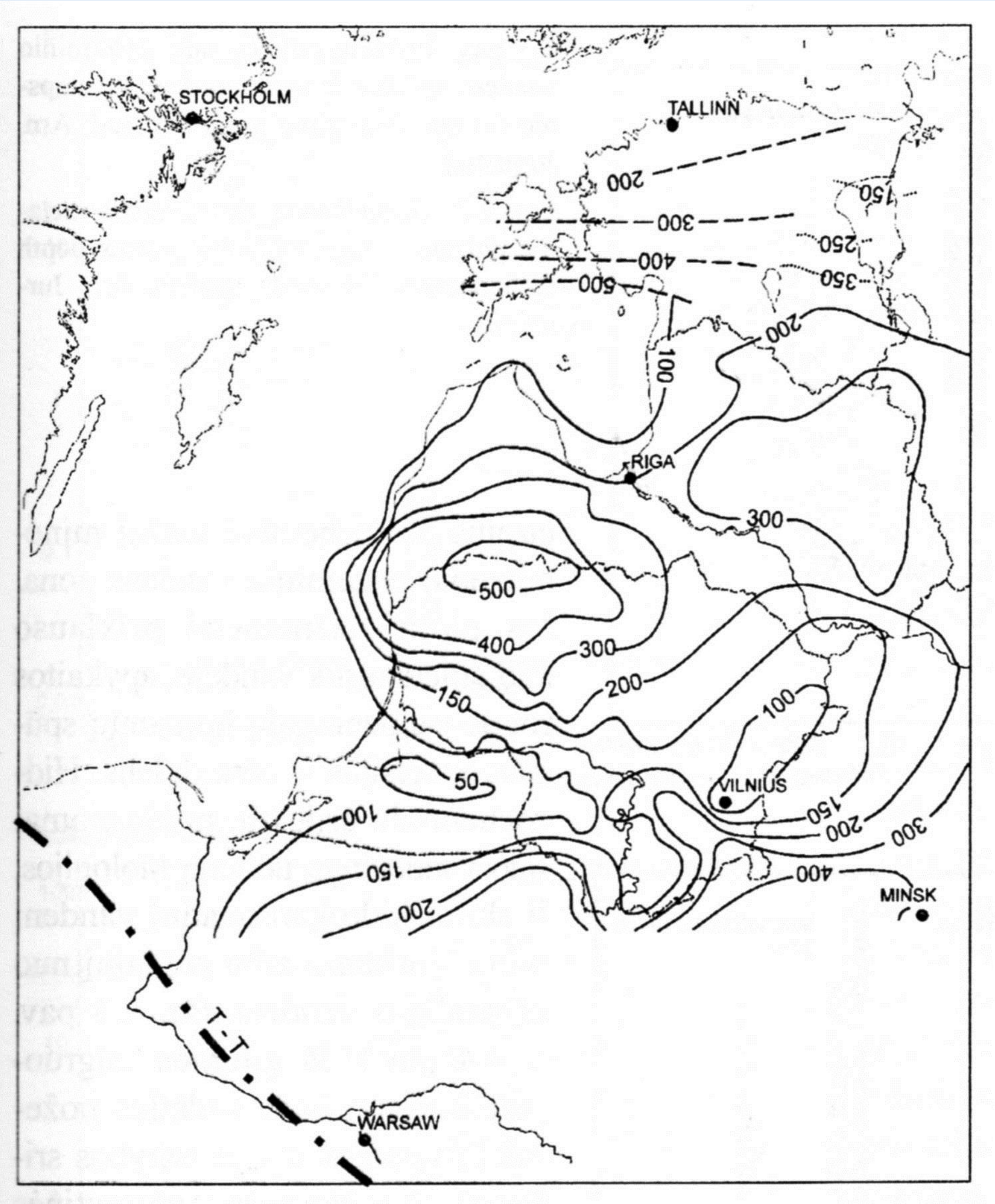
# FORMATION OF GROUNDWATER IN SEDIMENTARY BASINS: TRADITIONAL AND ALTERNATIVE MODELS

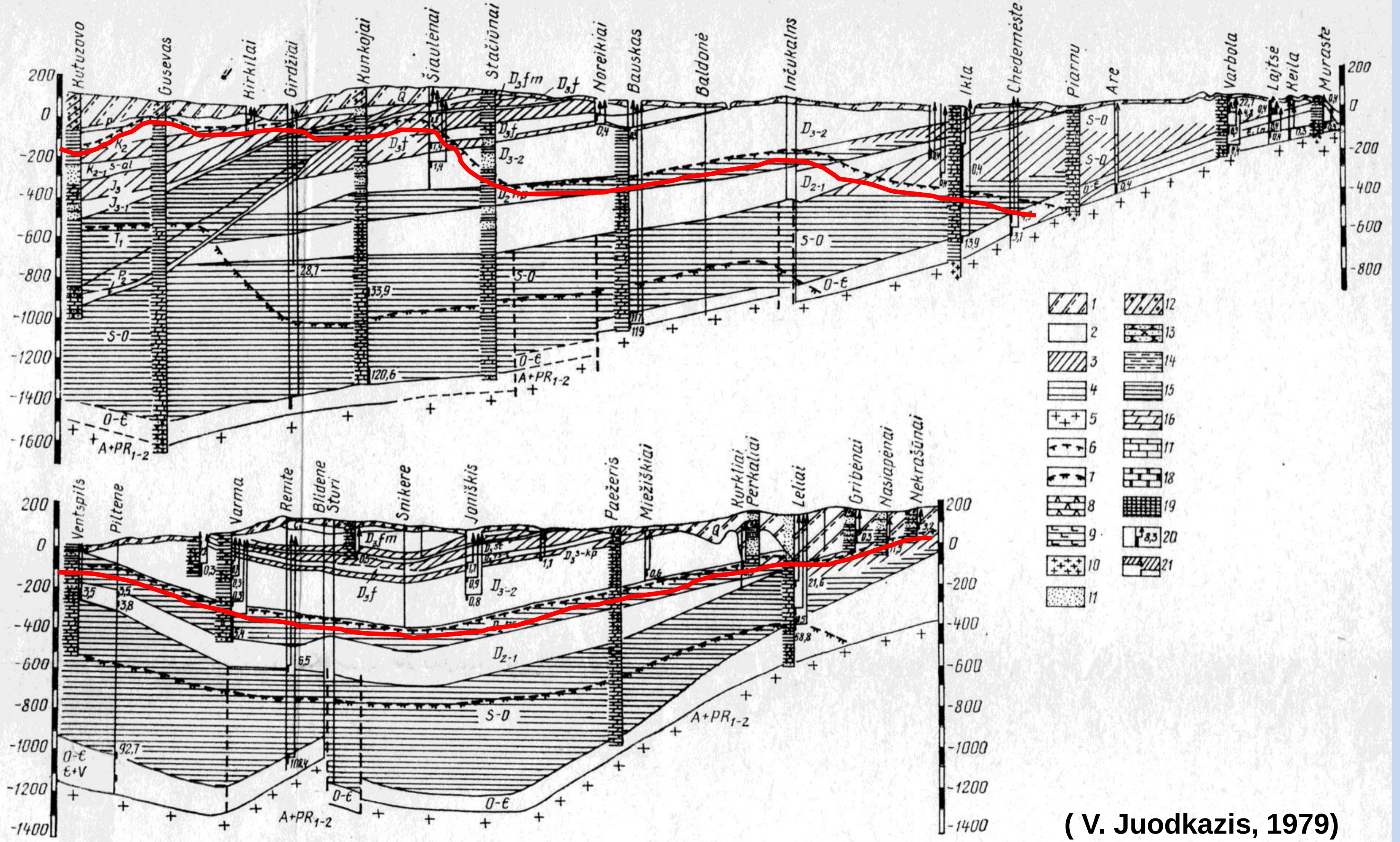
**Albertas Bitinas**

**Klaipėda University, Coastal Research and Planning Institute, H. Manto St. 84, Klaipėda, Lithuania, albertas.bitinas@corpi.ku.lt**




