A HYDROGEOLOGICAL MODEL AS A TOOL FOR INVESTIGATING THE PROCESSES OF NATURE: A CASE STUDY OF THE IECAVA RIVER BASEFLOW, LATVIA

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Introduction

In 2010–2012, the hydrogeological model (HM) of Latvia (LAMO) was established by the scientists of Riga Technical University (RTU). In 2013–2015, LAMO was upgraded. In 2015, the recent version LAMO4 was developed.

For the recent version (Fig. 1), the plane approximation step is 250 meters. The model simulates 27 geological layers and its 3-D grid contains 61x10^6 nodes. Most of the layers are outcropping (Fig. 2).

LAMO is run by the licensed program Groundwater Vistas (GV), version 6. It contains the MODFOW and MODPATH programs for supporting HM and for tracking groundwater particles, respectively. By using MODPATH, the case of the Iecava river was investigated, in order to find the sources that support groundwater inflow into the river (its baseflow).

The river is located in the flat land area of the country (Fig. 3). Its elevations are 68.5 m asl and 0.2 m asl for the source and mouth of the river, accordingly. The drainage basin area is 1174 km2. It includes the area of the small tributaries Smakupe and Girupe. The search was accomplished by the MODPATH program. In Fig. 3, the locations are shown of the Iecava river drainage basin and the large area outside the basin where the baseflow sources also were found. In this paper, the unforeseen results of this numerical experiment are described.

Fig. 1. Locations of LAMO and the Iecava river drainage basin.

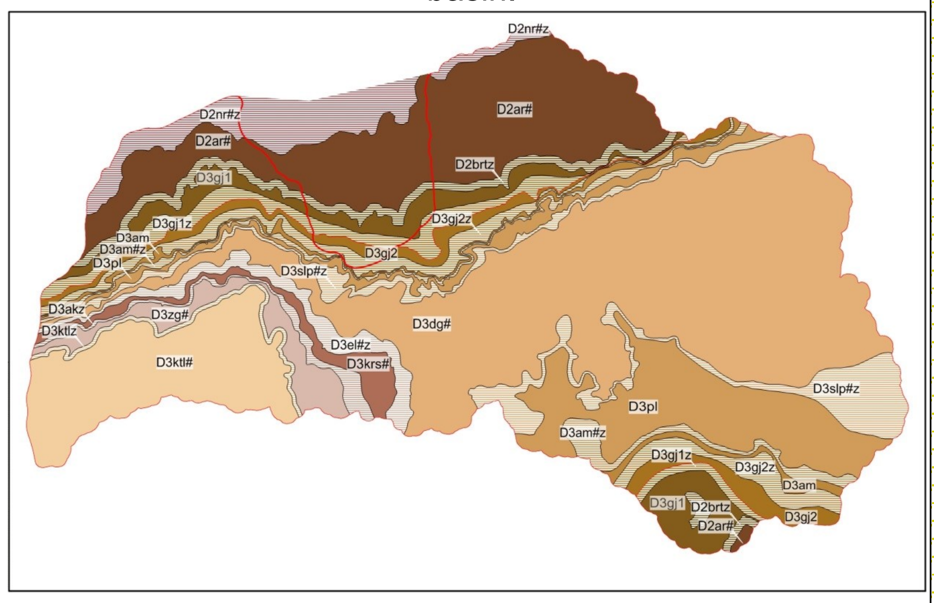

Fig. 2. Boundaries of primary geological strata.

