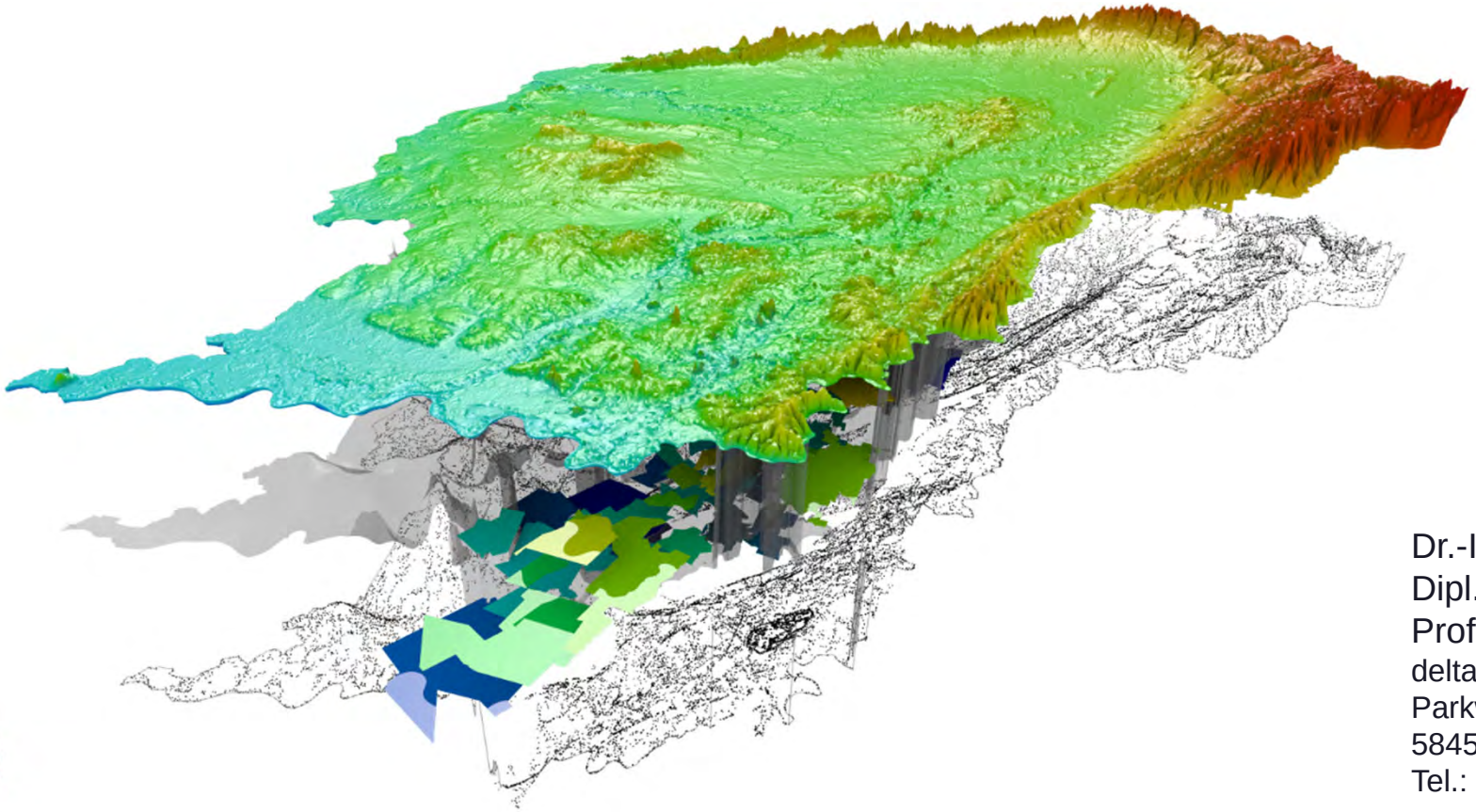
Modellstudie
zur Dichteverteilung in den Aquiferen des Münsterländer Kreidebeckens

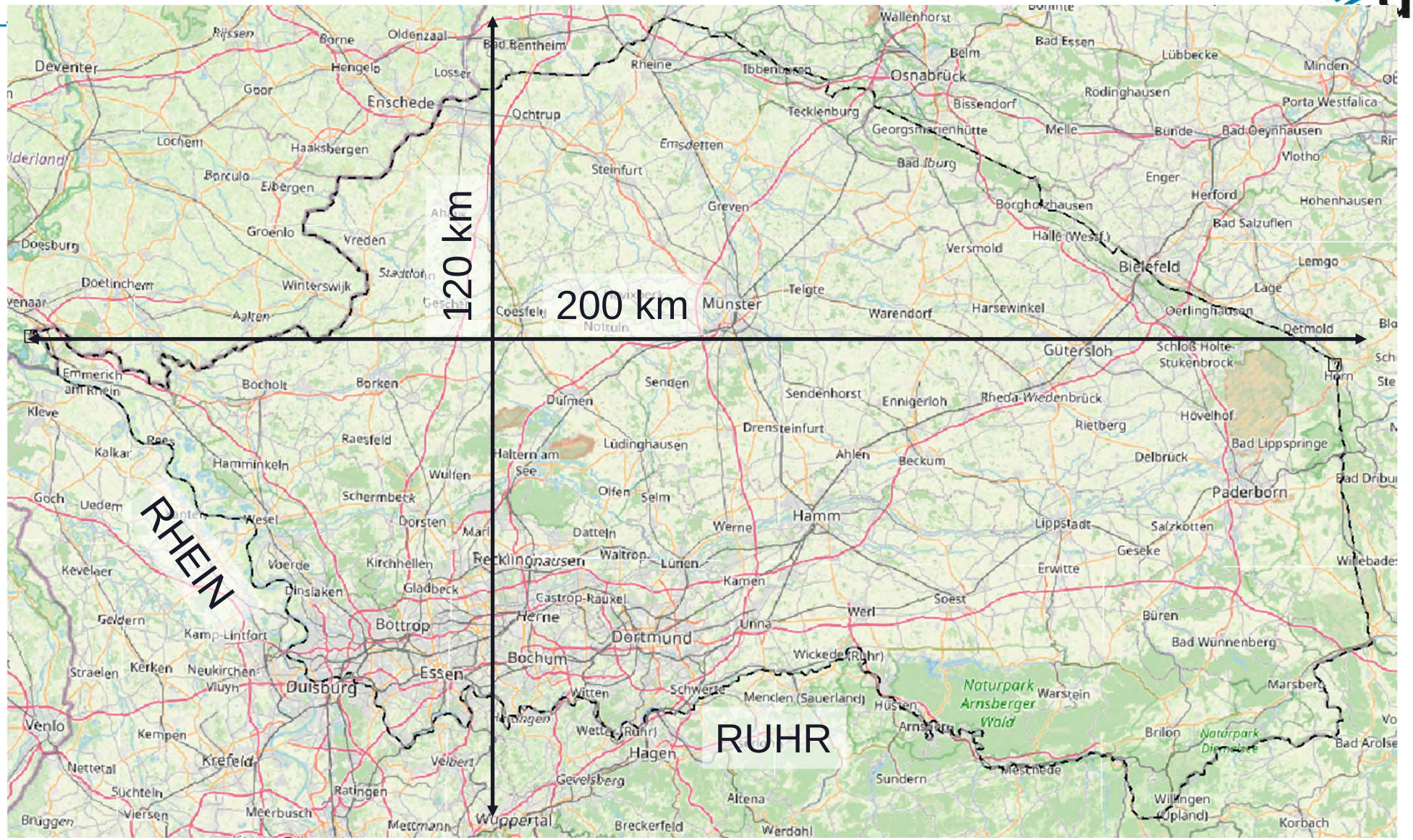


Dr.-Ing. Katrin Brömme
Dipl.-Geol. Torsten Seidel
Prof. Dr.-Ing. Christoph M. König
delta h Ingenieurgesellschaft mbH
Parkweg 67
58453 Witten
Tel.: 02302 91 406 28
e-mail: kb@delta-h.de

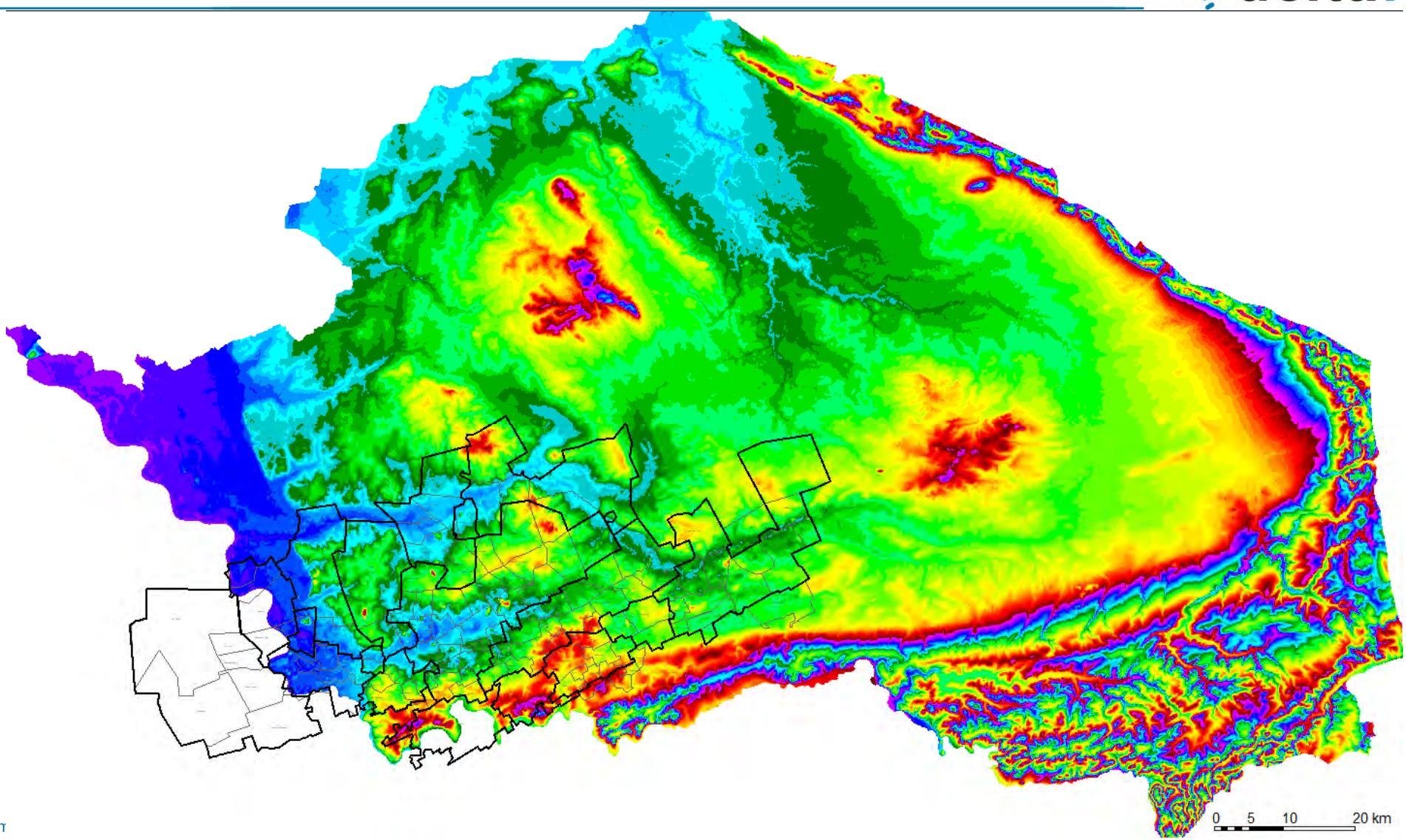
Gliederung

- Münsterländer Kreidebecken
- Verifikationsmodell nach Elder
- Dichteströmung in Schächten
- Modellvorstellung in zwei Schnitten
- Dichteschichtung, Messwerte
- Dichteabhängige Berechnungen mit SPRING
- Konvektionszellen
- Erste Ergebnisse

