

Flow transport in sedimentary basins

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1. Introduction: Hydrologic Regimes

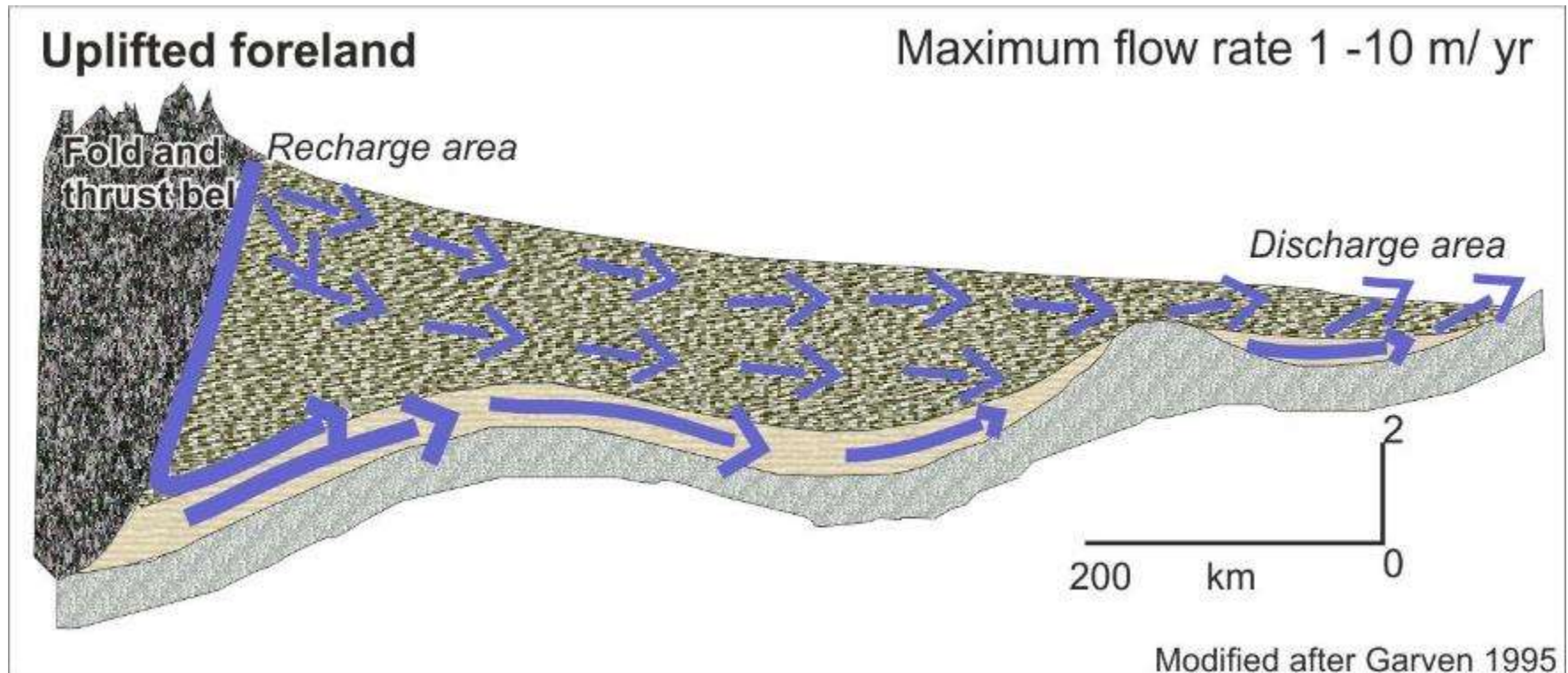
2. Governing equations - Stability criterias

3. Modeling Examples:

- The North East German Basin
- The Seferihisar-Balcova Geothermal System, Turkey

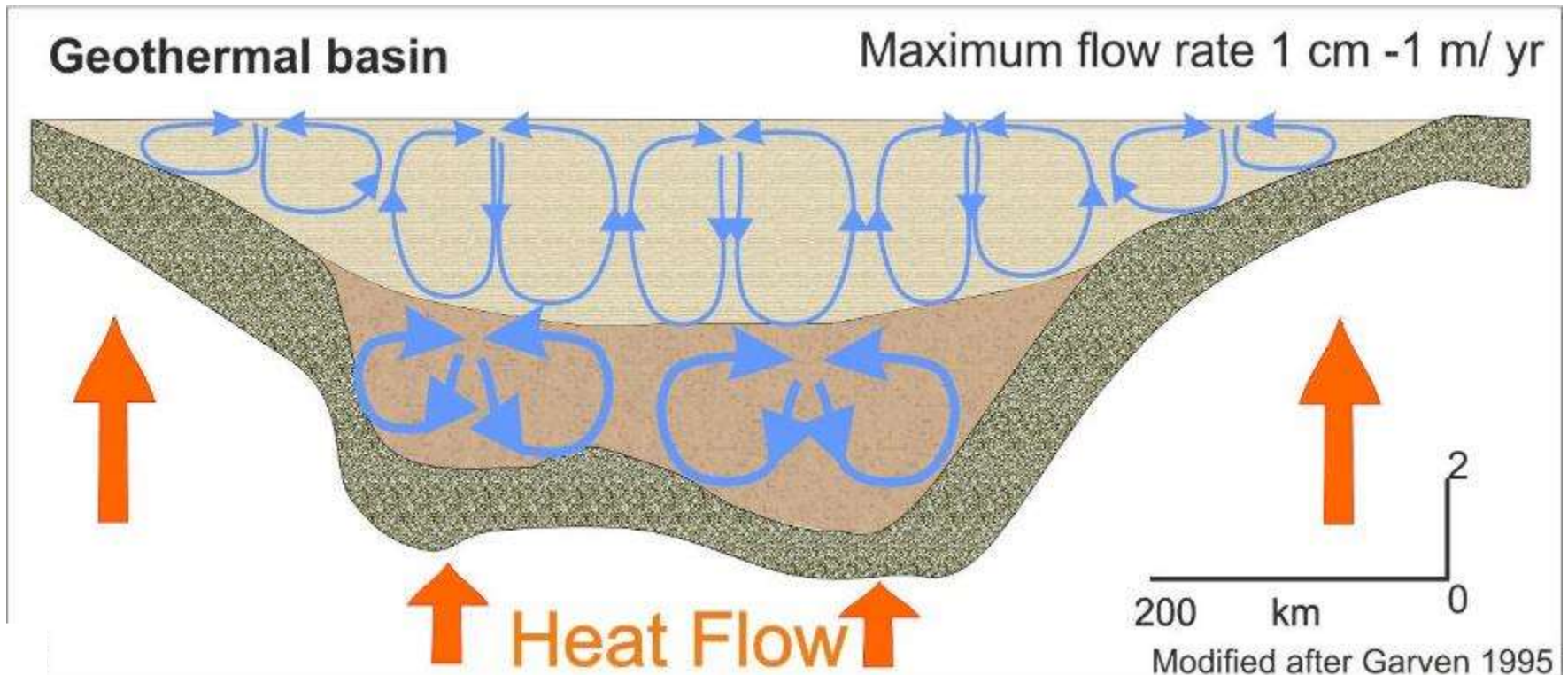
Hydrologic regimes

Topography driven flow (i.e regional flow)



