TRACER INVESTIGATION OF GROUND WATER DIRECTION AND FLOW VELOCITY IN THE FIELD OF DRAINAGE SYSTEM INTERACTION

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Abstract

The multiwell tracer technique has been used for determination of groundwater flow direction and velocity in selected regions of drainage barrier around the salt dome Dębina localized between two lignite exploited deposits in fields Bełchatów and Szczerców. The uranine water solutions has been used as a tracer. Twelve experiments have been carried out in the period 2002 – 2004. The depth of injection wells was from 180 to 345 meters, distance between injection point and observation pumped wells was from 32 to 235 m. Observation time in individual experiments differs from 990 to 1730 hours.

Any study of ground water usually needs determination of flow direction and velocity.

Two well mode tracer experiments are one of the possible resolution of the problem [1, 2]. The salt dome "Dębina" has divided the "Bełchatów" lignite deposit into two parts. The first, Bełchatów Field, which is actually being exploited, and second – Szczerców Field just started to be prepared for future exploitation (Fig.1).

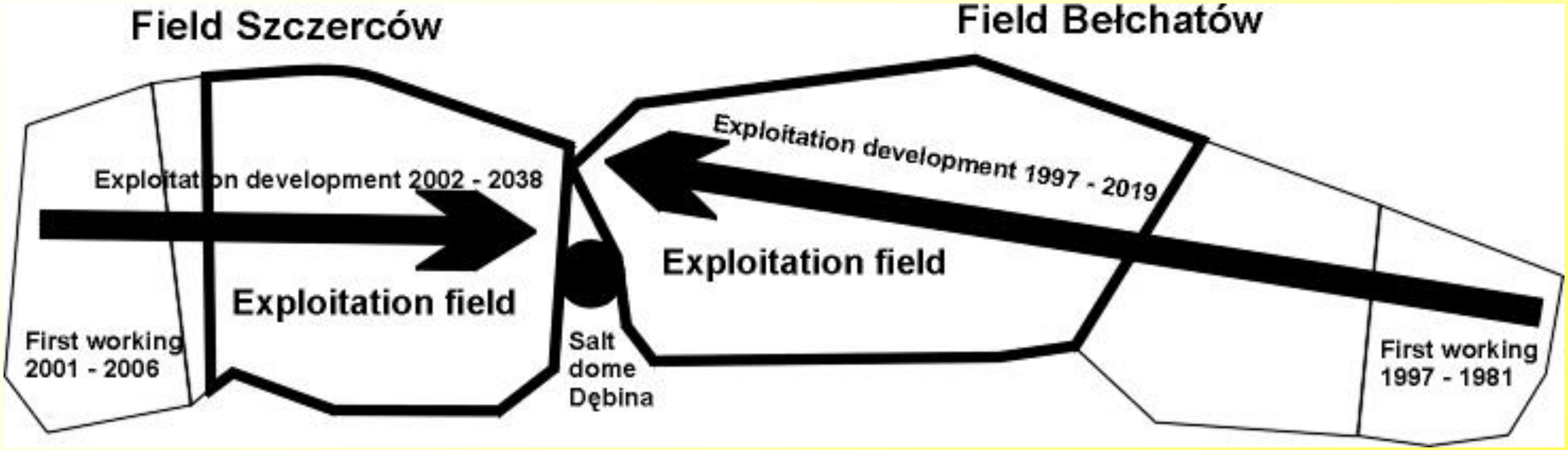


Fig.1 Scheme of strip exploitation development in mine "Bełchatów"

The salt dome drainage protection barrier consists of 40 wells (~250 m deep) localized around the salt deposit. The system has been successfully exploited since 1992. The main aim of the system is the elimination of ground water flow through the salt deposit sphere to avoid its dissolution and to prevent contamination of mine ground waters by brines.

The basic condition of the system is to keep the depression at the stable level.

The existing barrier fulfilled very well its aims during the past 10 years. At present, when simultaneously with the Bełchatów Field exploitation, preparation works of the Szczerców Field have begun, the efficiency of depression protection barrier of salt dome should to be increased (probably by a second ring of pumping wells localized outside the actually working barrier). Therefore, before starting the design process and build-up a new drainage system, an investigation on aquifer characteristic should be performed. The main problem is to determine hydrological conditions in the south-west part of the salt dome foreland as well as to estimate necessary input data for actualization of the hydrogeological model of the region.

