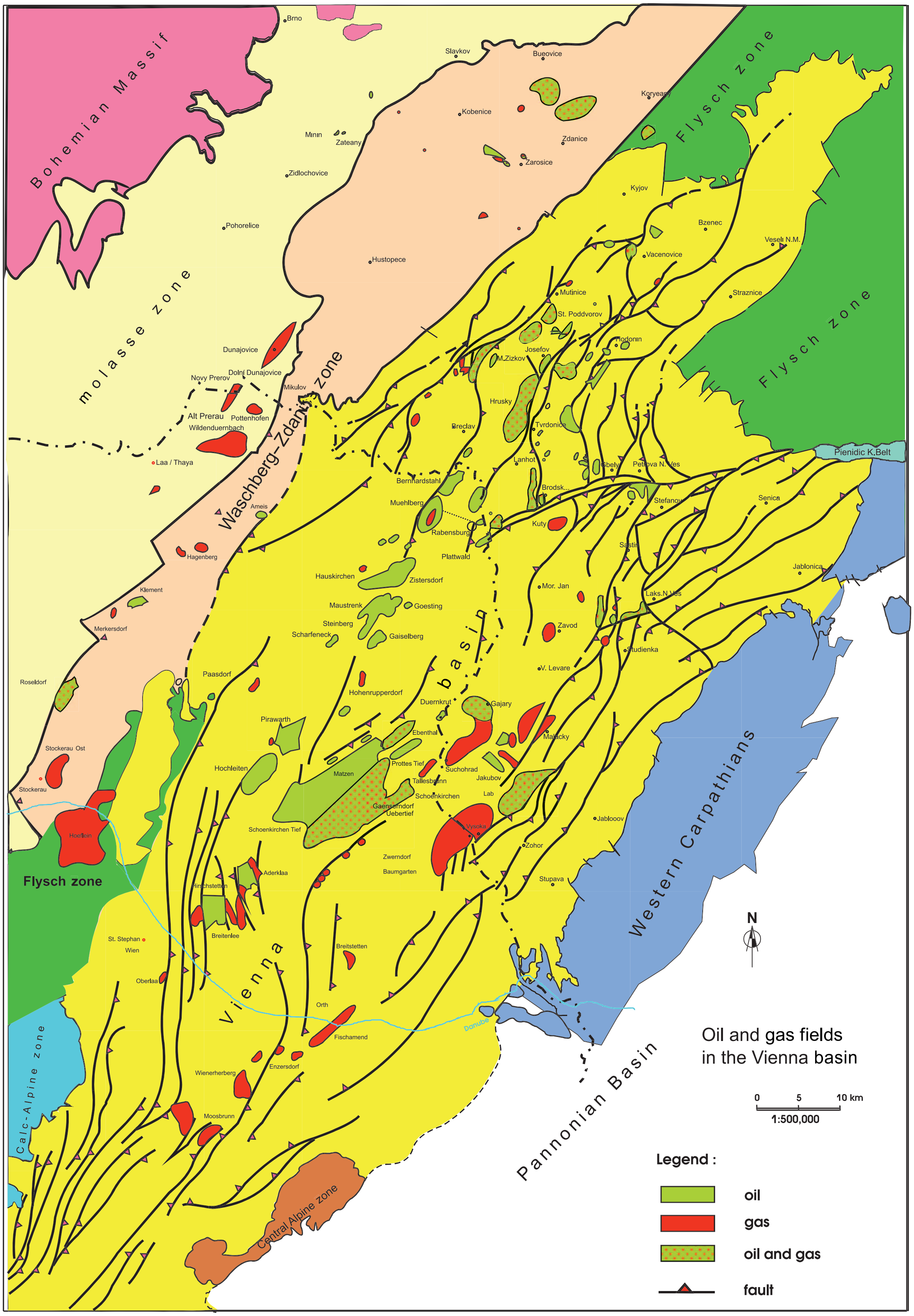


**Figure 6.** Oil and gas fields in the Vienna basin.

The number of Miocene sandstone horizons changes from province to province, as does the thickness and internal structure of the horizons. In the Matzen field, for example, 9 lower Miocene, 16 Badenian, 9 Sarmatian, and 4 lower Pannonian horizons are present that contain hydrocarbons.

In the northern fault provinces, oil has been produced from the lower to middle Miocene, especially from the Sarmatian sections. This is in contrast to the central provinces of Matzen and Aderklaa, where oil production is derived from the lower Miocene and Badenian horizons, whereas the Sarmatian and Pannonian horizons only contain gas.

In the southern and southeastern fault provinces, gas only occurs in the Badenian (Zwerndorf), Sarmatian (Fischamend, Orth, and Moosbrunn), and also, to a minor degree, the lower Pannonian horizons (Obersiebenbrunn, Markgrafneusiedl).

The most important zones in terms of production are the transgressive 16th Badenian horizon in the Matzen field, middle Badenian (called the Lab horizon in Czechia and Slovakia), and the eighth Pannonian horizon in Slovakia.

The majority of the traps are tectonically induced. Tilting of huge fault blocks also caused the combination of stratigraphic and structural traps, particularly in the lower Miocene. Along the faulted zones, hydrocarbon accumulations were discovered in adjacent fault blocks. The Steinberg fault creates a classic rollover structure.

Extended anticlines form traps in the central highs, such as in the Matzen, Aderklaa, and Zwerndorf fields. Faults in these areas are partly controlling the shape of the structures but do not act as significant trapping components. The use of 3-D seismic technology has increased the number of stratigraphic trap discoveries.

The Flysch zone below and juxtaposed to the Neogene is only productive in the area of the Steinberg high and related structures. It contains reservoirs in the Paleocene as well as the Eocene turbiditic sandstones.

The oil and gas fields of the Calcareous–Alpine floor are mainly located along the central highs. The main reservoirs are Upper Triassic dolomites (Hauptdolomit) and, in only one case, dolomitic limestones (Dachstein Limestone). The dolomites could reach thicknesses of as much as 500 m (1600 ft). Two types of traps can be distinguished: relief or buried hill traps and thrust internal traps that developed in the imbricated system. For the first type, Neogene marls act as a cap rock, whereas for the second, tight sediments of the Calcareous Alpine complex (Cretaceous to Paleocene shales and sandstones) seal the reservoirs.

The Schonkirchen Tief and Prottes Tief oil and the Aderklaa, Baumgarten, Zavod, and Borsky Jur gas fields are relief pools, whereas the Schonkirchen Ubertief, Reyersdorf, and Aderklaa Tief gas fields are internal traps. Remarkably, the gas derived from the internal reservoirs is sour gas.

Schonkirchen is of particular importance, because the Schonkirchen Tief pool is the second largest oil reservoir, and Schonkirchen Ubertief is the second largest gas reservoir of Austria. The trapping types in the Vienna basin have been described by Buchta et al. (1990), Kreutzer (1993a, b), and Hamilton et al. (2000).

The Vienna basin has become a leading factor in the development of oil and gas production in Austria and Slovakia first from the Neogene and then later from the Calcareous Alpine dolomites. In the Czech Republic, economic oil and gas production has only been obtained so far from the Neogene basin fill.

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