Münsterländer Kreidebecken



Geländeoberfläche mit Bergbaugrenzen

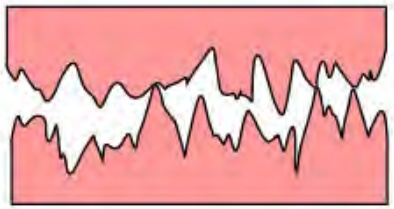


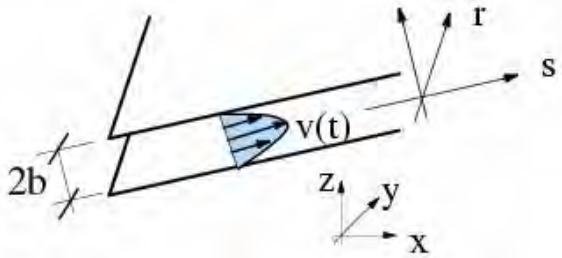
PDE für Kluft – Matrix mit Elementierung

$$\varsigma\left(S_w S_{op} + n \frac{dS_w}{dp} \right) \frac{\partial p}{\partial t} -$$

$$\frac{\partial}{\partial x_i}\left[\varsigma K_{ij} k_{rel} \frac{\varsigma g}{\mu} \frac{\partial}{\partial x_i}\left(\frac{p}{\varsigma g} + z \right) \right] = Q\varsigma$$

$$i,j = x,y,z$$

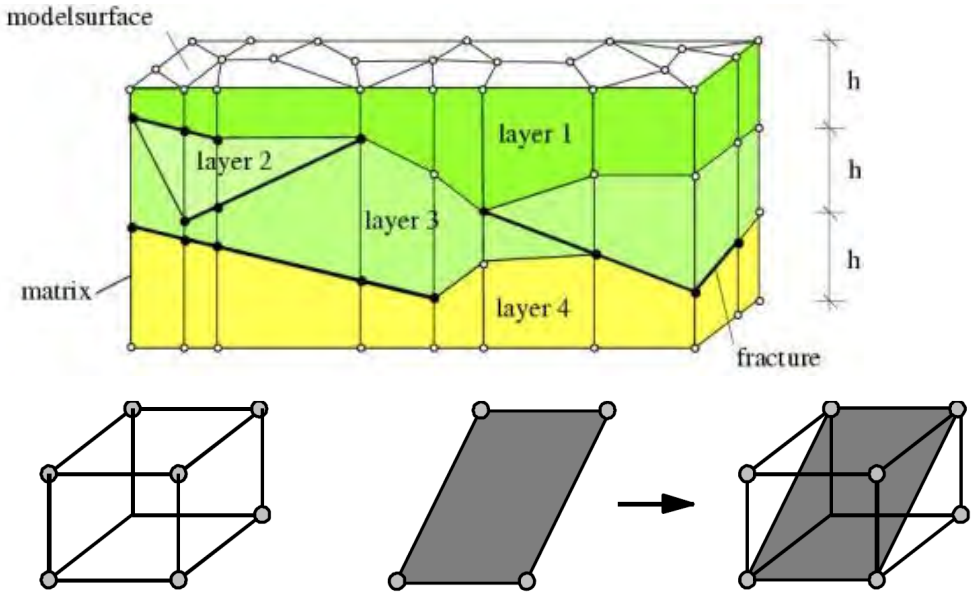




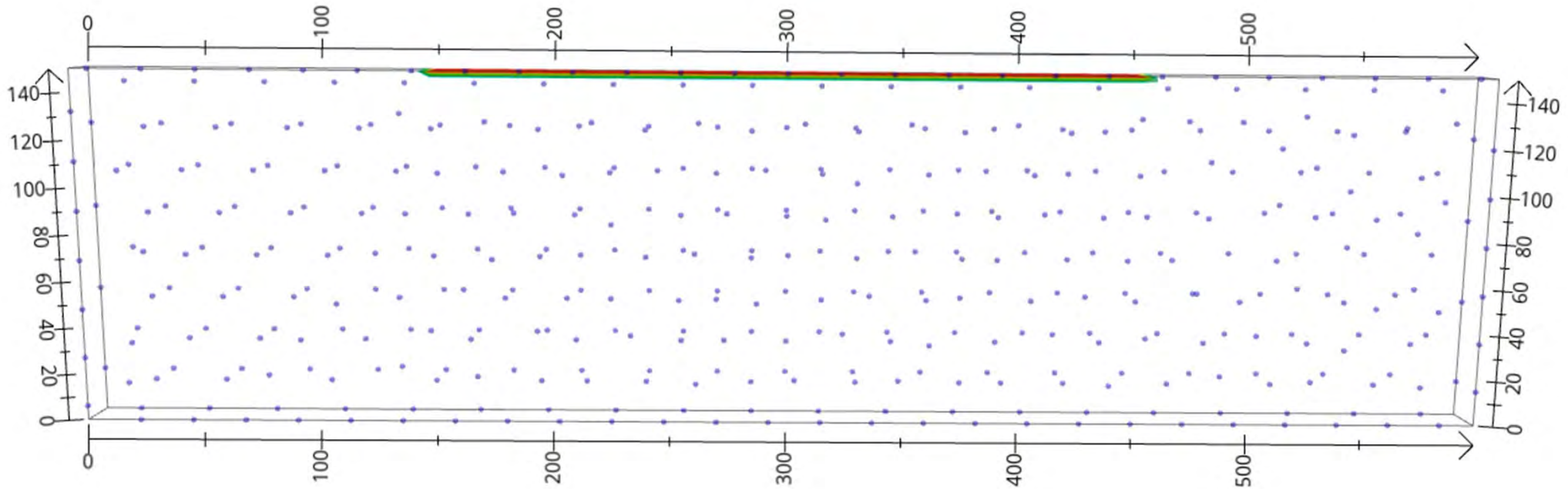
and the fractures:

$$b\left\{ \varsigma\left(S_w \beta + \frac{dS_w}{dp} \right) \frac{\partial p}{\partial t} - \frac{\partial}{\partial x_k}\left[\varsigma \frac{b^2}{12} k_{rel} \frac{\varsigma g}{\mu} \frac{\partial}{\partial x_l}\left(\frac{p}{\varsigma g} + z \right) \right] \right\} = Q\varsigma$$