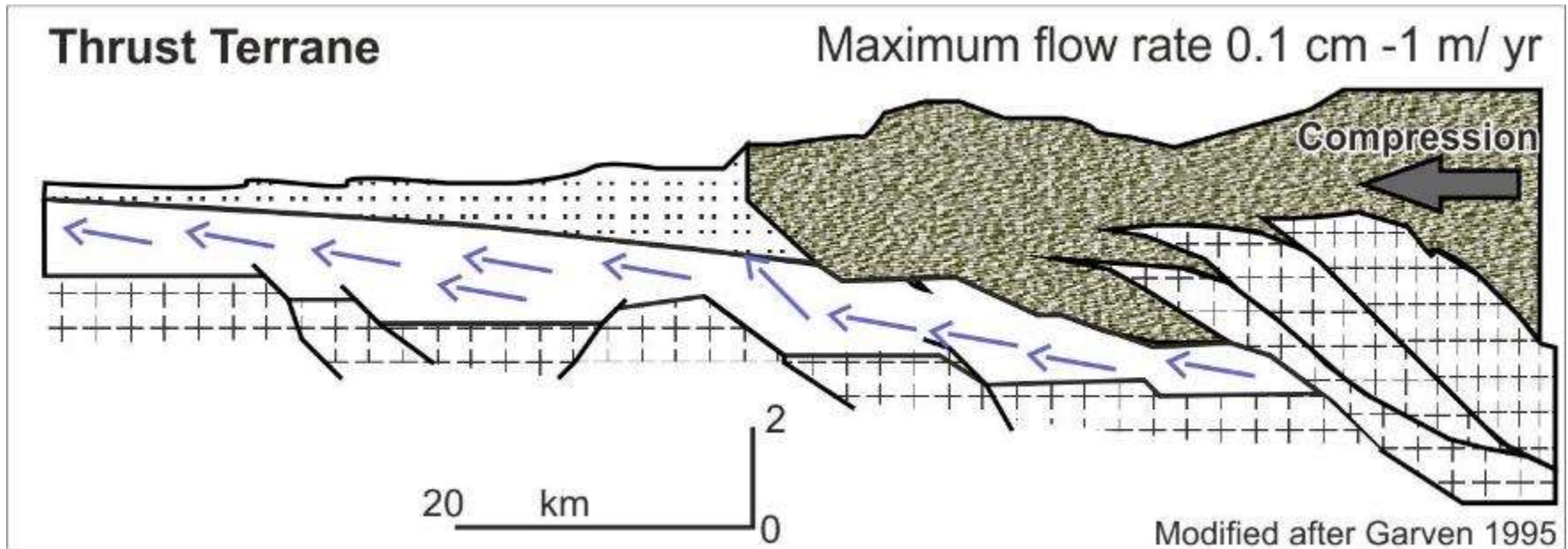
Hydrologic regimes

Thermally driven convection



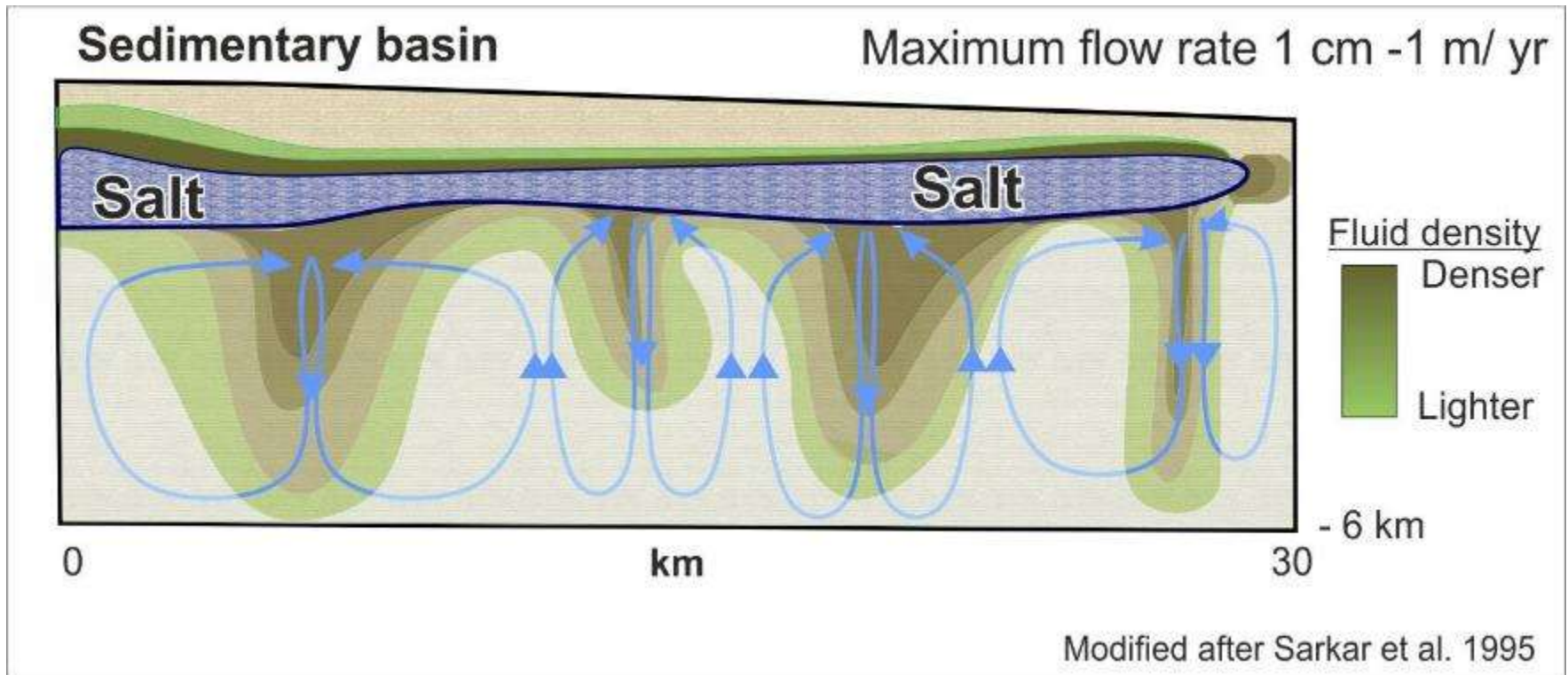
Hydrologic regimes

Tectonically driven flow



Hydrologic regimes

Density-driven flow (here mass is dissolved halite)



Other Hydrologic regimes

- **Overpressure during compaction**
 - **Seismic pumping**

Hydrologic regimes

IMPORTANT REMARK

IN NATURE THESE REGIMES OFTEN OCCUR TOGETHER:

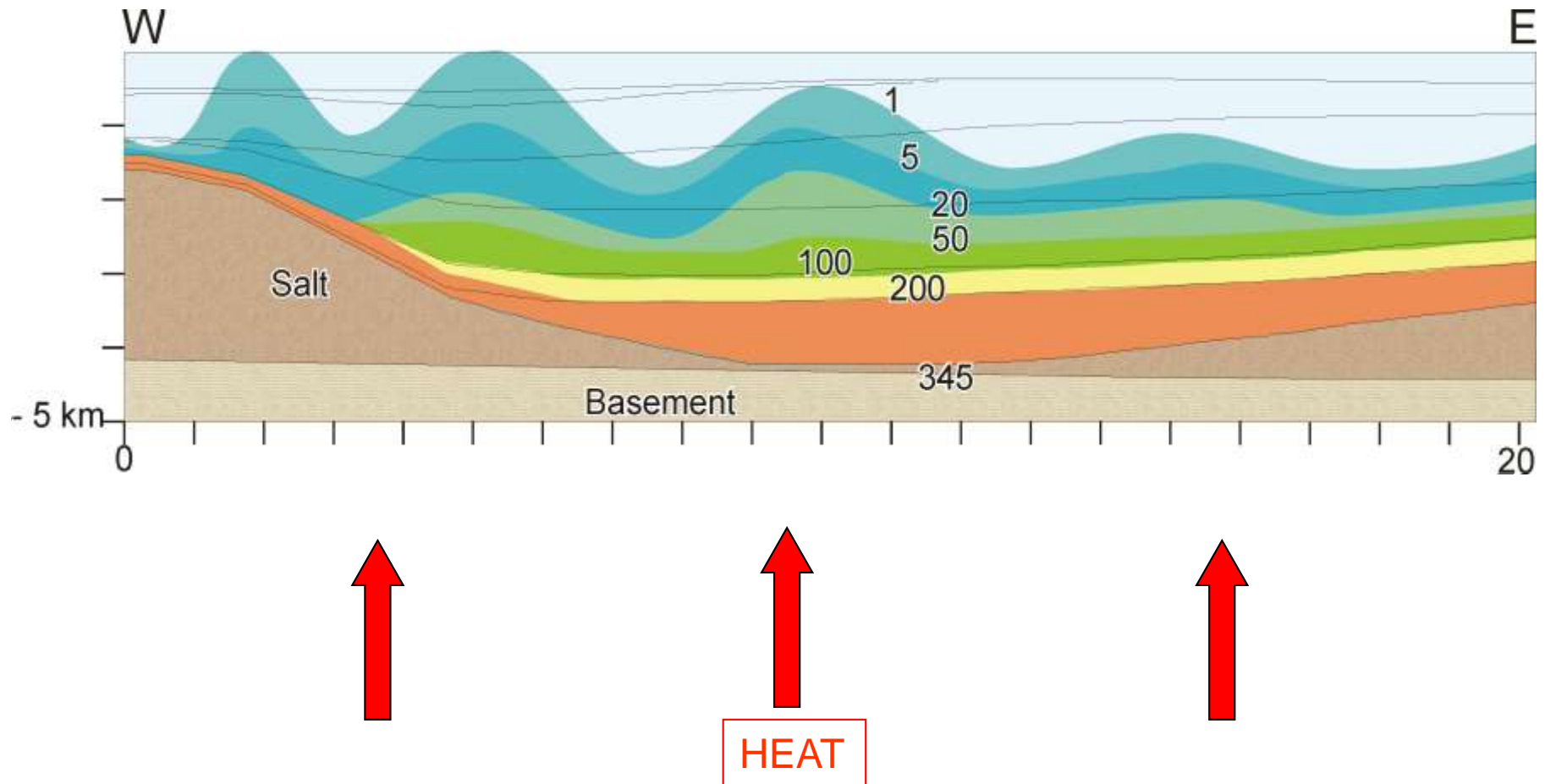
THEY CANNOT ALWAYS BE OBSERVED SEPARATELY

TRANSPORT PROCESSES IN SEDIMENTARY BASINS ARE

COUPLED

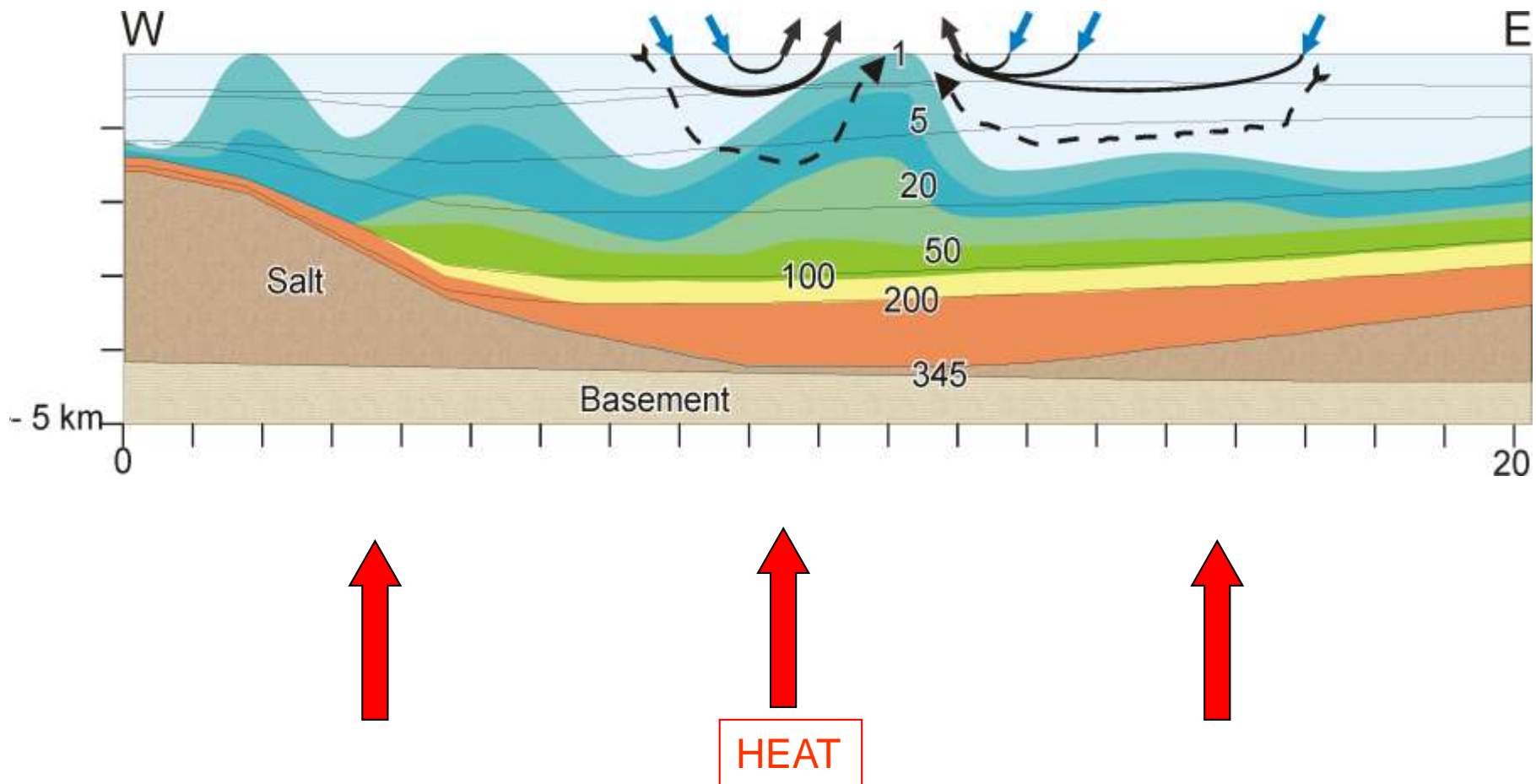
Hydrologic regimes

Thermohaline convection (temperature + halite)



Hydrologic regimes

Mixed convection (Thermohaline + regional flow):



Governing equations

$$S_0 \frac{\partial \varphi}{\partial t} + \text{div}(\mathbf{q}) = 0$$

$$\mathbf{q} = -\mathbf{K} \left(\text{grad}(\varphi) + \frac{\rho_f - \rho_{0f}}{\rho_{0f}} \right)$$

$$\frac{\partial \phi C}{\partial t} + \text{div}(\mathbf{q}C) - \text{div}(\mathbf{D} \text{grad}(C)) = Q_C$$

$$\frac{\partial}{\partial t} \left((\phi \rho_f c_f + (1 - \phi) \rho_s c_s) T \right) + \text{div}(\rho_f c_f T \mathbf{q}) - \text{div}(\lambda \text{grad}(T)) = Q^T$$

COUPLING $q=q(\varphi, C, T)$???

Governing equations

Coupling

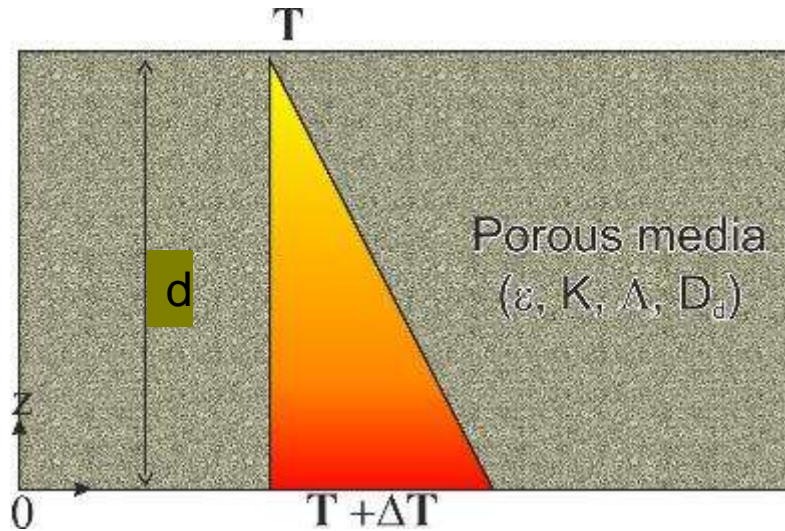
$$\mathbf{K} = \frac{\mathbf{k}\rho_{0f}g}{\mu_f(C,T)}$$

$$\rho^f = \rho_0^f \left(1 - \bar{\beta}(T,p)(T - T_0) + \bar{\gamma}(T,p)(p - p_0) + \frac{\bar{\alpha}}{C_{sat} - C_0} (C - C_0) \right)$$

