Describe the hydraulic requirements (i.e., spatial pattern of flow systems) for the formation of hydraulic traps in a complex regional groundwater flow field and their possible natural consequences and practical utilization.

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József & Erzsébet Tóth Endowed Hydrogeology Chair and Foundation

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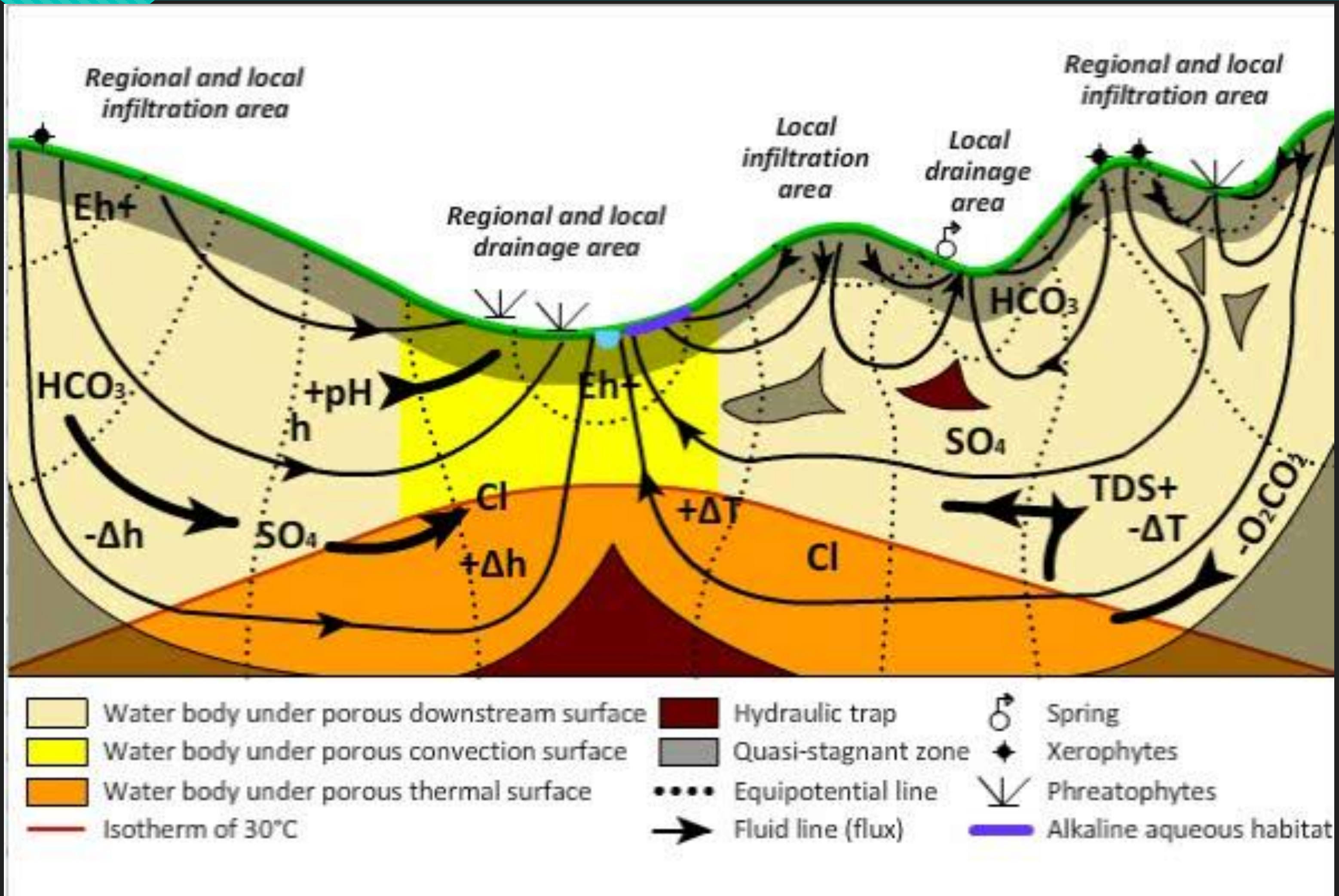
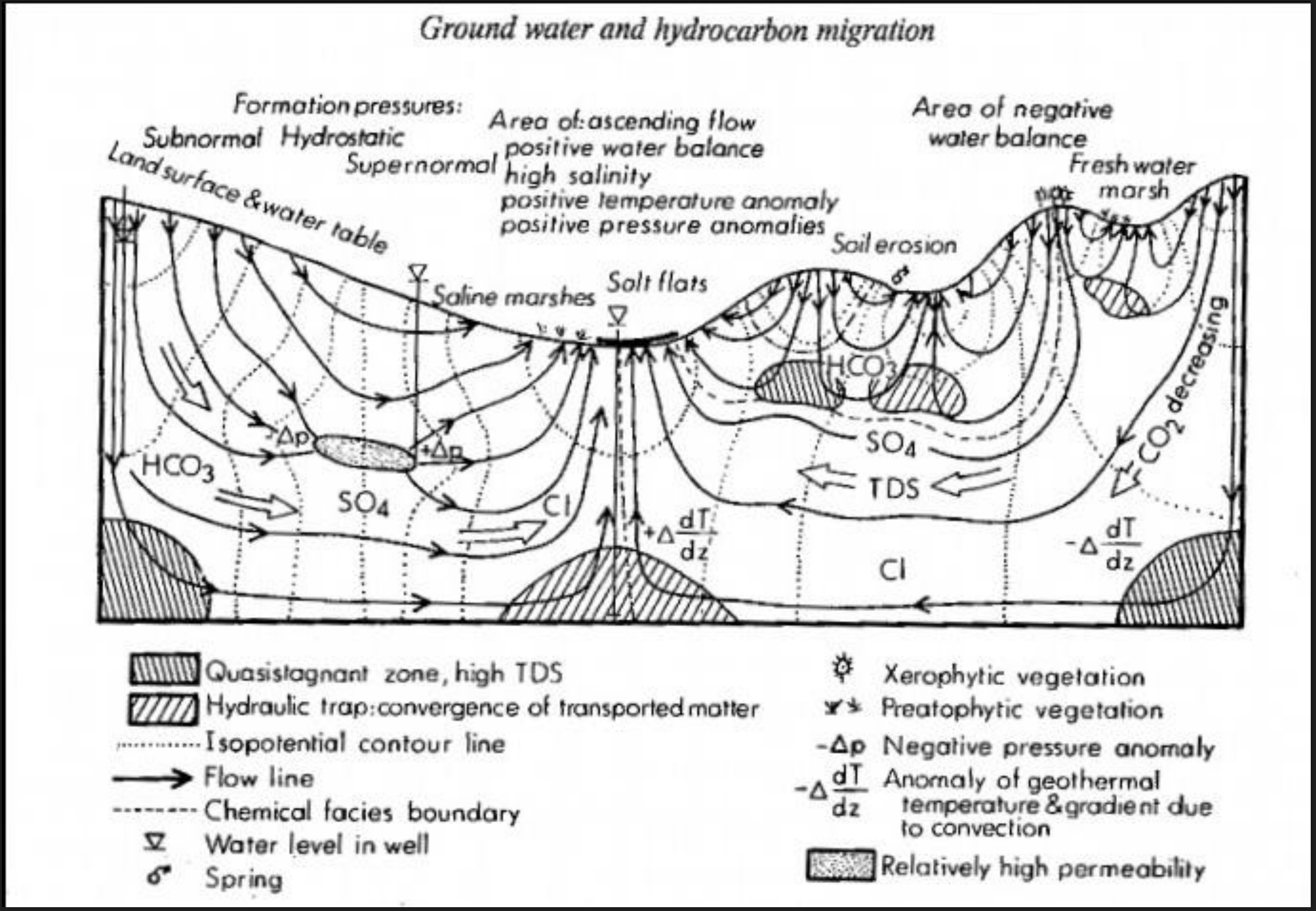
Groundwater
— the geologic agent



