

THE AQUIFER OF THE DEVONO-CARBONIFEROUS LIMESTONES OF HAINAUT (BELGIUM) : A KARSTIFIED MEDIUM, A NON-KARSTIC BEHAVIOUR – RESOURCES AND GENERAL KIND OF FLOW

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(3 figures)

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The aquifer of the Devono-Carboniferous limestones of Hainaut is bound by Devonian shales on the North and by the Namurian shales on the South. The superficial formations include Cenozoïc sands, clays and silts. These formations belong to the overburden aquifer, which has variable effectiveness depending on the proportion and thickness of clays.

The reservoir permeability comes from numerous fractures, joints and faults affecting the limestones. Some of them are altered and enlarged by karstification, causing the increase and the heterogeneity of the global transmissivity.

The classic concepts describe a global East-to-West flow. A recent study was made for the Walloon Region, and one of the aims of this study was the drawing of a new piezometric map, based on a complete inventory of wells, piezometers and all other means to obtain informa-

tion about the water table of the Devono-Carboniferous Limestones aquifer.

The new piezometric map (Fig. 1), drawn at regional scale, shows a flow between smaller basins, working as individual hydrogeological entities, and organized around their natural discharge (draining rivers). Sometimes, in intensively depressed zones, artificial recharge basins can develop. The boundaries of these basins are, of course, not fixed, and are subject to move with the fluctuations of the water-catchment volumes. The large scale piezometric map does not show any other influence on flow than natural or artificial discharge.

At a reduced scale, in regions where pumping activities strongly affect the natural water level (e.g. the quarries of Soignies (Fig. 2), and dewatering activities induce an artificial hydraulic gradient, preferential directions of flow can appear, revealing the presence of active karstic

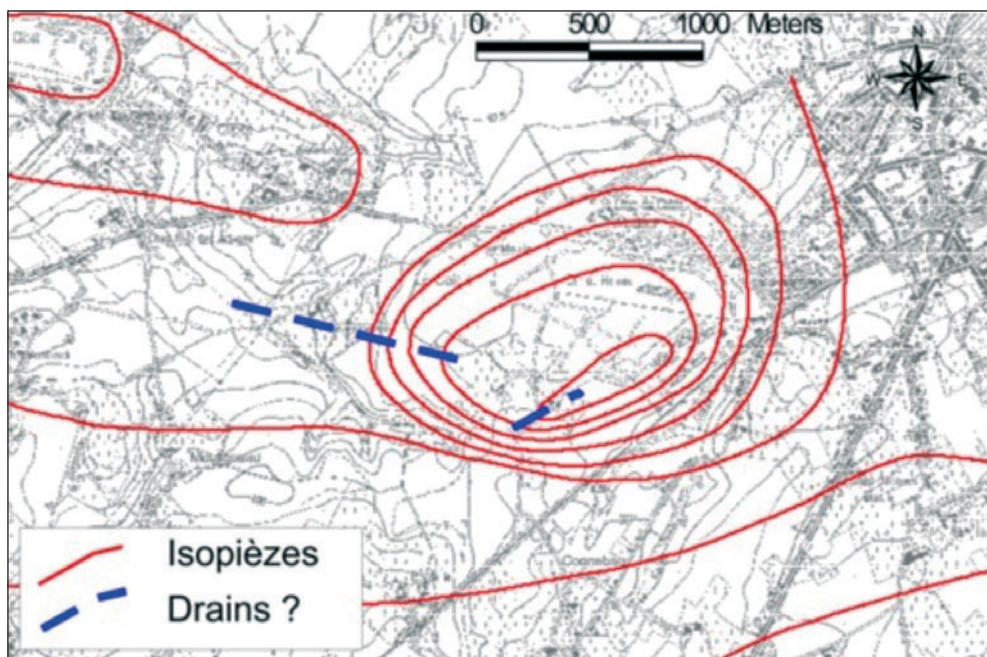


Figure 1: Piezometric map of the aquifer.