**Baltic Basin fresh groundwater zone thickness, meters**

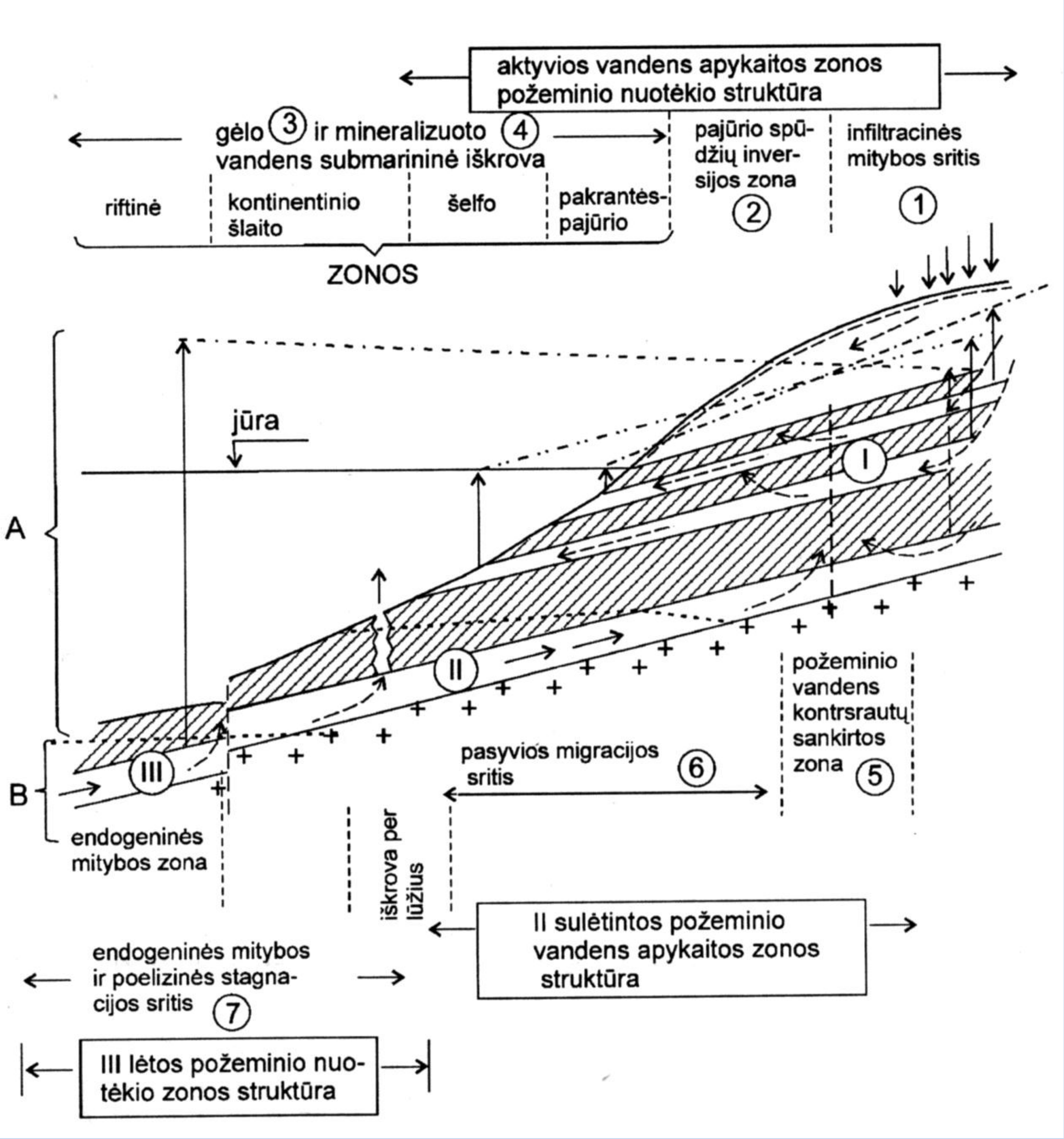
**(R. Mokrik, 2003)**




**( V. Juodkazis, 1979)**

**6 priedas.** Pabaltijo artezinio baseino schematiniai hidrogeologiniai pjūviai (sudarė V. Vienožinskis ir V. Juodkazis):

*1* — kvartero nuogulos; *2* — vandeningi horizontai ir kompleksai; *3* — mažai laidžios uolienos (kartais sporadiškai vandeningos); *4* — regioninės vandensparos, skiriančios artezinio baseino struktūrinius aukštus; *5* — artezinio baseino kristalinio pagrindo uolienos; *6—7* — požeminio vandens mineralizacijos riba vertikaliajame pjūvyje; *6* — 1 g/l; *7* — 35 g/l; *8—19* — gręžinių kolonėlių litologiniai ženklai: *8* — gipsas ir anhidritas; *9* — akmens druska; *10* — kristalinės ir metamorfinės uolienos; *11* — smėlis; *12* — moreninis priemolis; *13* — smiltainis; *14* — aleuritas; *15* — molis; *16* — mergelis; *17* — klintys; *18* — dolomitas; *19* — kreida (kreidos mergelis); *20* — išbandytas gręžinys, spūdžio didumas ir požeminio vandens mineralizacija (g/l); *21* — tektoninių sprūdžių linijos (pjūvių linijos nurodytos 5 priede).




**Scheme of groundwater flow formation in seaside artesian basins of ancient platforms**

**(R. Mokrik, 2003)**

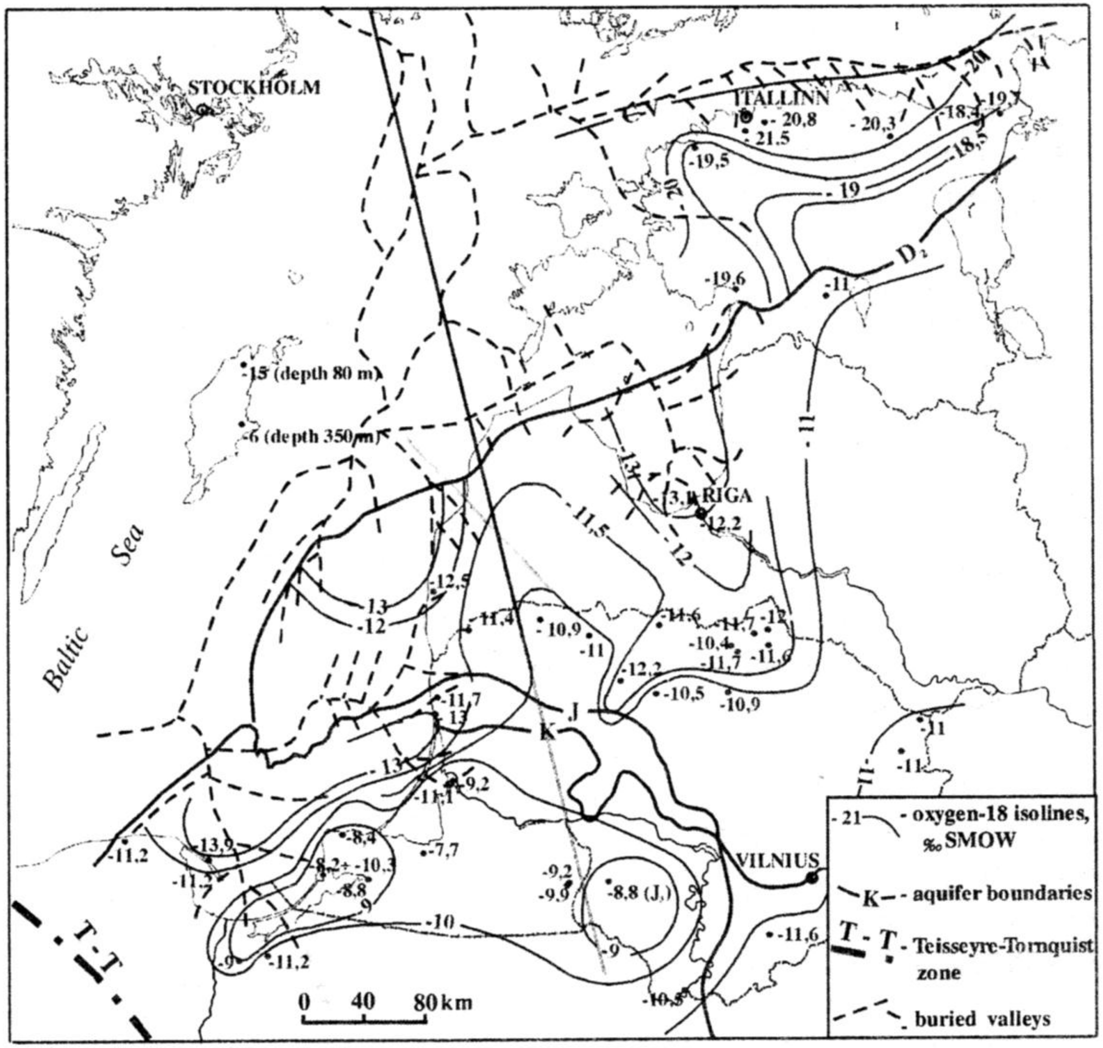
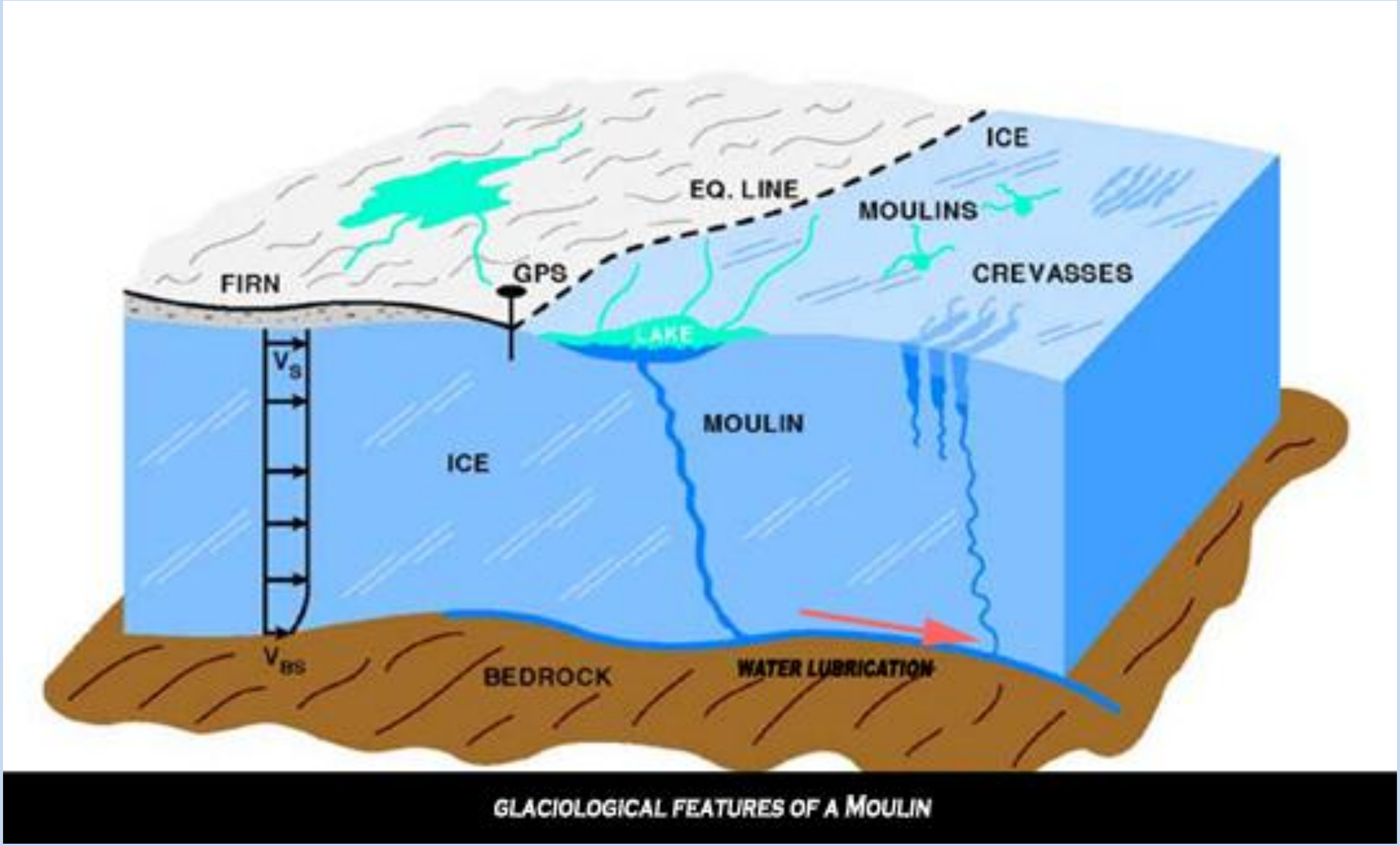