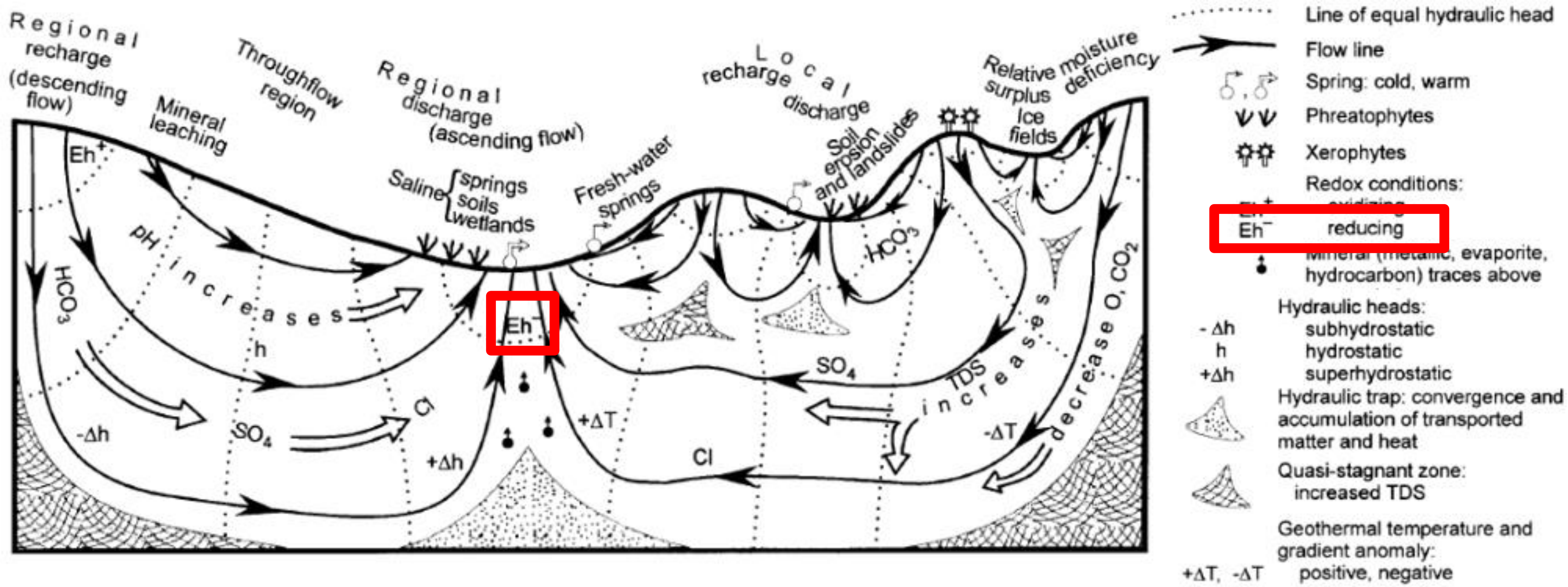
Szűcs P. (2014)

