chen Profilmessung. Hier belegt die Refraktionstomographie und Refraktionsseismik (oberstes Bild) den weiteren Verlauf der durch die Kernbohrung erbohrten Festgesteinsoberkante und die Mächtigkeit der Lockersedimente. Der Verlauf der Refraktorgeschwindigkeit (mittleres Bild) legt nahe, dass sich der erbohrte Kalkmarmor nur zum Teil über den nördlichen Profilbereich erstreckt. Das Ergebnis der Geoelektrik (unteres Bild) illustriert die Ausdehnung des trockenen Hangschuttbereichs im Süden und die Erstreckung des Grundwasser führenden Talbereichs.

Oil-oil and oil-source rock correlations in the Alpine Foreland Basin of Austria

Gratzer, R.[1], Bechtel, A.[1], Sachsenhofer, R.[1] & Schulz, H.-M.[2]

[1] Department für Angewandte Geowissenschaften und Geophysik, Montanuniversität Leoben, Peter Tunnerstr. 5, A-8700 Leoben;
[2] Sektion 4.3, Organische Geochemie GFZ Potsdam, Telegrafenberg B 424, D-14473 Potsdam

Introduction: The Alpine Foreland Basin is a minor oil and a moderate gas province in central Europe. The majority of the fields are located in Austria and southeastern Germany. Exploration resulted in discoveries of 193 relatively small fields, 53 are still producing (IHS Energy 2004). Two different petroleum systems occur in the Austrian part of the Alpine Foreland Basin: a Mesozoic to lower Oligocene oil and thermal gas system and an Oligo-Miocene biogenetic gas system (Wagner 1996).

The goal of the present paper is to geochemically characterize oil from the Austrian part of Molasse Basin, to determine differences between different fields, and to compare them with the source rocks by biomarker fingerprinting.

Geological setting: The Alpine Foreland Basin stretches along the northern margin of the Alps from Geneva to Vienna (Roeder & Bachman 1996, Wagner 1998). The southern part of the basin was overthrust by the Alpine nappes. Within the Alpine foreland, the sedimentary history was characterized by three stages separated by unconformities: Permo-Carboniferous graben sedimentation; Mesozoic mixed carbonate-siliciclastic shelf sediments; and Cenozoic molasse sedimentation. The sedimentation within the Molasse Basin took place from late Eocene through Miocene time, starting with the deposition of fluvial and shallow-marine sandstones, shales and carbonates. In the eastern part of the basin during the Oligo-Miocene deep marine turbiditic and contouritic deposits up to several hundred meters in thickness were deposited. The western part of the basin was dominated by a prograding-retrograding delta system.

The main source for oil and thermogenic gas is the lower Oligocene Schöneck Fm. The Schöneck Fm., by a present day thickness from 0 to 20 m on the upper paleo-slope and more than 30 m basinwards, is characterized by organic carbon (TOC) contents up to 12 % and Hydrogen Index (HI) values between 500 and 600 mg/g TOC (Schulz et al. 2002). The Schöneck Formation is subdivided from bottom to top into the marly units a/b and the shaly unit c. Unit c is overlain by the Dynow Fm. TOC contents up to 3 % and HI values up to 600 mg/g TOC suggest that it is an additional source for hydrocarbons in the Alpine Foreland Basin (Sachsenhofer & Schulz 2006).

Most important reservoirs for thermogenic hydrocarbons are upper Eocene sandstones typically on the upthrown side of W-E trending antithetic normal faults. Some hydrocarbons are trapped in Eocene carbonates. Additional reservoirs occur in Mesozoic and Oligocene horizons. The Voitsdorf field with an E-W extension of about 10 km is the largest oil field in the Alpine Foreland Basin.

The source rock is immature where the oil fields are located and enters the oil window in 4-6 km depth only beneath the Alpine nappes indicating long distance migration (Schmidt & Erdogan 1996). Oil generation started during thrusting in Miocene time and may still be continuing.

Samples and methods: The study is based on a total of 59 samples from 28 oil fields. Twelve samples are from the Voitsdorf field, six are from the Sattledt (Sat) field. All other fields are represented by only one to three samples. Bulk molecular composition and biomarker distributions of the oils were determined using methods and instrumental settings summarized in Sachsenhofer et al. (2006).

Results and discussion: For the presentation of data, the oils are grouped geographically from west to east into a western group (K, Ktg, R, MS, Stbg), a central group (Mdf, Eb, Ob, Ra, Sat, Sths, Sths-N), and an eastern group (BH, BH-N, Ke, En, Sier). The Trattnach (Trat) and Voitsdorf (V) fields later including Hiersdorf (Hier) are discussed separately.

In general, the differences between oils from different fields are minor. However, oils from the western group plot separately in several diagrams. Considering the minor differences between different fields, the in-field variation within the Voitsdorf field is considerable. Neither clear geographic, nor depth trends can be observed in the Voitsdorf field.

