Application of stable isotope content in groundwater to validate the results of the hydrogeological model of the Baltic artesian basin

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Aim of the work

In this study we tried to apply stable oxygen isotope content and major ion chemistry to verify the response of the developed and calibrated Baltic Artesian Basin numerical model.

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Introduction

- Total area 480 000 km^2
- Calibrated
- Steady state flow model

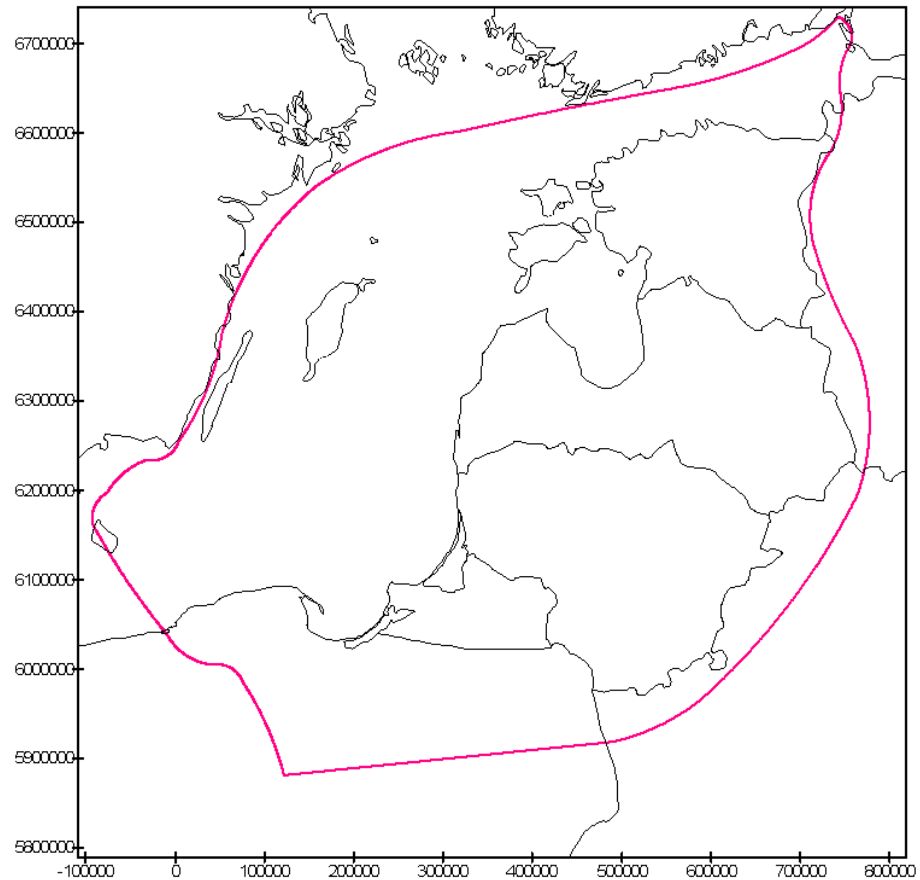

Fig.1 Boundary of Baltic artesian basin.

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How it works?

What was used?

- *flow directions*
- *flow velocities*
- *Stable oxygen ratios*
- *chlorine concentrations*