Fig. 1. Oxygen-18 distribution (‰ SMOW) in fresh groundwater of the Baltic Basin

1 pav. Gėlo požeminio vandens deguonies-18 izotopo (‰ SMOW) pasiskirstymas Baltijos baseine

**(R. Mokrik, J. Mažeika, 2003)**




**http://www.global-greenhouse-warming.com/moulin.html**

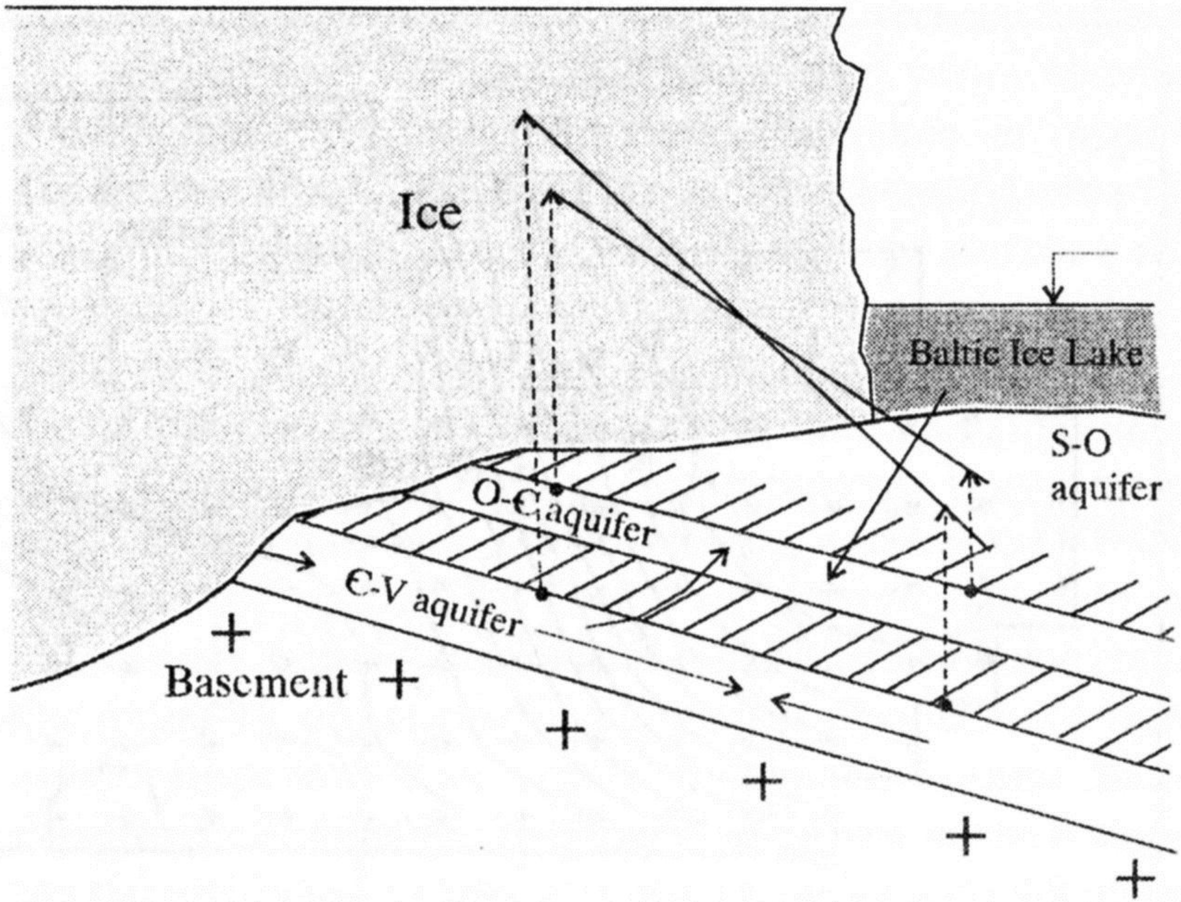



Fig. 8. Principle scheme of groundwater flow formation during ice sheet recession
8 pav. Požeminio nuotėkio principinė schema ledyno recesijos metu

(R. Mokrik, J. Mažeika, 2003)

