IAEA-SM-361/21

ISOTOPICALLY HIGHLY ENRICHED SHALLOW GROUNDWATER BELOW DRY SEDIMENTS

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The isotopic compositions of oxygen and hydrogen of the shallow groundwater in the Gurinai Grasslands west of the Badain Jarim Desert in China are unusual: The $\delta^{18}O/\delta^{2}H$ values fit an apparent local meteoric water line with an extremly low deuterium excess of <-20‰ (Fig. 1; [1]). Four possible causes are considered: (a) the presence of fossil lake water in the groundwater, (b) input of water from the Black River, (c) unusual isotopic compositions of the regional precipitation, and (d) processes which secondarily modify the isotope signature of the groundwater. Cases (a) and (b) can be excluded on the basis of our earlier results and the geohydraulic circumstances in the study area.

In two other case studies, similar unusual isotope compositions have been found for shallow groundwater in the Valle del Río Copiapó in the arid part of central Chile [3] and for water in lakes along the northern tree line of Canada [2].

The extremely low deuterium excess can be explaned by the physical processes in the unsaturated zone which modify the isotopic compositions of the pore water in semiarid and arid regions [4]. The slope of the evaporation lines in the $\delta^{18}O/\delta^{2}H$ plot decreases from 4 – 5 for open water systems down to about 2 in the unsaturated zone with increasing thickness of dry cover sediment of the shallow groundwater.

In the Gurinai Grasslands and at the foot of the megydunes in the Badajilin Desert the dry cover sediments are 0.5 to 3.5 m thick, the groundwater level and the isotope enrichment due to evaporation are constant over the year. There is a linear interrelationship between the $\delta^{18}O$ values and the depth of the water table. The unusual isotope compositions are understandable if (i) evaporation lines with different slopes are assumed, (ii) the composition of the cover sediments is uniform, (iii) steady-state conditions along the isotope profiles are established before the next recharge event, and (iv) groundwater recharge is lower than the amount of pore water in the unsaturated zone. This is also the case for the explanation of the unusual isotopic compositions of two other case studies in northern Canada [2] and in the Valle del Río Copiapó [3].

This finding can be helpful to estimate regional evaporation rates for balance studies of shallow groundwater.

References

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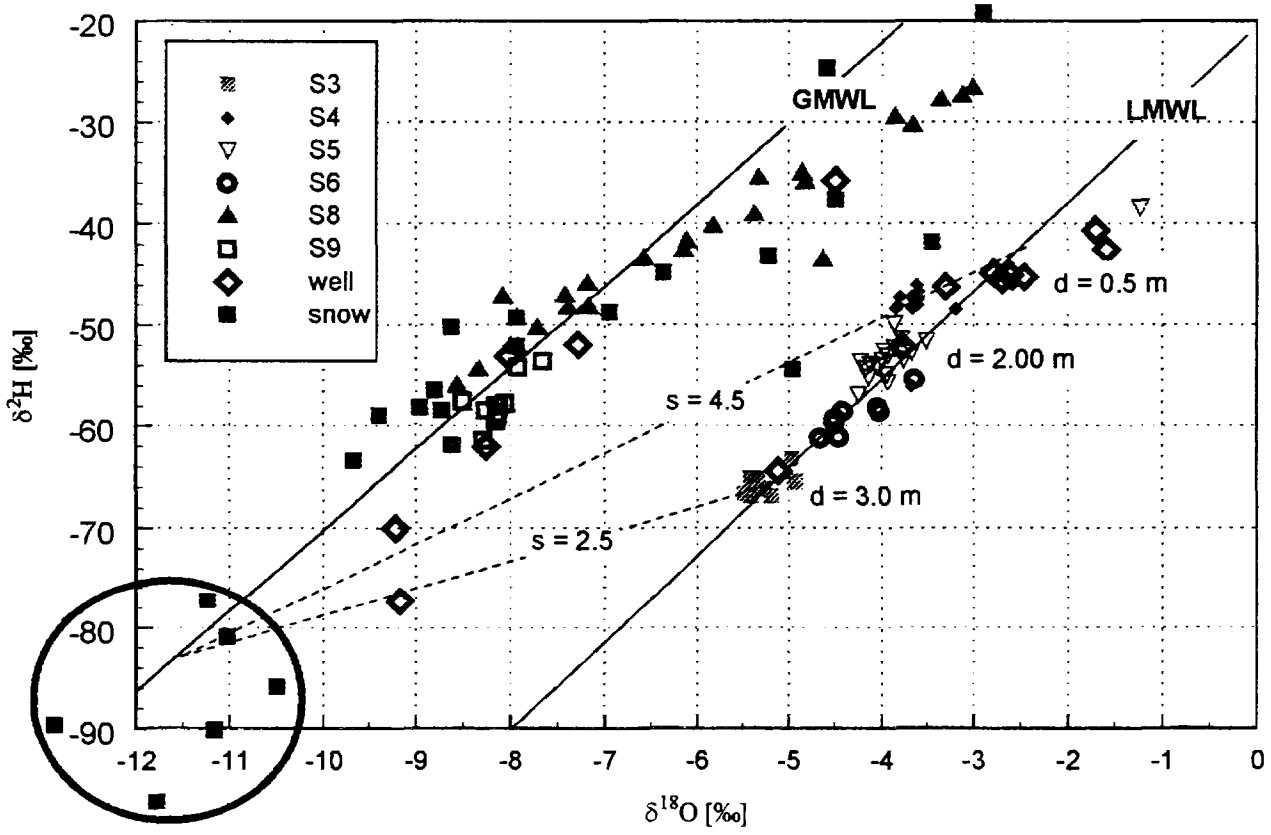

FIG 1. Apparent "Local Meteoric Water Line" (LMWL) with a deuterium excess of < –20‰ of the groundwater in the Gurinai Grasslands in the arid part of central China [1]. There is a linear interrelationship between the $\delta^{18}O$ values and the depth of the water table. The $\delta^{18}O$ and $\delta^{2}H$ values may be explained assuming a decreasing slope of the evaporation line with increasing thickness of the dry cover sediments above the saturated zone. The blue squares belong to precipitation at the Black River and within the Badajilin Desert (blue squares within the blue circle) east of the Gurinai Grasslands. The green dotes belong to the water from the Black River which is isotopically enriched during the hot summer time.