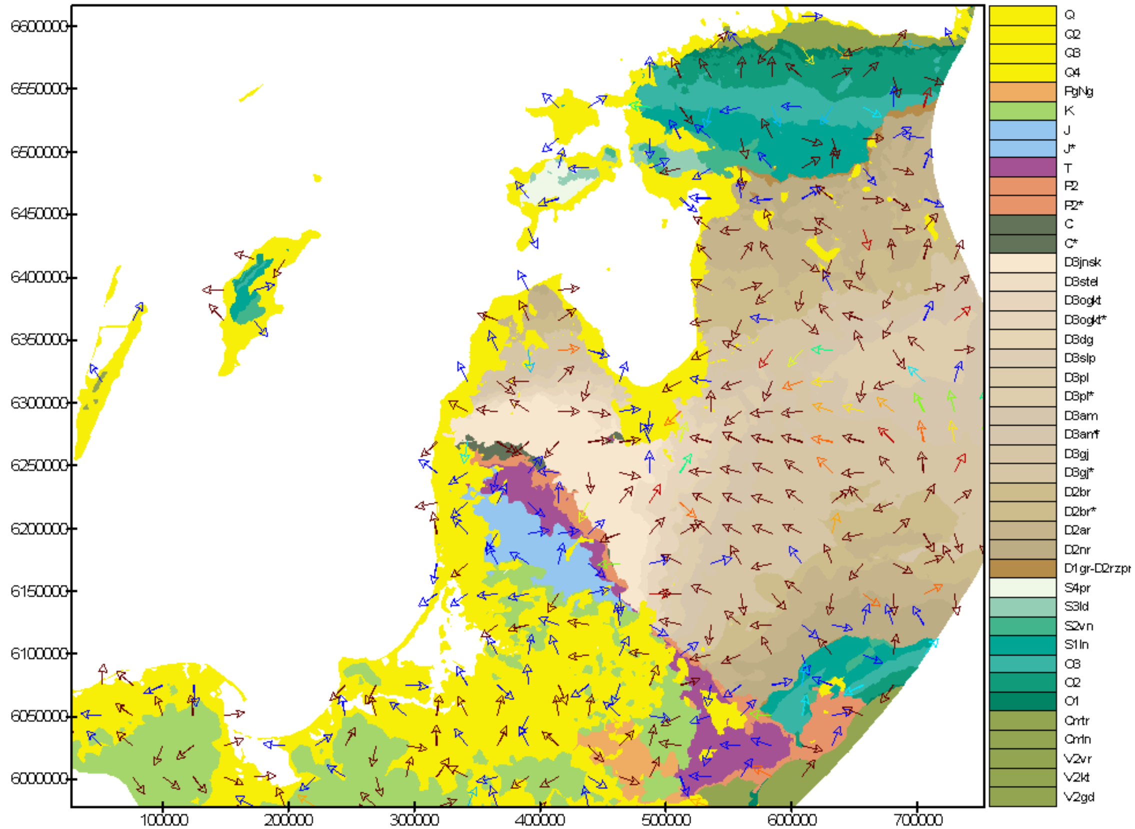


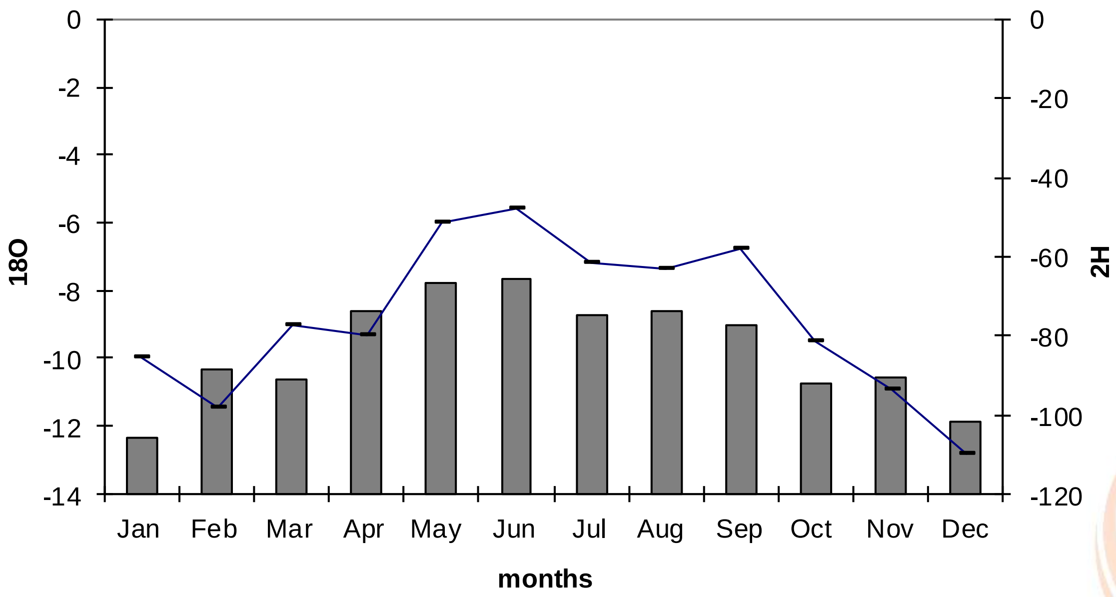
Fig.2 Horizontal cross-section at 1m below sea level. Flow directions at the particular deptht

Oxygen isotope content in precipitation

According to IAEA, mean weighted δ18O‰ ratio in precipitation in Riga is -9.74 ‰

Less depleted ratios are observed in June (-7.77 ‰) and more depleted in January (-12.32 ‰)

Riga, Latvia. Monitoring 1980-1988



Montly distribution of δ18O and δD mean values in precipitation data at Riga monitoring site. IAEA/WMO (2006). Global Network of Isotopes in Precipitation. The GNIP Database. Accessible at: http://www.iaea.org/water

Stable oxygen is representing recharge conditions. It should be the same as average weighed signal in precipitation during the aquifer recharge. ***If not….***

<u>If ratio in groundwater is more positive</u>

- warmer period
- additional recharge in aquifer from lakes, bogs or rivers
- sea water intrusion
- intrusions from brines
- rock dissolution

<u>If stable oxygen ratio is more negative</u>

- Recharge during colder period
- More continental climate
- Recharge mainly during cold season
- Water from previous spring

Chlorine as well can be used as natural tracer

<u>Increase in chlorine concentrations can be due to:</u>

- Pollution, or artificial recharge
- Sea intrusions
- Intrusion from deepest aquifers with higher chlorine content
- Halite dissolution