Gravity-driven regional groundwater flow — the Tóthian model

- Main driving force: gravity
- Cross-formational groundwater flow
- Hierarchically nested flow systems
    1. Local
    2. Intermediate
    3. Regional
- Different flow regimes
    1. Recharge
    2. Midline
    3. Discharge



Tóth J. (1988)



Tóth J. (2015)

T

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discharge

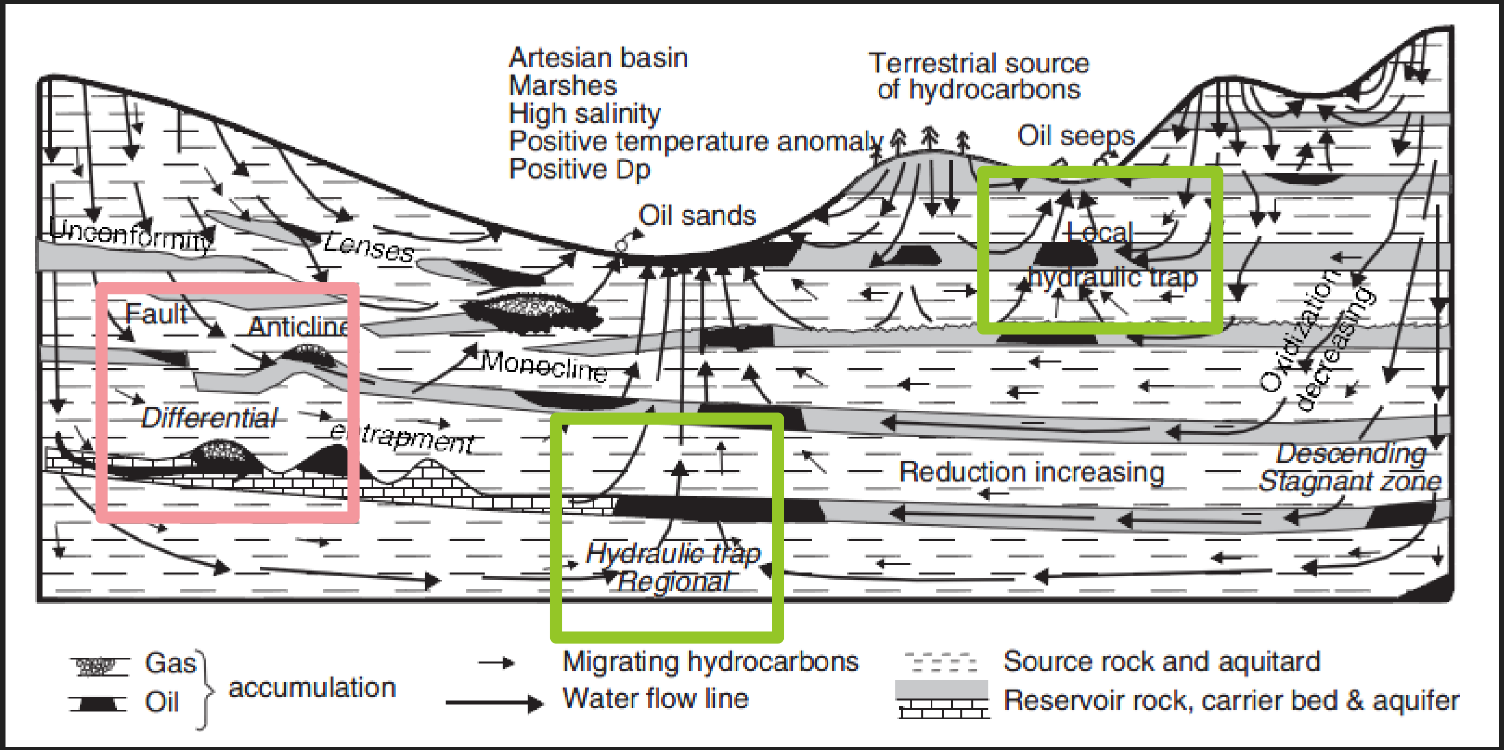
increasing TDS content

change in anion facies

recharge

Hydrocarbon entrapment

a fundamental condition for the dynamic trapping is the ***FLUID-POTENTIAL MINIMUM***



Tóth J. (1988)

3 possible situations:

1. no water flow – hydrostatic conditions
2. unidirectional water flow

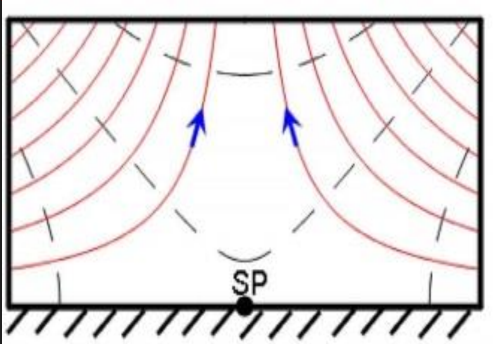
needed: **lithology, structure** → ***hydrodinamic traps*** (Hubbert, 1953)

3. opposite directed water flows

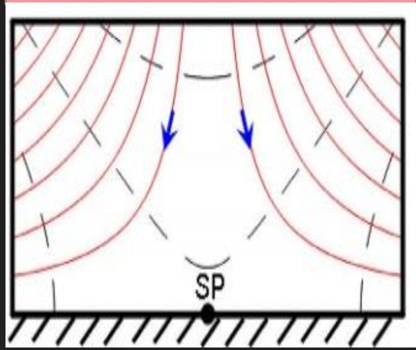
→ ***hydraulic traps*** (Tóth, 1980)

What is the hydraulic trap?

