Quality of Groundwater, Proceedings of an International Symposium, Noordwijkerhout,
The Netherlands, 23–27 March 1981, W. van Duijvenbooden, P. Glasbergen and H. van Lelyveld (Eds.),
Studies in Environmental Science, Volume 17

HYDROGEOCHEMICAL INVESTIGATIONS UNDER AN INFILTRATING SURFACE WATER[+]

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A 140 years old drainage gallery (107 m long) in Southern Germany was investigated for the chemistry of infiltrating surface water and for the solids (sinters etc.) deposited by the infiltration. The gallery is located under a former navigation channel. So it was possible, for the first time, to examine the hydrogeological processes involved not only in bank infiltration but also in infiltration directly below a surface water bed.

Organic decomposition of infiltrating water increases the CO_2-concentration, and $CaCO_3$ is extracted from the surrounding Dogger marls and claystones. Thus along the main flow lines the underground is already completely decarbonated. The water shows low oxygen and nitrate (denitrification) concentrations as well as a sour pH-value and increased iron and manganese contents (table 1 sub $\boxed{1}$ - $\boxed{3}$). Infiltration in this zone produces fast growing sinters of amorph Fe-hydroxide (with or without Mn) that contain no carbonate (plate 1 sub b+c). - In some distance from the channel where there is still carbonate available in the underground, the water becomes harder and pH-values may rise up to 7.9. This stage shows a low Fe-contents, there are Mn-hydroxide-gel sinters, and (at times) pure calcite ($CaCO_3$) is deposited (lamination).

The drainage gallery also yields evidence for 2 stages of infiltrating precipitation water: The first sampling spot at an aeration shaft entering the gallery from above shows infiltration after a very short time of residence; the water is aggressive (plate 1 sub d) and has a high O_2 concentration. - Water of the second stage enters the gallery by "normal" infiltration and shows a considerable rise in hardness, paralleled by organic decomposition and NO_3-reduction (table 1 sub $\boxed{4}$ + $\boxed{5}$).

Water of the 1st stage produces no deposits in the gallery, whereas water of the 2nd stage ($\boxed{5}$) results in Fe-Hydroxide- and calcite sinters and stalactites. At both stages, Manganese is hardly involved at

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[+] This work was sponsored by the Deutsche Forschungsgemeinschaft.