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Study areas

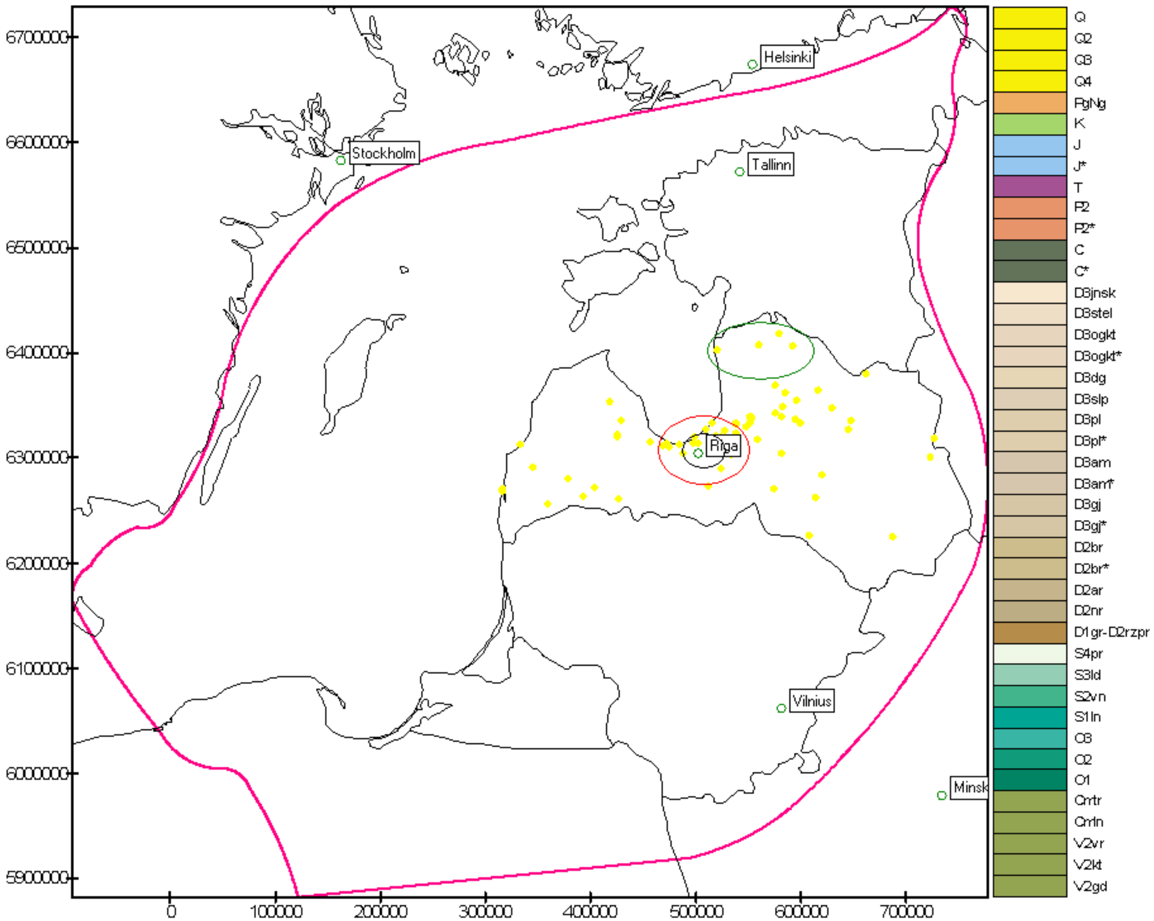

Fig.3 ***Experimental study areas*** *.Yellow points – analysed samples.*

1. Quaternary aquifer in Riga vicinity
2. Upper Devonian aquifer in Riga vicinity
3. Middle-Lower Devonian below Narva aquitard

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Quaternary aquifer

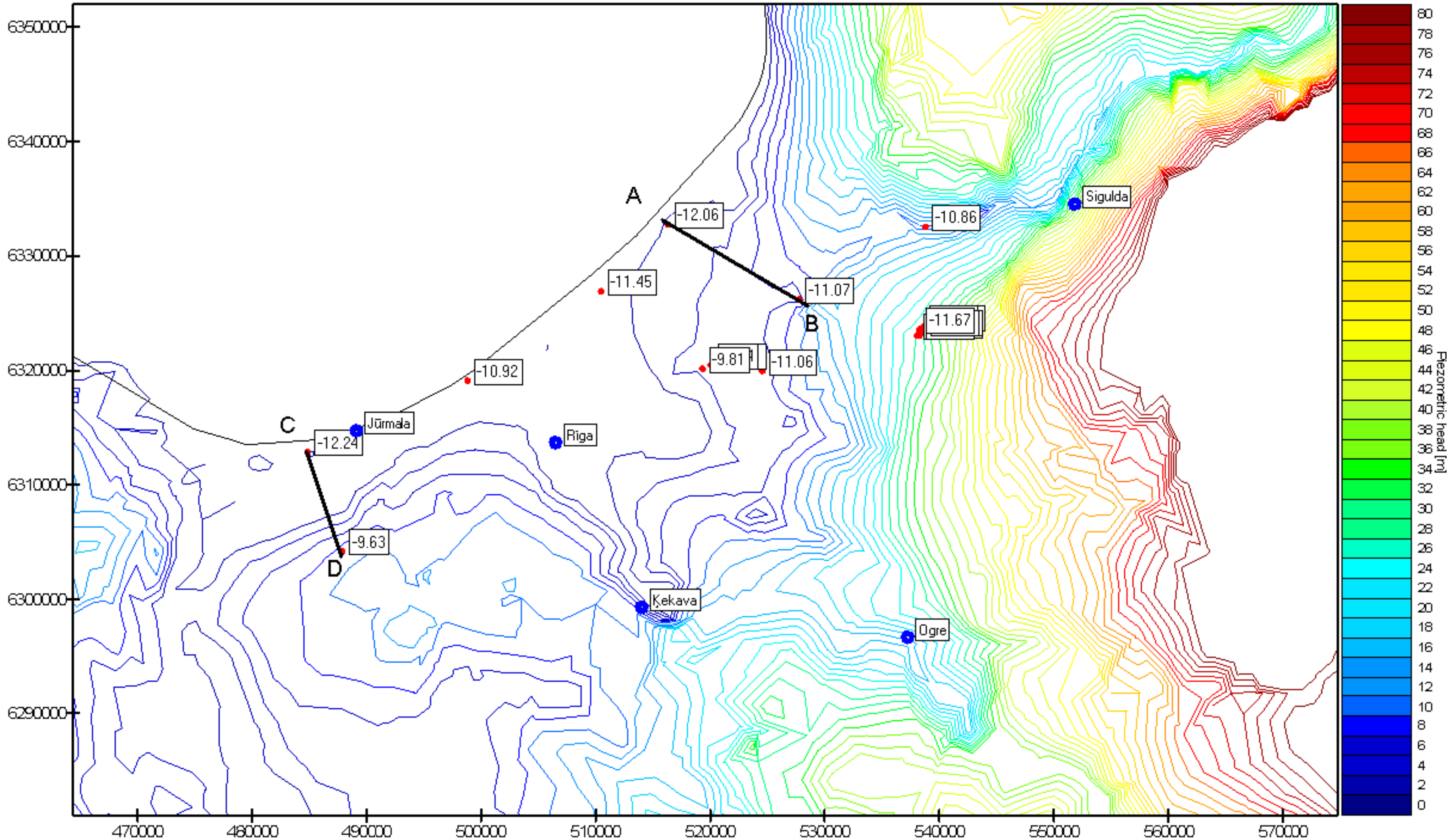

Fig.4 ***Riga vicinity, piezometric levels as isolines and isotopic data as dots.***

