Environmental Tracers in Groundwater of the North China Plain

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Environmental tracers such as stable isotopes or noble gases in groundwaters are important tools to study issues of water resources and to obtain palaeoclimate records. Applications of these methods to semi-arid regions are of particular interest. On the one hand, noble gas studies in such regions have shown that, in addition to recharge temperatures, the “excess air” phenomenon may be useful as a climate proxy for the important parameter humidity, and that changes in humidity may influence the relationship between air and soil temperature [1] [2]. On the other hand, in dry areas groundwater is a unique and scarce resource. Old groundwaters in such places are not only climate archives, but in the first place water resources of high quality but finite quantity.

The investigated area of this study is the North China Plain, which consists of the deposits of the Yellow River and is the largest alluvial plain of eastern Asia. The plain is bordered on the west by the Taihang Mountains and fronts the Bohai Gulf in the east. It reaches up to the Yen Mountains in the north and to the Yangtze River in the south. The North China Plain is one of the most densely populated areas of the world. The plain has a temperate continental monsoon climate, with clear-cut seasons, dry winters and humid summers. The aquifer studied here has its recharge area near the mountains in the west and becomes deeper and confined to the east near the coast.

In March 2004 twenty-six wells along a transect from the recharge area near Shijiazhuang to the coastal area near Tianjin were sampled (see map Fig. 1, left panel). Each well was sampled for \textsuperscript{14}C, \textsuperscript{3}H, stable isotopes (\textsuperscript{2}H and \textsuperscript{18}O) and noble gases. The wells in the recharge area were additionally sampled for SF\textsubscript{6}. The SF\textsubscript{6}-analyses show that the groundwater in the area near the mountains (west of Shijiazhuang), which was taken from comparatively shallow wells, is quite young. Further analyses of \textsuperscript{3}H and \textsuperscript{3}He shall give us information about groundwater residence times and recharge rates in this area.

Groundwater in the confined part of the aquifer will be used to derive a palaeoclimate record from noble gas concentrations and stable isotope ratios, dated by \textsuperscript{14}C. Previous measurements by Zongyu et al. [3] indicate that the age of the water east of Shijiazhuang increases steadily to a maximum of more than 20 kyr in the coastal region near Tianjin. The samples from this part of the aquifer, which were taken from depths between 100 m and 500 m below the surface, should therefore cover the whole period from present time back to the last glacial maximum. Zongyu et al. [3] observed a clear decrease of stable isotope values with age, which they interpreted as indicating a 6 - 9 °C warming at the end of the last glacial period.
The stable isotope results of the present study confirm the previous findings by exhibiting a systematic variation of the isotope ratios of the groundwater along the transect (Fig. 1, right panel). The data show a strong decrease of the $\delta^D$-values in the first section of the confined part of the aquifer, reaching a minimum of $\sim 20$ ‰ lower values than in or near the recharge area, and a gradual increase thereafter.

**Fig. 1:** Left: Map of the northern part of the North China Plain (from Nelles Maps “Northern China”). The solid line represents the transect along which samples were taken, from the outcrop area west of Shijiazhuang towards the coast near Tianjin. Right: $\delta^2H$ values as a function of approximate flow distance along the transect, reflecting climatic changes during the past $\sim 25$ kyr.

Noble gas data will be used to derive an independent and quantitative estimate of the glacial-interglacial temperature change in this region. This will constitute the first noble gas palaeotemperature record from East Asia. Furthermore, it will be of interest to see whether the excess air component in the groundwater from the North China Plain reflects the known changes of humidity in this presently semi-arid region. Noble gas analyses are presently performed and results will be presented at the conference.