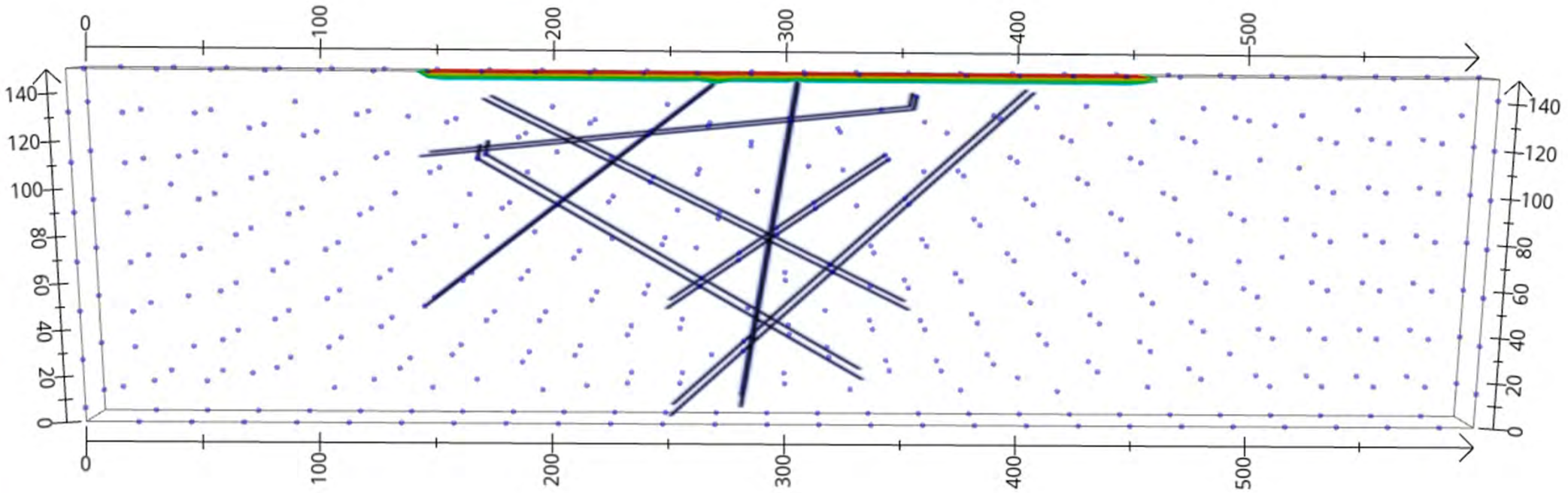
$$k,l = r,s.$$



Testmodell nach ELDER 1967

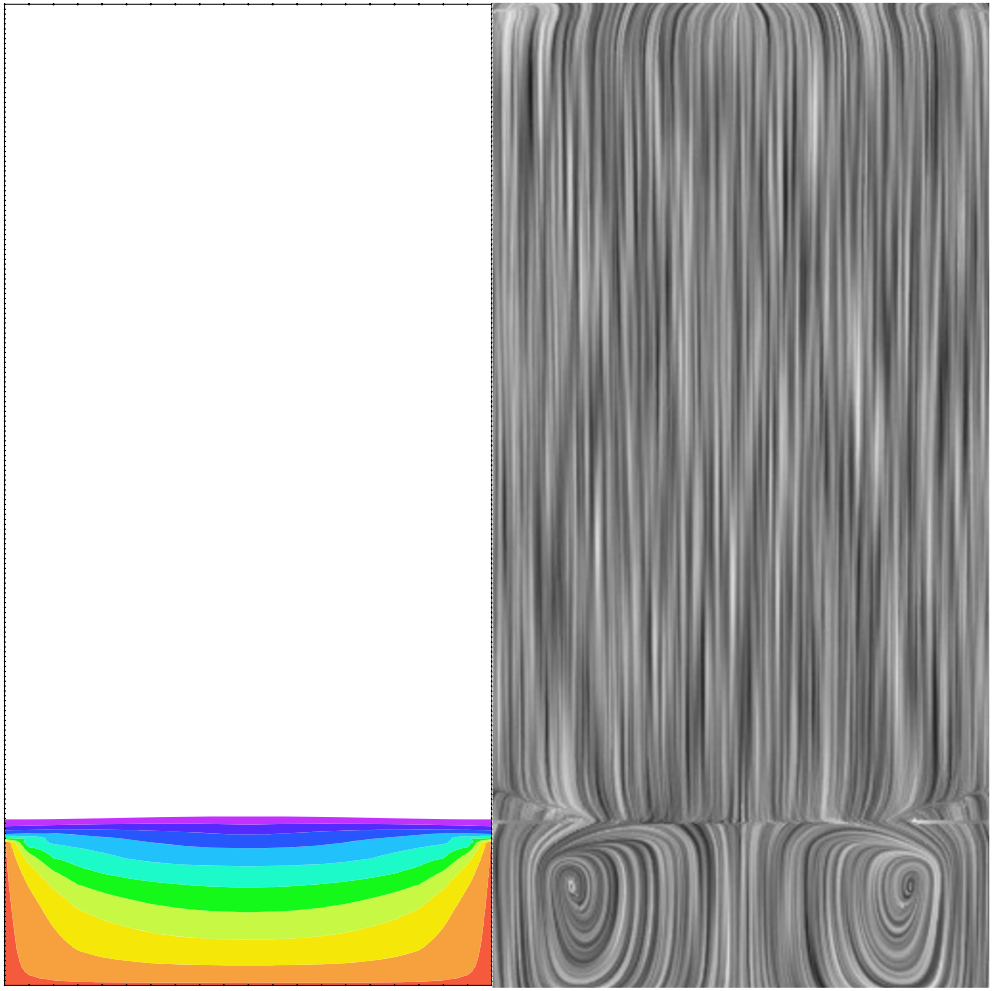


Testmodell nach ELDER 1967 mit Klüften

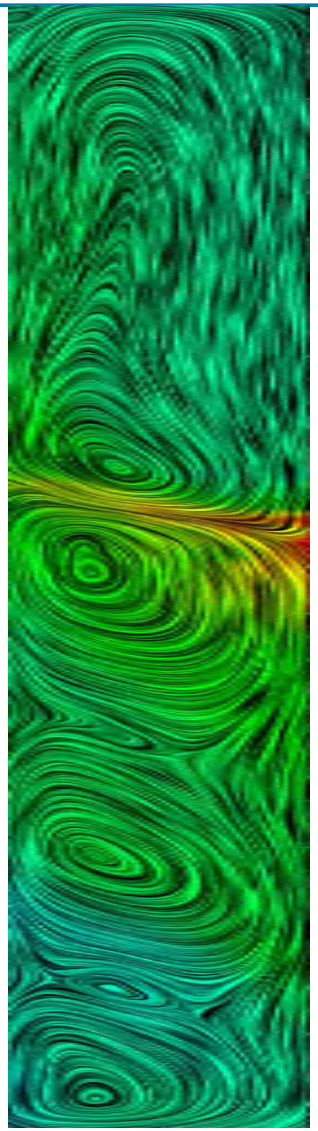


Schachtmodell:

Süßwasser – Salzwasser mit Temperaturgradient



Schachtmodell: Süßwasser über Salzwasser



Süßwasser

Salzwasser

Salinitäten des Norddeutschen Beckens

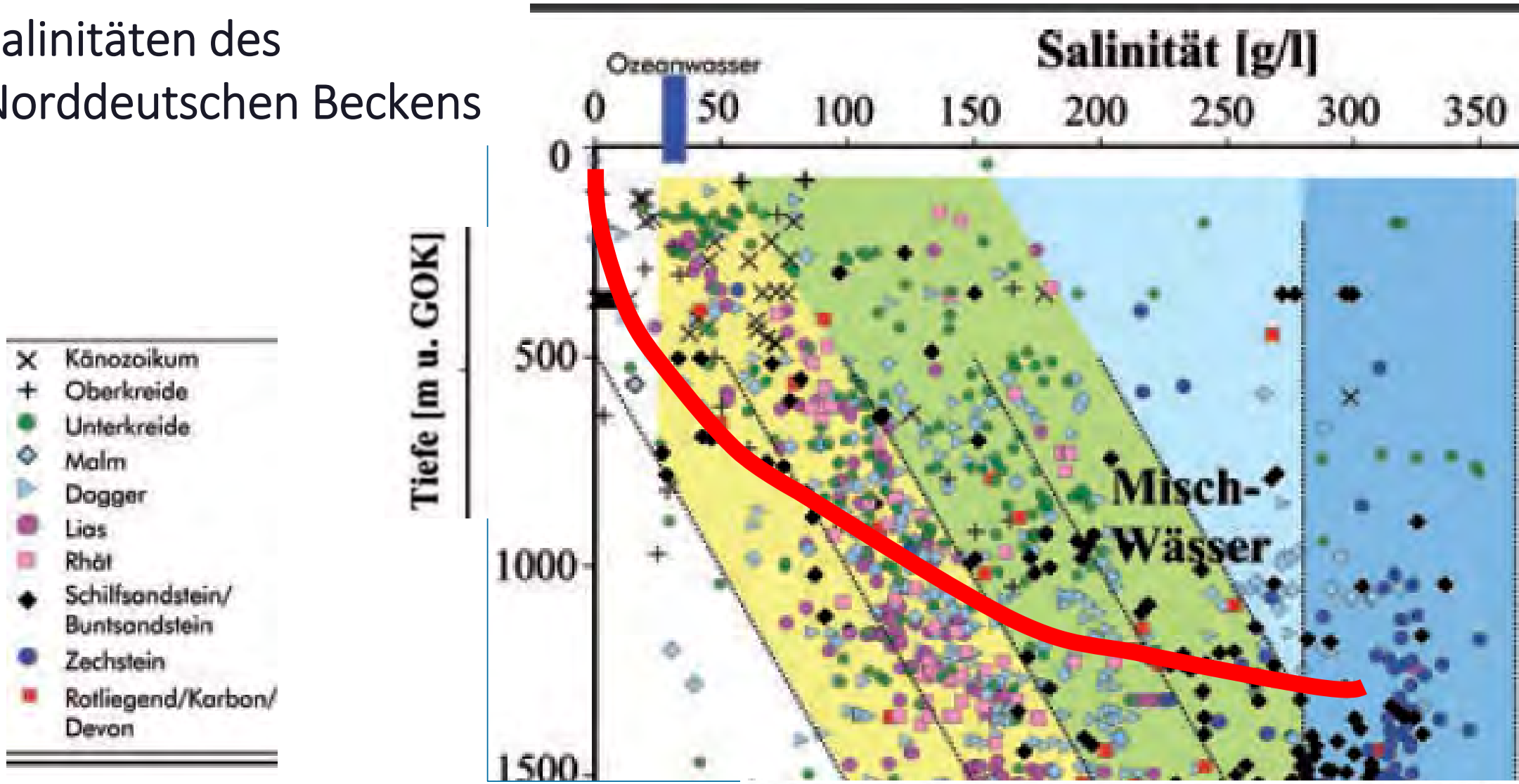
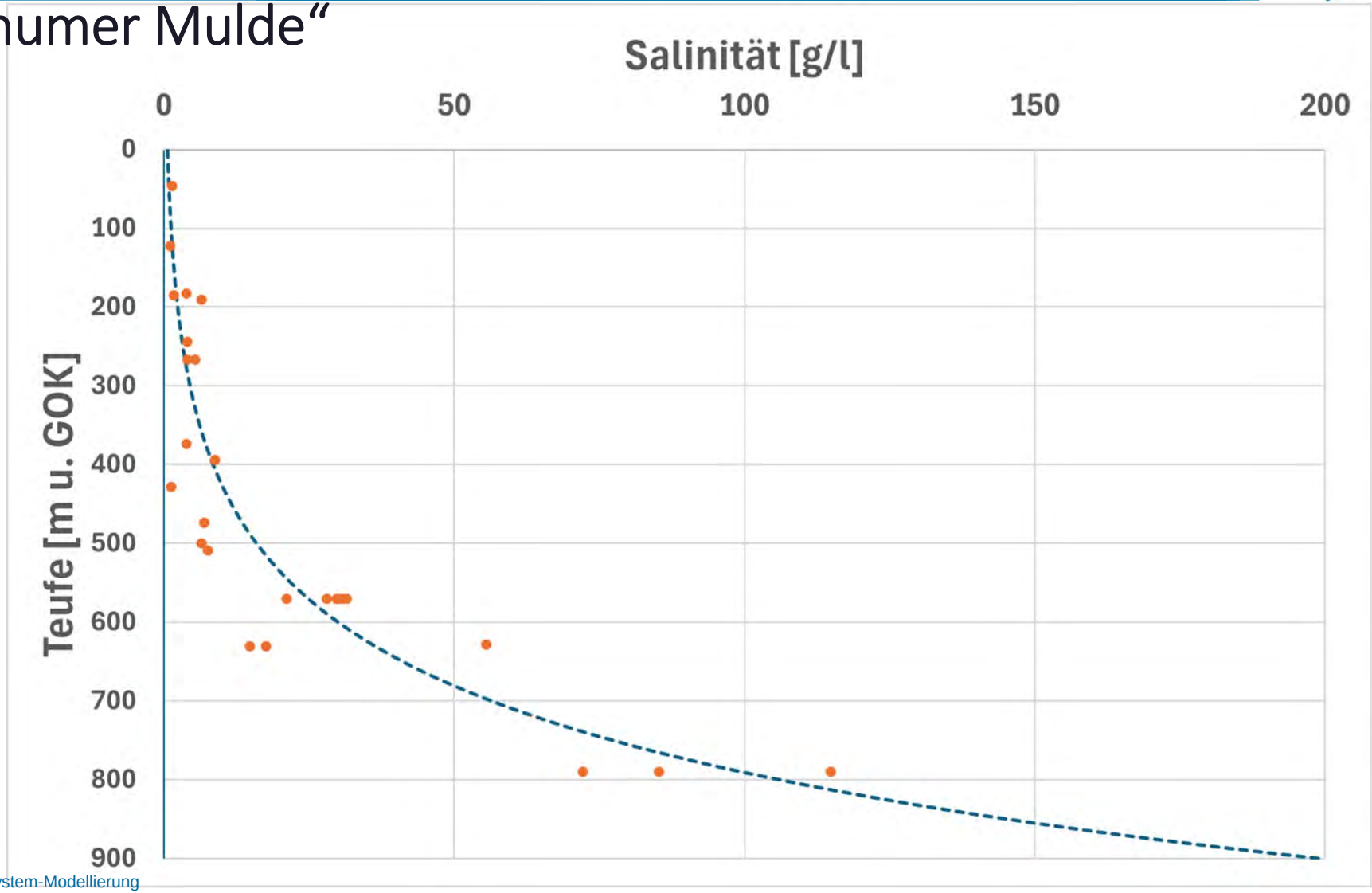
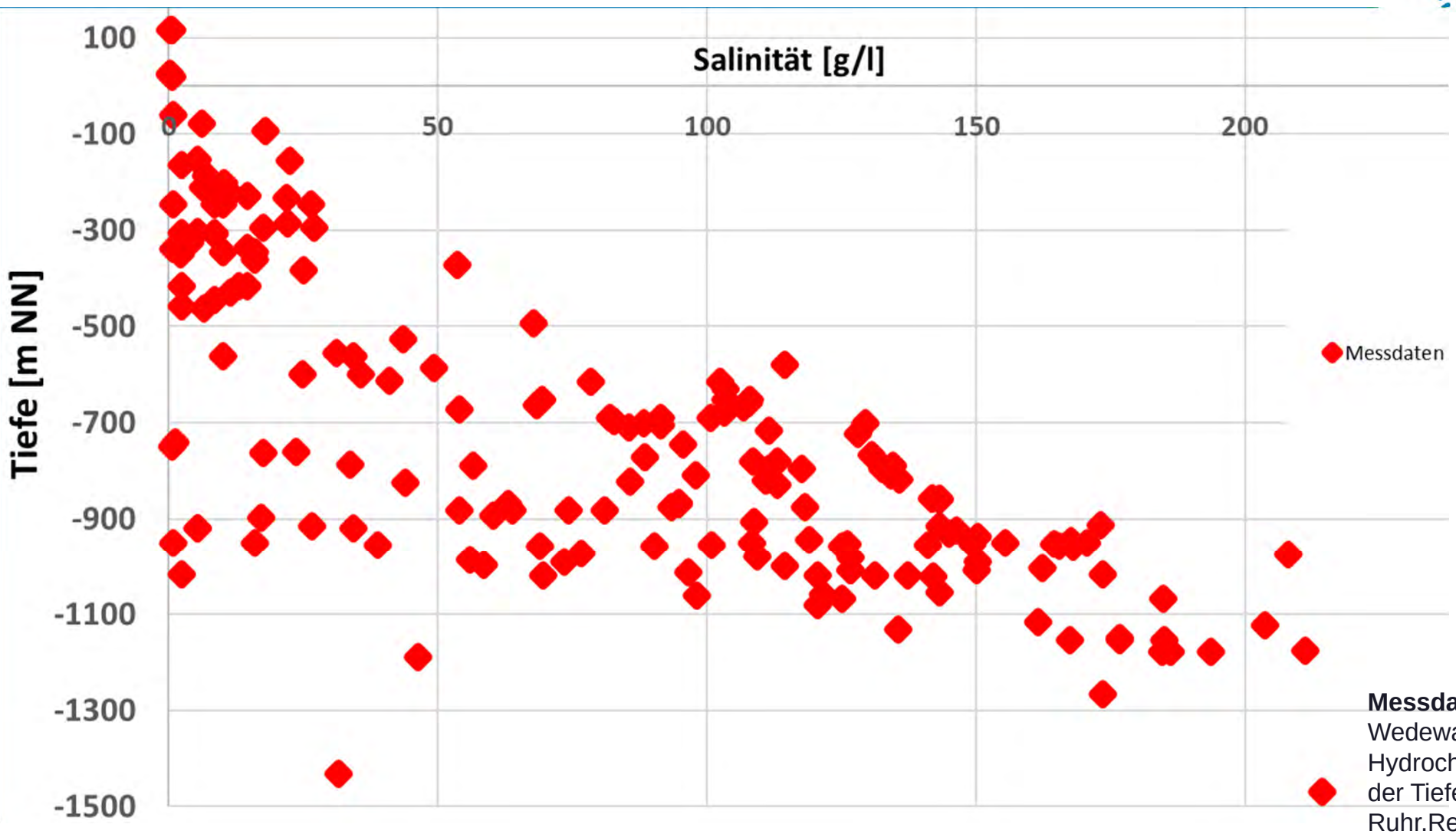