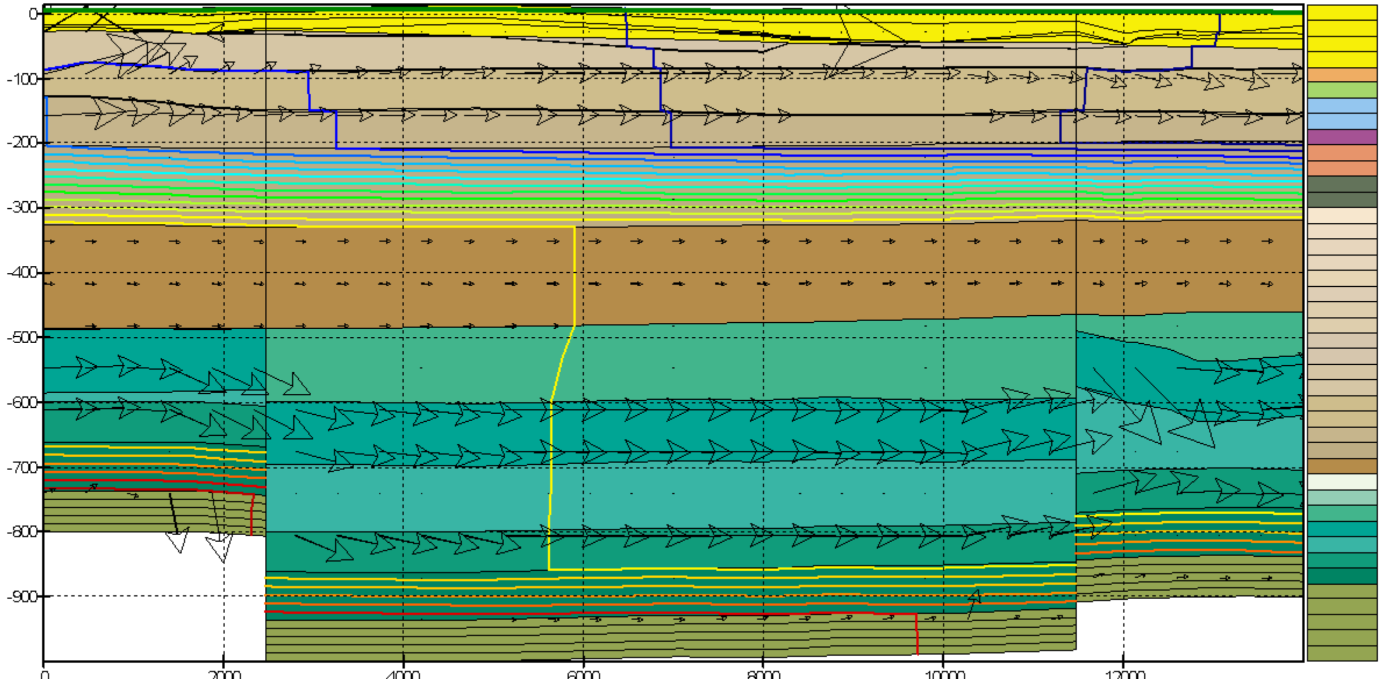

Fig.5 Cross section at line A-B from fig.4*.* *Arrows ilustrate velocity modulus*

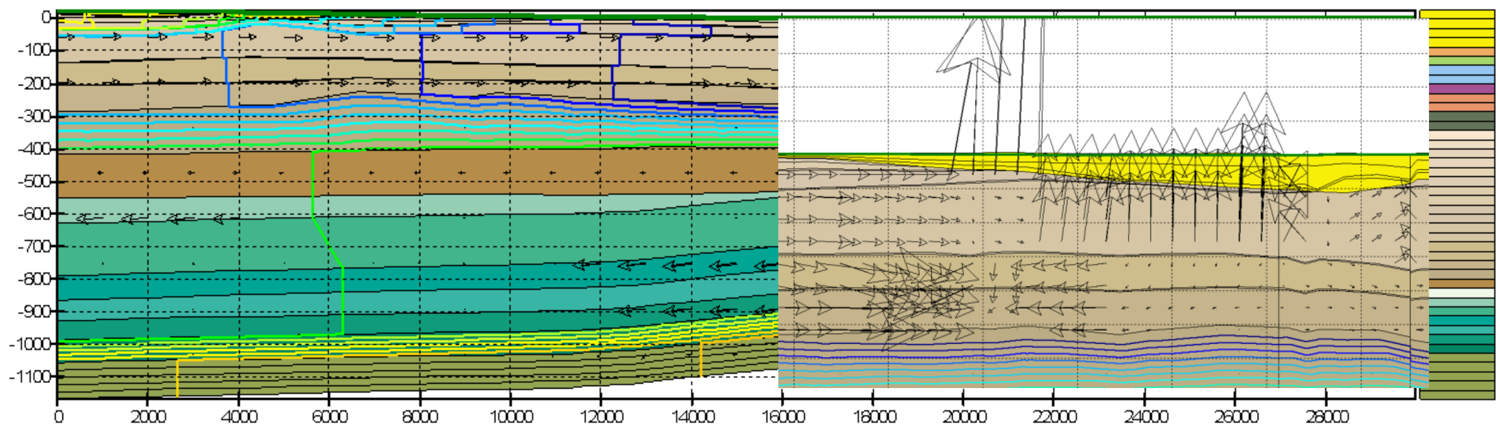

Fig.6 ***Cross section at line C-D from fig.4****. Arrows ilustrate groundwater velocity modulus.*

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Upper Devonian Gauja aquifer