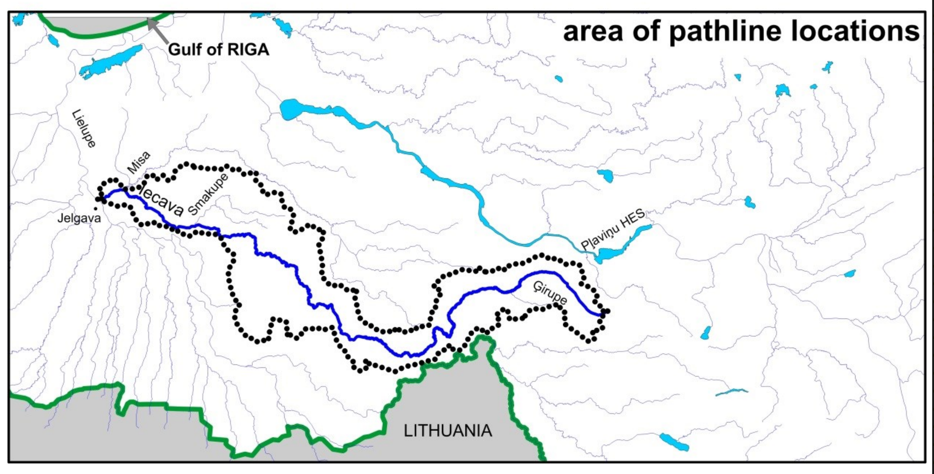

Fig. 3. Locations of the Iecava river and its drainage basin.

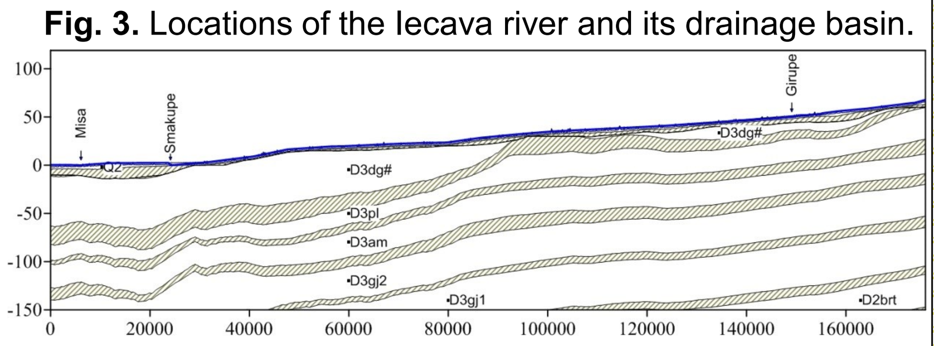

Fig. 4. Vertical cross-section along the Iecava river

Finding Baseflow Sources for the Iecava River

The Iecava river is linked with the model in 1027 grid cells of the Quarternarry aquifer (see Fig. 3. and Fig. 4.). The cells joined with the Iecava river were used as the particle starting locations. None of the two small tributaries (Smakupe and Girupe) were involved, in order to make the numerical experiment simpler. The porosity value 0.1 was used for all layers of HM. The travel time of particles was not limited.

It was expected that the baseflow should be originated by meteoric water of the river drainage basin. However, the result (Fig. 5) was a surprise, because many baseflow sources were located far from the river drainage basin. Their pathlines sank down, moved sidewise and climbed up to the river. In Fig. 5, to show the results explicitly, only the each tenth pathline in turn is exposed.

In Fig. 6, the relationship between the number of particles and the length of their pathlines is shown. It can be deduced from the data of Fig. 6 that for 830 particles, the length of their pathlines does not exceed 20 kilometers; therefore,~80 % of the particles have rather short pathlines.

In Fig. 7, the maximal travel time spent by the particles in the layers of HM is shown. Probably, the travel times that exceed 4000 years are spent by the particles with long pathlines. The time 30 thousand years is spent by the particles in the thick D2nr# aquitard (layer No. 26).

In Fig. 8, the ly-projection for the particle No. 800 along its pathline is shown. Its travel time (age) is 8015 years. The cross section was created by using SURFER and the special software tools developed by the RTU specialists.

It can be concluded from Fig. 8 that the appearance of the long pathlines which sources are located far from the drainage basin is caused by the infiltration at the hilly areas of the country. There, a particle can reach a deeply located aquifer and then migrate a long distance, until the Iecava river is reached. In Fig. 8, the particle passes through the D2brtz aquitard four times. This fact is caused by the vertical groundwater flows at the places where the particle enters the D2brt aquifer and then returns in the D3gj1 aquifer.