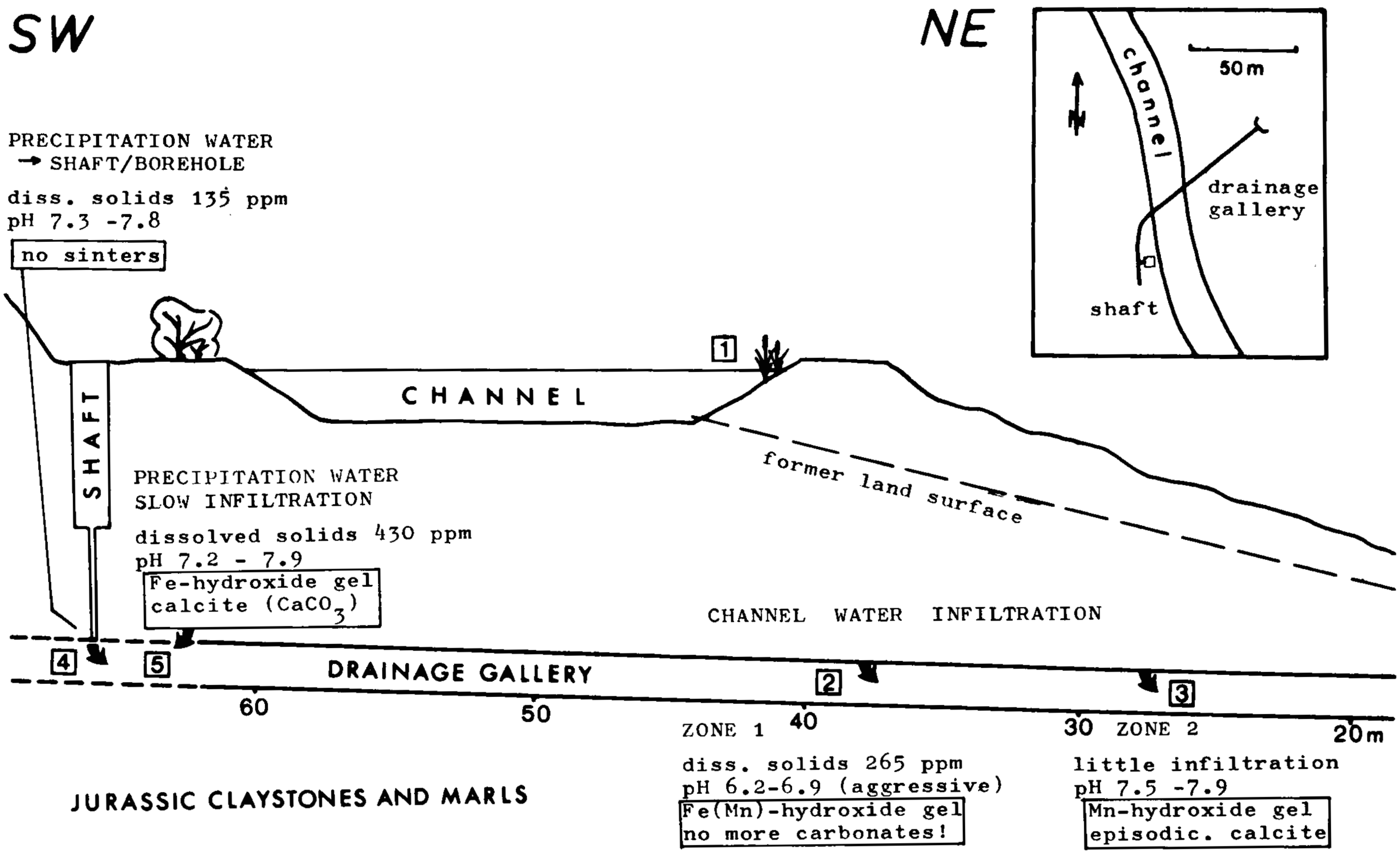


Fig. 1. Cross section of channel and drainage gallery.

TABLE 1

Hydrochemical analyses (mean values; in ppm)

constituents	channel (surface) $\boxed{1}$	infiltr.channel water zone 1 $\boxed{2}$	zone 2 $\boxed{3}$	infiltr.precipitation stage 1 $\boxed{4}$	stage 2 $\boxed{5}$
Hydr.Carbonate	151.	162.	226.	60,4	271.
Sulphate	34,2	16,9	24,1	26,4	42,7
Chloride	14,7	15,1	17,3	7,2	7,2
Nitrate	21,7	o,49	2,1o	1,13	o,54
Phosphate	o,11✦	o,02✦	n.b.	o,15✦	o,02✦
Calcium	61,9	46,4	71,2	21,2	82,4
Magnesium	11,7	11,6	11,o	9,oo	13,o
Strontium	o,12✦	o,14✦	n.b.	o,05●	o,53✦
Sodium	5,88	3,46	3,67	4,oo	1,91
Potassium	4,02	4,oo	2,65	3,16	8,75
Iron	o,37	2,1o	o,02●	o,08●	o,45
Manganese	o,05	1,51	1,54✦	o,04✦	o,04●
Dissolv.Oxygen	9,92	2,75	n.b.	8,06	2,62
DOC ($KMnO_4$)	10,5	4,2	5,3	7,1	2,8
Dissolv.Solids	306.	264.	360.	133.	429.
pH-value	7,72	6,46	7,71	7,6o	7,55