$$\bar{\alpha} = \frac{\rho_{sat}^f - \rho_0^f}{\rho_0^f}$$

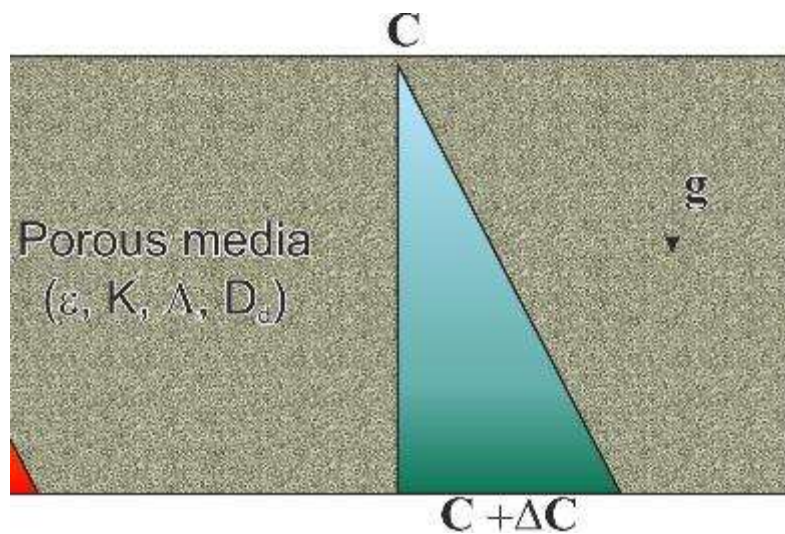
Governing equations

Stability criteria



Thermal Rayleigh number

$$Ra_T = \frac{K \bar{\beta} \Delta T d}{\Lambda}$$

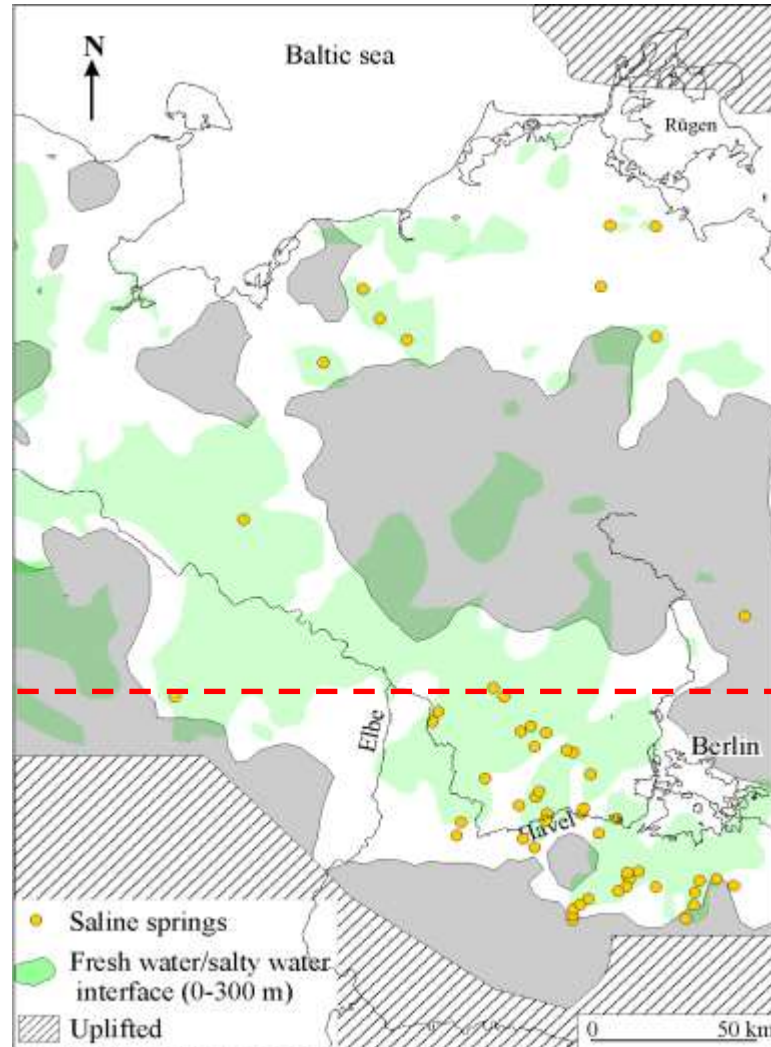


Solutal Rayleigh number

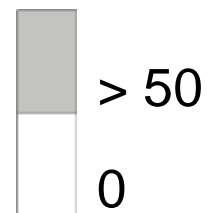
$$Ra_s = \frac{\bar{\alpha} K \Delta C d}{\epsilon D_d (C_{sat} - C_0)}$$

Modeling Examples

The North East German Basin (NEGB)

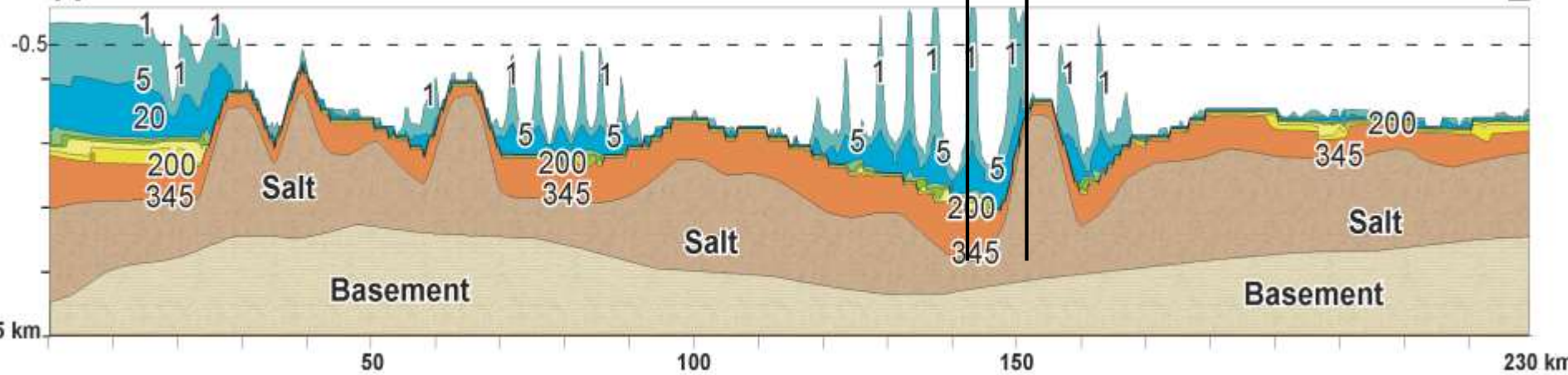


Elevation (m)

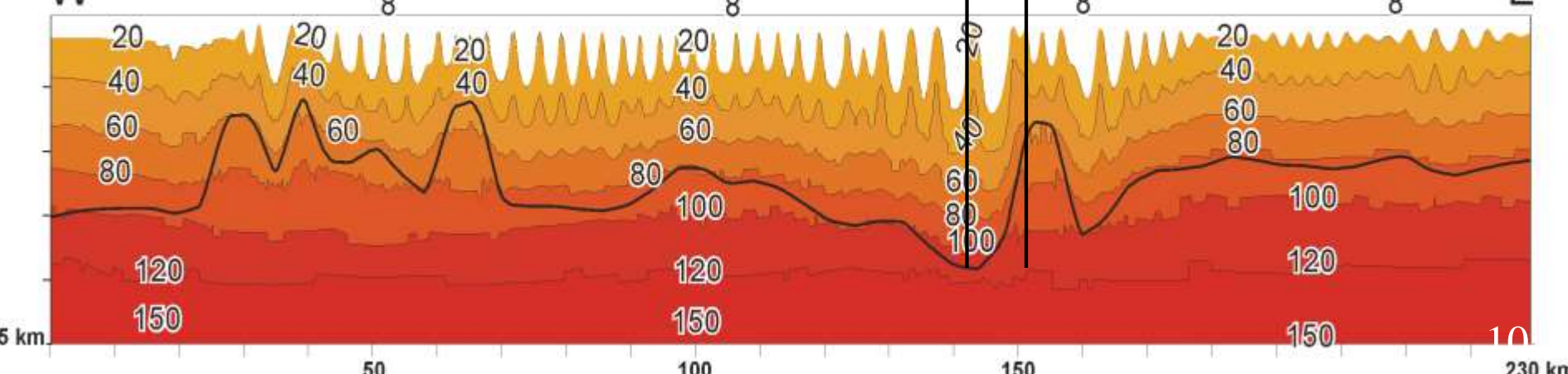


The North East German Basin (NEGB) Magri et al. (2002-2009)

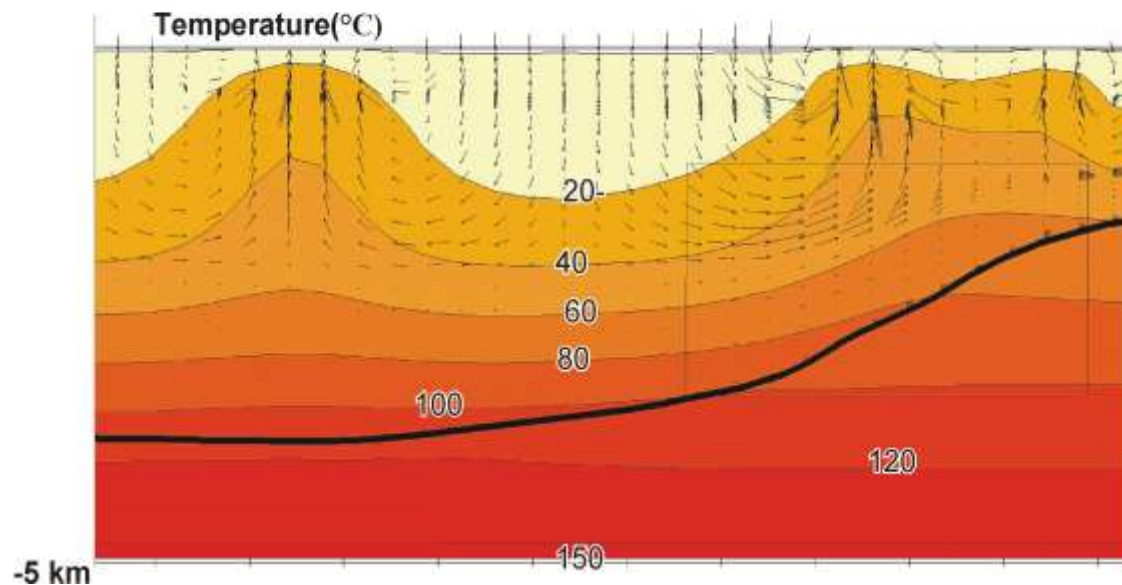
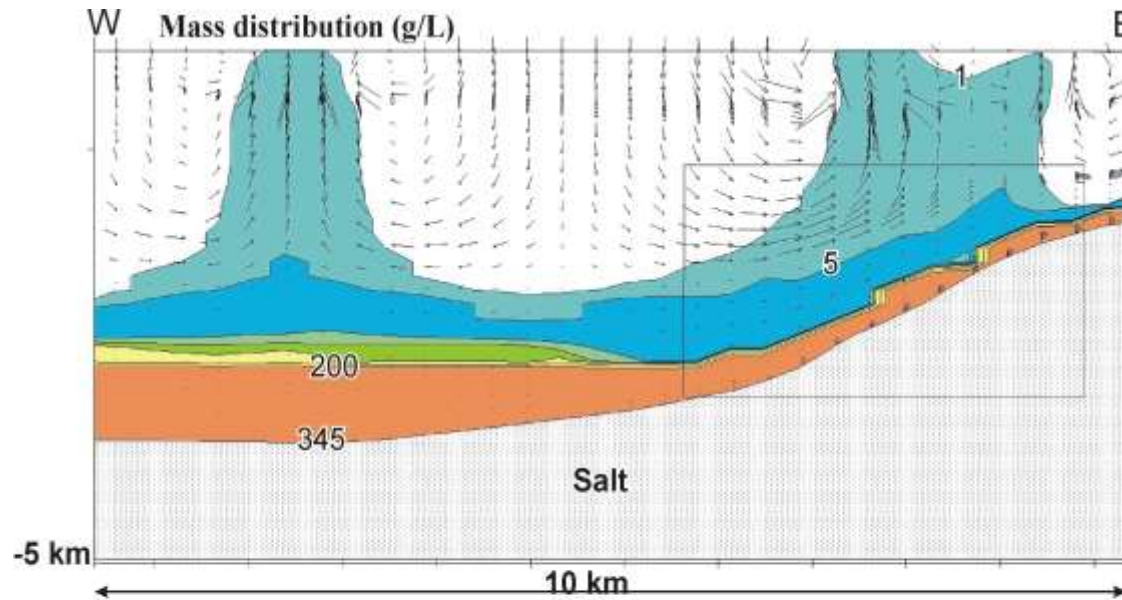
W Mass distribution (g/L) at t = 200 ka E