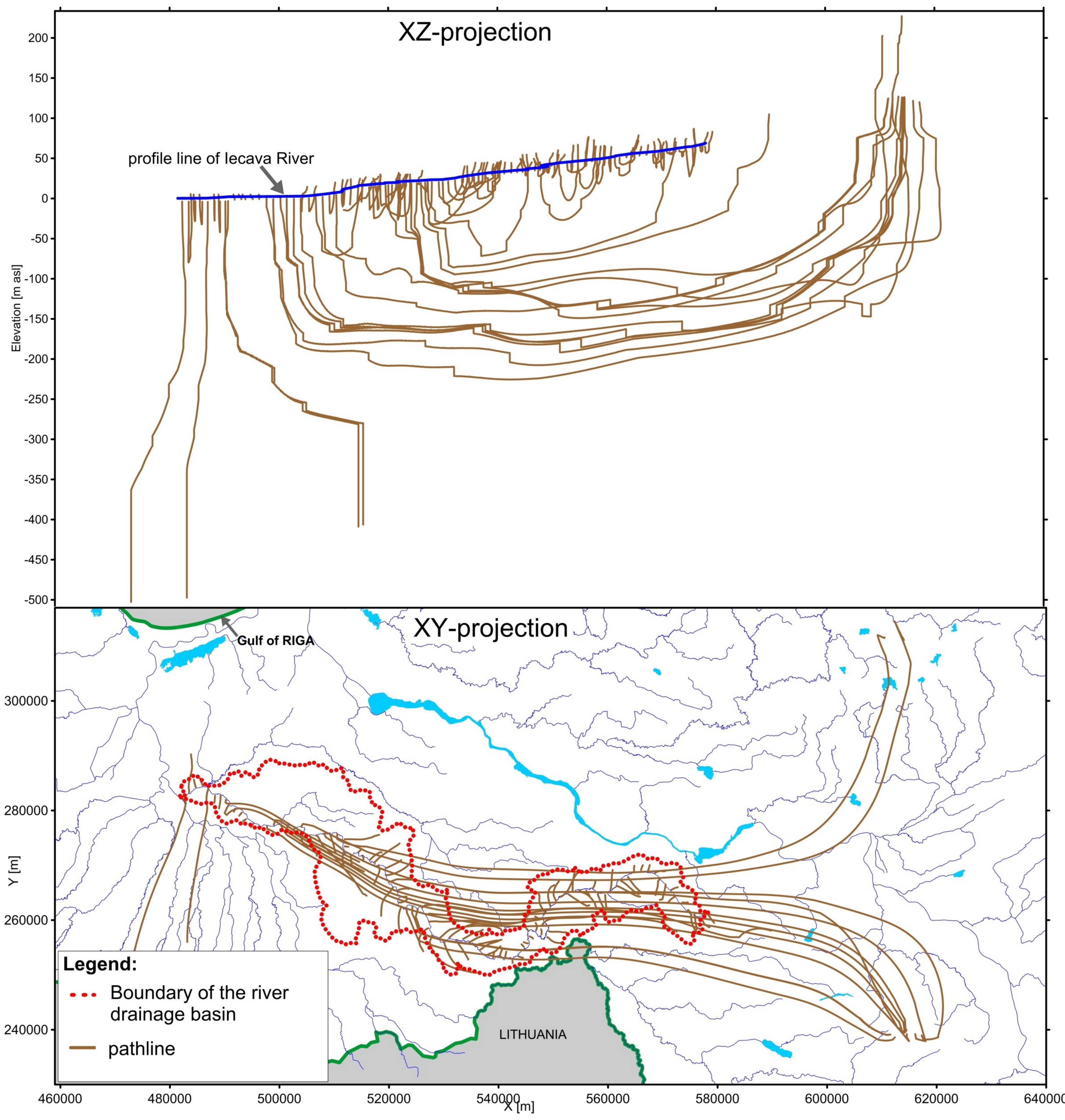

Fig. 5. Display of xy and xz-projections for pathlines.
Only the each tenth pathline in turn is exposed (~100 pathlines from 1027).