✦ = single values

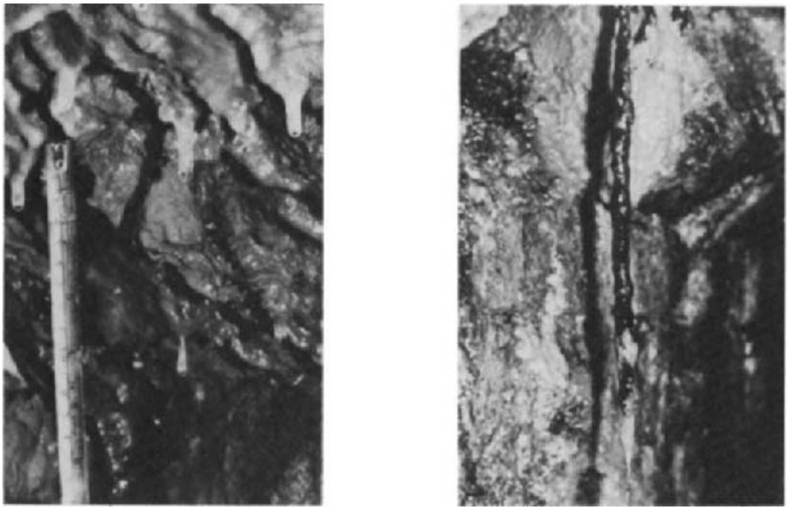
all, neither in ground-water nor in the sinters. (This could mean that the Mn-concentration in infiltrating channel water originates from the mud at the bottom of the channel; further evidence for this assumption is needed.)

Quite generally, there are very few substances the concentrations of which do not change during infiltration. Particularly, there is little change with chloride, which may also serve to identify infiltrating channel and precipitation water. - Magnesium concentrations do not change during channel water infiltration, but they show temporal variation in the young stage of precipitation infiltration where they also have lowest mean values (fig. 1 sub $\boxed{4}$). - Alkali concentrations are somewhat unusual in the gallery. In normal river infiltration, ion exchange processes lead to a lowering of potassium concentrations. In the present case, however, 140 years of infiltration have obviously exhausted the subsurface exchange capacity; and in one instance there is even a rise in K-contents - possibly because the clays consist mainly of Illite, a clay mineral rich in potassium. Sodium concentra-

PLATE 1.

(a) Small white calcite stalactites ("maccaroni"-) and iron-hydroxide sinters at sampling point $\boxed{5}$ (see fig. 1).

(b) Fast growing Fe-hydroxide stalactite $\boxed{2}$ partly coated with black Mn-hydroxide film; growth rate: 2 mm per week (!); total length: 36 cm; perennial high CO_2 concentration (aggressive water!).



(c) Wall of the drainage gallery covered by black Mn-hydroxide, partly coated by calcite layers $\boxed{3}$.

(d) Gallery wall (Lias limestone) heavily corroded by aggressive precipitation entering the aeration borehole ($\boxed{4}$). Jurassic fossils (mostly *dactylioceras*) are exposed by carbonate corrosion.

Ca. 1/6 natural size

tions, on the other hand, present a general decrease during infiltration, which may also be attributed to ion exchange processes.

Details on the growth of the sinters and stalactites and on seasonal changes in water quality are given in ref. 4. For technical and historical data on the locality investigated see ref. 1.

REFERENCES

1 F. Birzer, Die Dammrutschungen am Ludwigskanal bei Ölsbach. - Geol. Bl. NO-Bayern, 24 (Erlangen 1974) 285-91.

2 A. Bögli, Karsthydrographie und physische Speläologie, Springer, Berlin, Heidelberg, New York, 1978.

3 W. Kanz, Die Uferfiltrationsanlage von Karlstadt a.M. - eine Modelluntersuchung, in Bayerisches Landesamt für Wasserwirtschaft (Ed.), Das Mainprojekt, hydrogeologische Studien zum Grundwasserhaushalt und zur Stoffbilanz im Maineinzugsgebiet, Schriftenreihe No. 7, Bayerisches Landesamt für Wasserwirtschaft, München, 1978, Ch. 3.3 = pp.174-82.

4 W. Kanz, Geologische, hydrochemische und petrographische Untersuchungen an rezenten Sintern und Tropfsteinen, in K. Poll (Ed.), Gedächtnisband Friedrich Birzer, Erlangen, 1981. - in print

5 G. Matthess and A. Pekdeger, Chemisch-biochemische Umsetzungen bei der Grundwasserneubildung. - Das Gas- und Wasserfach, 121.5 (München 1980) 214-9.