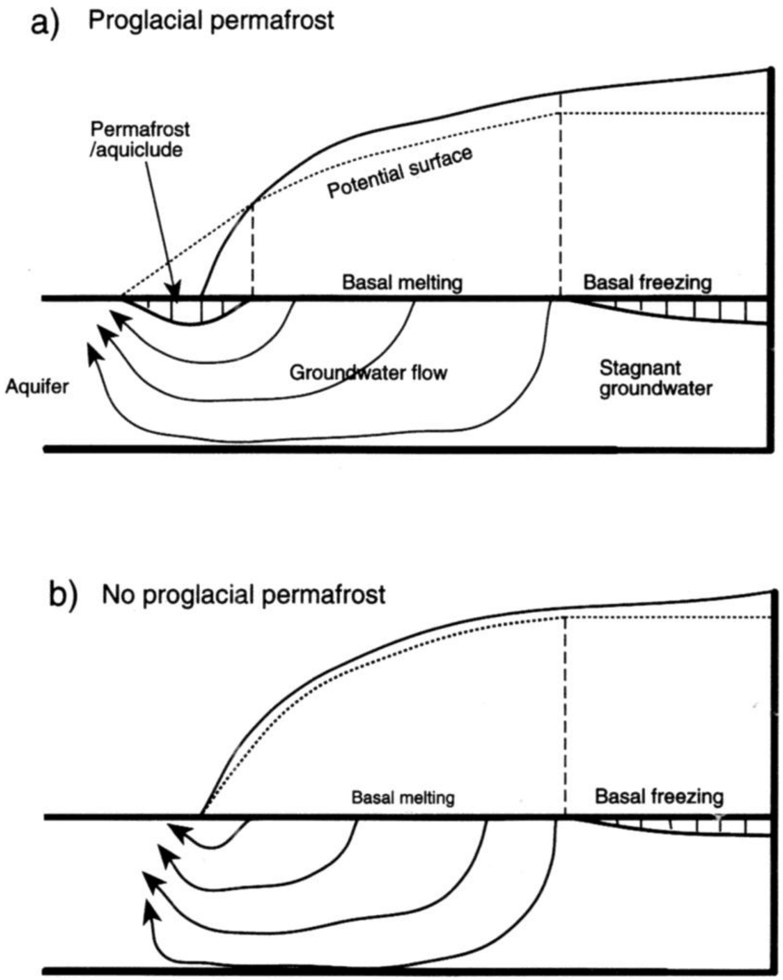



FIG. 1. Schematic diagram showing water movement through a subglacial aquifer in (a) the presence of proglacial permafrost; (b) the absence of proglacial permafrost. Proglacial permafrost generates overpressuring in groundwater because of the need for a large potential gradient to sustain glacially-driven discharge beneath the permafrost. Rocks or sediments of relatively low permeability in the place of permafrost will generate a similar effect.

**(G. S. Boulton, P. Caban, 1995)**

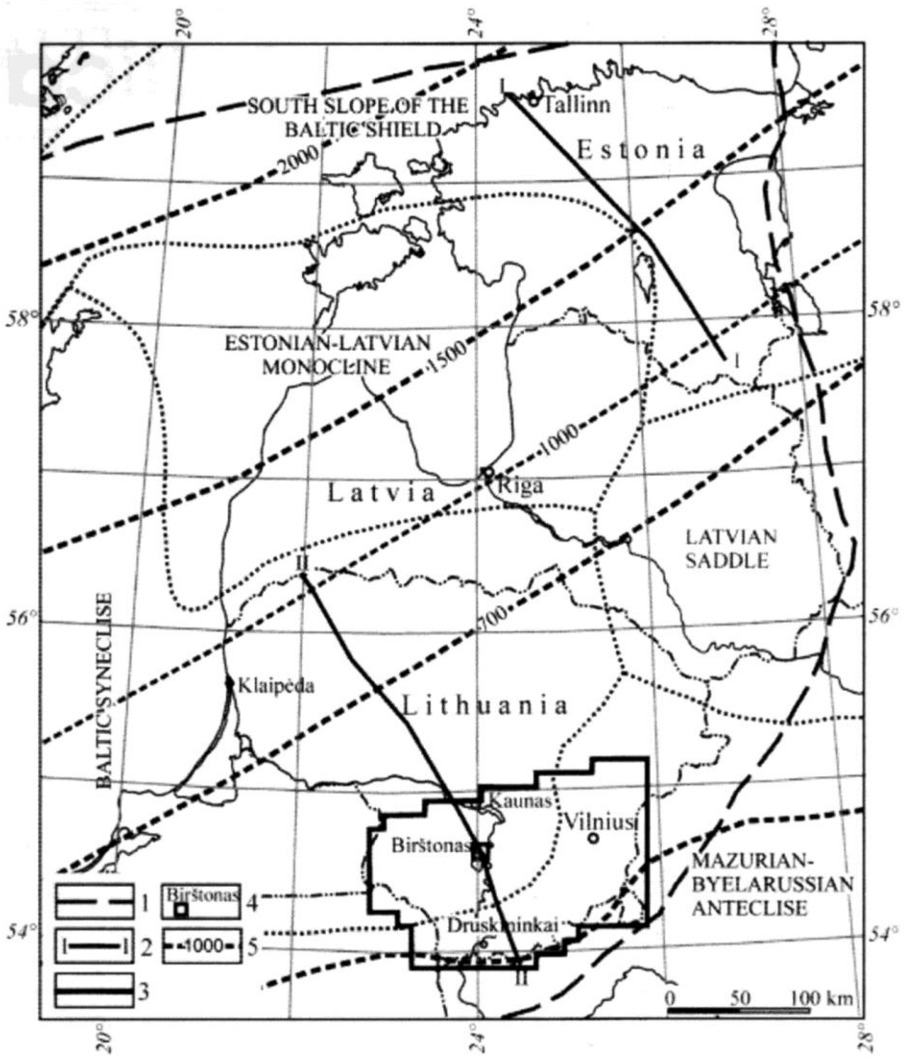



Fig. 1. A tectonic scheme of the Baltic Artesian Basin (BAB) (after Suveizdis 2003): 1–boundary of the artesian basin; 2–direction of the hydrogeological sections; boundary of the modelled area: 3- in southern part of BAB; 4-in the environs of Birštonas; 5–glacier isopahs during LGM.

**(A. Zuzevičius, 2003)**

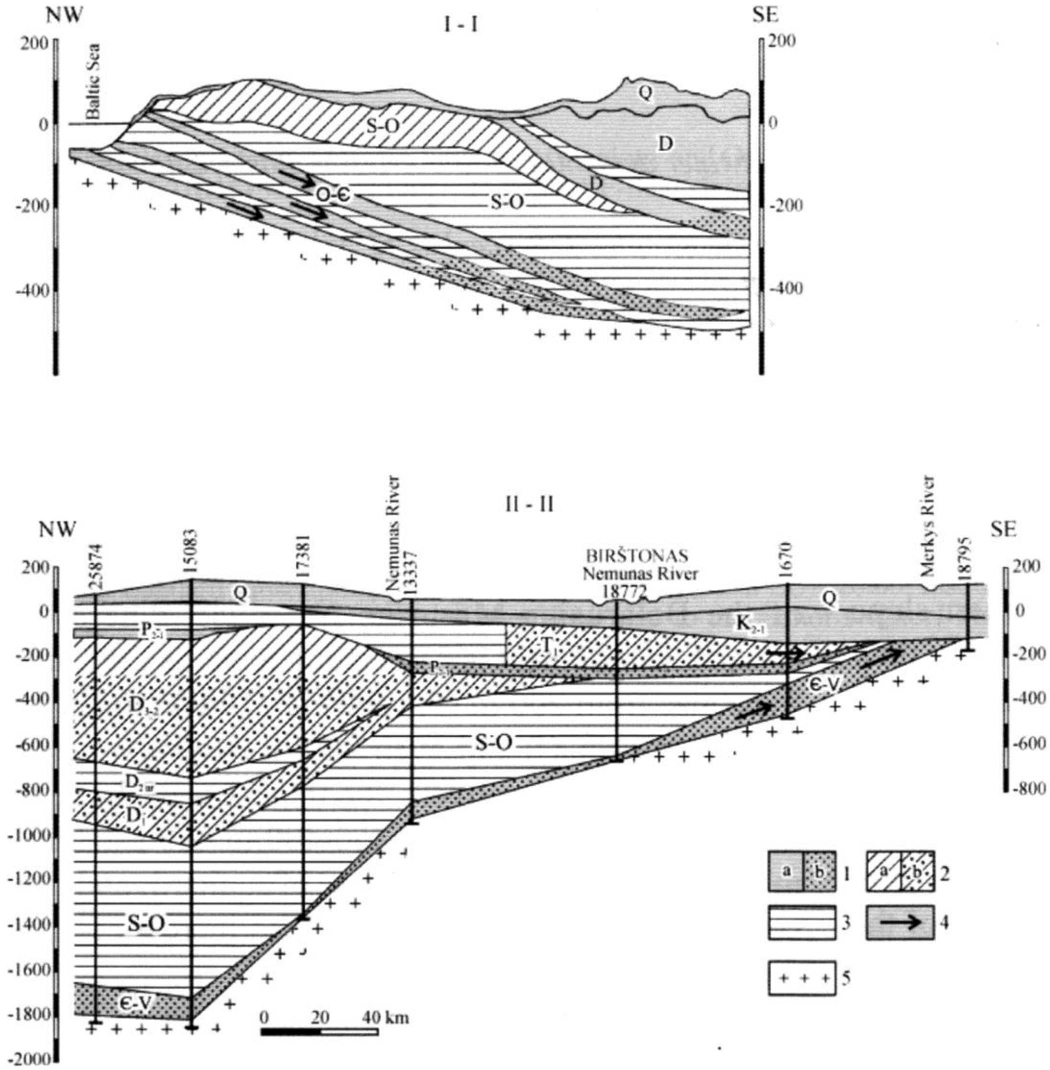



Fig. 2. Hydrogeological sections of the Baltic Artesian Basin (BAB): I-I–across BAB's northern part, II-II–across BAB's southern part: 1–aquifer with fresh (a) and mineralised (b) water; 2–sporadically water-bearing bed with fresh (a) and mineralised (b) water; 3–aquitard; 4–presumptive direction of groundwater flow during the Pleistocene glaciations. The age of sediments is marked by capital letters in accordance with an International Stratigraphic Chart.