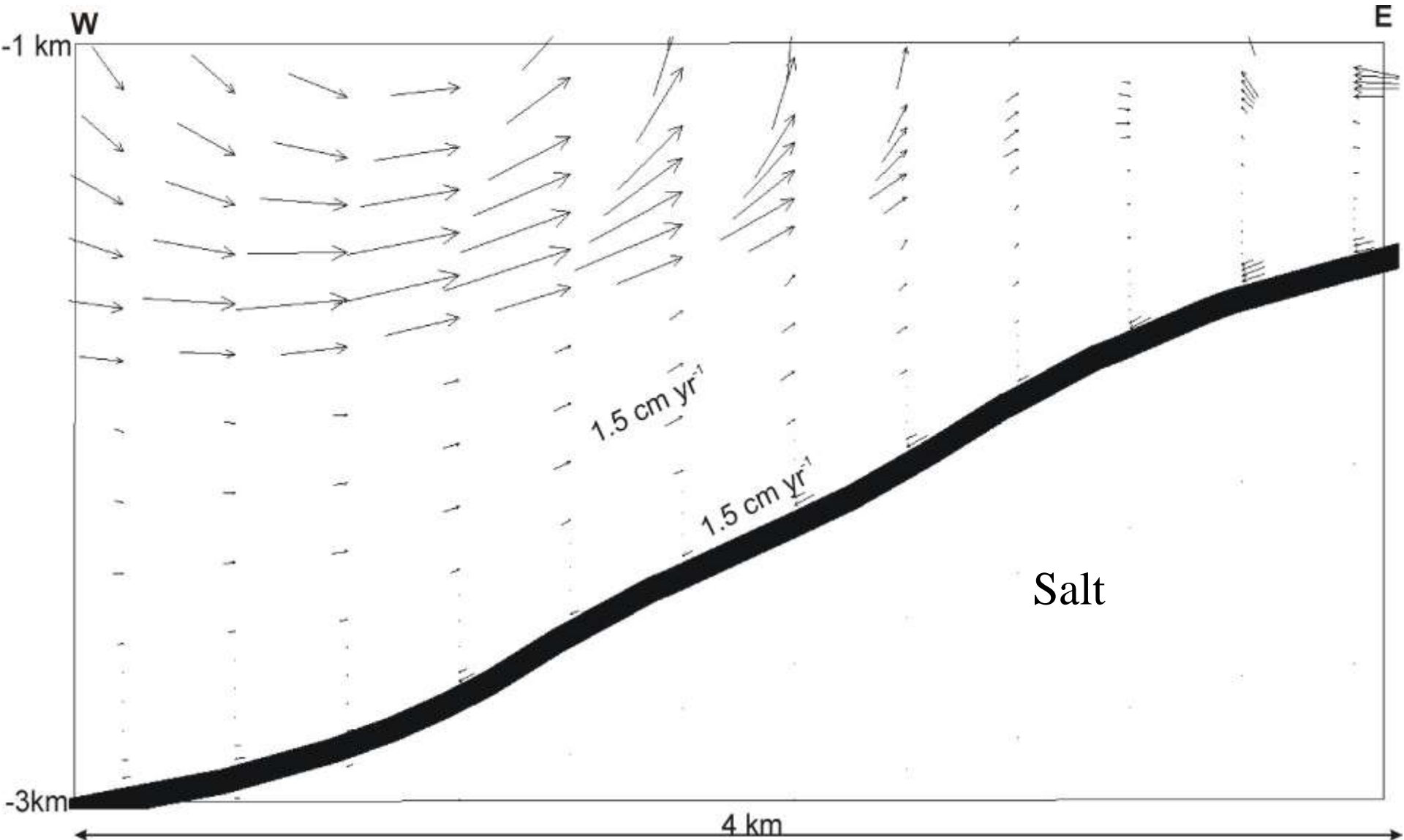
W Temperature profile (°C) at t = 200 ka E



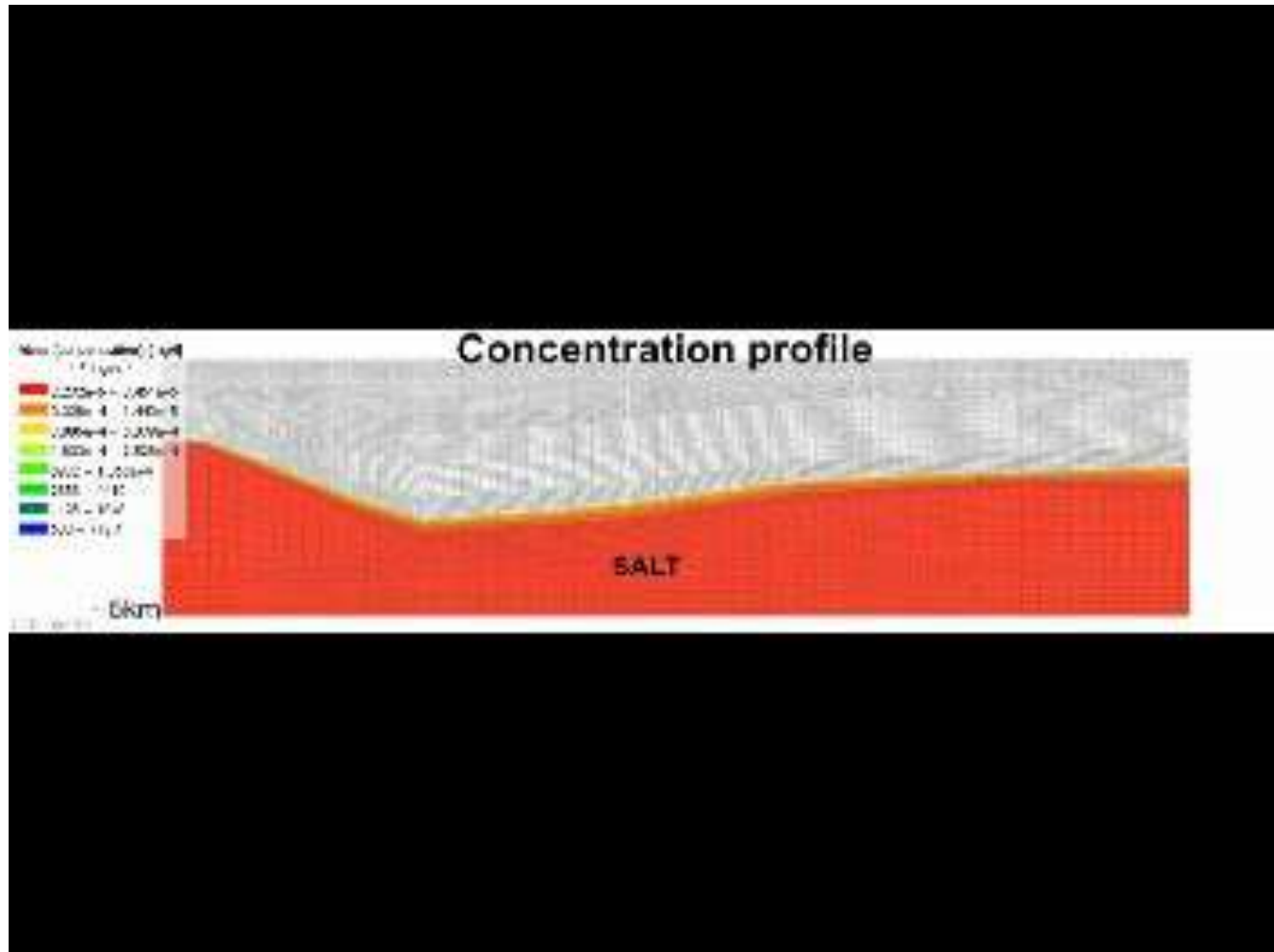
The North East German Basin (NEGB)