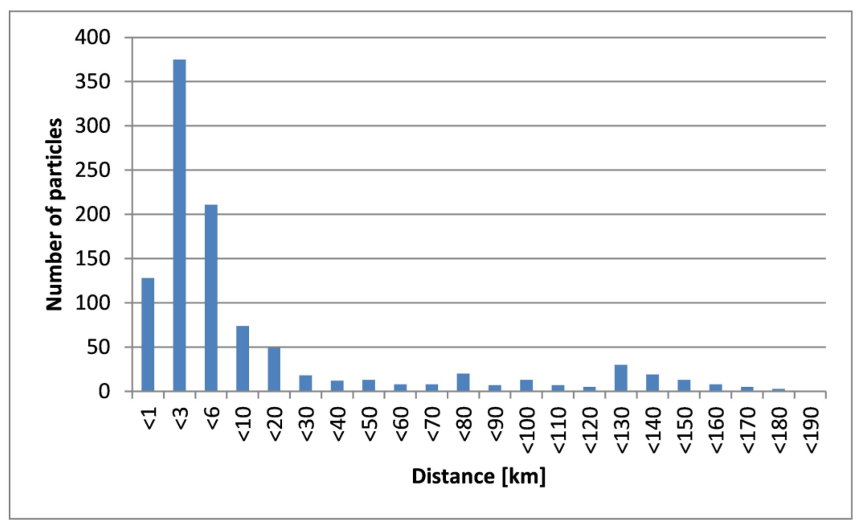

Fig. 6. The length of pathlines versus their number

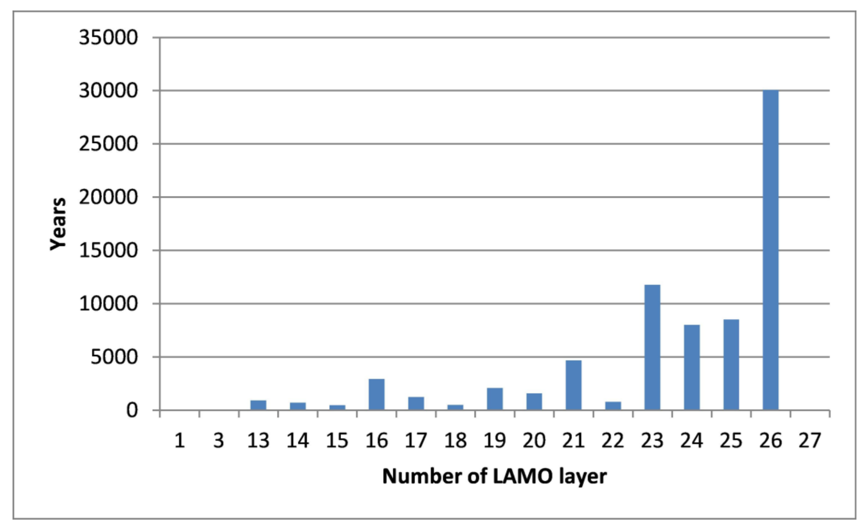

Fig. 7. Maximal travel time within layers.