**(A. Zuzevičius, 2010)**

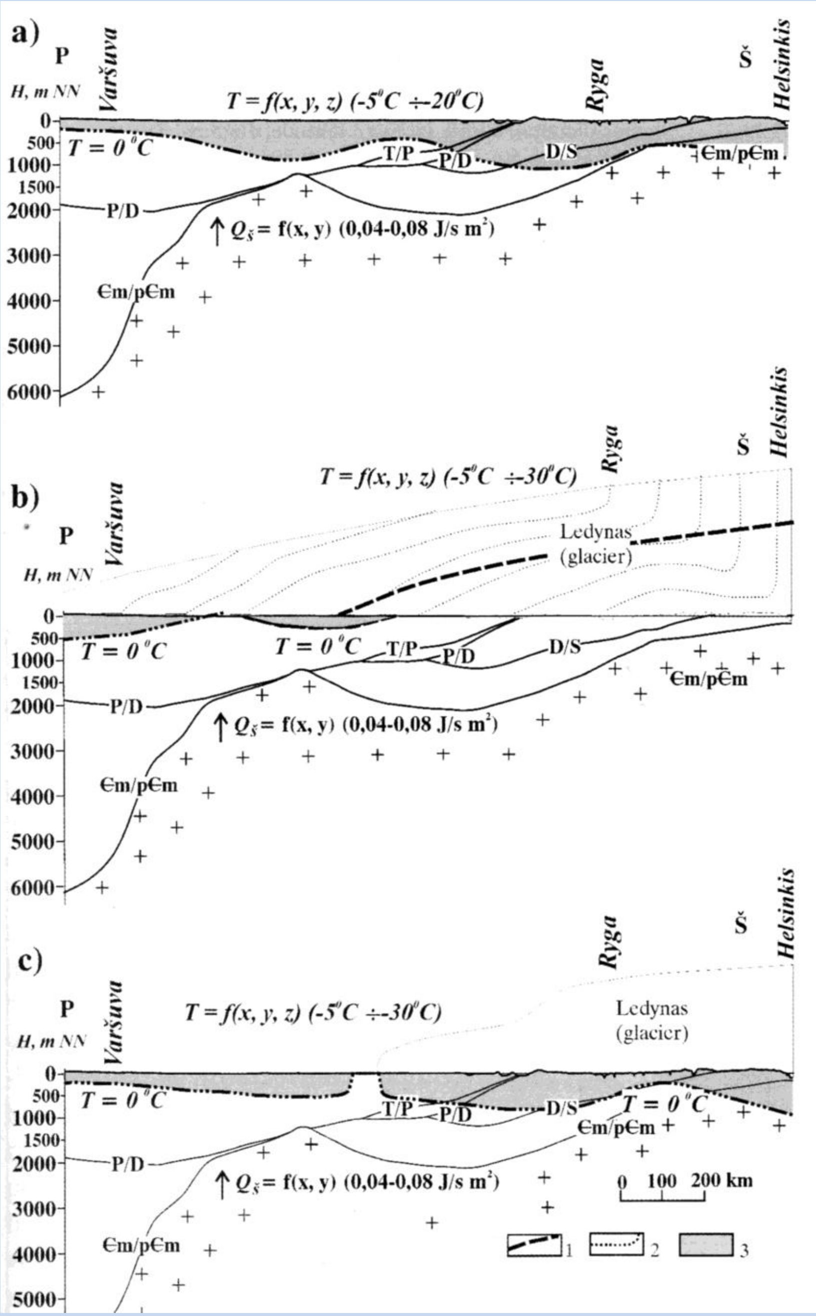



**Fig. 3.** Permafrost formation schemes in the Baltic region: a) climate cooling; b) the last glaciation maximum (LMG); c) deglaciation: 1 – boundary of Weichselian glacier; 2 – flowlines of glacier; 3 – frozen rocks.

**(A. Zuzevičius, 2003)**

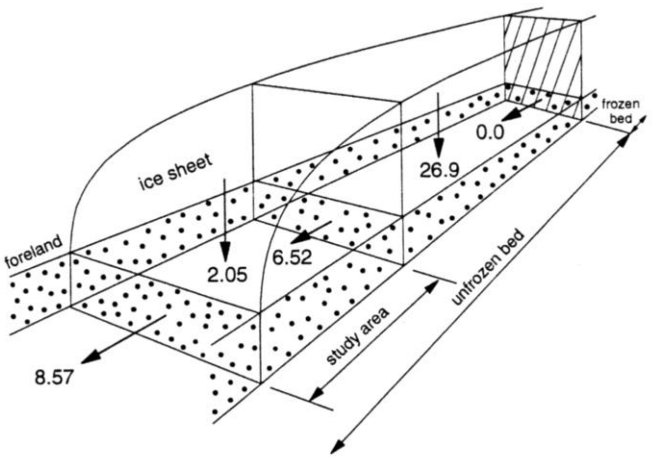



FIG. 10. Schematic representation of subglacial water balance under that portion of the ice sheet which was in the catchment area of the present study area. Out of 26.9 $m^3$ $s^{-1}$ of basal meltwater production up-ice from the study area, only 6.52 $m^3$ $s^{-1}$ could have been drained through the substratum as groundwater flow, because of a generally low hydraulic transmissivity of bed sediments. Remaining 20.38 $m^3$ $s^{-1}$ were evacuated in subglacial channels (tunnel valleys), abundantly found in northwestern Germany. Marginal permafrost fringe is not considered here.