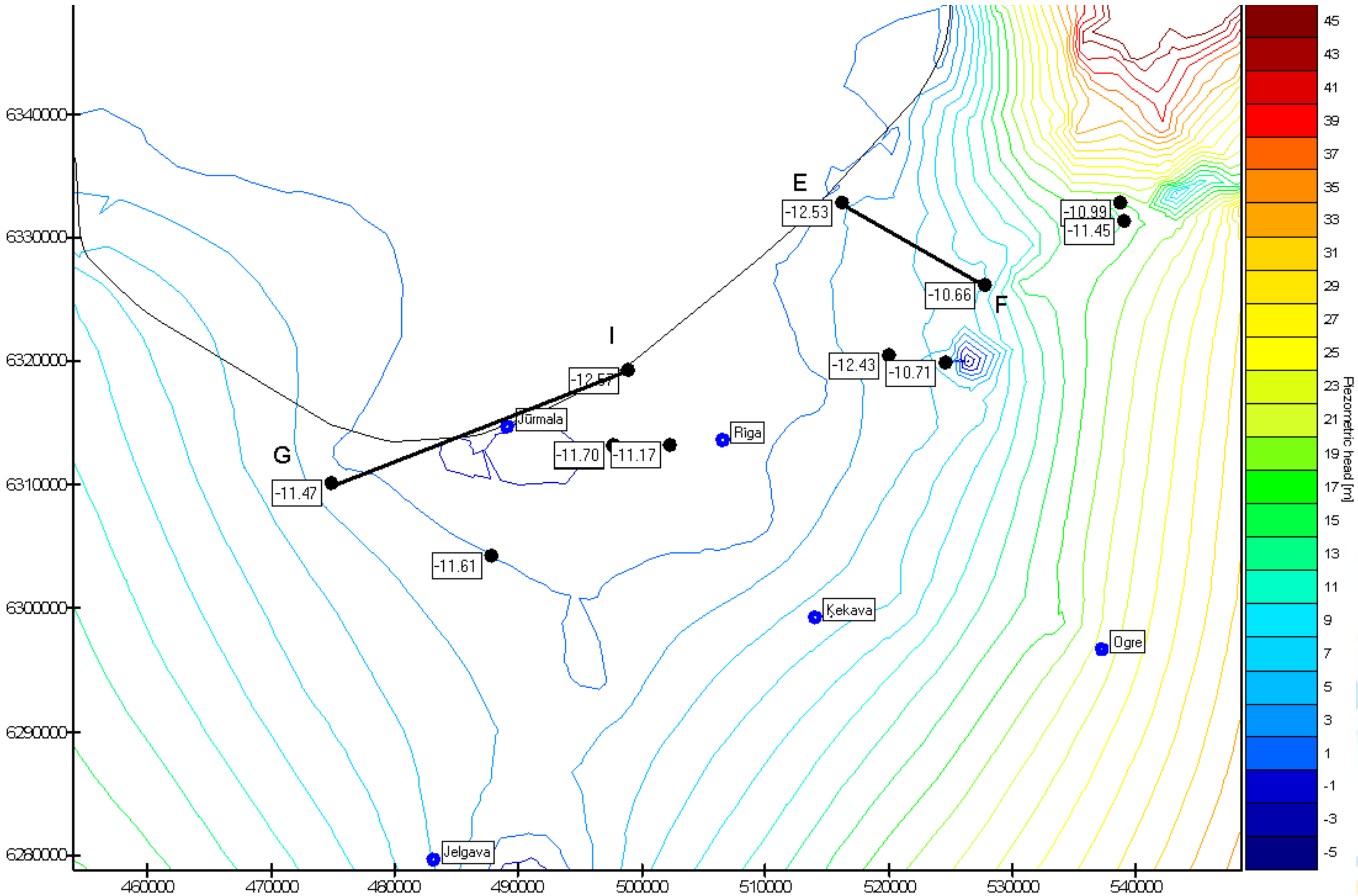
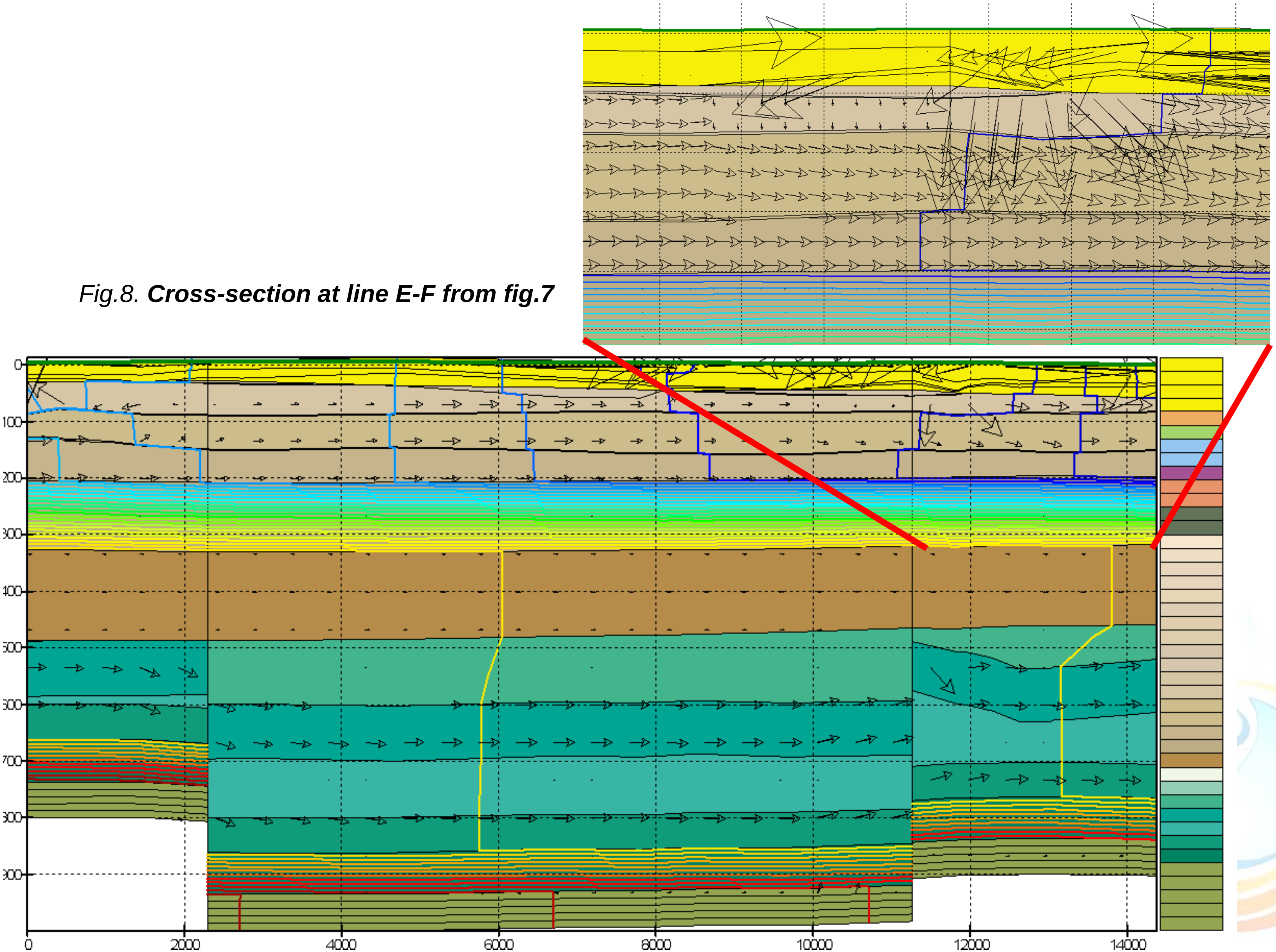