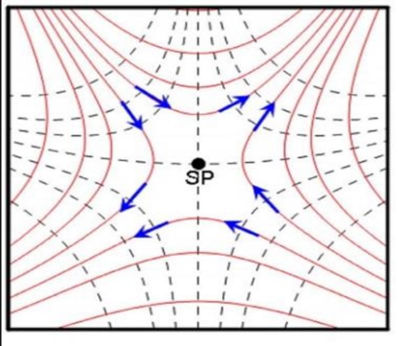
1. Convergence of two flow systems



2. Divergence of two flow systems

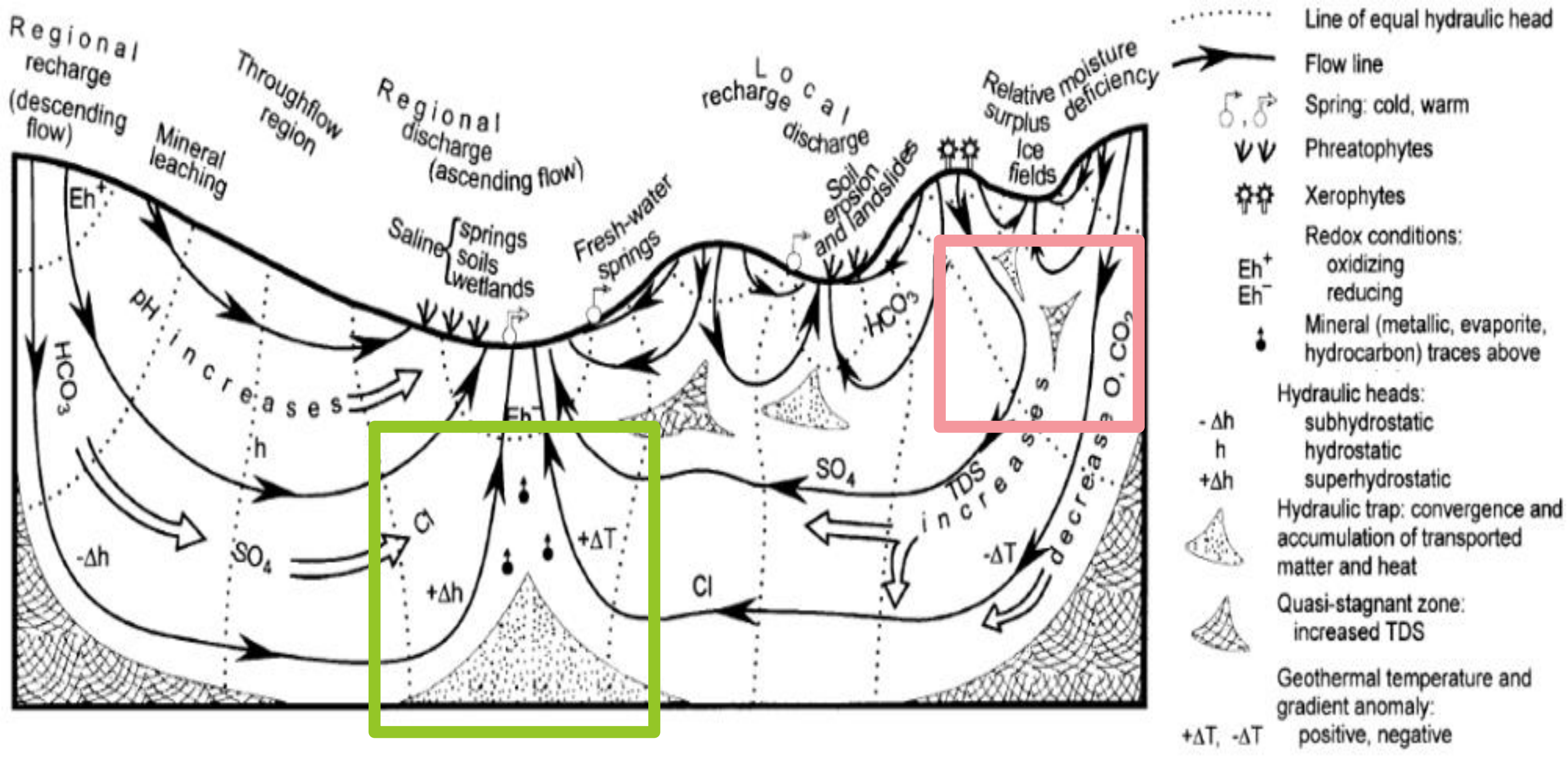


3. Divergence of four flow system



Xiao-Wei Jiang et al. (2012)