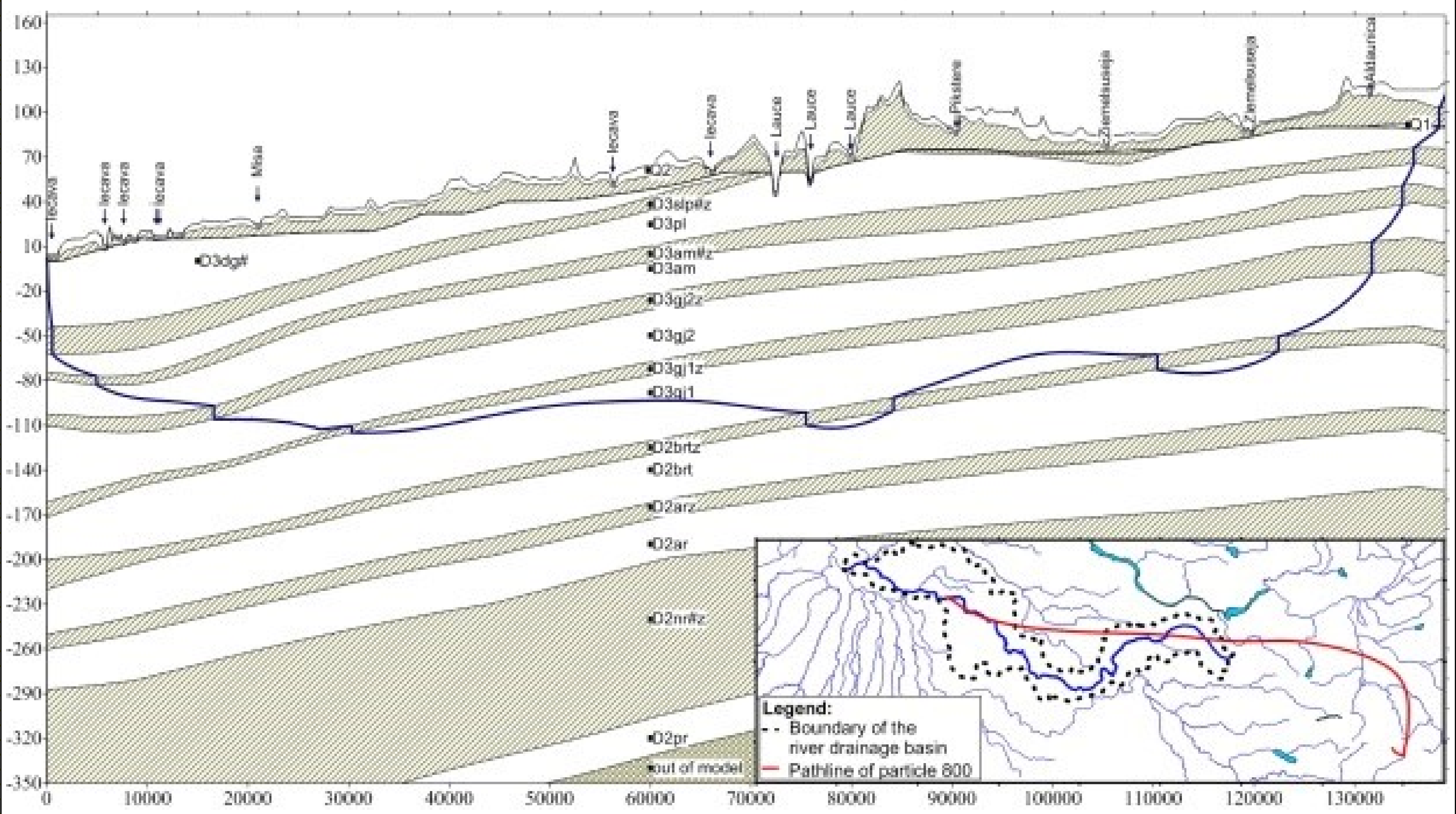

Fig. 8. Vertical cross section along the pathline No. 800.

Conclusions

The hydrogeological model of Latvia LAMO4 was used as the driver for the MODPATH program. The attempt was made to find sources of the baseflow of the Iecava river. Unforeseen results were obtained: many sources were located very far from the river drainage basin; even within the basin, the shape of pathlines was very complex. The results of this numerical experiment demonstrate usefulness of applying a large regional HM for investigating the complex processes of nature.

Upgrading of the LAMO3 and LAMO4 versions were supported by the Latvian State Research Program EVIDENT.