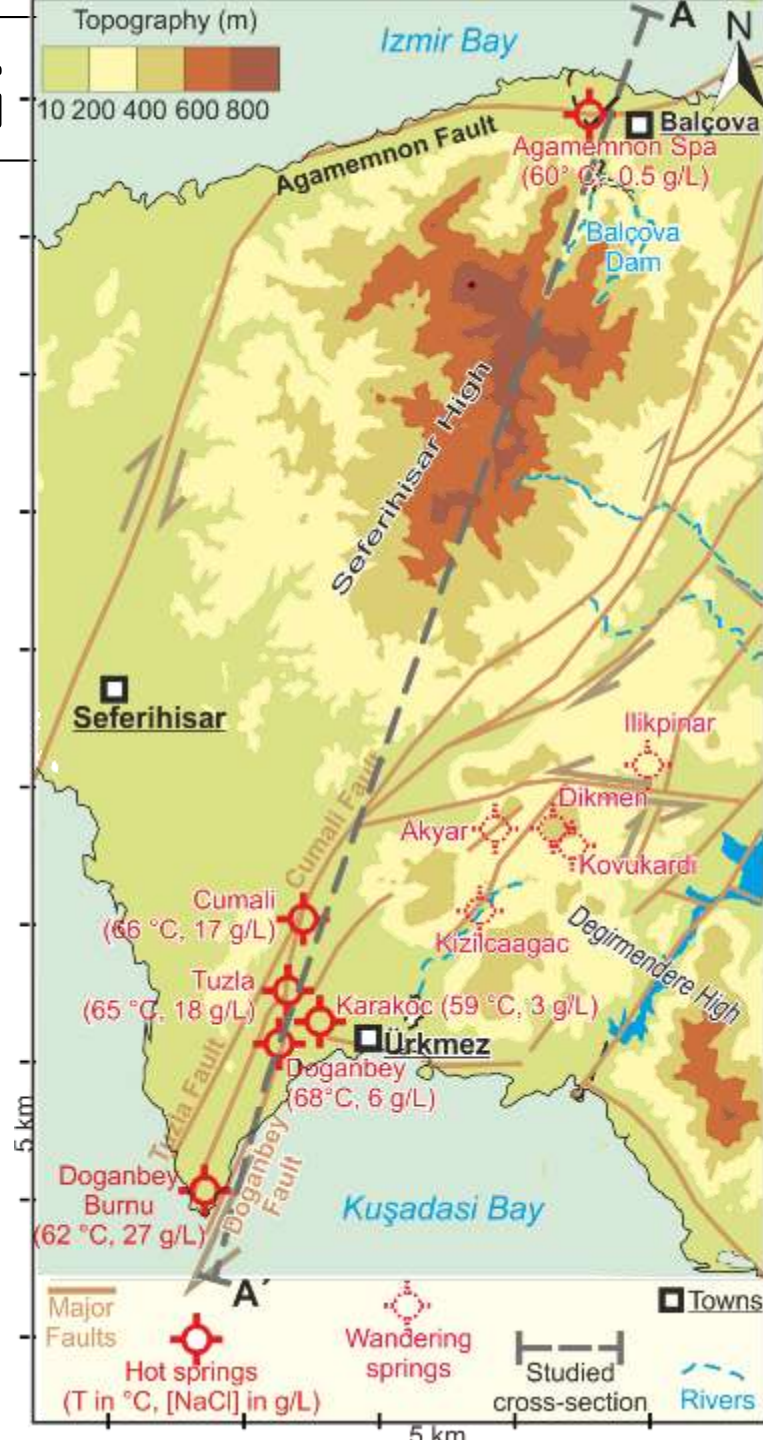
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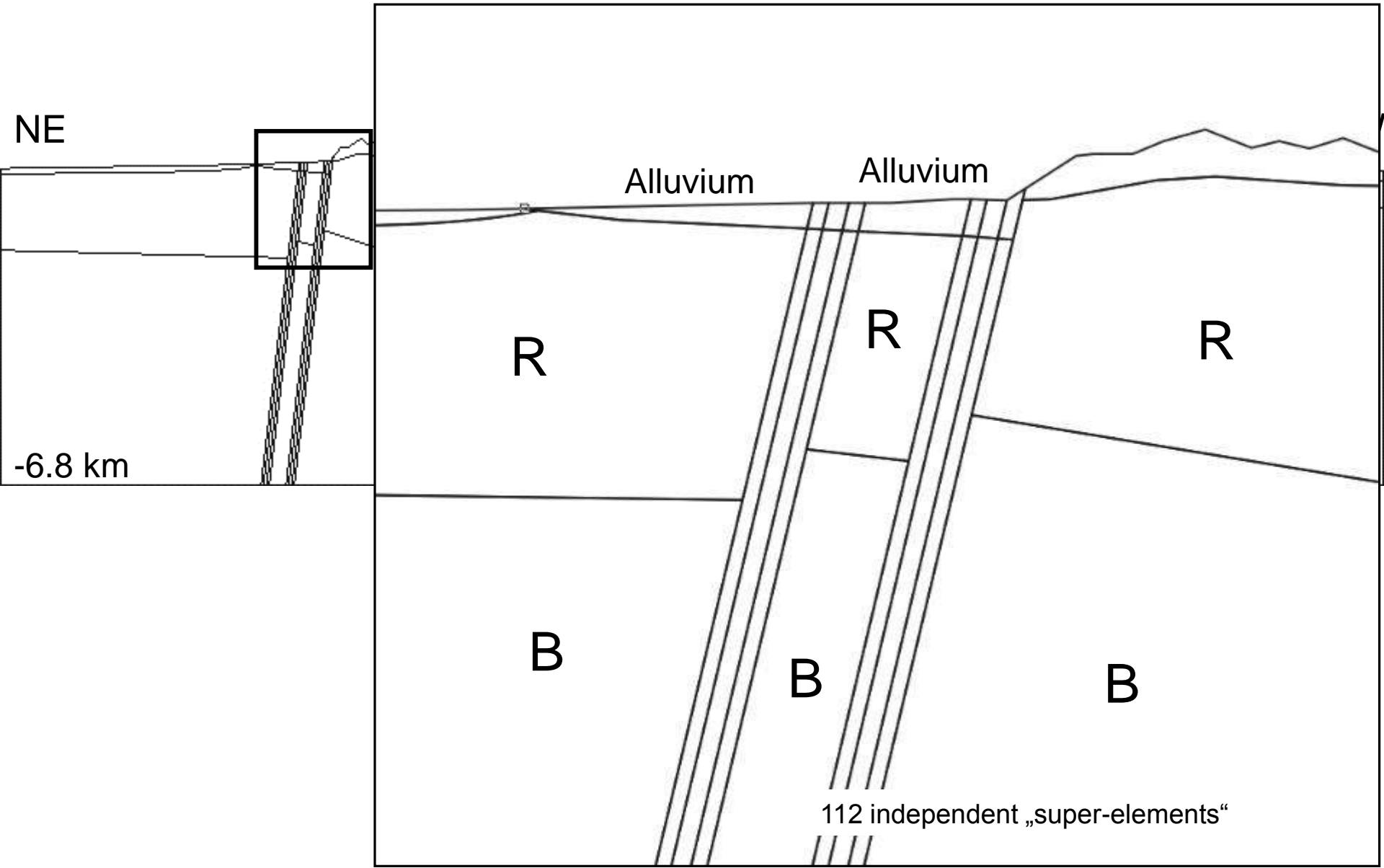
The North East German Basin (NEGB)