- flow pattern determines the location of hydraulic traps
- fluid potential minimum → ***stagnant zones***
- these hydraulic traps are always attributed to the quasi-stagnant zones
- high TDS content
- temperature and pressure decreases into the direction of the surface



Tóth J. (2015)

Changing of hydraulic traps

Flow systems also ***change!***

Changing of boundary conditions

⬇

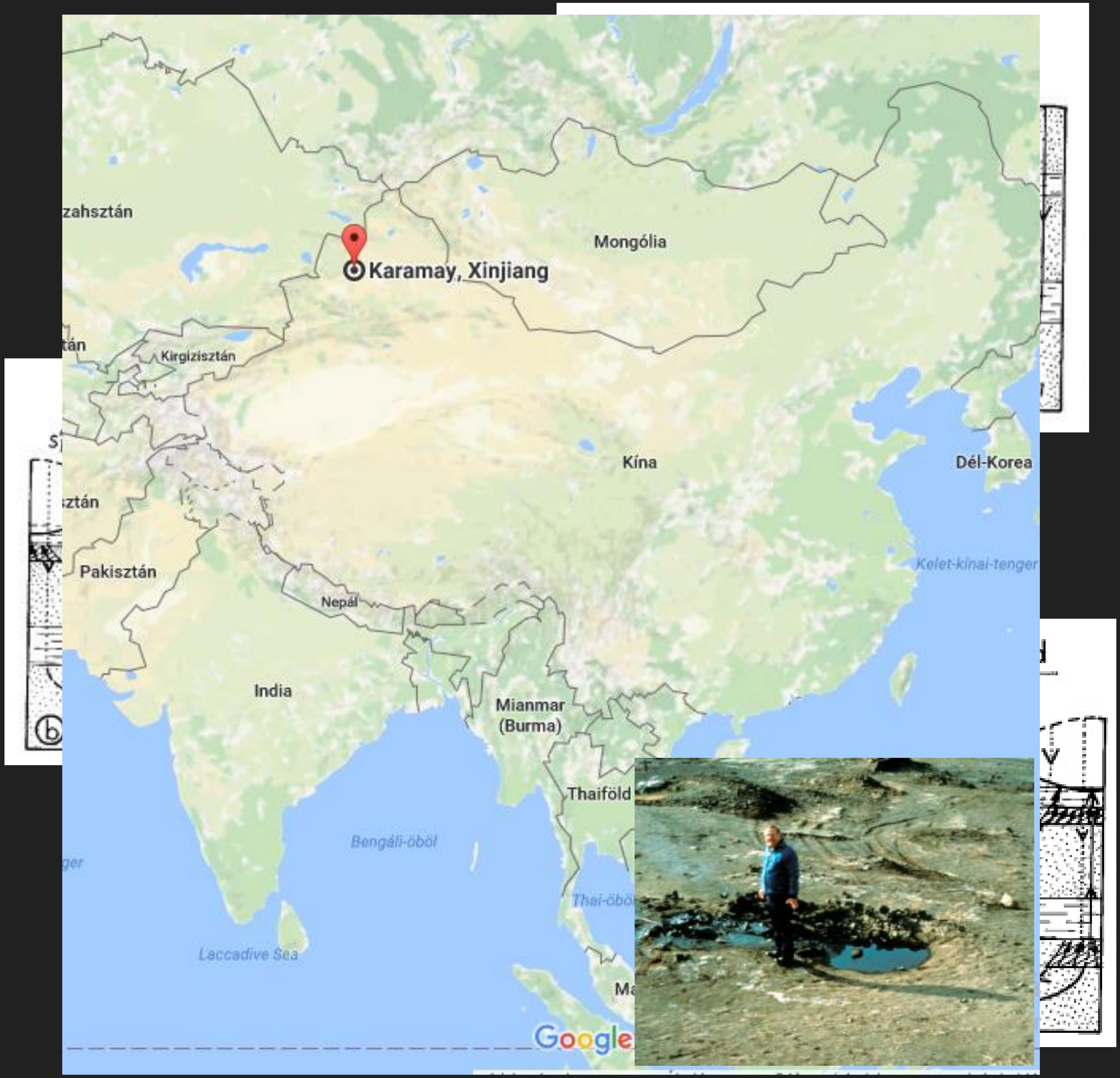
Adjustment of flow systems

⬇

Delay in time

⬇

Repositioning of hydrocarbons



Tóth J. (1988)