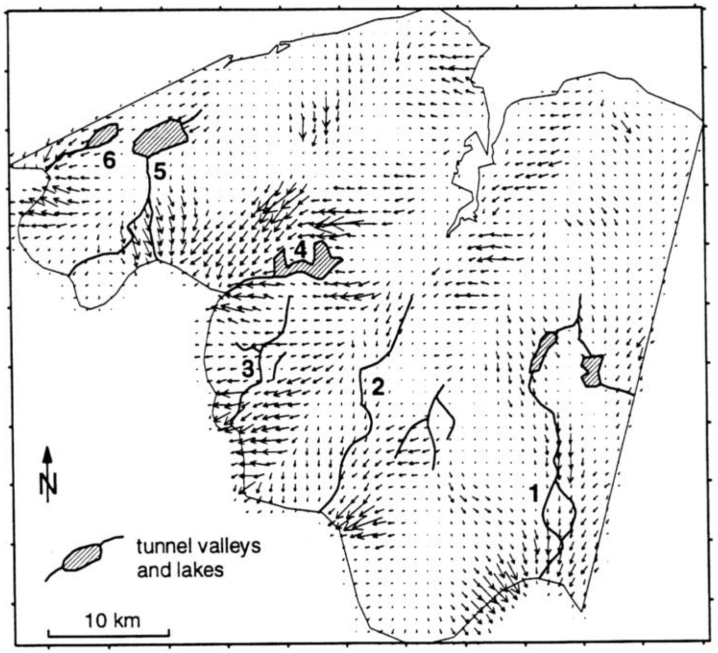
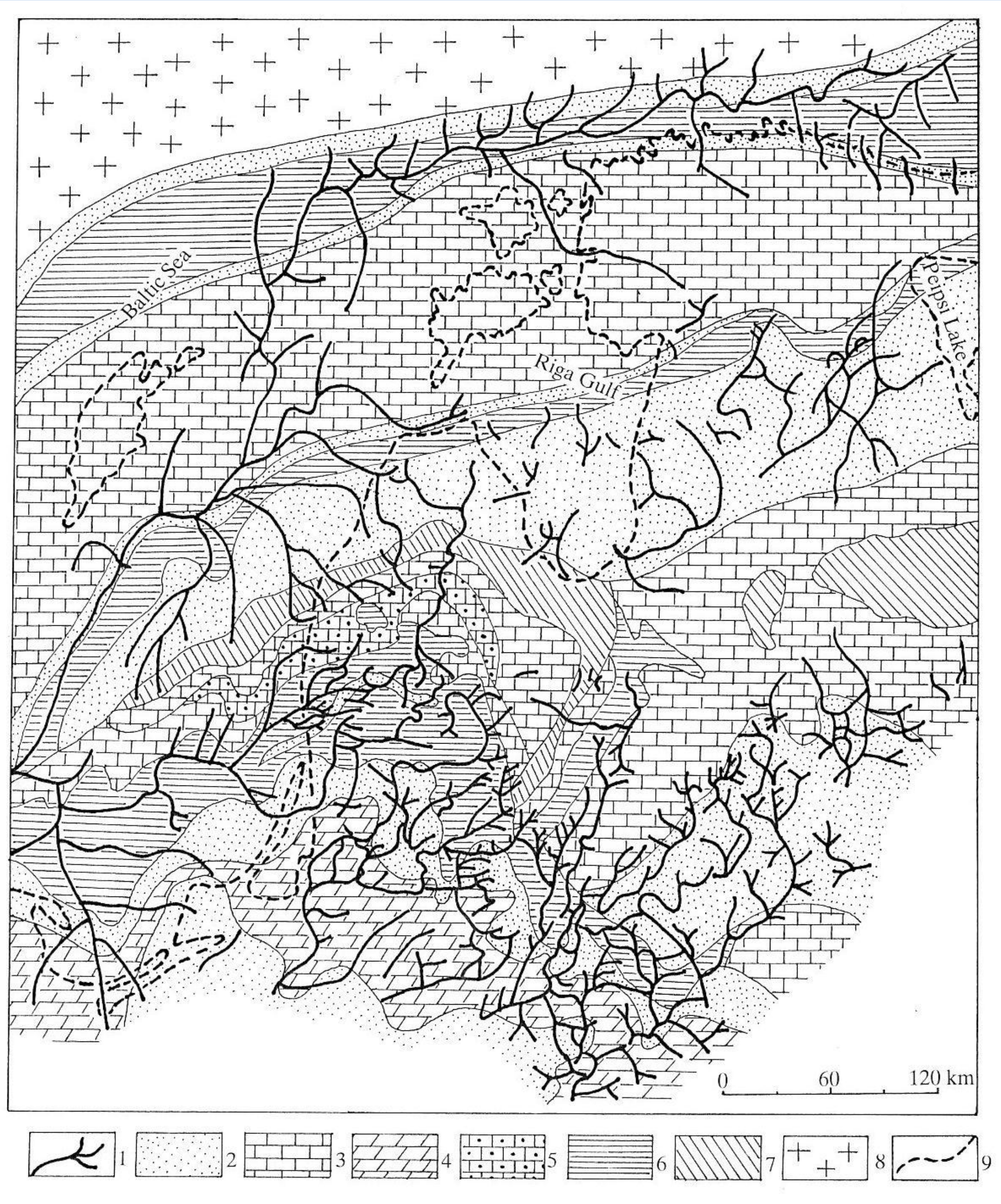



FIG. 11. Major Weichselian tunnel valleys (1 — Bornhöved, 2 — Einfeld, 3 — Borgdorf See, 4 — Westensee, 5 — Wittensee, 6 — Bistensee) projected onto the simulated groundwater velocity vectors under the Weichselian ice sheet. Groundwater flow was simulated without considering tunnel valleys. Note that all tunnel valleys occur in areas of increased groundwater dynamics. Velocity vectors are shown at a different scale than the analogue vectors in Fig. 9A.

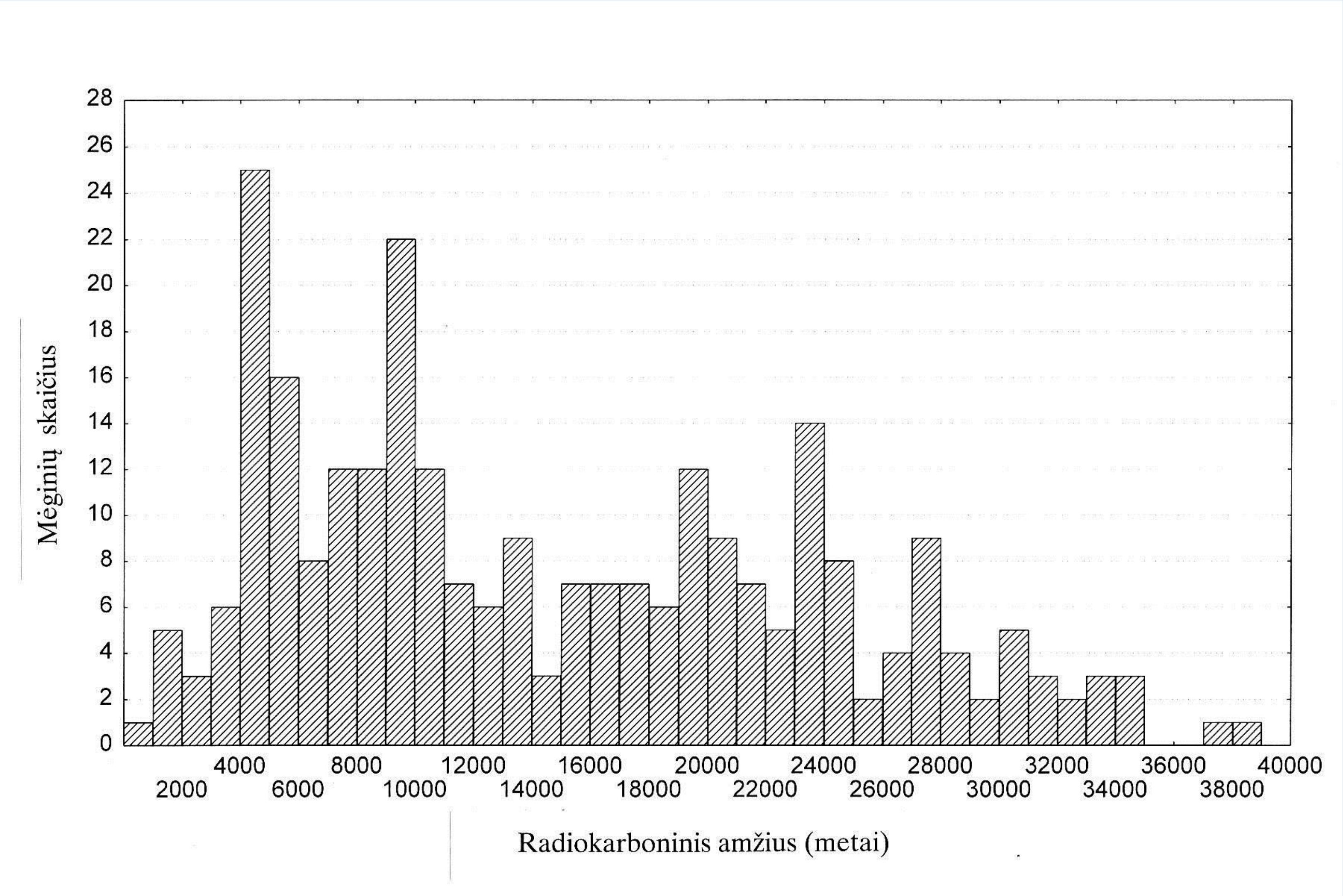
**(J. Piotrowski, 1997)**




**Distribution of paleoincisions and hydrogeological properties of upper part of Pre-Quaternary bedrocks of the territory of the Eastern Baltic region and adjacent area of the Baltic Sea. The scheme compiled according to published data of V. Juodkazis (1979) and A. Šliaupa *et al*. (1995)**