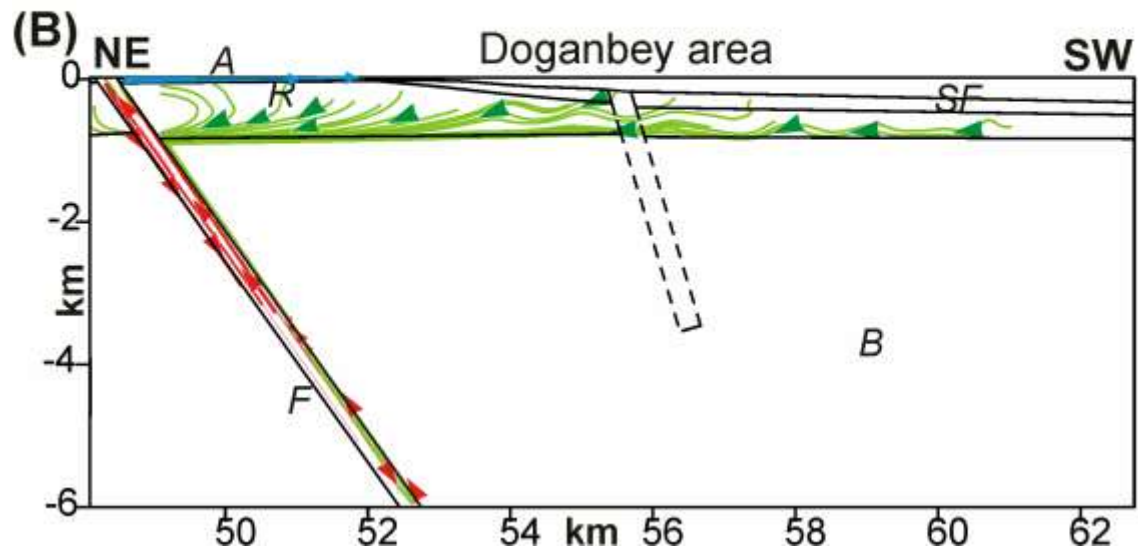
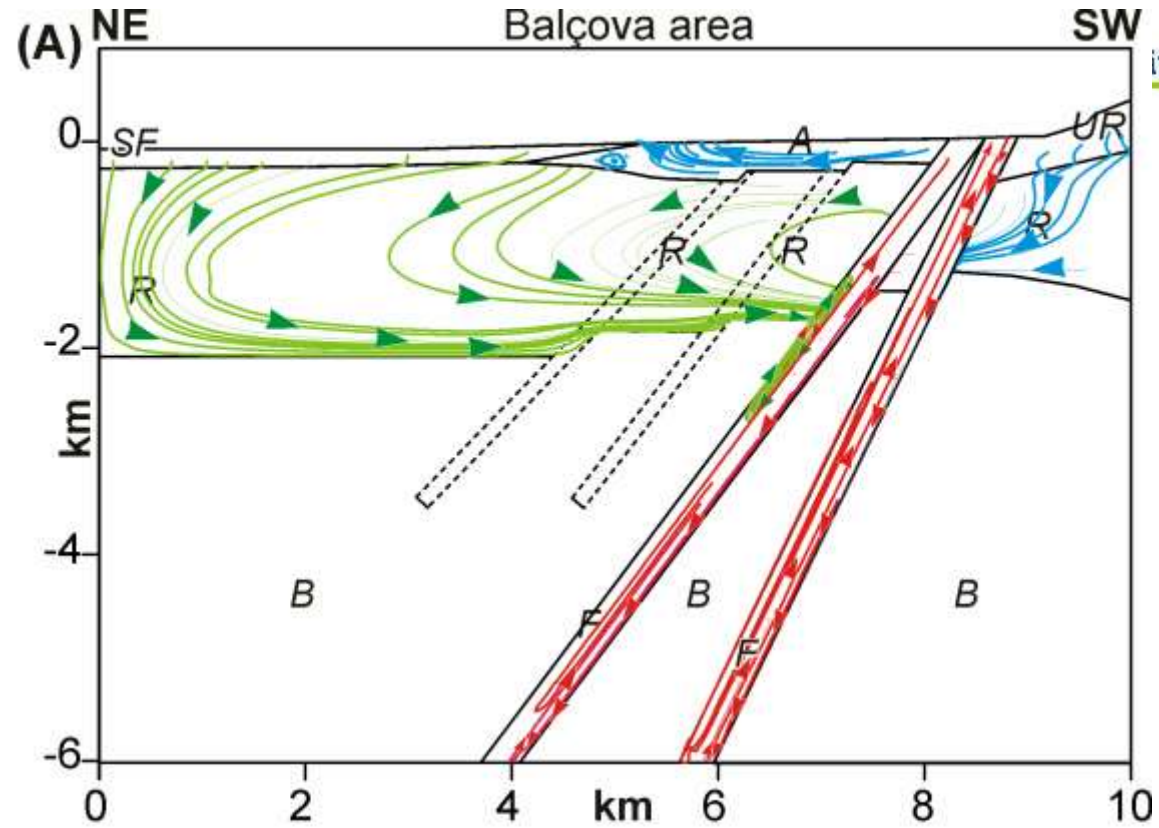
The SBG

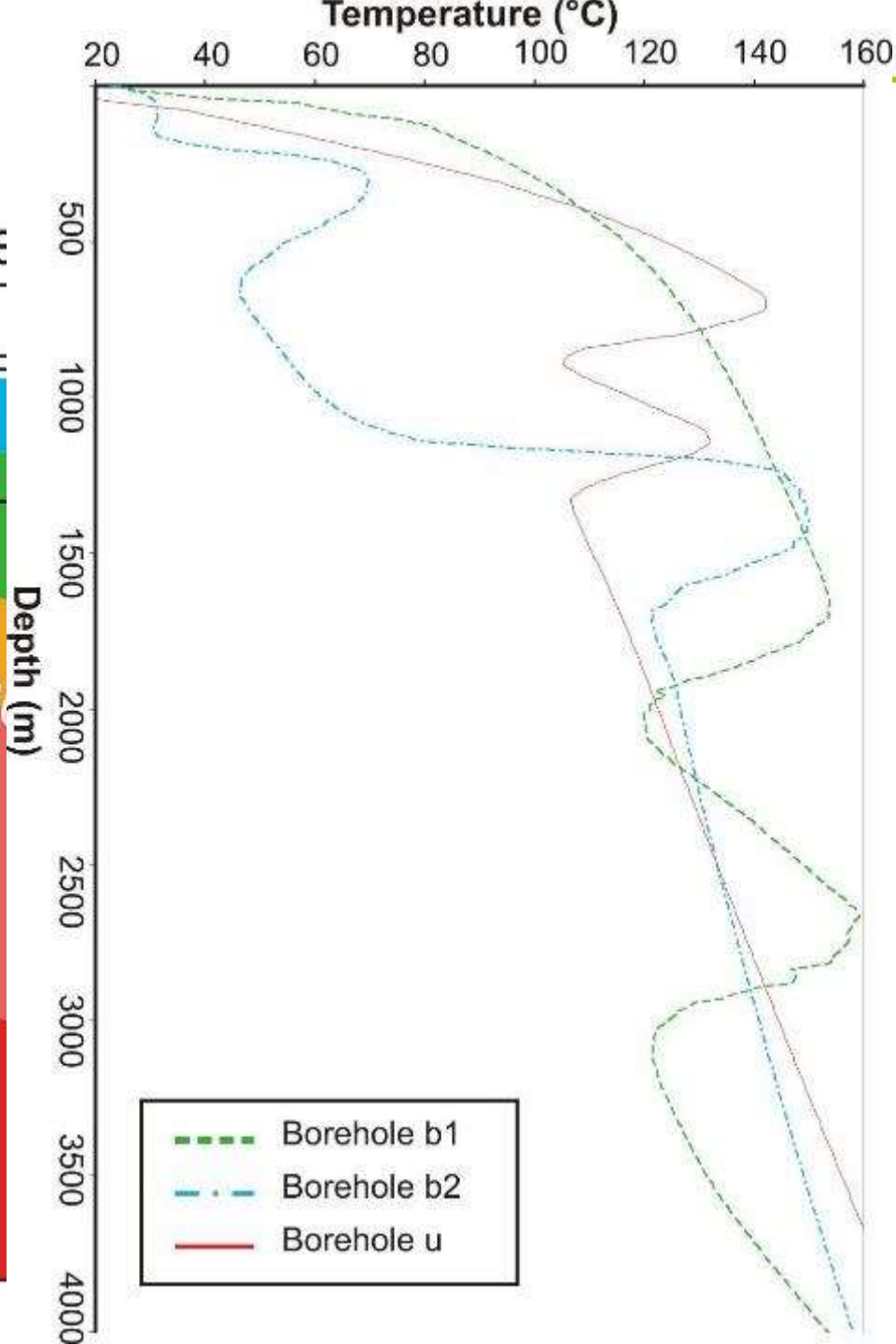
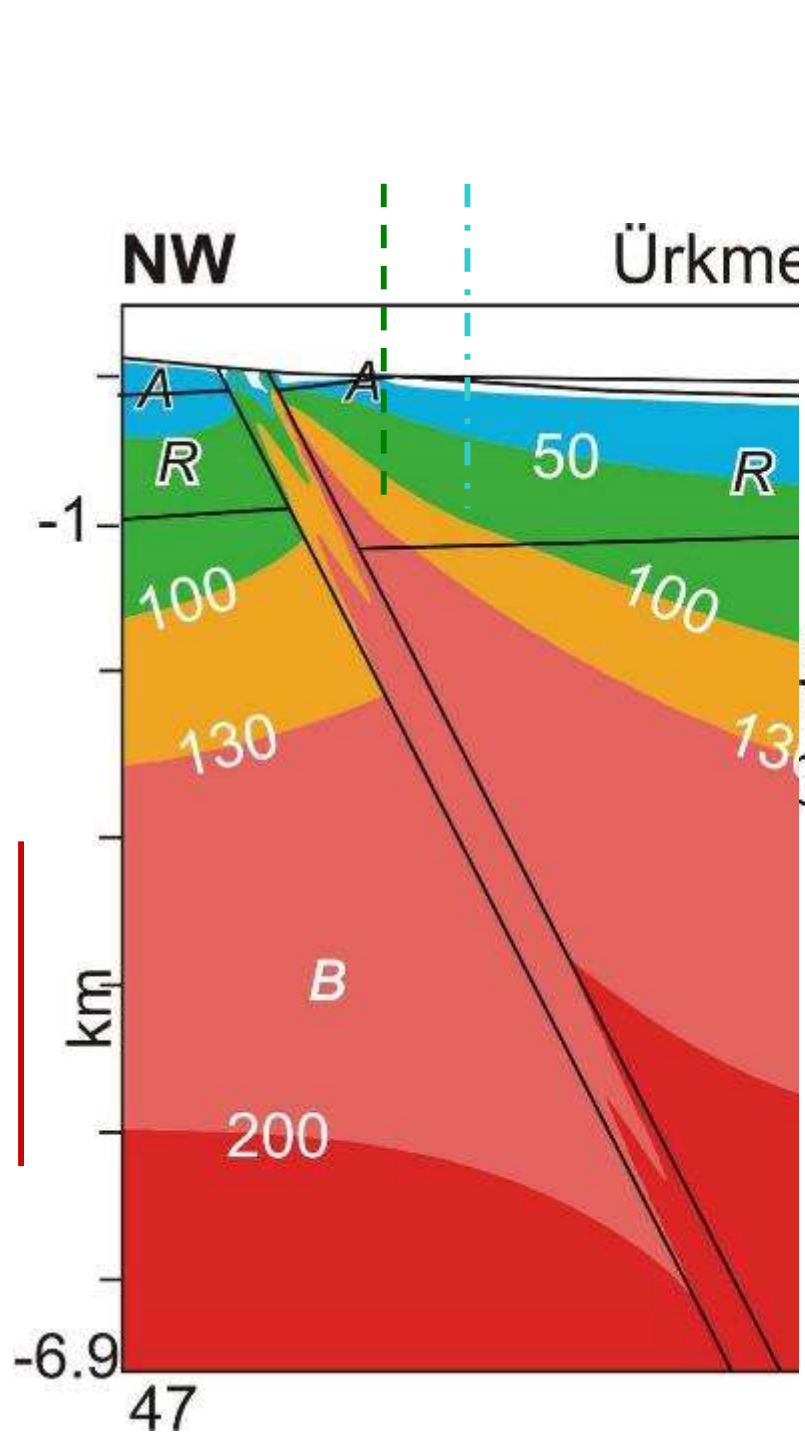


