auf den drei verschiedenen Terrassen zu erfassen, um so deren Grundwasserschutzfunktion zu charakterisieren.

Neben der Untersuchung der klassischen Parameter wie Mächtigkeit, Korngröße, Mineralogie, pH und Austauschkapazität, wurde ein Hauptaugenmerk auf die insitu-Permeabilität und Porosität der äolischen Deckschichten gelegt, wobei 12 Lokalitäten in Oberösterreich für die Bearbeitung ausgewählt wurden.

Die Ergebnisse zeigen, dass es innerhalb der äolischen Deckschichten eine enorme Variabilität u.a. beim Tongehalt (12 - $\geq$50 %) wie auch bei der Durchlässigkeit (E-06 – E-11 m/s) gibt. Bei den untersuchten Hochterrassen - Standorten, wo heutzutage Niederschlagsverhältnisse von 700 - 850 mm/a vorherrschen, ist diese Variabilität zum Großteil durch die Distanz zum Auswehungsgebiet (z.B. Nähe zur Terrassenkante) bestimmt. Dieser Trend ist großräumig auch bei den Deckenschotter - Standorten erkennbar. Beachtenswert ist hier allerdings, dass die für den Grundwasserschutz wichtigen Parameter, wie pH und Pufferkapazität, stark mit der heutigen Niederschlagsverteilung korrelieren. So ist in Gebieten mit 700-850 mm/a ein pH-Wert von >6,9 und Karbonat vorhanden, wogegen in Regionen mit höherem Niederschlag (>1000-1100 mm/a) das Material pH Werte von < 5 aufweist und der - für den Grundwasserschutz nachteilige – Kationenaustausch–Pufferbereich erreicht ist.

Generell besteht eine gute Korrelation zwischen den statistischen Parametern der Korngrößenverteilung und der Durchlässigkeit. Letztere zeigt die beste Korrelation mit dem Gehalt an großen Poren (Durchmesser D >10 µm). Hinsichtlich der Abschätzung des Grundwasserschutzpotentials der äolischen Deckschichten haben wir 3 Ansätze für die unter-suchten Lokalitäten gewählt: Als ein „worst case" –Szenario für den Grundwasserschutz haben wir erstens einen gesättigten Wasserfluss in Poren mit D >10 µm angenommen, um so die minimale Verweilzeit für infiltrierende Wässer zu errechnen. Die derart gewonnenen Daten sind inkonsistent zu den Ergebnissen bei Anwendung des Konzepts von Hölting et al. (1995), wo die Verweilzeit über nicht-hydraulische Daten wie Korngröße etc. ermittelt wurden. Der 3. Ansatz war ein Relativvergleich der Standorte, wobei die Parameter Durchlässigkeit, Austauschkapazität und Pufferung kategorisiert und mit Punkten bewertet und anschließend mit der Mächtigkeit multipliziert wurden.

Die Kombination des gesamten Datensatzes unter Berücksichtigung der regionalen (z.B. pH) und morphologischen Trends (z.B. Durchlässigkeit) mit einem Löß-Mächtigkeitsmodell, wie wir es versuchsweise für die Traun-Enns Platte erstellt haben, stellt den nächsten Schritt in Richtung einer zukünftigen Karte des Grundwasserschutzpotentials in Oberösterreich dar.

Hölting, B., Haertle, T. et al., 1995: Konzept zur Ermittlung der Schutzfunktion der Grundwasserüberdeckung. Geol. Jb., C 63, 5-24.

Moser, G.& Reitner, J., 1998: Untersuchung der Lösse und Lösslehme in Oberösterreich südlich der Donau hinsichtlich ihrer Grundwasserschutzfunktion. Unpubl. Bund/Bundesländerkooperationsbericht OC-13, 1-80.

The Molasse Imbricates Belt – the Last Oil & Gas Exploration Frontier in a Mature Basin?

W. Nachtmann

RAG, Vienna, Austria

In 1958, the Perwang 1 well, some 6 km north of the Alpine Flysch front, encountered a six fold repetition of Eocene and/or Cretaceous rocks belonging to the base of the Molasse fill. This was the first indication of the existence of imbricates reaching "far into" the Molasse basin. The imbricates have only limited lateral extension and are not mappable with 2D-seismic. Well cuttings, micropaleontology and well log characteristics remained the key tools for identification of imbricates in the subcrop for the following three decades. In the early nineties, RAG started to cover the gas prone central and southern part of the Molasse basin between the border to Bavaria in the west and the Attersee in the east with 3D-seismic. An intensive mapping campaign, using modern seismic interpretation and visualisation techniques combined with newly adopted geological and sedimentological concepts, led to the identification of a number of projects within what is now called the Imbricates Belt.

The Imbricates Belt comprises projects in the triangle zone, in imbricates sensu strictu, in piggy back basins between packages of imbricates, and in the so-called south slope facies – potentially thick sandstone units derived from olistostroms as well as from turbidites on the flank of and above imbricates.