Natural consequences

Gravity-flow related hydrogeologic
phenomena can be categorised as:

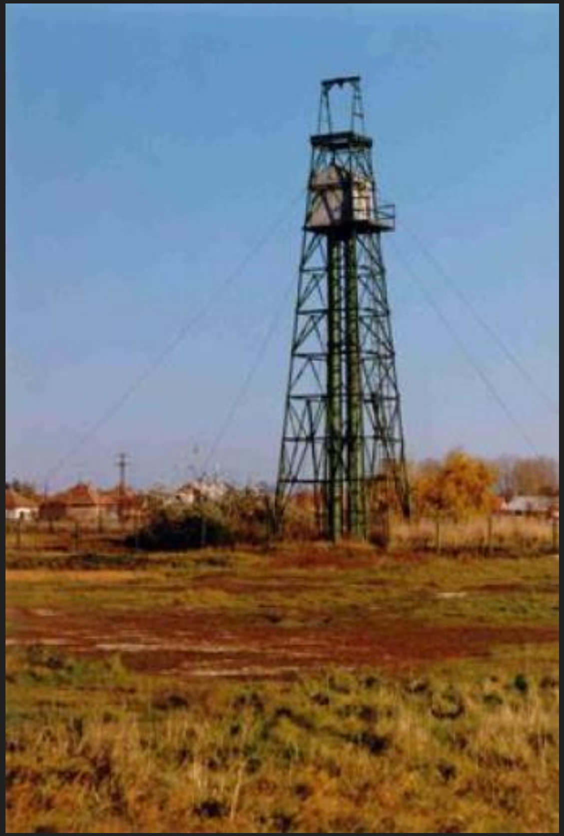
indicators of petroleum accumulation!

created by processes that may generate petroleum deposits

main characteristics of discharge areas, hydraulic and hydrodynamic traps

- fluid potential minima
- superhydrostatic pore pressures
- **flowing artesian wells**
- slight/zero lateral potential gradients
- slighter theoretically calculated tilt of oil-water interfaces than the dip of caprocks
- positive geothermal anomalies
- **marshes**

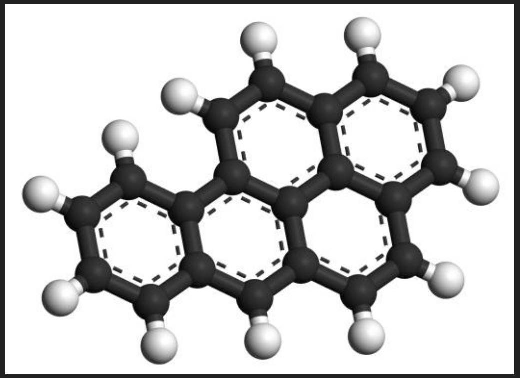
- **soil salinization**
- salt-water discharge
- increases in formation water salinity
- reducing near-surface conditions
- altered soils
- H2
- **sulfide ores**
- radiometric and electrotelluric anomalies