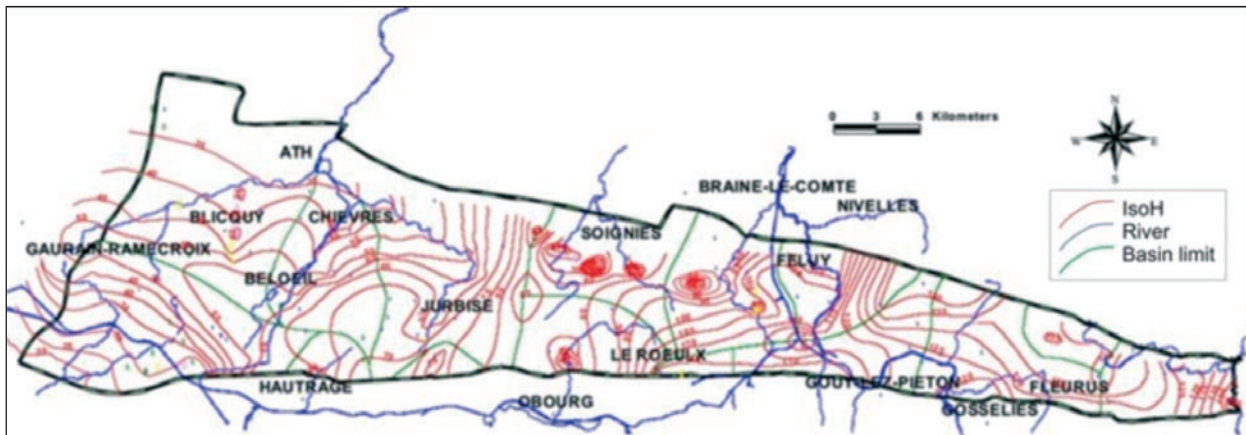


Figure 2: Piezometric map around a quarry near Soignies.

drains. Such karstic phenomena are most probably present everywhere in the aquifer, but their existence has not necessarily consequences for the apparent hydrogeological behaviour.

The pumping test represented on Fig. 3 was realized in Erbaut, in a karstified area, as confirmed by the cavities met during the drilling of the well. It is traditionally assumed that karstic aquifers, because of their great permeability, are often submitted to turbulent flow. But the results of this test do not show the usual characteristics of a karstic turbulent flow, and are very near of a typical pumping test in laminar flow conditions, verifying Darcy's Law.

The explanation of this lack of indication of karstic activity, usually connected to turbulent flow, has to be found in the validity limits of Darcy's Law. This law sets the proportional relationship between flow speed and hydraulic head variations. It is supposed to be valid in laminar flow conditions only.

If flow speed increases, and passes a determined value, the flow equations become non-linear. The threshold between laminar and turbulent flow is fixed by the Reynolds number, linked to flow speed, fluid characteristics and porosity type. It appears that in fissures of significant dimensions, the flow speed must reach important values to pass in turbulent flow conditions.

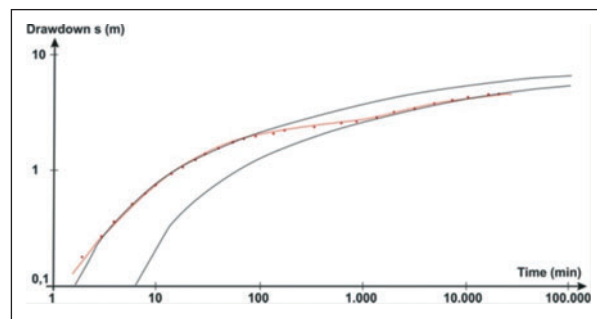


Figure 3: Pumping test in Erbaut – Drawdown curve.

This can explain why, in the Aquifer of the Devonian-Carboniferous Limestones of Hainaut, even if karstic forms are evident in quarries as well as in drilling works, the expected turbulent flow behaviour does not appear. Most of the time, the hydraulic head gradient is low, and the flow speed is not important enough to pass the limits of turbulent flow conditions. In intensively depressed zones, where the induced hydraulic head gradient is strong and where the flow speed is artificially increased, karstic behaviour can appear, and the aquifers begin to behave following non-linear laws as a classic drain-and-reservoir system, typical for karstic aquifers.