Fig.7 ***Piezometric levels in Upper Devonian Gauja aquifer. δ18O‰ ratios***

Fig.8. ***Cross-section at line E-F from fig.7***



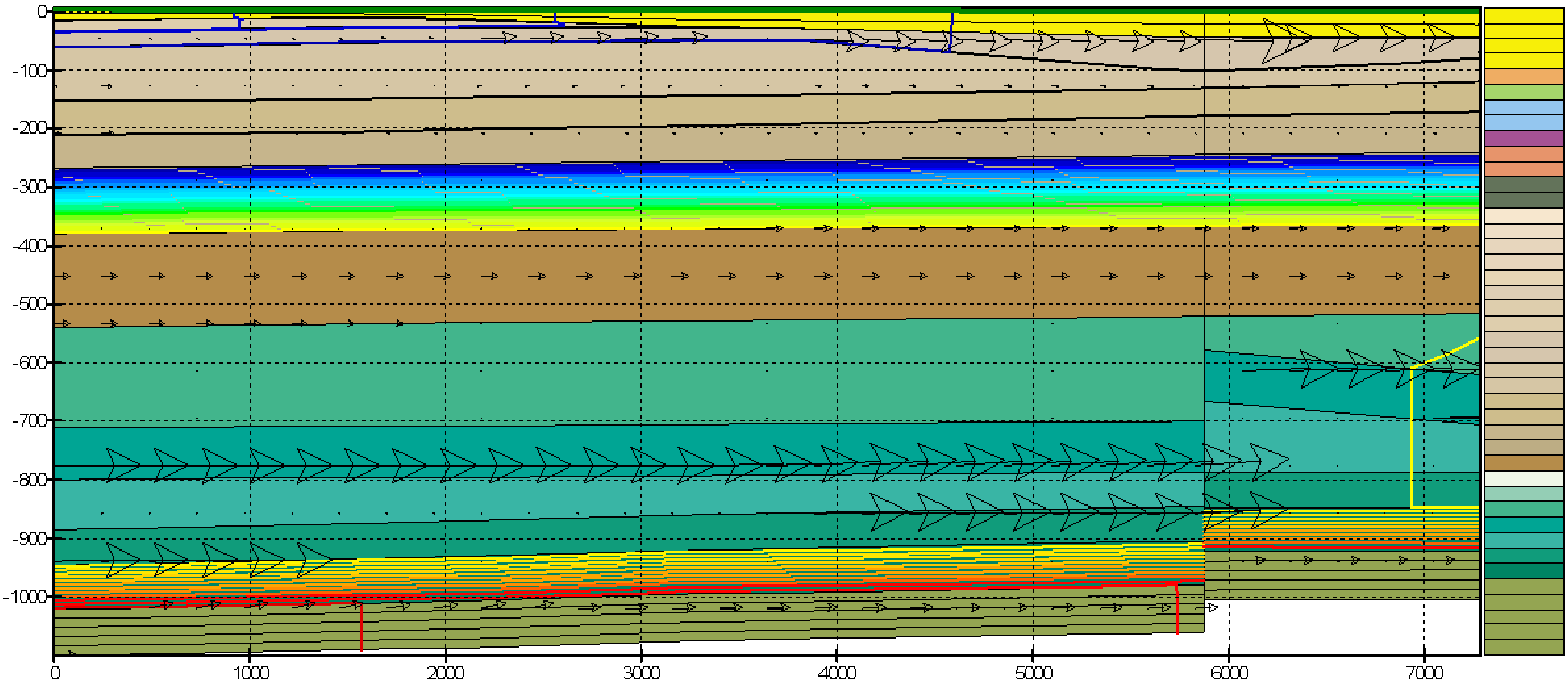


Fig.9. ***Cross-section at line G-I from fig.7***

D1-2

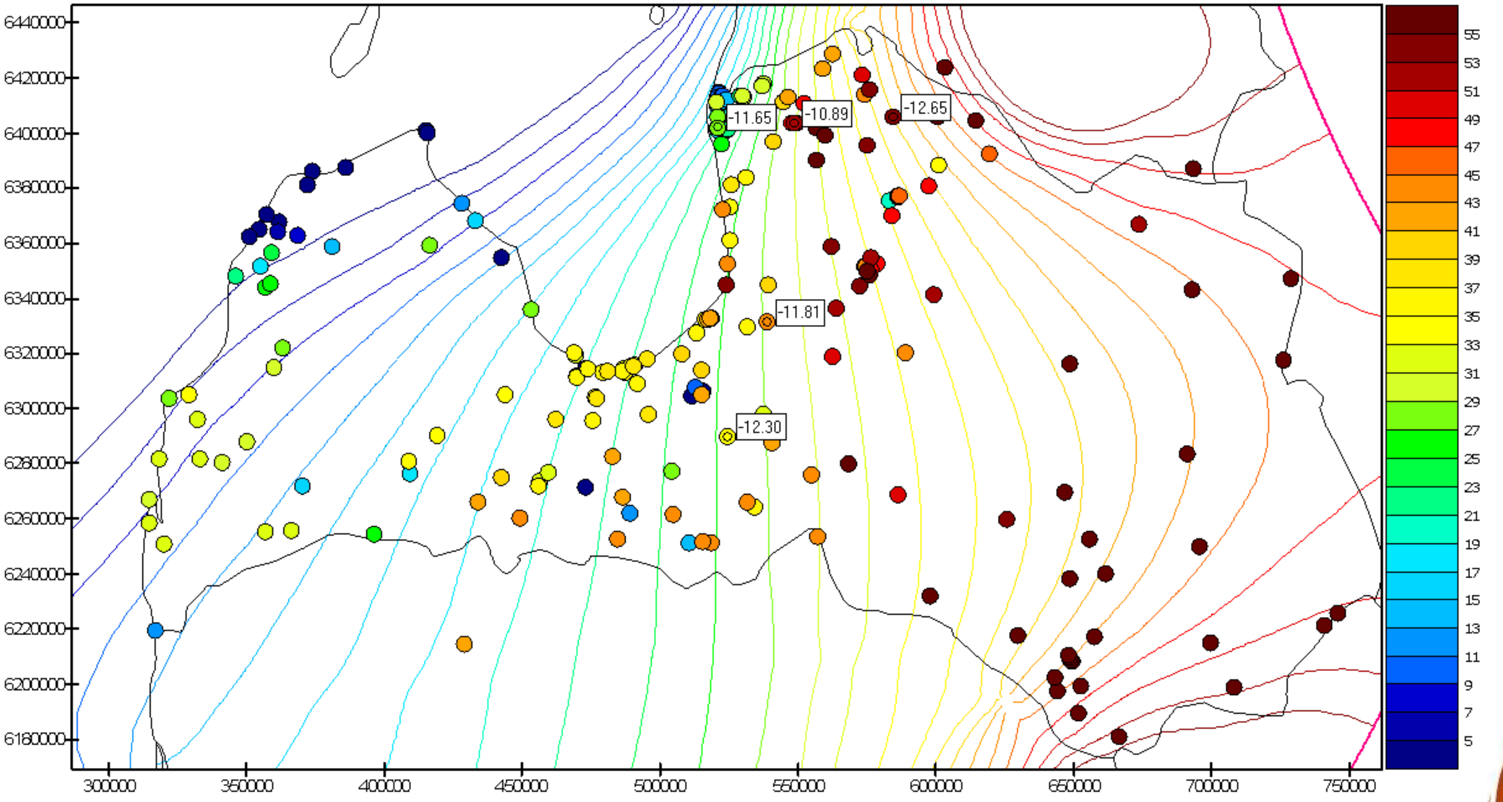