Abbildung 3.2-1: Salinitäten von Tiefenwässer-Proben des Norddeutschen Beckens als Funktion der Tiefe aus 1718 Datensätzen (WOLFGRAMM et al. 2011).

Verschiedene Geothermieprojekte in der „Bochumer Mulde“

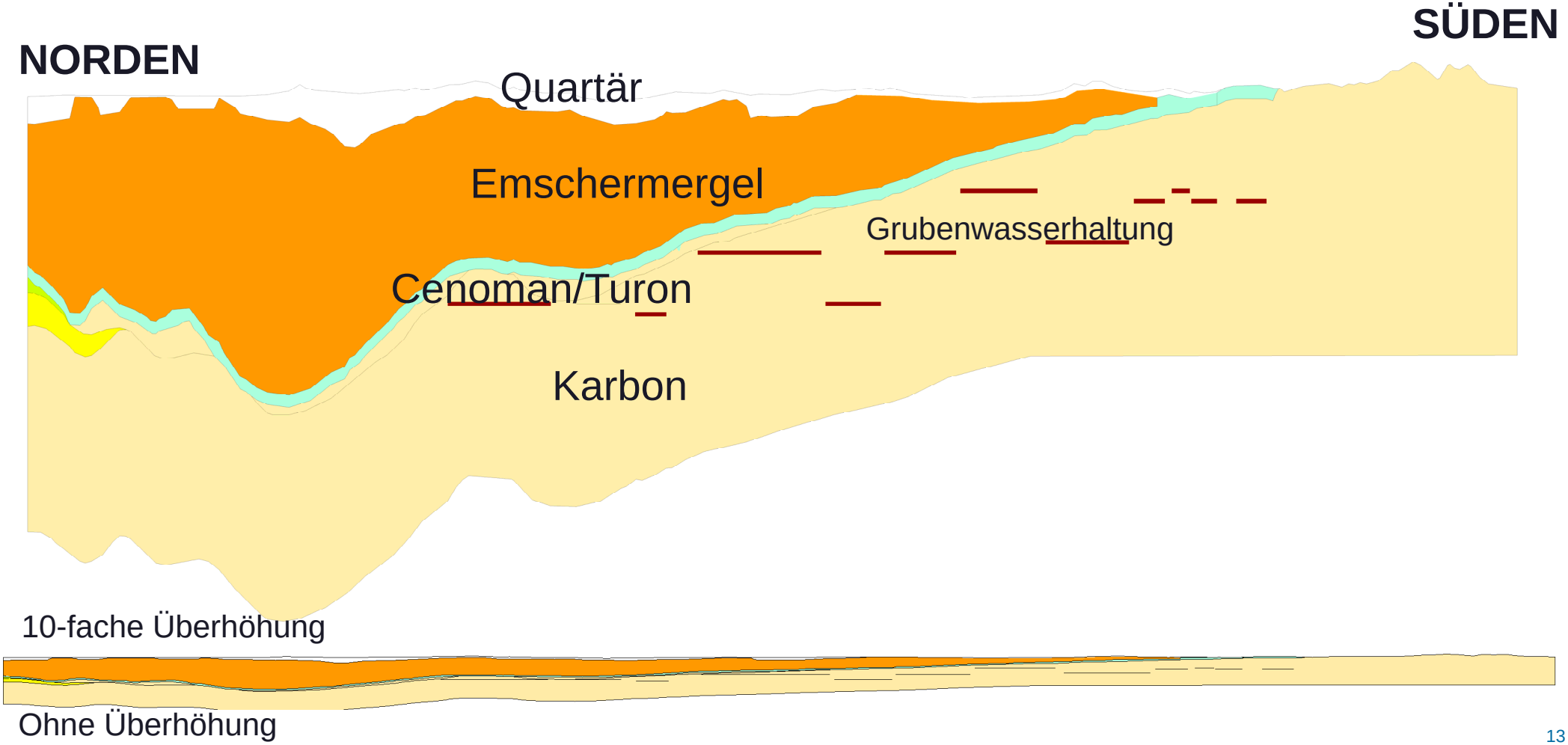


Verteilung der Salinität im Ruhrrevier

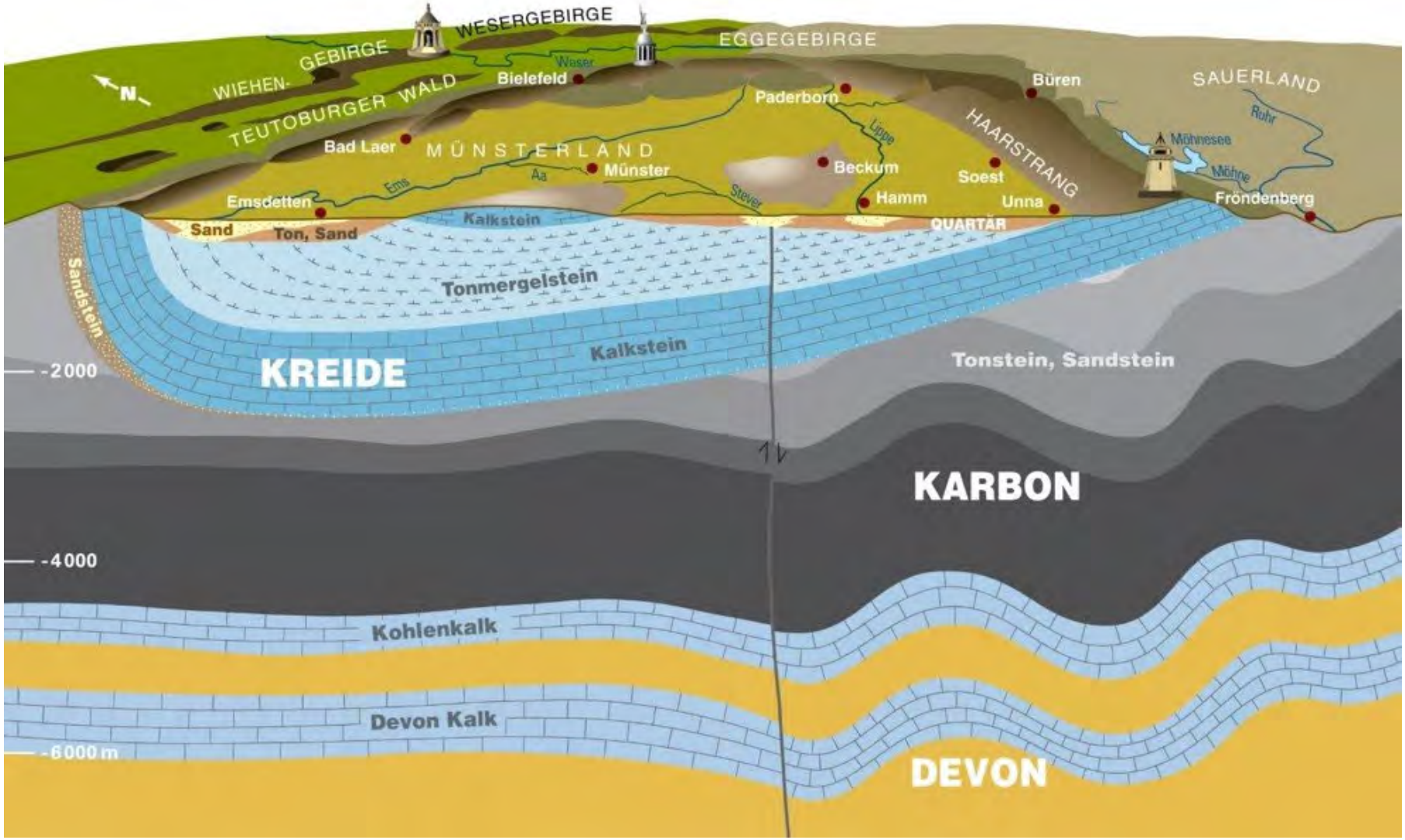


Messdaten aus:
Wedewardt, Marec;
Hydrochemie und Genese der Tiefenwässer im Ruhr.Revier; DMT 1995