As the drilling results in the traditionally explored and exploited foreland had been below target for several years, the overall interest turned toward the imbricates belt with its tectonic and sedimentologic "infrastructure" as a challenging frontier for doing exploration for hydrocarbons. A program of two imbricate-wells per year found approval and started in 1994/95. Encouraging results alternated with heavy disappointments.

In 1997 the Haidach field was discovered with an expected ultimate recovery of some 3 to 4 billion m³ of gas. This quickly proved to be RAG's largest single reservoir gas field in Austria. Immediately the hunt for

"Haidach-look-alikes" was opened but with limited success. The smaller Nussdorf discovery in 2000 was the result of comparing seismic features in the available 3D-data volumes with the sequence of seismic reflectors corresponding with the Haidach Sand.

Ongoing 3D-seismic acquisition and (re)processing are for improving and optimizing the data quality. The expected economic result of all these activities is a portfolio of sound, drillable prospects to further explore the still undiscovered hydrocarbon potential in the imbricates belt. Due to the existing surface infrastructure and vicinity to the customers a rapid production start up of new discoveries is ensured.

Contrasting Late Cretaceous to Neogene ore provinces in the Alpine-Balkan-Carpathian-Dinaride collision belt

F. Neubauer

Institute of Geology and Palaeontology, University of Salzburg, A-5020 Salzburg, Austria

Internal sectors of the Alpine-Balkan-Carpathian-Dinaride (ABCD) orogen comprise fundamentally different ore deposits along strike in three temporally and spatially distinct belts. These were formed by several short-lived, late-stage collisional processes (including slab break-off) during Late Cretaceous and Oligocene to Neogene times. Reconstruction of Late Cretaceous (ca. 92–65 Ma) collisional structures, magmatic features and mineralisation reveals contrasting variations along strike, including: (1) the Alpine-West-Carpathian sector, which is characterised by a strong metamorphic overprint, lack of magmatism and both syn- and late-orogenic formation of metasomatic and metamorphogenic talc, magnesite, siderite and vein- and shear zone-type Cu and As-Au due to the exhumation of metamorphic core complexes; (2) the contemporaneous Late Cretaceous "banatite" magmatic belt, which extends from Apuseni mountains to the Balkan, associated with porphyry Cu-Au, massive sulphide and Fe-Cu skarn mineralisation. The magmatism is interpreted to represent either post-collisional or Andean-type calcalkaline due to continuous subduction or break-off of the subducted lithosphere.

Oligocene-Miocene mineralisations includes (1) the Oligocene-Miocene Serbo-Macedonian-Rhodope metallogenic zone extends across several structural units from the Bosnian Dinarides to the Rhodopes and to Thrace. It includes both a belt with volcanic-hosted and vein-type Pb-Zn deposits and a belt of porphyry Cu-Au-Mo and epithermal Au mineralisation, which is more common in the south. Both belts appear to relate to microcontinent collision and associated subsequent magmatism due to slab break-off. (2) Different types of mineralisation were also formed along internal Inner Carpathian and Alpine sectors during Late Oligocene to Miocene collision. In the Alps, mineralisation formed due to eastward extrusion of fault-bounded blocks into the Carpathian arc. Associated mineral deposits are always related to exhumation of metamorphic core complexes and include: sub-vertical mesothermal Au-quartz veins and replacement As-Ag-Cu ore bodies within the metamorphic core complex, fault-bounded mineralisations (Pb-W-Au) along low-angle ductile normal faults along the upper margins of the metamorphic core complex, mineralised (Sb-Au) strike-slip faults and sub-vertical Au-Ag-Sb-bearing tension veins. (3) In contrast, nearly all Miocene ore deposits within the Carpathians are related to volcanic activity contemporaneous with the invasion of fault-bounded blocks into the Carpathian arc. These have been related to slab break-off and cessation of subduction. Mineralisations include structurally controlled Au-Sb-Cu-Pb-Zn ore bodies within shallow volcanic edifices, with preference of steep tension veins parallel to the motion direction of laterally escaping crustal blocks. The data presented above indicate that slab break-off is a principal tectonic process which is able to explain the post-collisional origin of magmatism and mineralisation as well as the punctuated nature of magmatism and mineralisation in eastern sectors of the ABCD belt, both during the Late Cretaceous and Oligocene-Neogene. Based on observations in the ABCD belt, several distinct features characterise both magmatism and mineralisation in orogenic belts: (1) the post-collisional tectonic setting; (2) lateral, ca. orogen-parallel migration; and (3) systematic changes of metal contents due to changes in the origin of fluids, heat source and nature of the underlying crust. Tomographic observations on the shallow mantle and deep crust and the collisional geometry allow predictions on distribution of possible locations of various mineralisations.