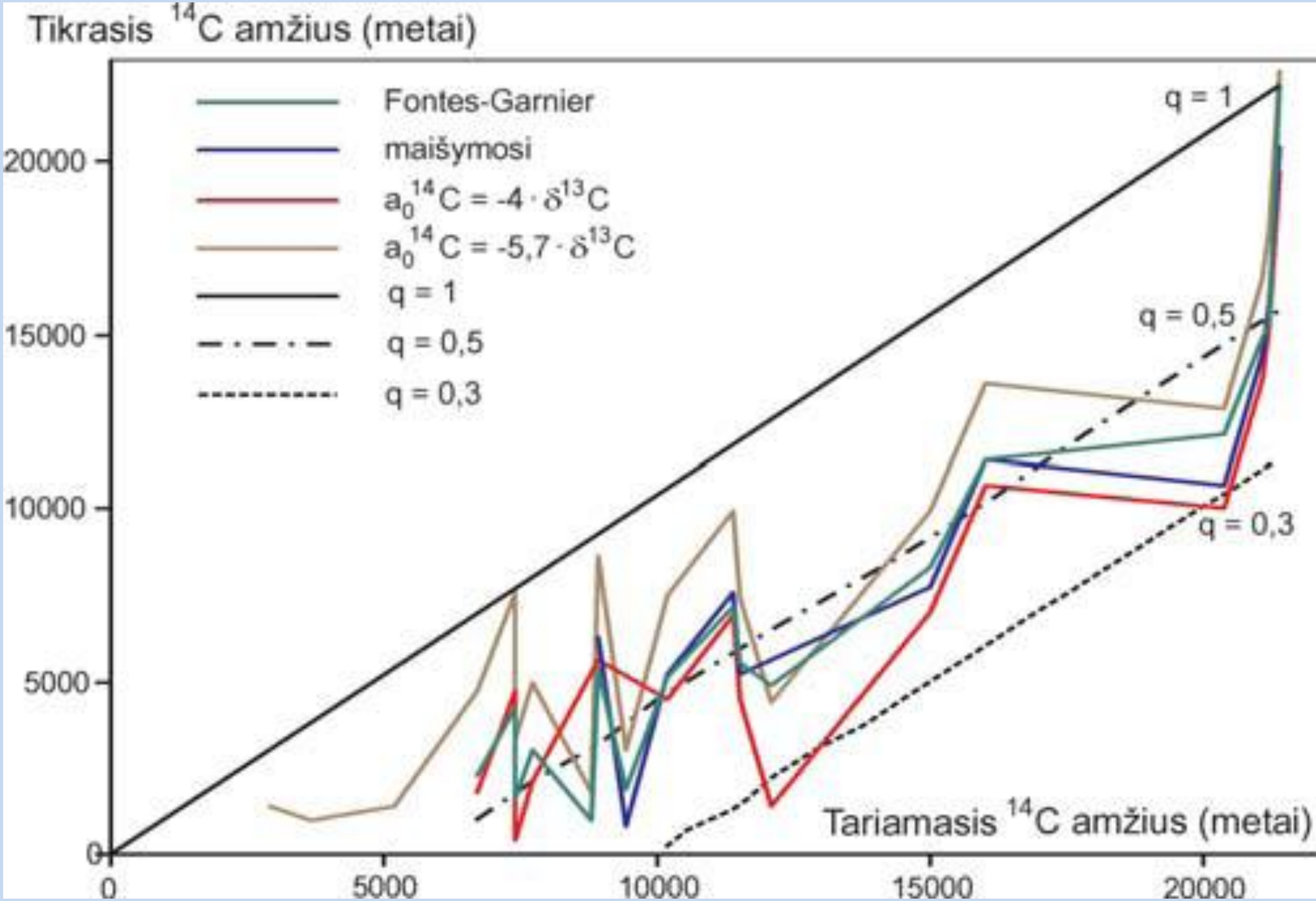
**1 – paleoincisions; 2 – porewater aquifers (sand, sandstone).**
**Porewater and fractured aquifers:**
**3 – limestone, dolomite; 4 – chalk, marl; 5 – stratification of sandstone, marl, limestone and dolomite;**
**6 – aquitard (clay, cayey-carbonate rocks) 7 – semipermeable rocks containing groundwater lenses;**
**8 – crystalline rocks; 9 – coast lines of Baltic Sea and Peipsi Lake.**

**( A. Bitinas, 1999, 2011)**



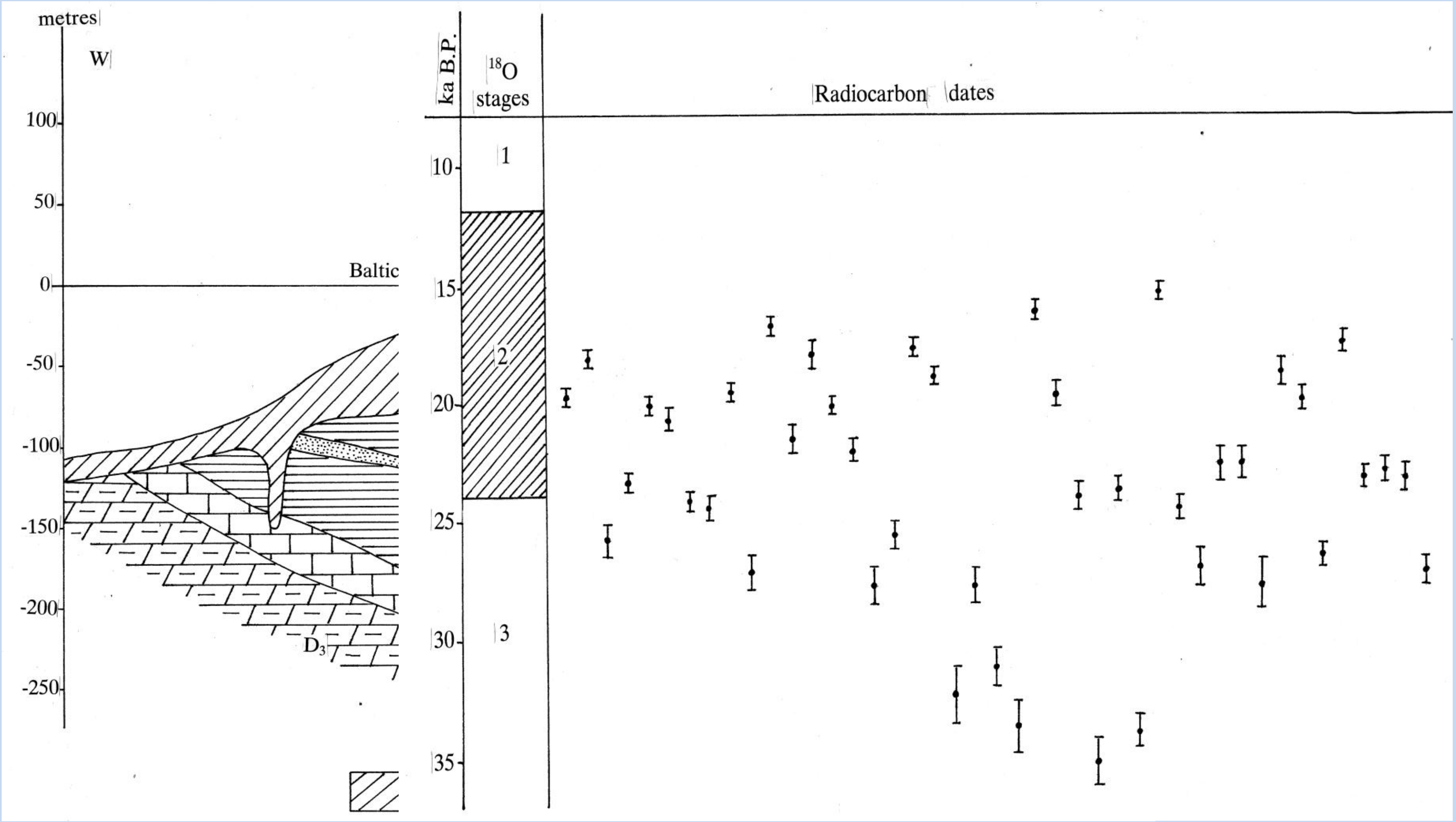

**Frequency histogram of the radiocarbon ($^{14}C$) age of groundwater (dissolved carbonates). Data of 268 samples from the main freshwater aquifers from Lithuania and cross-border areas of Latvia and Belarus**