Konzeptmodell: Vertikalmodell NORD-SÜD

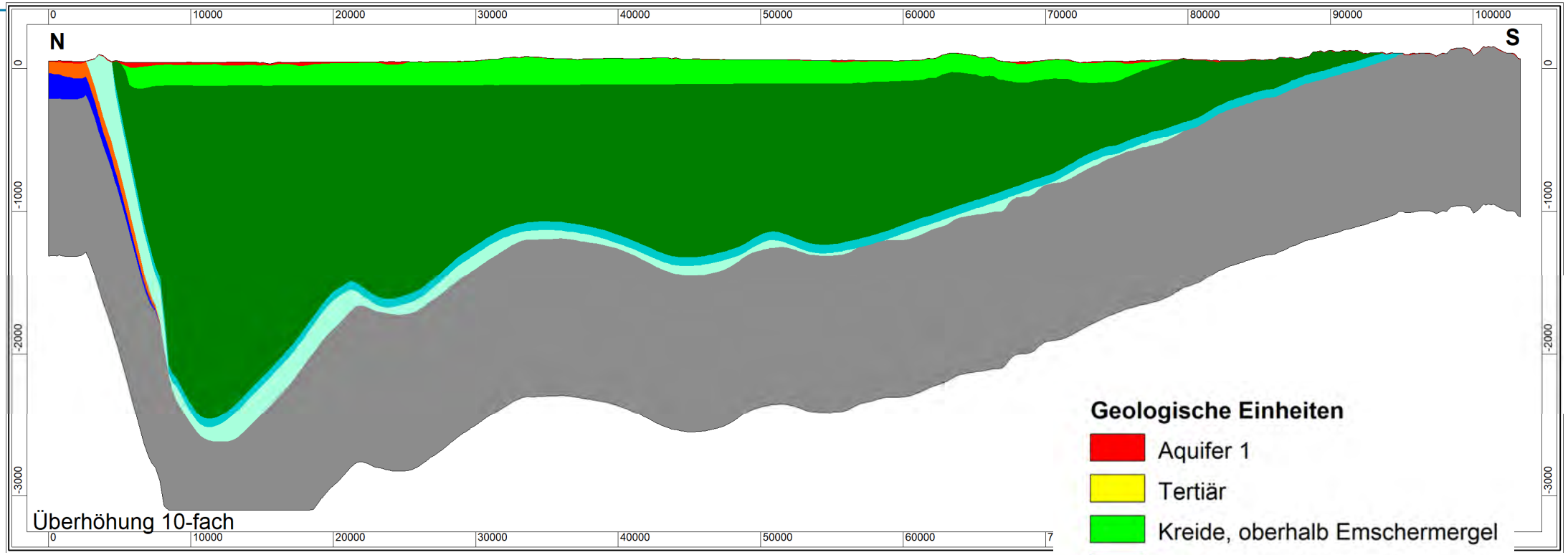


Modellkonzept GD



https://geowaerme.nrw.de/die-geologische-entwicklungsgeschichte-des-muensterlandes

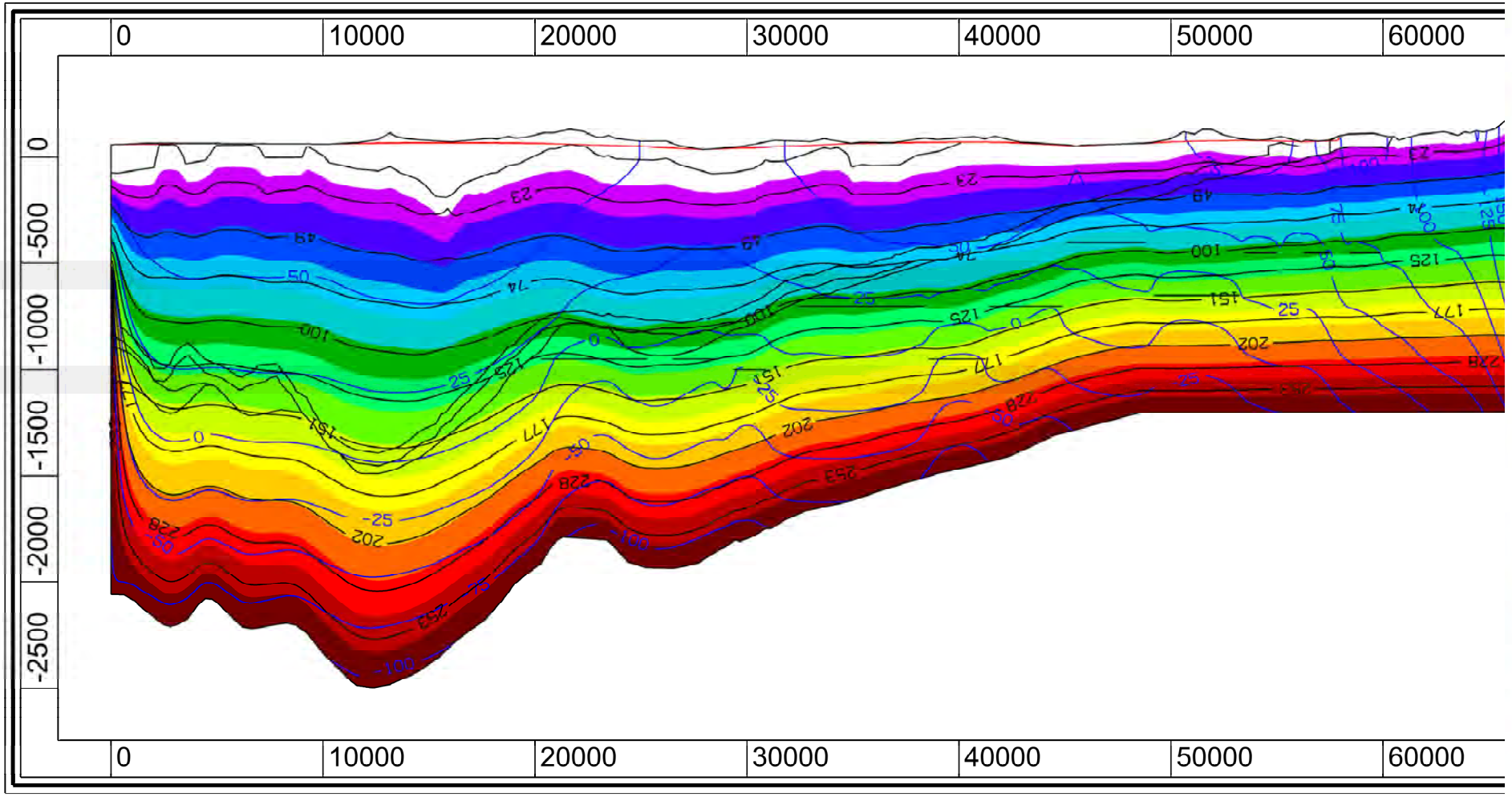
Modelleinheiten (Nord-Süd-Schnitt)



Geologische Einheiten

- Aquifer 1
- Tertiär
- Kreide, oberhalb Emschermergel
- Kreide, Emschermergel
- Kreide, Cenoman/Turon
- Unterkreide
- Buntsandstein
- Zechstein
- Karbon

Stationäre Rechnung: Dichteschichtung vor Bergbau



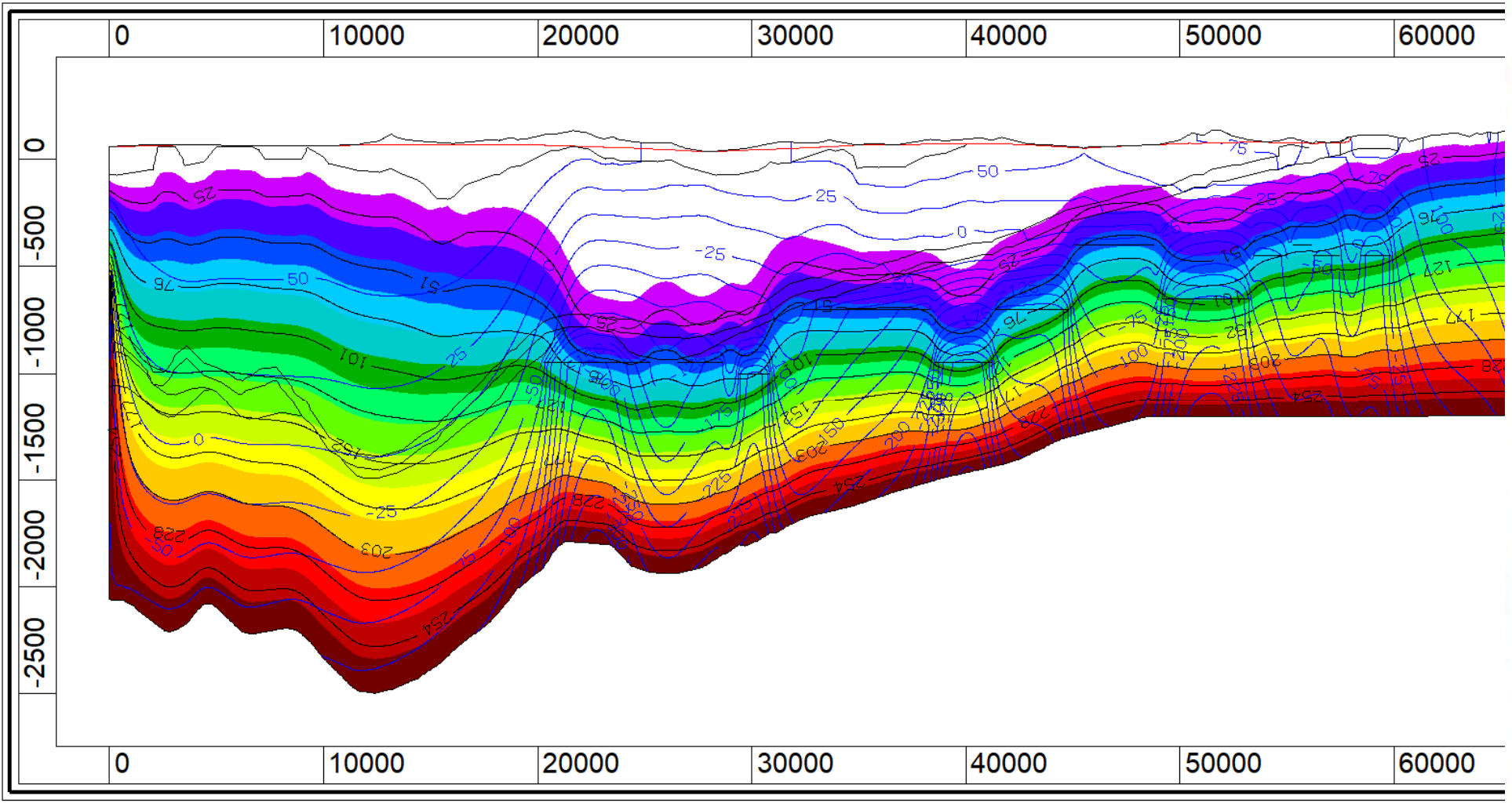
LEGENDE

Dichte (kg/m3)