Parameters related to the depositional environment of the source rock shows that most oils are characterized by pristane/phytane ratios between 1.2 and 1.8 and dibenzothiphene/phenantrene (DBT/Ph) ratios ~0.25. Only oils from the western group (K, Ktg, R, MS, Stbg) are characterized by slightly higher DBT/Ph ratios indicating a higher sulphur content.

Differences between the groups are also highlighted on a diagram showing 18α(H) trisnorneohopane/17α(H) trisnorhopane (Ts/Tm) and hopane/moretane ratios, which is sensible both to facies and maturity variations. The western oil group is characterized by the lowest and the Voitsdorf oil by the highest Ts/Tm ratios.

With the exception of the eastern group, sterane isomerisation is close to equilibrium, the Methylphenanthrene Index (MPI; Radke & Welte 1983) suggests that the maturity of the source rock varies between 0.75 %Rr (western group; Voitsdorf) and 0.90 %Rr (Trattnach).

The plot of C_{28}/C_{29}-sterane ratios vs. C_{27}-diasteranes/C_{27}-steranes ratios shows a more distinct arrangement of the different oil groups, but also a wide scatter within the groups. According to this figure, the oil from the western group has been generated from a source rock containing less terrestrial plant input than that of the other oils. Different diasteranes/steranes ratios indicate variations in the clay content of the source rock.

Data from potential source rocks are compared to oil data. Sterane patterns suggest that the Schöneck Formation is the main source for the accumulated molasse oils. A slight contortion of the cluster representing the molasse oil is interpreted to reflect a minor contribution from the Dynow Formation.

The correlation diagram of pristane/*n*-C_{17} versus phytane/*n*-C_{18} (Connan & Cassou 1980, Peters et al. 1999) shows a wide scatter of data from the Schöneck Formation. Nevertheless, the Schöneck Formation (or parts of it) is considered to be the main source for oil in the Austrian part of the Alpine Foreland Basin.

Pyrolysis/GC data (unpubl.) show that the middle part of the Schöneck Formation (unit B) is able to generate a S-rich oil and, therefore, is considered the main source for thiophene-rich oil from the western group.

The carbon isotope compositions of saturated and aromatic hydrocarbons show a significant decrease in $\delta^{13}C$ from the western to the eastern fields. Biodegraded oils are characterized by light carbon isotopes. This trend probably reflects the isotope heterogeneity of source rocks.

The benzocarbazole ratio (BCR) and the contents of benzocarbazoles decrease with increasing distance to the proposed hydrocarbon kitchen located below the alpine thrust front.

Conclusion: In general, the differences in the composition of oil from the Austrian part of the Alpine Foreland Basin are minor reflecting a common lower Oligocene source rock (Schöneck Fm.) and refer to homogenization during long-distance lateral migration. Nevertheless, a regional subdivision into different oil groups is suggested by biomarker data.

- The western group of oils (K, Ktg, R, MS, Stbg) is characterized by relatively low maturity (low MPI and Ts/Tm values), high hopane/moretane ratios and high C_{29}-steranes and sulphur contents as well as high $\delta^{13}C$ values of hydro-carbons. Benzocarbazoles are absent. Its main source is probably the middle part of the Schöneck Formation („unit b").
- Trattnach oils are heavier than any other studied oil (<30° API) and have been generated by a source rock with a relatively high maturity (~0.9 %Rr). Benzo-carbazoles were missing.
- Oils from the Voitsdorf field and the central group display a northward in-crease in maturity (MPI values). Differences in Ts/Tm and diasterane/sterane ratios indicate variations in the facies (e.g., shale content) of the source rock.
- The eastern oil group displays a northward increase in maturity. The saturated and aromatic hydrocarbons are characterized by low $\delta^{13}C$ values. Benzocarbazoles were present and show in content and BCR a decrease to the north.

The authors thank Rohöl-Aufsuchung AG for permission to publish the study.

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New insights to depositional environments of long-lived Lake Pebas (Middle/Late Miocene; Western Amazonia)

Gross, M.[1], Piller, W.E.[2], Ramos, M.I.F.[3] & Paz, J.D.S.[4]

[1] Department for Geology & Palaeontology, Universalmuseum Joanneum, Graz, Austria;
[2] Institute of Earth Sciences, University of Graz, Austria;
[3] Museu Paranese Emilio Goeldi, Belem, Brazil;
[4] Instituto de Ciencias Exatas e da Terra, Universidade Federal de Mato Grosso, Cuiaba, Brazil

North-western South America was shaped by a huge system of interconnected lakes and wetlands in Miocene times. This enormous inland water system is subsumed as „Lake Pebas", which affected dispersal pathways of terrestrial taxa between the Guyana shield and the northern Andes for millions of years. However, aquatic biota like molluscs and ostracods faced impressive speciation events within „Lake Pebas" and provide model cases for studying evolutionary processes linked to, e.g., ecological changes or