The aqueous solution of uranine has been used as tracer in all experiments. The injection piezometers and observation pumped wells have been chosen on the basis of the existing system of protection barrier around the salt dome "Dębina" (Fig.2).

The tracer has been injected strictly to the filtrated zone of each investigated wells (32 – 375 m below ground level). After uranine injection has been done the well was filled with 0.4 – 2.5 m^3 of water causing the tracer to investigate the aquifer strata. The observations of tracer appearance in the samples taken from neighboring wells was carried out during the period from 40 to 72 days.

Uranine injection

1. Injection of uranine solution strictly to filtrated area of piezometer (32 - 375 m below ground level),
2. Filling the piesometer with water - forsing the tracer to penetrate the investigating aquifer area,
3. Taking samples from neighbourning pumping wells (experimented period 40 - 72 days),
4. Florimetric measurements

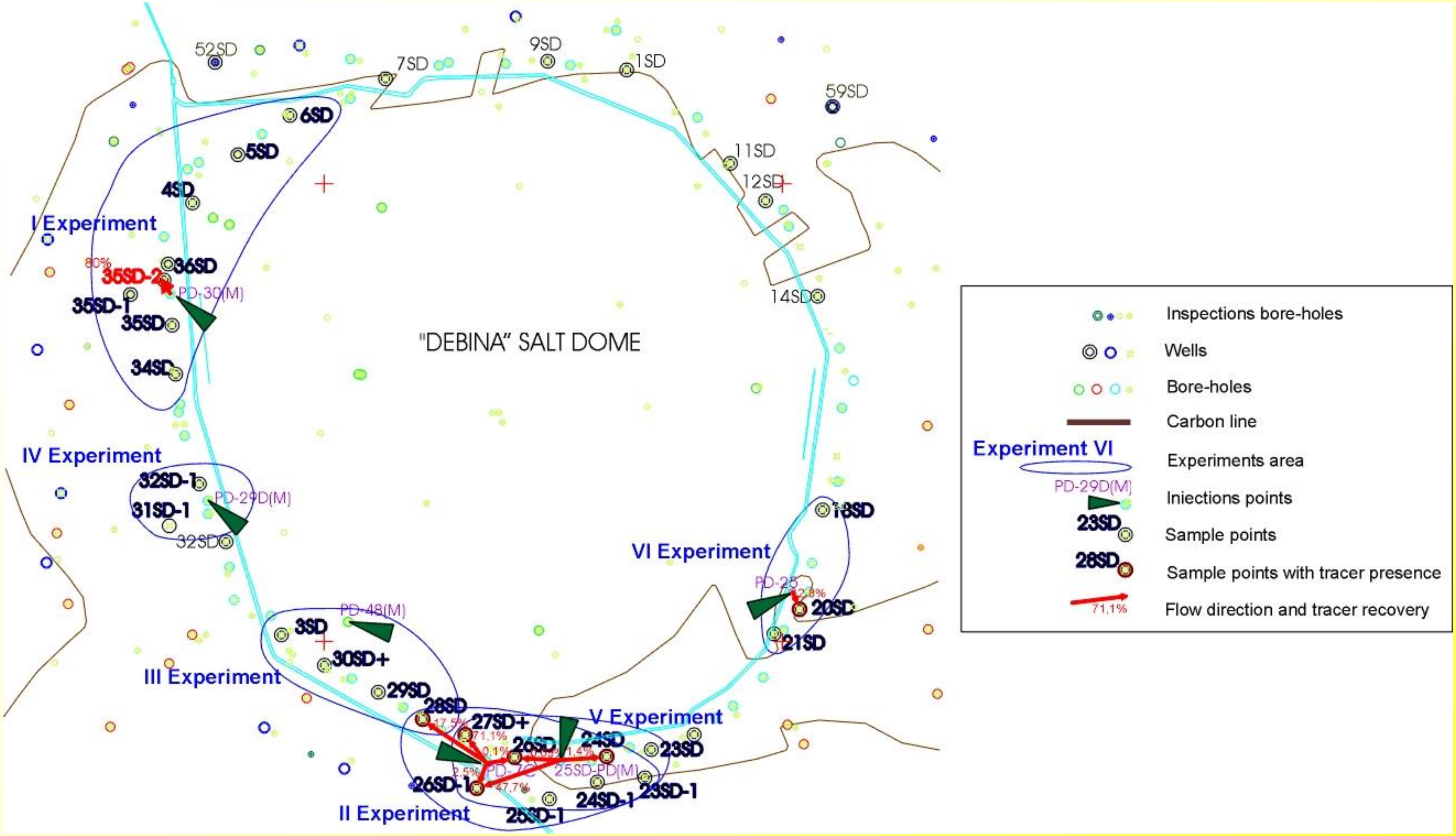


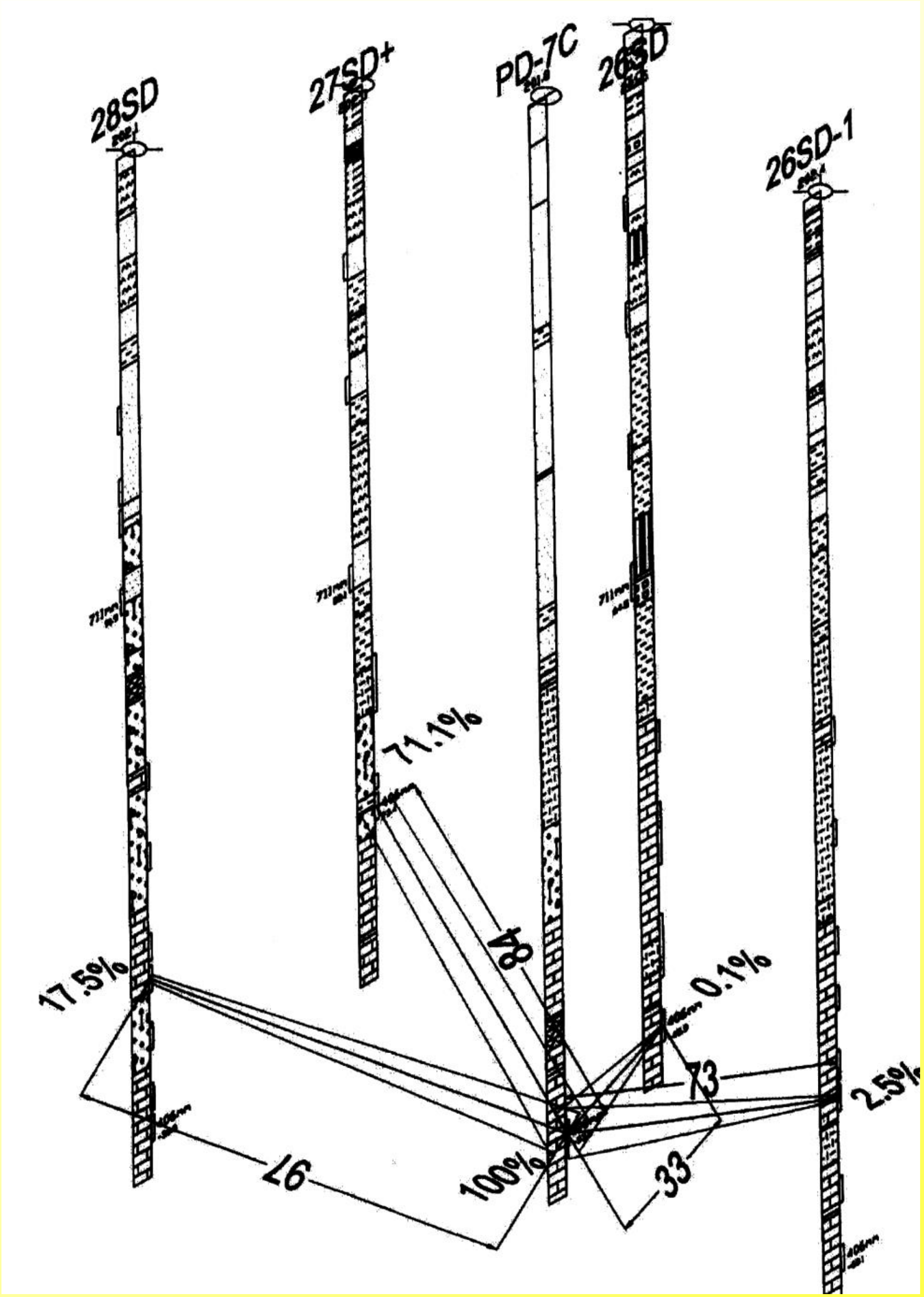
Fig.2 Localization of experiments

$$E = \left(\frac{D}{\mathrm{vx}}, \frac{t}{t_0} \right) = \frac{1}{\sqrt{4\pi \frac{D}{\mathrm{xv}} \left(\frac{t}{t_0} \right)^3}} \exp\left[- \frac{\left(1 - \frac{t}{t_0} \right)^2}{4 \frac{D}{\mathrm{vx}} \cdot \frac{t}{t_0}} \right] \quad \textbf{(1)}$$