1010.00	1015.00
1015.00	1020.00
1020.00	1025.00
1025.00	1030.00
1030.00	1035.00
1035.00	1040.00
1040.00	1045.00
1045.00	1050.00
1050.00	1055.00
1055.00	1060.00
1060.00	1065.00
1065.00	1070.00
1070.00	1075.00
1075.00	1080.00
1080.00	1085.00
1085.00	1090.00
1090.00	1095.00
1095.00	1100.00
1100.00	1105.00
1105.00	1110.00
1110.00	1115.00
1115.00	1120.00
1120.00	1125.00
1125.00	1130.00
1130.00	1135.00
1135.00	1140.00
1140.00	1145.00
1145.00	1150.00
1150.00	1155.00
1155.00	1160.00
1160.00	1165.00
1165.00	1170.00

SPRING VERTIKALMODELL Auswertung SITRA+ NACHLAUF

Stationäre Rechnung: Dichteschichtung mit Bergbau

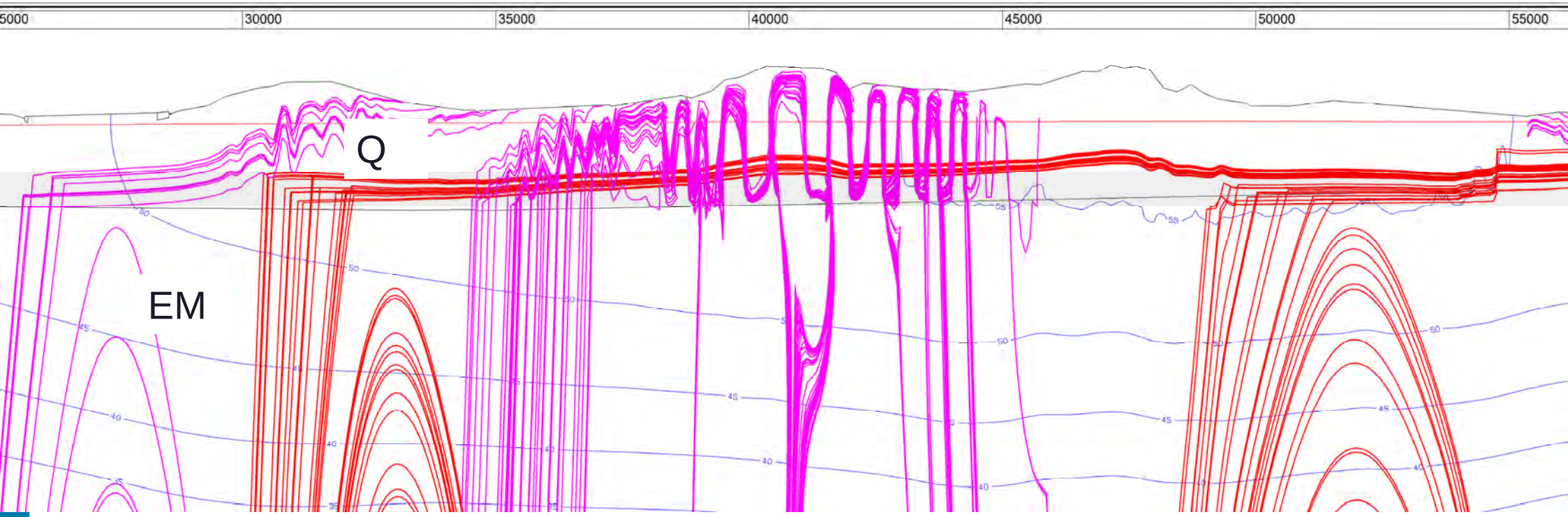


LEGENDE

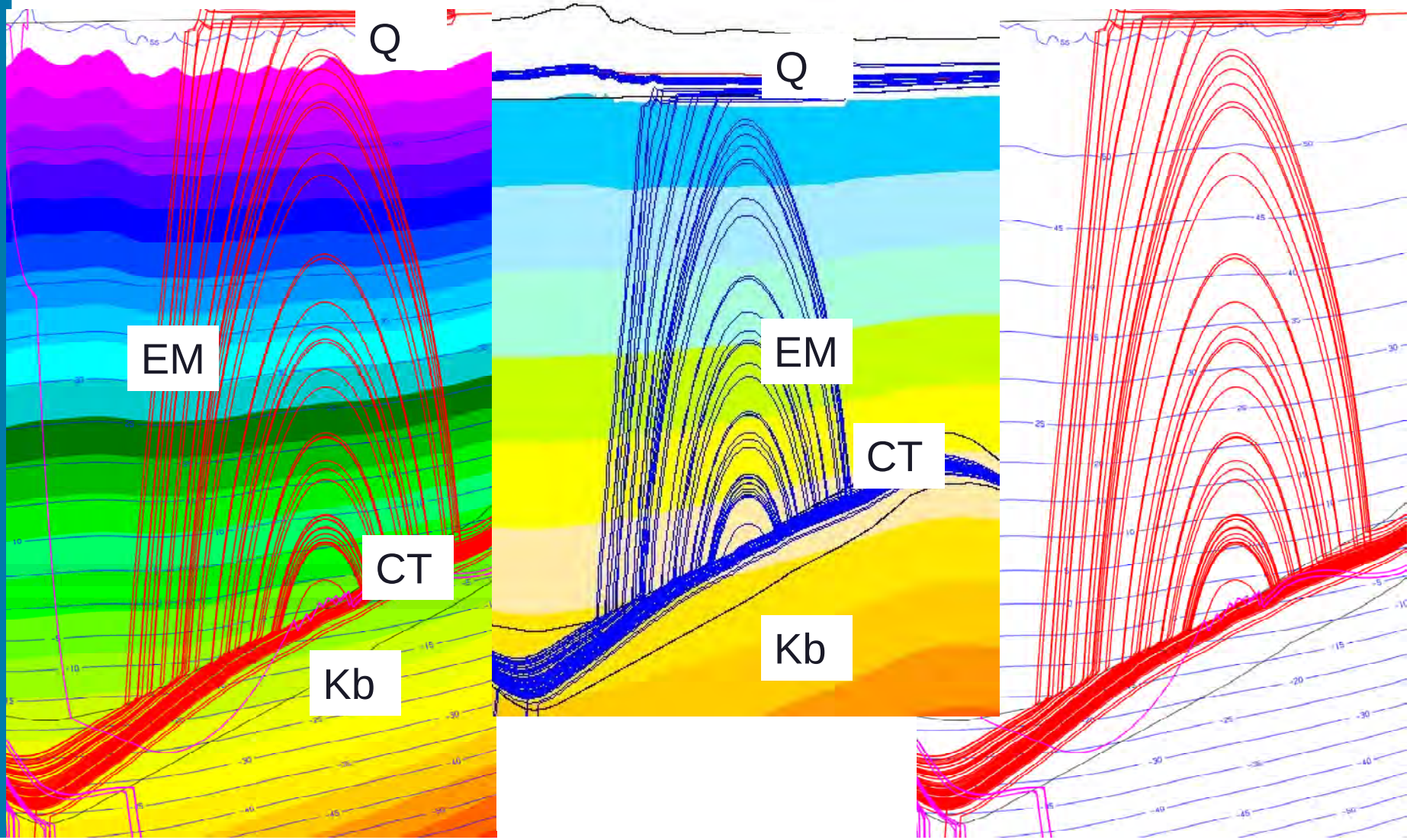
Dichte (kg/m3)

1010.00	1015.00
1015.00	1020.00
1020.00	1025.00
1025.00	1030.00
1030.00	1035.00
1035.00	1040.00
1040.00	1045.00
1045.00	1050.00
1050.00	1055.00
1055.00	1060.00
1060.00	1065.00
1065.00	1070.00
1070.00	1075.00
1075.00	1080.00
1080.00	1085.00
1085.00	1090.00
1090.00	1095.00
1095.00	1100.00
1100.00	1105.00
1105.00	1110.00
1110.00	1115.00
1115.00	1120.00
1120.00	1125.00
1125.00	1130.00
1130.00	1135.00
1135.00	1140.00
1140.00	1145.00
1145.00	1150.00
1150.00	1155.00
1155.00	1160.00
1160.00	1165.00
1165.00	1170.00

