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Isotopically light subglacial meltwater from Scandinavian Ice Sheet in the Cambrian-Vendian aquifer system of north Estonia

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In Europe, the greatest changes in the groundwater formation took place during the last ice age which culminated about 20 000 to 18 000 years ago. At that time, the ice sheet covered the whole of Scandinavia and the territories of the present-day Baltic States, its southern margin extended as far as northern Germany and Poland.

The effect of the last glaciation on the groundwater regime varied with regions. In the coastal areas of western and southern Europe, the movement of water in deep aquifer systems intensified because of the drop of sea level. In periglacial areas, the groundwater regime was at first influenced by permafrost, and later the groundwater regime came to be affected by glacial meltwater which entered the aquifers by different ways. The purpose of this research was to determine the possible origin of isotopically light groundwater in the Cambrian-Vendian aquifer system in the north Estonia.

The Cambrian-Vendian aquifer system is the lowermost of the six aquifer systems of Estonia. Its thickness amounts to 90m and outcrops along the northern coast of Estonia on the bottom of the Gulf of Finland. The aquifer system is, as a rule, confined by 60 to 90m thick clays of the Lontova formation, having a strong isolation capacity. However, in places the bedrock formations are penetrated down to the crystalline basement by ancient buried valleys, filled mostly with loamy till but sometimes glacio-fluvial gravel occurs in the lower portion of the valleys.

Isotope investigations of the groundwater were combined with geochemical studies in order to understand the processes and climate conditions during the palaeorecharge,

the age structure of deep waters and the mixing components and their variation. Also amount and composition of extracted gases were determined. A three-dimensional hydrodynamic model covering the whole territory of Estonia was developed for to study the groundwater dynamics. The oxygen isotope composition of groundwater in most of aquifer systems in Estonia ranges from -11.0 to -12.2 permil. However, the groundwater in the Cambrian-Vendian aquifer system has a heavily depleted oxygen isotope composition. The values of δ^{18}O vary mainly from -18.1 to –22.0 permil. At the same time, the long term mean annual δ^{18}O values in contemporary precipitation in Estonia are -10.4 permil. Low δ^{18}O values in the Cambrian-Vendian aquifer are indicative of recharge in cold conditions, whilst low ^{14}C concentrations are indicative of long residence time of groundwater. Analyses of the gas composition in some samples showed rather high concentration of methane. This is indicative of the influence of biogenic reactions in the groundwater, which could cause the low δ^{13}C values, measured in many wells. Results of δ^{13}C analyses in two methane samples also show, that the methane has most probably biogenic origin. Low ^{3}H concentrations in most of studied wells confirm that, as a rule, no detectable intrusion of modern water into the Cambrian-Vendian aquifer has been occurred.

Conclusions

- In north Estonia the Cambrian-Vendian aquifer system contains fresh palaeowater recharged during the last glaciation. The main properties are determined by natural reactions of paleaowater with Cambrian-Vendian silt- and sandstones in anaerobic conditions during the last more than 10 ka.
- The most characteristic feature of the groundwater of the Cambrian-Vendian aquifer system in north Estonia is its lightest known oxygen isotopic composition in Europe. These waters have δ^{18}O values of around -22 permil, while the long-term mean annual δ^{18}O values in contemporary meteoric water in Estonia are –10.4 permil.