**(A. Bitinas, 1999, 2011)**




**Comparison of different radiocarbon age correction models**

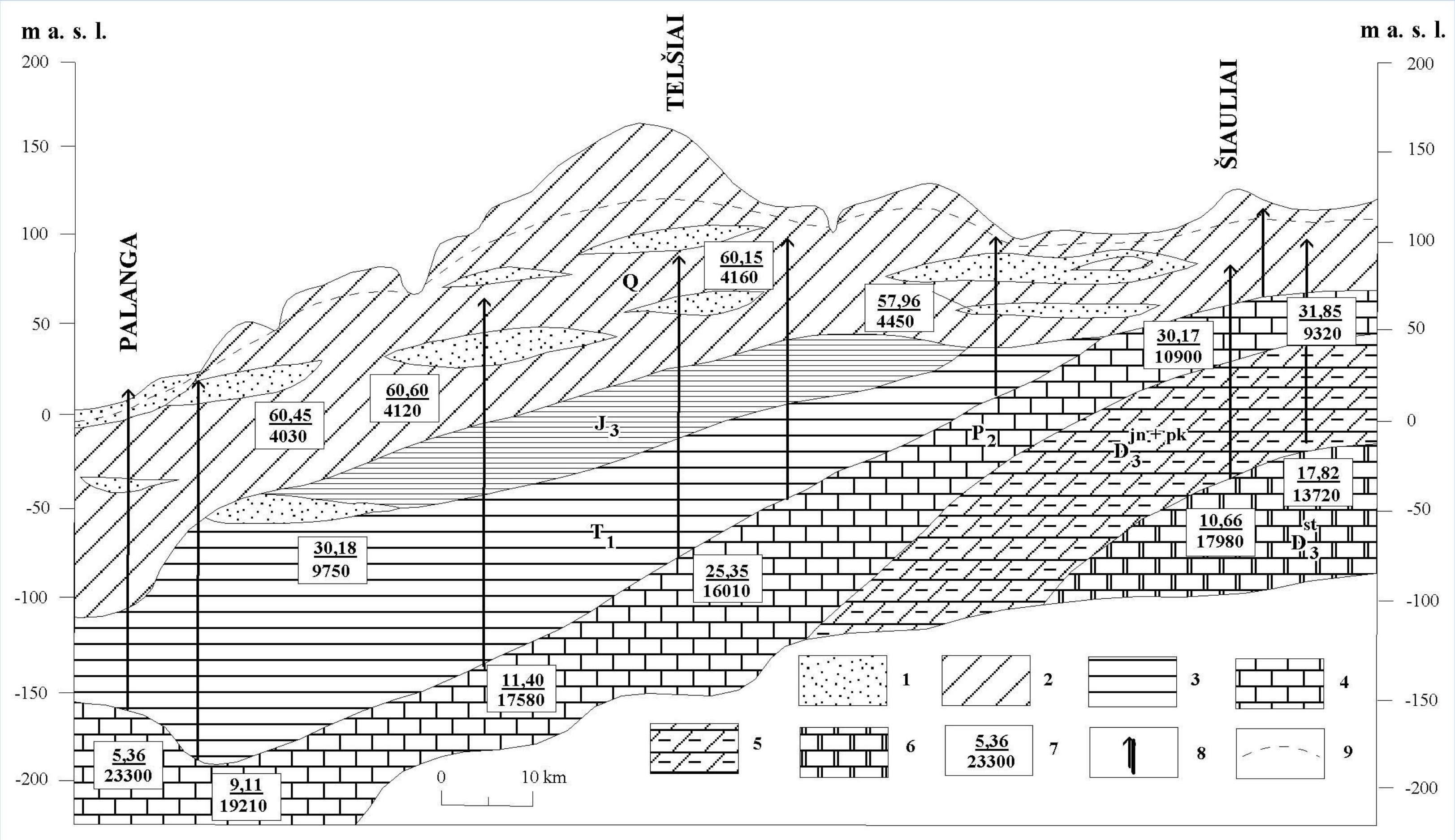
**(R. Mokrik *et al*., 2008)**




**Geological occurrence of the Upper Permian aquifer in the Western Lithuania and radiocarbon age of groundwater (dissolved carbonates) of this layer**

**1 – Quaternary deposits; 2 – clay; 3 – sand; 4 – fractured limestone; 5 – clayey marl and limestone. Age of deposits: $D_3$ – Upper Devonian; $P_2$ – Upper Permian; $T_1$ – Lower Triassic; $J_3$ – Upper Jurassic**

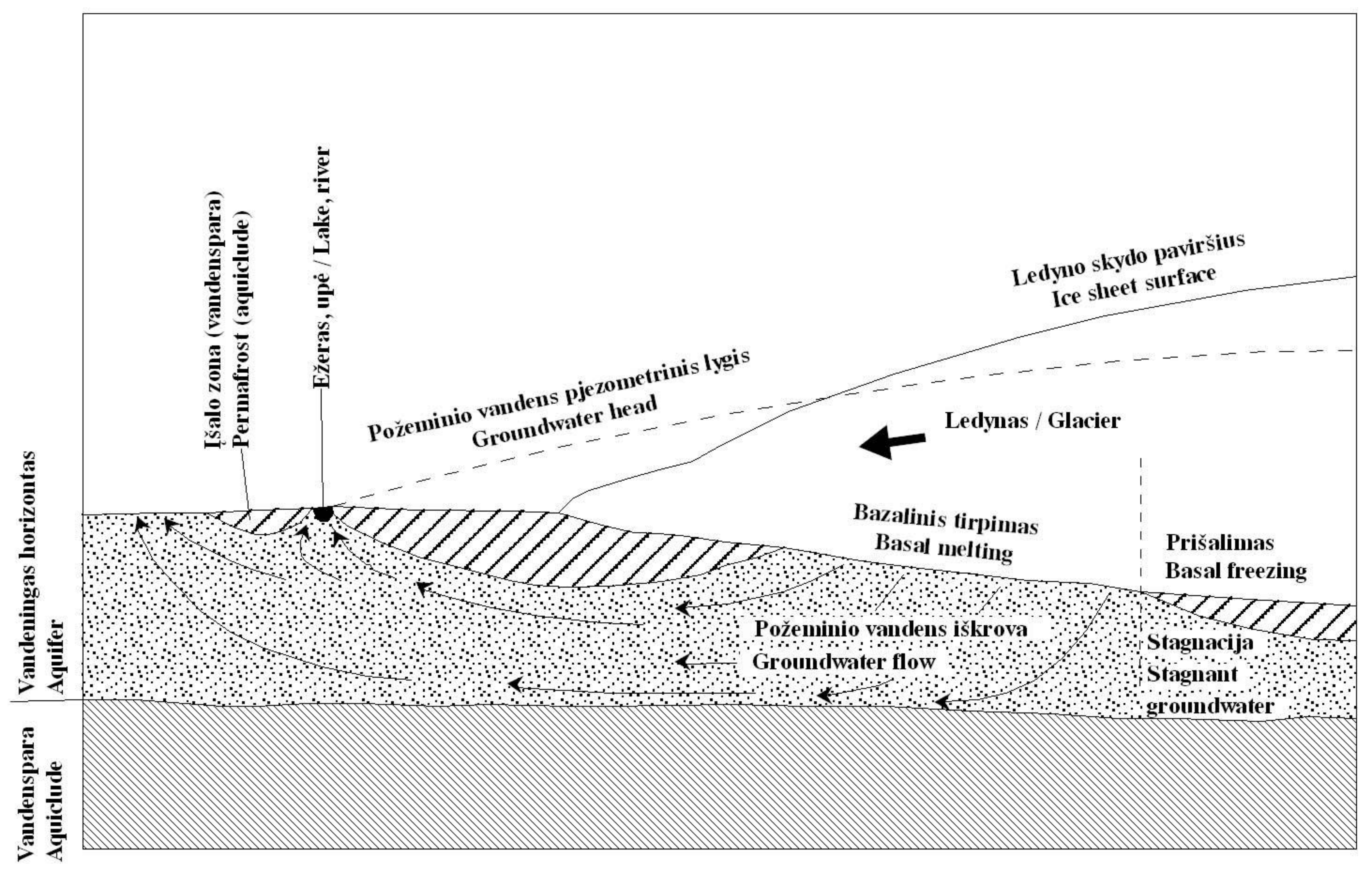
**(A. Bitinas, 1999, 2011)**




**Hydrogeological cross-section of upper part of Baltic artesian basin hydrodynamic system and radiocarbon age of groundwater (dissolved carbonates) of groundwater**

**1 – sand; 2 – moraine (till); 3 – clay; 4 – cracked limestone; 5 – clayey limestone and marl; 6 – cracked dolomite; 7 – results of radiocarbon dating: in numerator – $^{14}C$ content (pmc), in denominator – established age (years, without error of dating); 8 – hydrostatic pressure; 9 – groundwater level of Quaternary thickness. Indexes: Q – Quaternary; $J_3$ – Upper Jurassic; $T_1$ – Lower Triassic; $P_2$ – Upper Permian; $D_3^{jn+pk}$ – Upper Devonian Joniškėlis and Pakruojis Strata; $D_3^{st}$ – Upper Devonian Stipinai Formation**

**(after V. Juodkazis, 1979; modified)**




**Idealized diagram showing subglacial meltwater discharge beyond the continental ice sheet (compiled after Boulton *et al*., 1993; Boulton, Caban, 1995)**

**(A. Bitinas, 2011)**

# INSTEAD OF CONCLUSIONS

A different interpretation of groundwater dating results as well as a new perception of continental glacier dynamics and the mechanism of its meltwater circulation enable to change the attitude not only to almost dogmatic approach to glacial geology, but also to modify the already settled viewpoints on groundwater dynamics in aquifers during ice ages and the formation of fresh groundwater resources. Thus, we have to answer a number of new questions:

- Supposing that a part of fresh groundwater resources in the Eastern Baltic region has been formed due to meltwater injections, what are their real exploitation resources?

- Possibly, they are much smaller than we imagine?

- Are most of them reasonably considered as the renewing ones?

# Thank you for your attention