Bahnlinen im im stationären Dichtemodell vor Bergbau



Dichteverteilung im stationären Zustand vor Bergbau

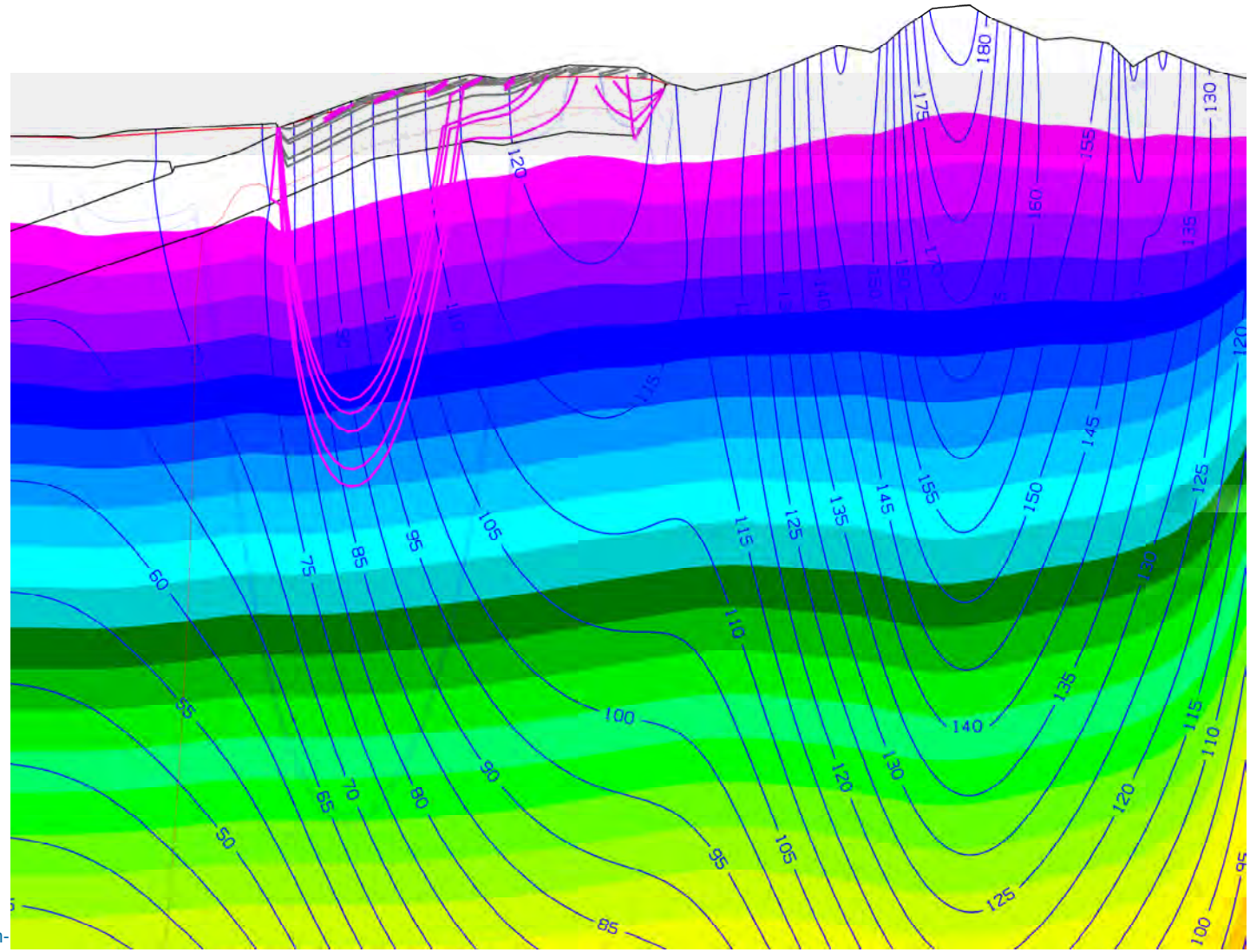


LEGENDE

Dichte (kg/m3)

1010.00	1015.00
1015.00	1020.00
1020.00	1025.00
1025.00	1030.00
1030.00	1035.00
1035.00	1040.00
1040.00	1045.00
1045.00	1050.00
1050.00	1055.00
1055.00	1060.00
1060.00	1065.00
1065.00	1070.00
1070.00	1075.00
1075.00	1080.00
1080.00	1085.00
1085.00	1090.00
1090.00	1095.00
1095.00	1100.00
1100.00	1105.00
1105.00	1110.00
1110.00	1115.00
1115.00	1120.00
1120.00	1125.00
1125.00	1130.00
1130.00	1135.00
1135.00	1140.00
1140.00	1145.00
1145.00	1150.00
1150.00	1155.00
1155.00	1160.00
1160.00	1165.00
1165.00	1170.00

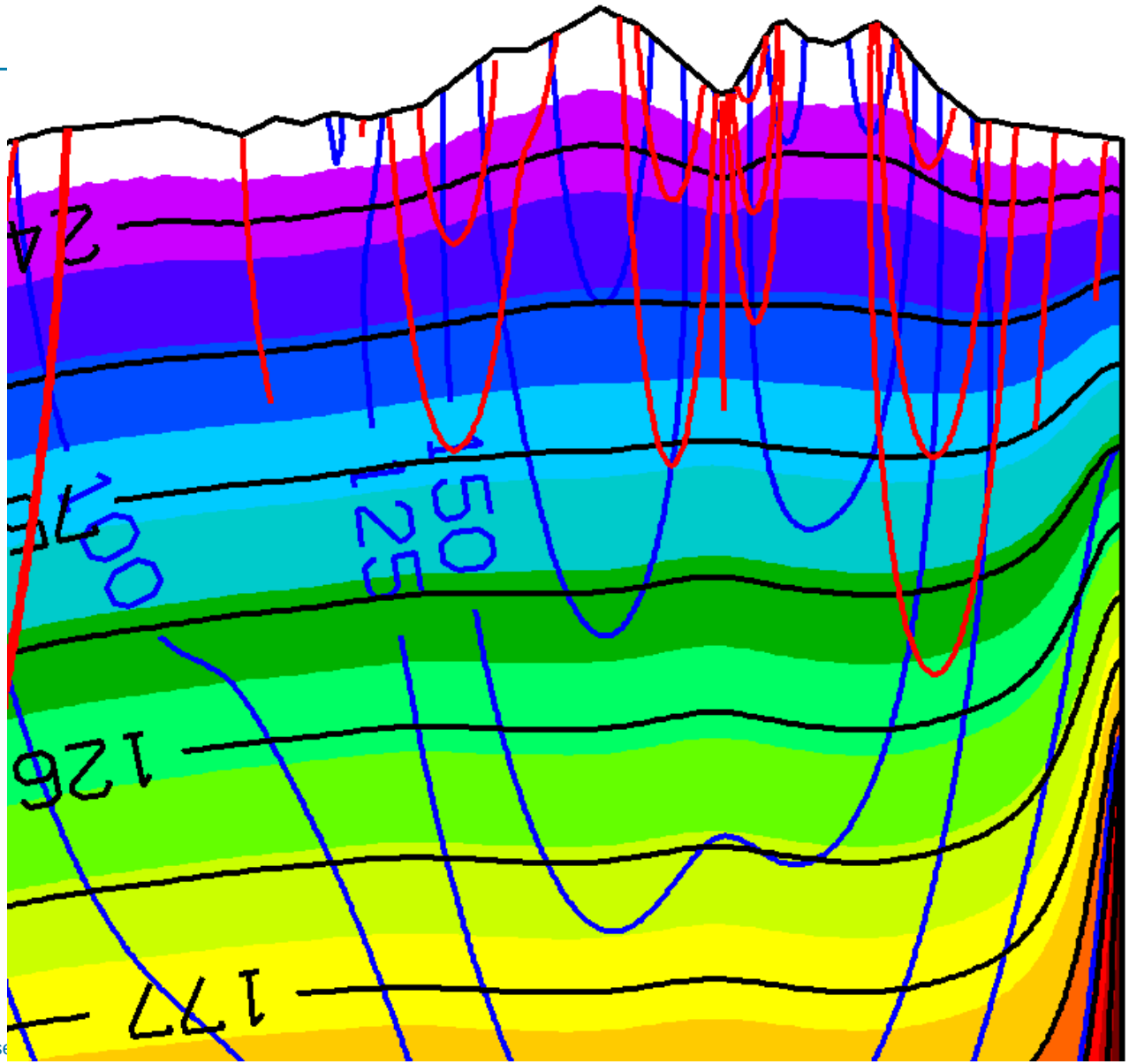
Dichteverteilung im stationären Zustand vor Bergbau - Bahnlinien

