frühen und anschließend wiederum höhere $\delta^{18}O_{Apatit}$-Werte im späten Virgilian. Ein Vergleich der Daten aus den Kansas-Zyklen mit den $\delta^{18}O_{Apatit}$-Werten von Conodonten aus dem Moskauer Becken zeigt einen deutlichen Unterschied im $\delta^{18}O_{Apatit}$ zwischen beiden Lokalitäten mit teilweise signifikant schwereren Werten im Moskauer Becken. Dies kann eventuell mit dem Einfluss kalter Meeresströmungen erklärt werden.

Hydrochemical and Isotope Study of the Upper Part of the Kupa River Drainage Area - Croatia

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Upper part of the Kupa river drainage area is typical karst terrain developed on part of the Dinaric carbonate platform. The terrain is made of rocks from under layered Palaeozoic deposits; Mesozoic and Tertiary carbonate rocks, limestones and dolomites. The complex structural relations were formed as a consequence of subduction of the African under the European plate in the combination with disintegration of the lower deposits of the carbonate platform during the younger geological period. Results are elements of overthrust tectonics that have special roles in shallow zones important for underground water flow paths.

Main characteristics of the region is a presence of the large water dividing zones between the Adriatic sea and the Black sea catchments, which is situated in the mountain area of the Risnjak massive. That area is very rich in precipitation what together with lithologic and structural characteristics cause the presence of the large groundwater reserves and few large karst springs in the Kupa river drainage area: Čabranka spring, Kupa spring, Zamost, Velika and Mala Belica, Kupica spring and Zeleni Vir spring. Also, on the other side of the mountain massive, in the Adriatic Sea catchment, is a large perennial spring of the Rječina river outflow. That spring is located at the same altitude as the spring of Kupa river. But, annual precipitation regime with long summer dry period has influence on high groundwater recharges amplitude of those springs.

Performed hydrogeological and isotopic studies have regional character to recognise the origin of spring waters regarding to recharge area of particular springs. During the 1997, 1998 and 1999, in different annual vegetation and hydrologic conditions were performed spring water sampling for hydrochemical and isotopic analysis and measurements of temperature, conductivity, pH and TDS on mentioned large springs and on the Rječina spring (Adriatic sea catchments). Hydrogeochemical facies of the study area mainly vary from Ca-HCO_3, CaMg-HCO_3 to MgCa-HCO_3 main ionic composition as a result of dissolution of the carbonate rocks, limestones and dolomites. The presence of Palaeozoic clastic deposits in the drainage area of some springs causes increasing of magnesium, some heavy metals, non-metals, transition elements, actinide and lanthanide elements (Kupica spring, Zeleni Vir).

Usually, the stable isotope $\delta^{18}O$ and $\delta^{2}H$ ratios are influenced by temperature and pressure (altitude effect) prevailing during recharge as well as a consequence of the distance from the sea (continental effect). Therefore in our case, study spring waters become enriched towards to the sea (Figure 1). Also, established variations of the stable isotope content, which

have been observed, appear to result from local seasonal influx of precipitation into the particular drainage system.

Distribution of stable isotopes and tritium in the spring waters suggest that in that region, were distinguished a four different sub-catchments. The first one is the group of Rječina, Kupa and Kupari springs, which have, practically unique catchments area, situated in the Risnjak Mountain. The second group of the springs, Zamost, V. Belica, M. Belica and Kupica have the similar catchments situated in the middle part of the study area and they form tributaries of the north bank of the Kupa river upper part. Čabranka spring and Zeleni Vir spring drainage areas cover the larger part of terrains which borders are situated far from the springs. The Čabranka catchments is in the Slovenian mountains at higher altitudes while Zeleni Vir catchments lay deeply in the inland part of the Gorski Kotar region.