The SBG Turkey



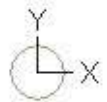
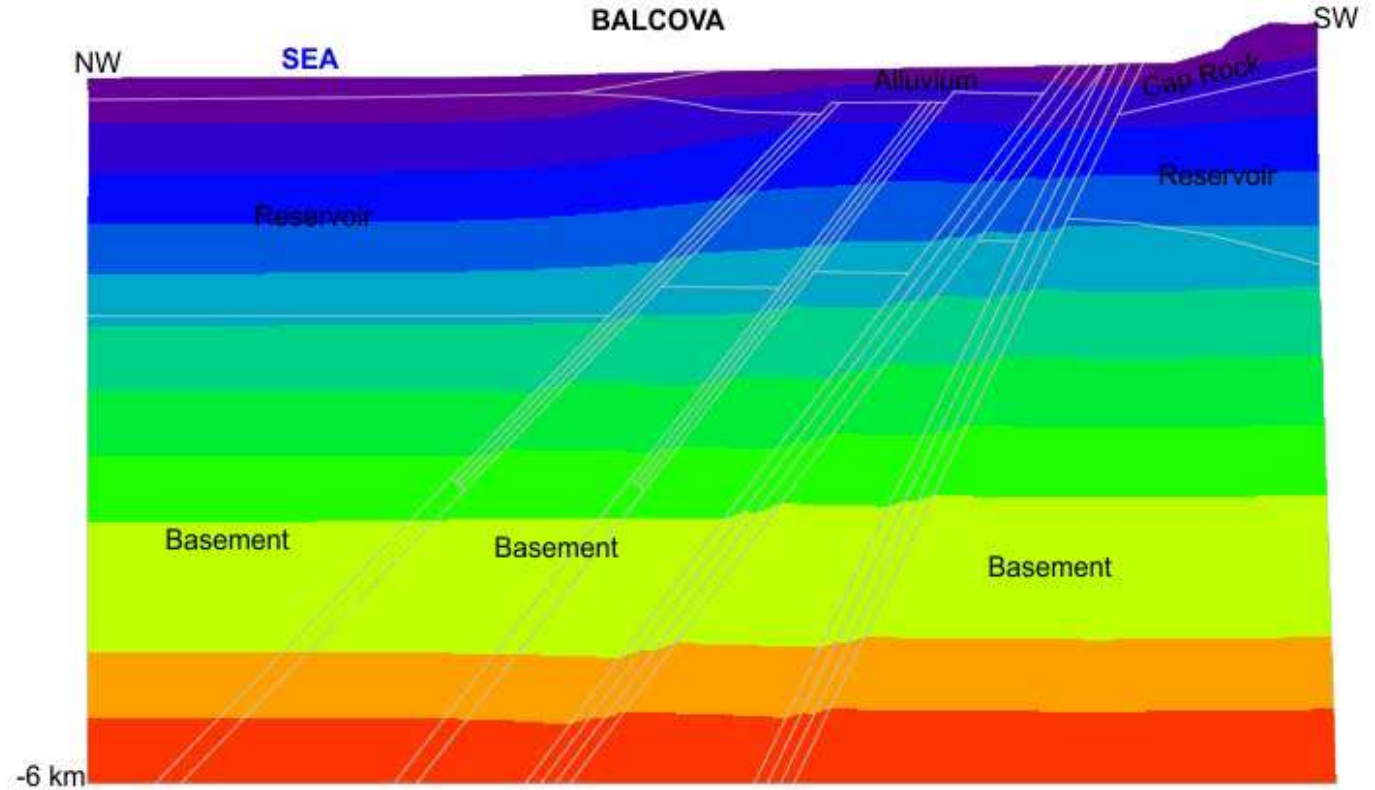
Flow paths





The SBG Turkey

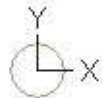
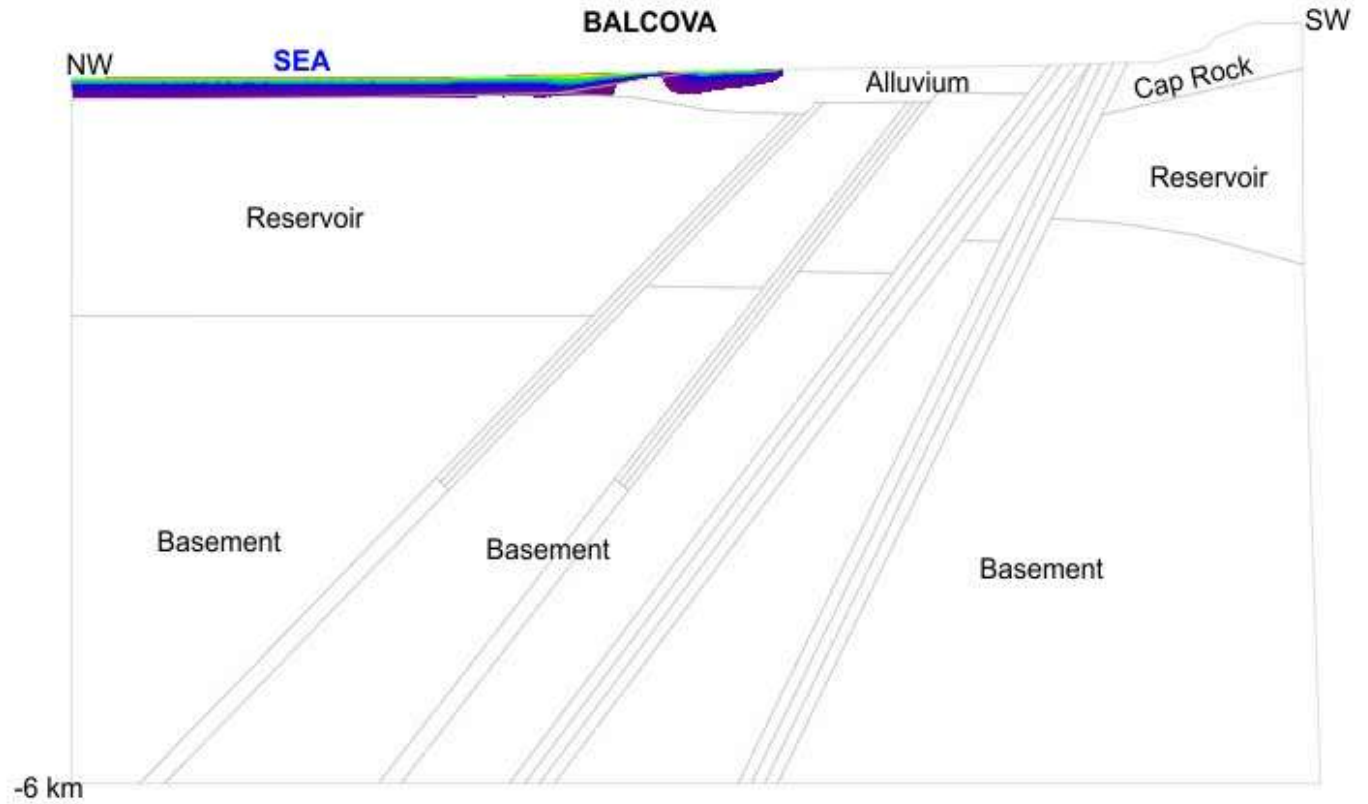
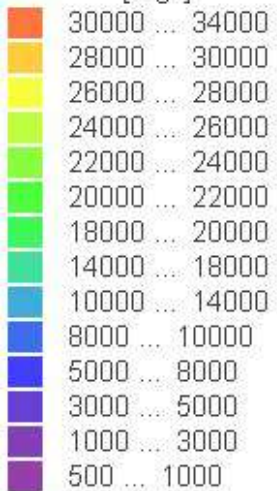
Temperature
- Fringes -
[°C]



0 [d]

The SBG Turkey

Mass concentration
- Fringes -
[mg/l]



0 [d]

The SBG Turkey