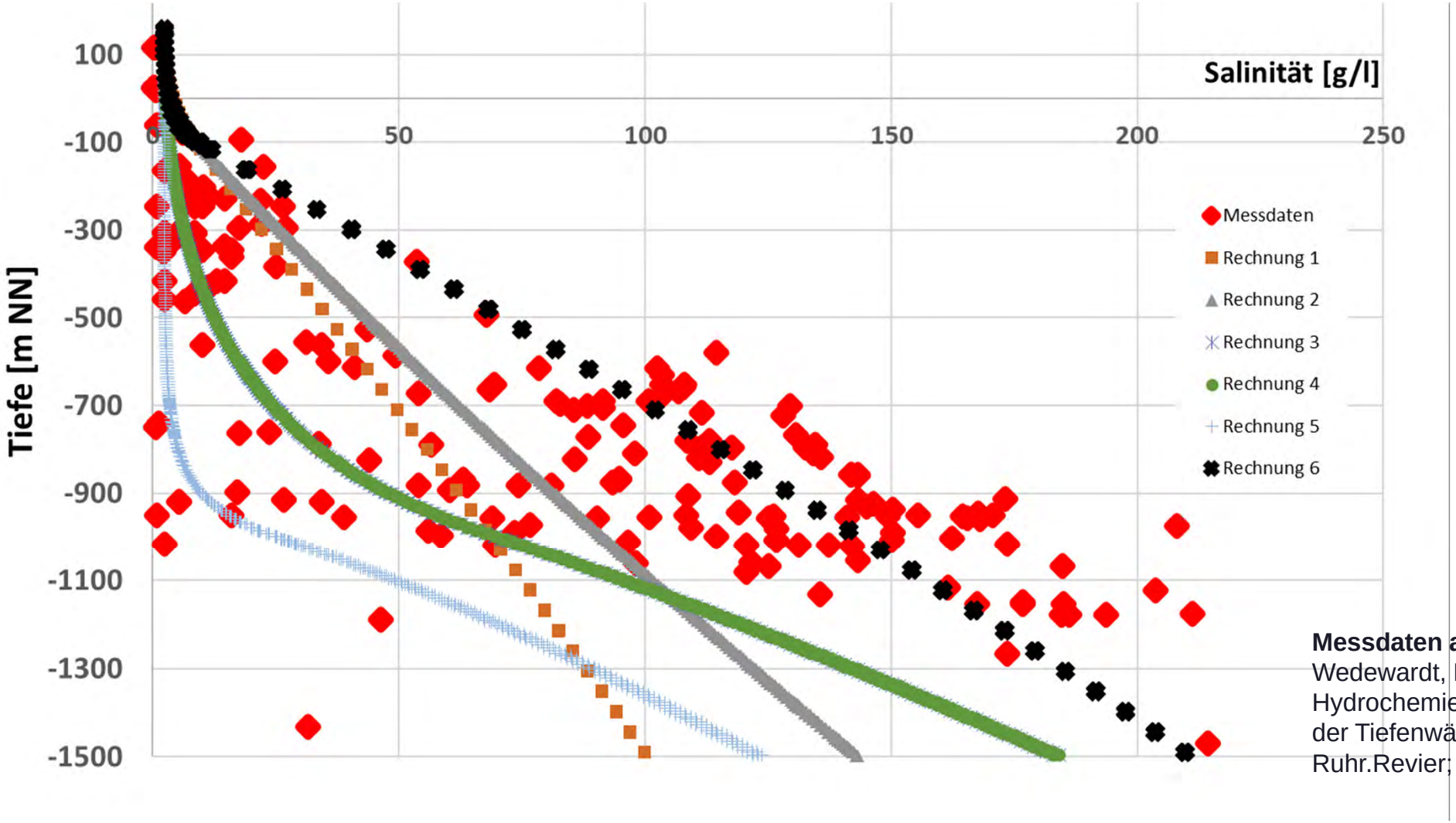


LEGENDE

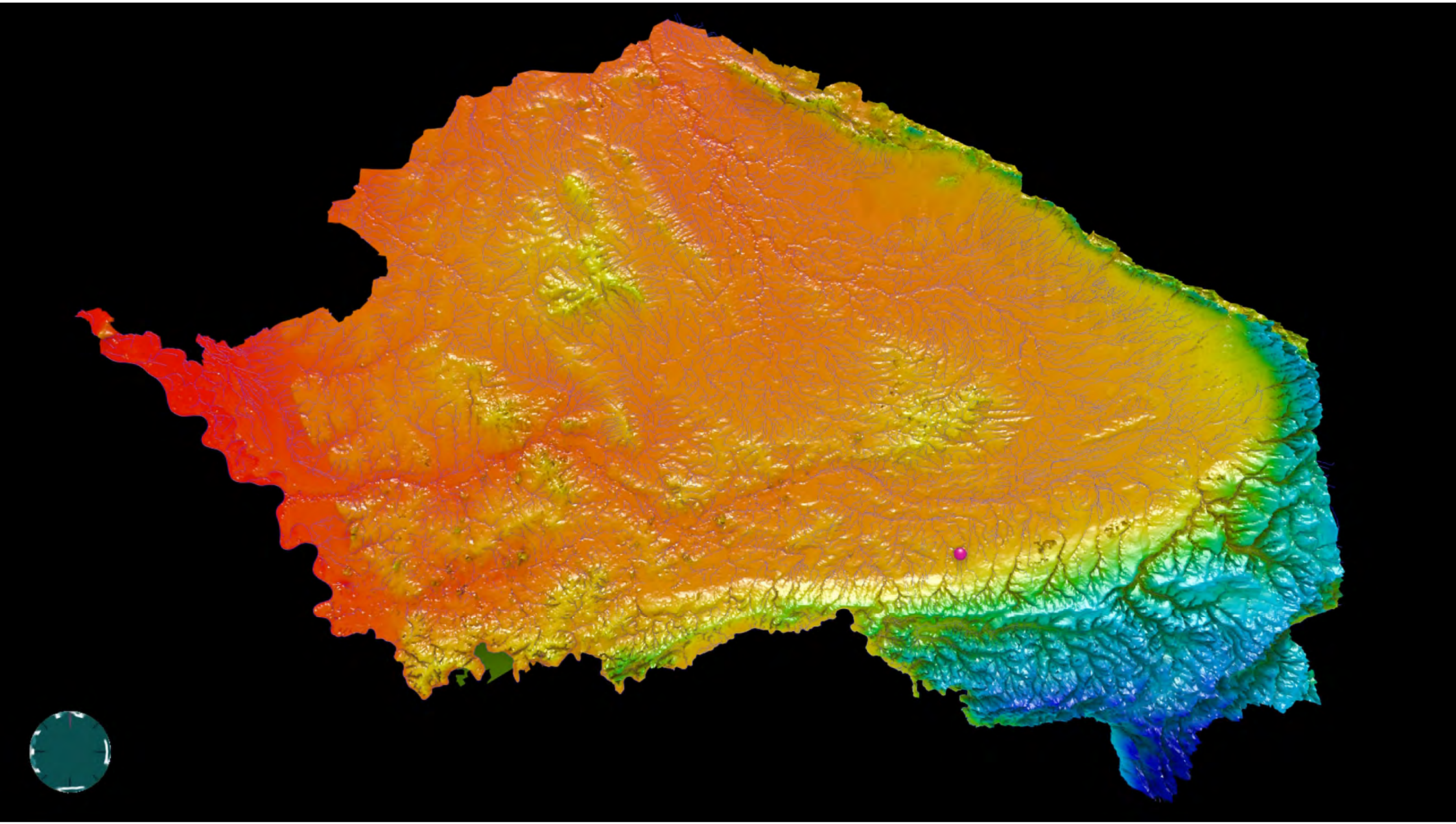
Dichte (kg/m3)

1010.00	1015.00
1015.00	1020.00
1020.00	1025.00
1025.00	1030.00
1030.00	1035.00
1035.00	1040.00
1040.00	1045.00
1045.00	1050.00
1050.00	1055.00
1055.00	1060.00
1060.00	1065.00
1065.00	1070.00
1070.00	1075.00
1075.00	1080.00
1080.00	1085.00
1085.00	1090.00
1090.00	1095.00
1095.00	1100.00
1100.00	1105.00
1105.00	1110.00
1110.00	1115.00
1115.00	1120.00
1120.00	1125.00
1125.00	1130.00
1130.00	1135.00
1135.00	1140.00
1140.00	1145.00
1145.00	1150.00
1150.00	1155.00
1155.00	1160.00
1160.00	1165.00
1165.00	1170.00

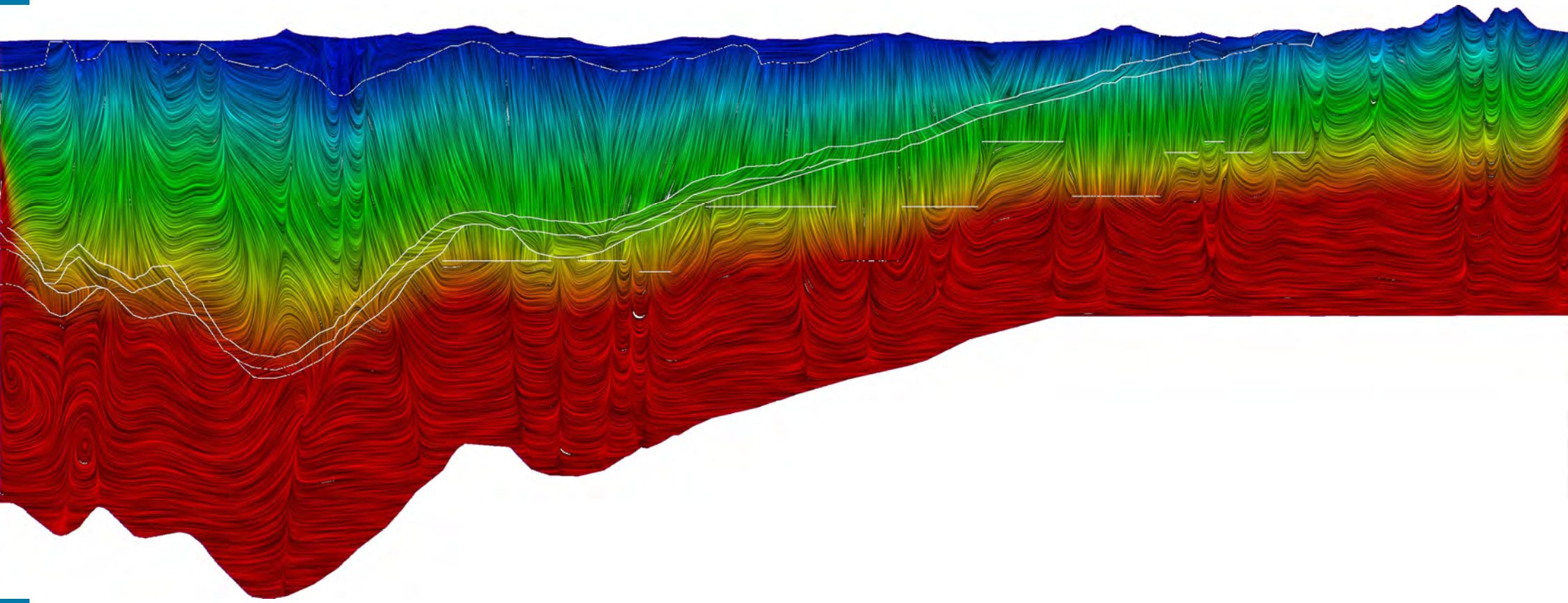
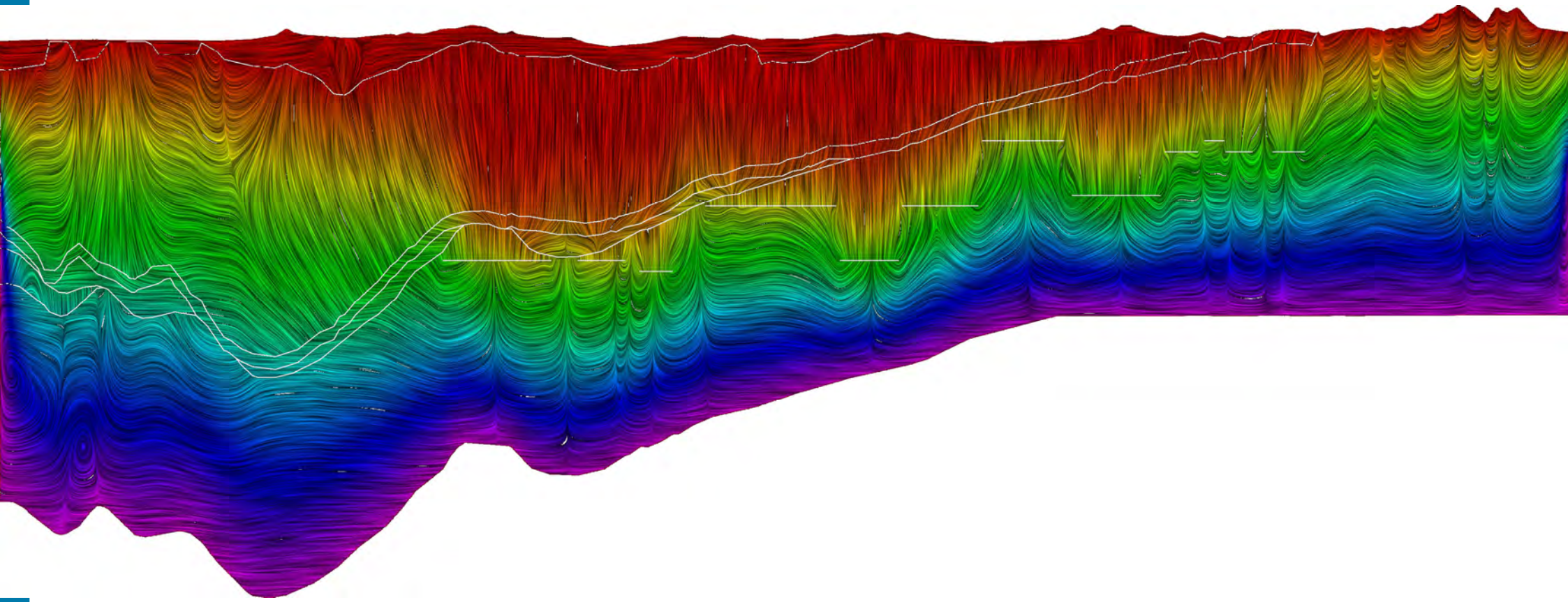

0
-500
-1000



Messdaten aus:
Wedewardt, Marec; Hydrochemie und Genese der Tiefenwässer im Ruhr.Revier; DMT 1995



Salzwasserrechnung



Süßwasserrechnung