$$\frac{D}{\mathrm{vx}} = \frac{1}{Pe}; \frac{t}{t_0} = \tau \quad \textbf{(2)}$$

where:
D – dispersion coefficient,
v – velocity,
t – time,
x – distance,
Pe – Peclet number.

$$t_0 = \frac{\int_0^\infty t \cdot C(t) dt}{\int_0^\infty C(t) dt} \quad \textbf{(3)}$$


28SD
27SD+
PD-7C
26SD
26SD-1
71.1%
84
17.5%
0.1%
73
2.5%
97
33
100%

Experiment 1

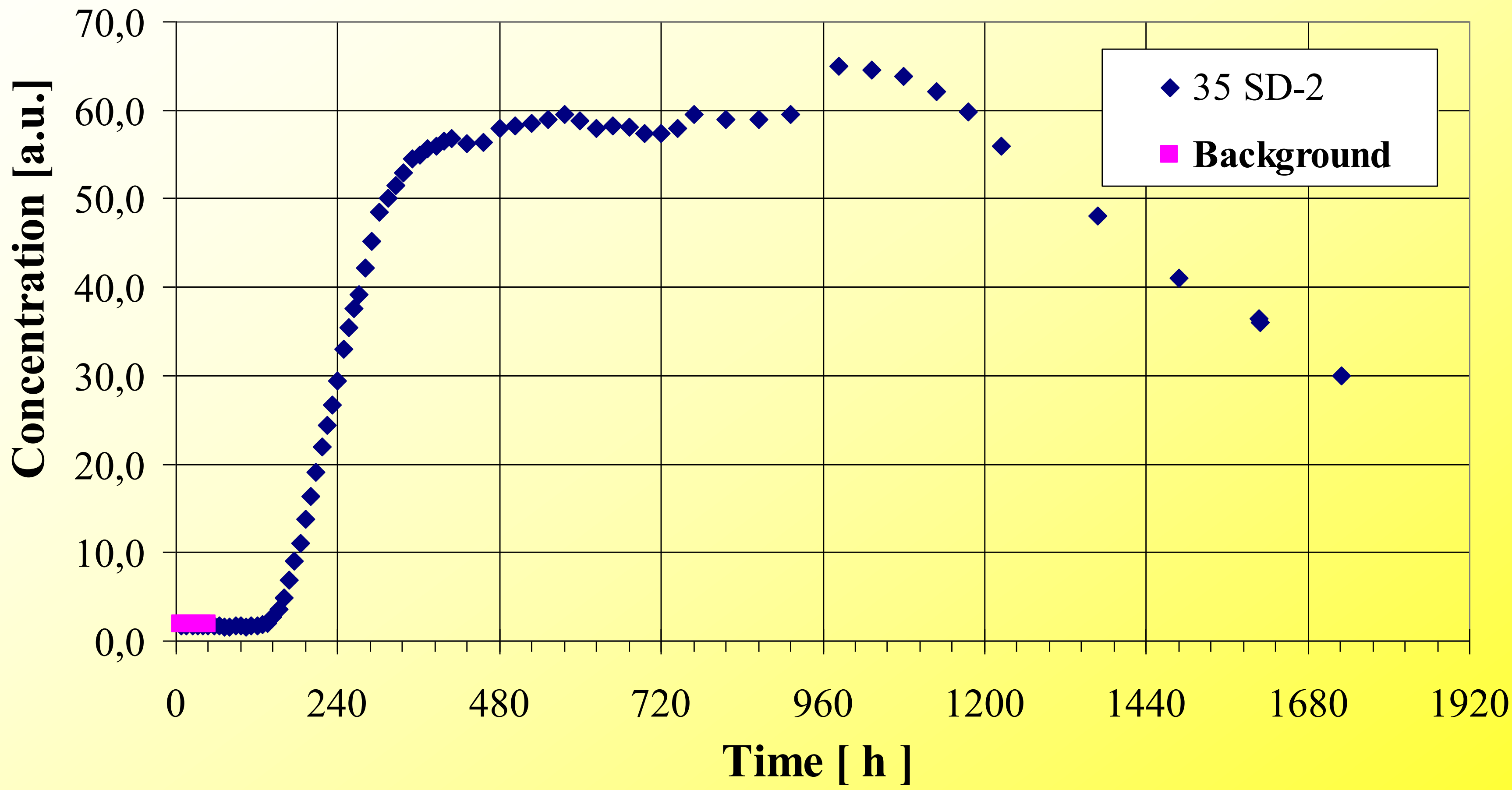


Fig.3 Tracers concentration changes in well 35SD-2 experimental and model curves

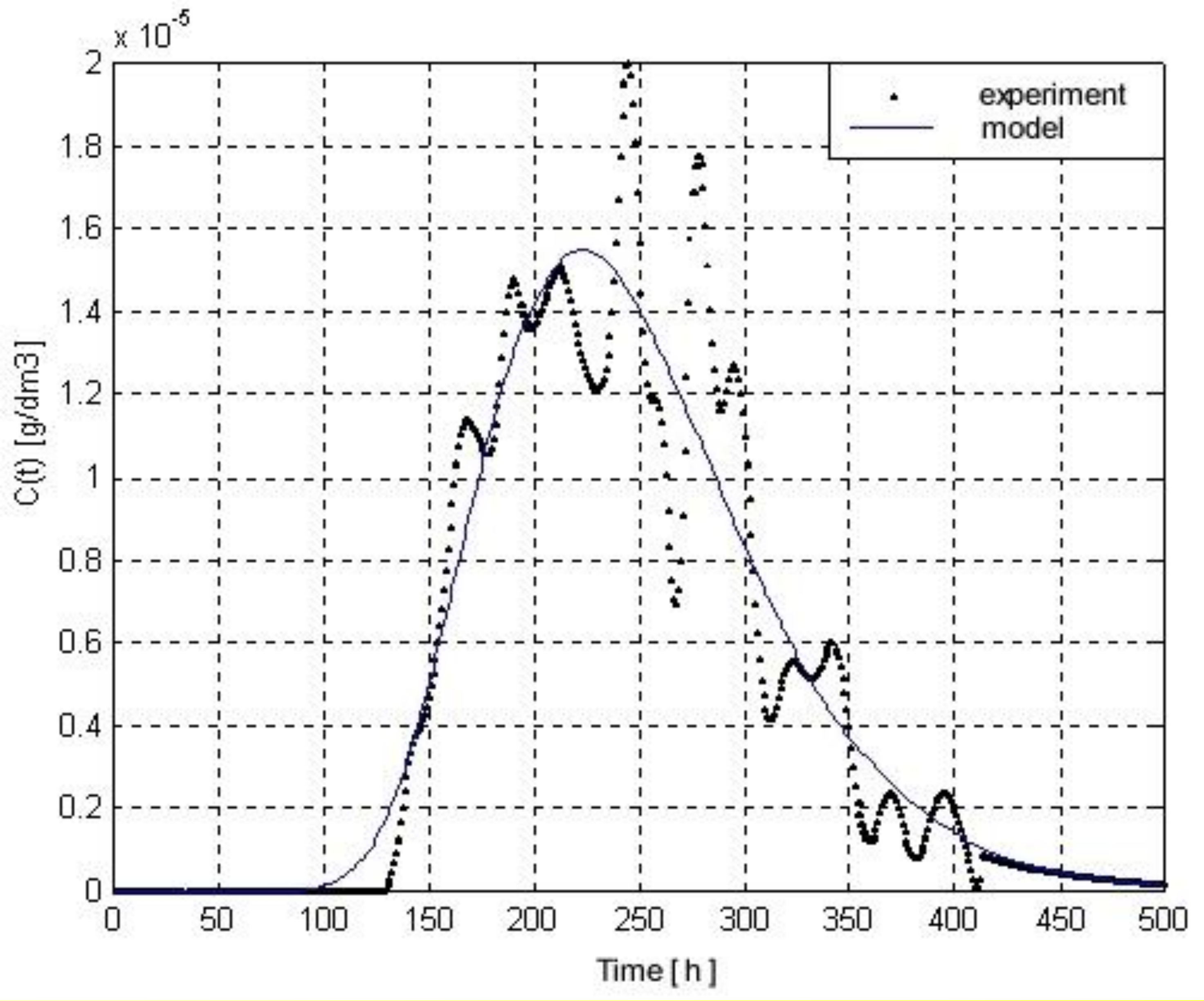


Fig.4 Concentration of the tracer in the well 35SD-2

Experiment 2

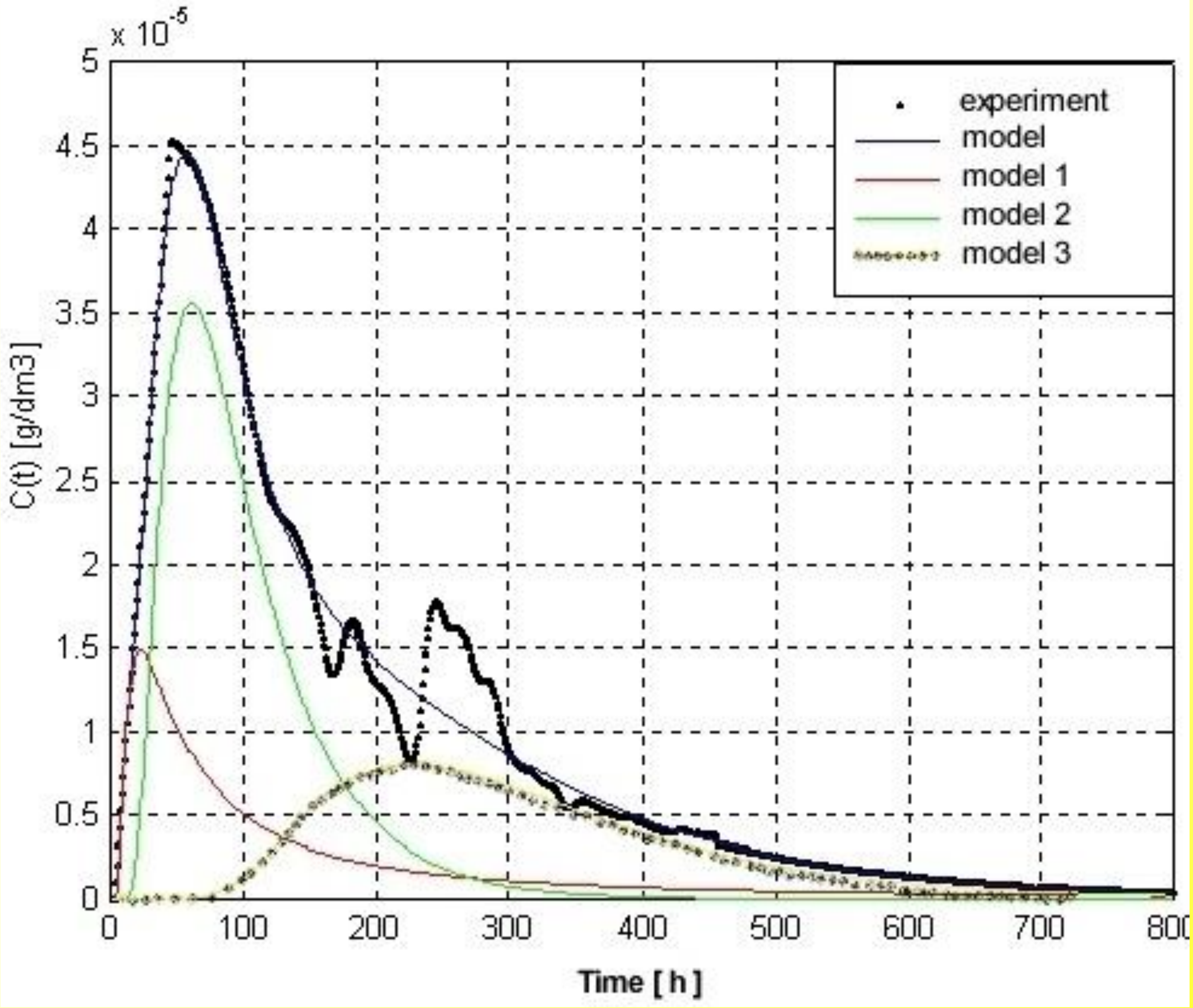


Fig.5 Concentration changes in the well 24SD experimental and model curves

Conclusion

So, the individual interpretation of the obtained tracer response curves enables to determine the mechanism of water transport, its velocity and direction as well as longitudinal dispersion coefficient.