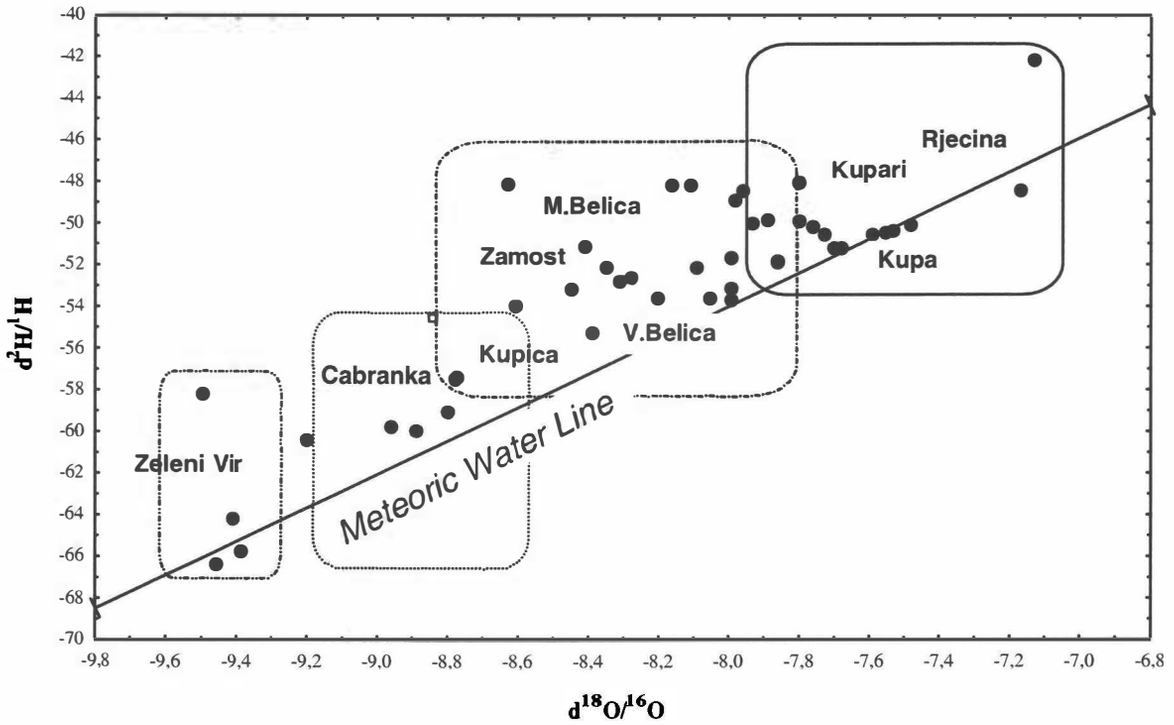

Figure 1. Stable isotope ratio $\delta^{18}O$ vs. $\delta^{2}H$ in spring waters of the Kupa river drainage area

Tritium activity of the spring waters corresponds with tritium activity of the recent precipitation of the study area. Highest activities were detected during the spring hydrological maximum, while during the extremely dry summers at some springs outflow groundwaters with tritium activity below detected limits. It has shown that deep underground of the upper part of the Kupa river drainage area contains groundwater with relatively long mean residence time. Such circumstances reflect the high water potential suitable for the water supply, storage in the deep karstified underground of the study area.

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Water and anion transport conversion in highly heterogeneous, recultivated open mining fields with very different carbon levels and pH values: multitracer lysimeter studies

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The movement of water and the related transport of bromide and nitrate were studied in soil used for agriculture from an open mining field near Espenhain/Saxony by means of tracer techniques (D_2O, [^{15}N]nitrate, Br tracer) in monolithic and reconstructed lysimeters. Despite the similarly high level of seepage, the breakthrough volumes were very different, namely 82 l (L 12/1), 147 l (L 12/3) and 30 l (L124) for D_2O. After the experiments had continued for 36 months, the recovery standardised for 600 l seepage of bromide and deuterium respectively were calculated to be 22% and 39% for L 12/1, 15% and 19% for L 12/3, and 4% and 46% for L 124. The differences in the seepage recovery of the reactive tracer [^{15}N] nitrate were even greater for the three lysimeters, namely 3,7% (L 12/1), 0.7 % (L 12/3) and 1.5 % (L 124).

The findings regarding the transport of D_2O indicate that water transport in the soil monolith of L 12/1 is mainly determined by preferential flow, whereas in L 12/3 and L 124 conditions are largely shaped by piston flow and delays corresponding to the cascade model. Taking into account plant uptake, the sometimes much lower recovery of bromide compared to D_2O in lysimeter L 12/1 and especially in L 124 couid be attributed to reactions resulting from the strong acidic conditions (pH 1.5–2.0) in the soil water of these lysimeters, the extremely high sulphate levels (over 4%) and/or the reactive carbon from lignite residues. Under these conditions, the bromide appears to undergo temporary chemisorption and possibly even chemical conversion. The seepage recovery of [^{15}N] nitrate in the open mining field soil is significantly lower than in natural soils. [^{15}N] nitrate recovery in 600 l seepage of 3.7% (L 12/1), 0.7% (L 12/3) and 1.5% (L 124) are probably caused by nitrate decomposition via denitrification under the partly extreme soil conditions.