Fig.10. ***Observed piezometric heds in Middle-Lower Devonian aquifer as isolines.***
Observed piezometric levels as dots. Stable oxygen ratios in samples as labels.

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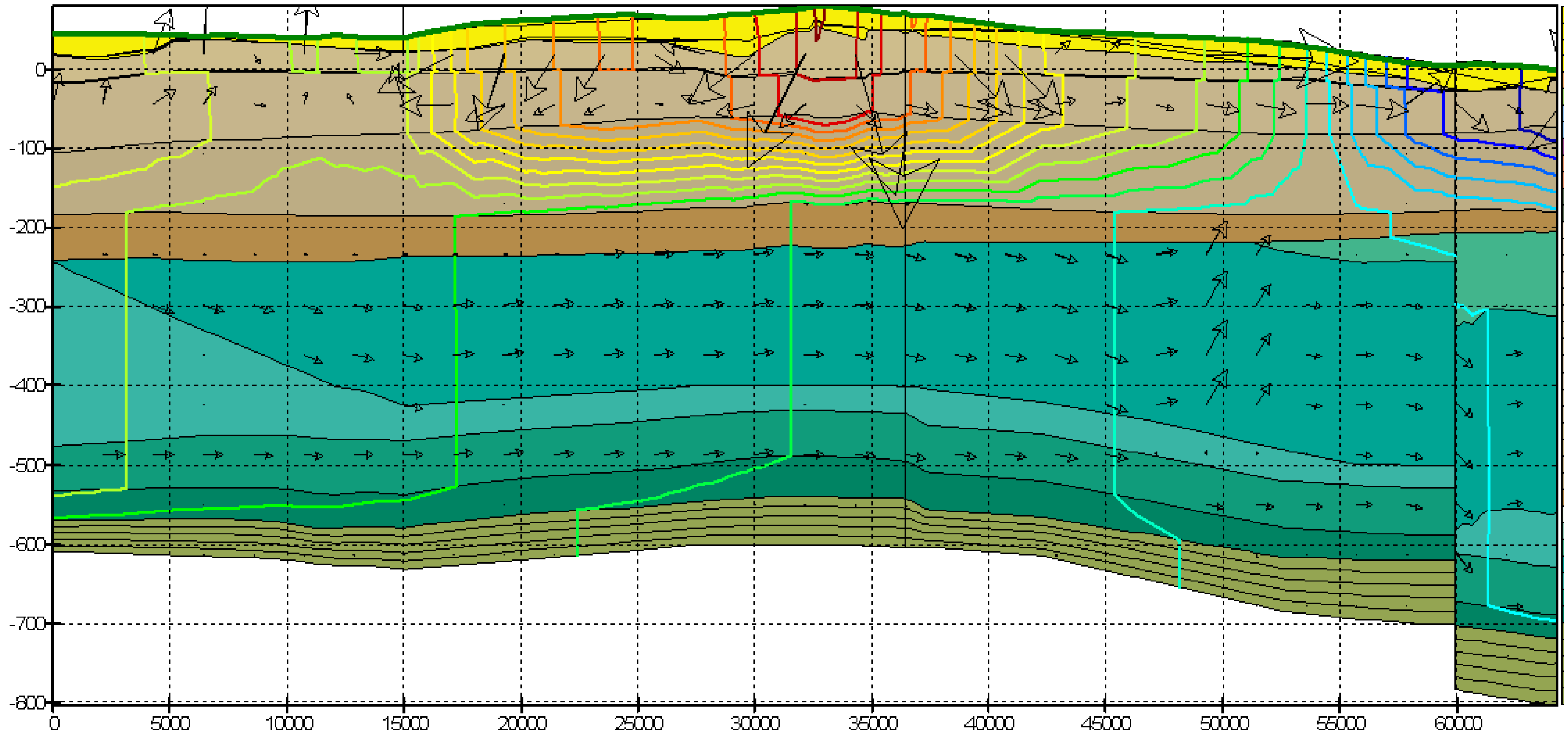

Fig.10 ***Cross-section at line M-N***

How it can be?

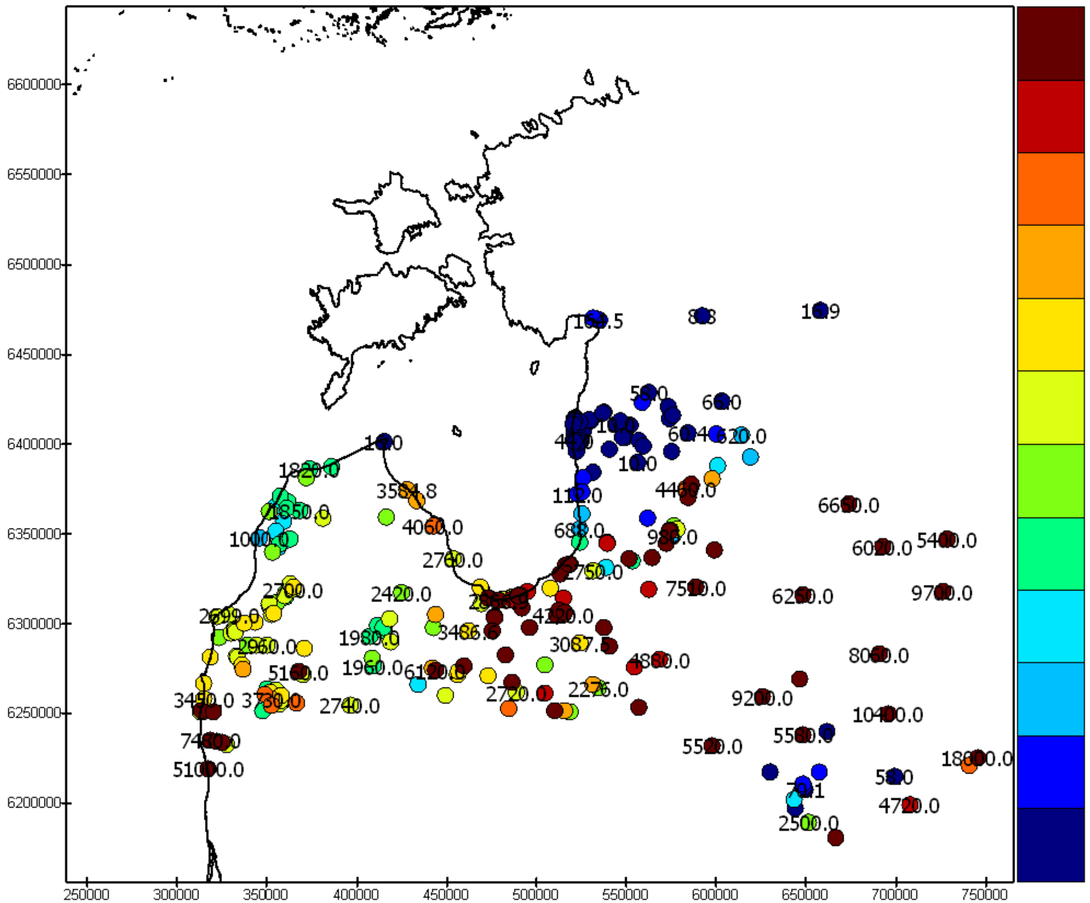

Fig.11. ***Concentration of clorine ion in groundwater of Middle Devonian Pernava aquifer***

A(Qc)+B(Qc)=C(Qc)

were,
Q- volume
c – concentration

If:
A (11%; -4.5 δ18O)
C(100 %; -12.30 δ18O)
than:
B is 89%; -13.26 δ18O

Isotopes for model will be useful

- In mixing model
- In paleoreconstruction model
- To evaluate flow along faults
- To determine boundaries of groundwater subbasins
- To determine interaction between different aquifers.

Conclusions

At the moment what we can do is only give qualitative assessment, as we don’t have any tools to evaluate it in a quantitative way !!!

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Thank you for your attention!

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