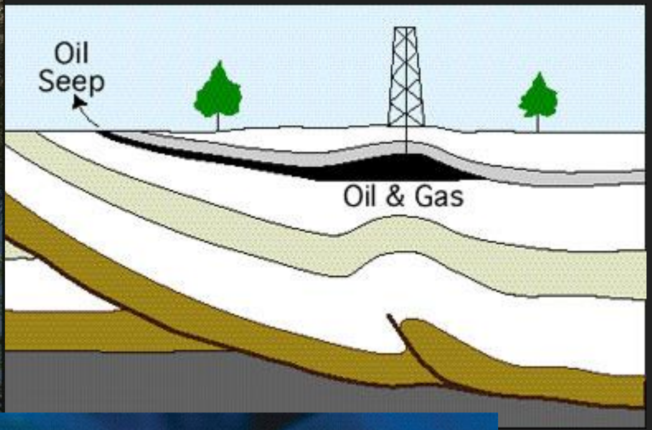


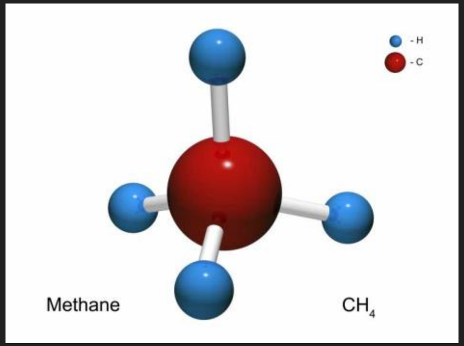
Direct petroleum indicators

phenomena with a contribution from petroleum deposits

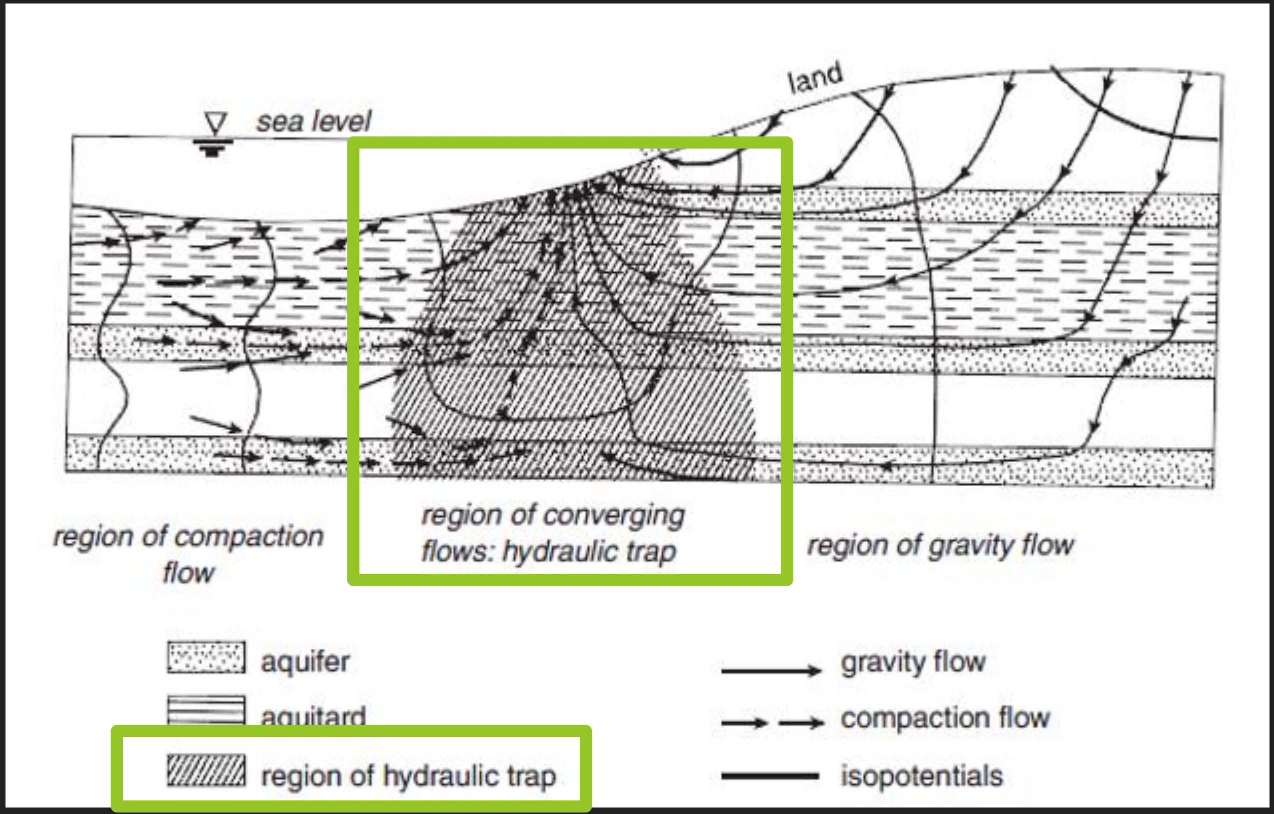
- oil springs
- oil seeps
- hydrocarbon gases in spring waters
- soil wax
- anomalous growth of hydrocarbon-metabolizing bacteria
- oil sand



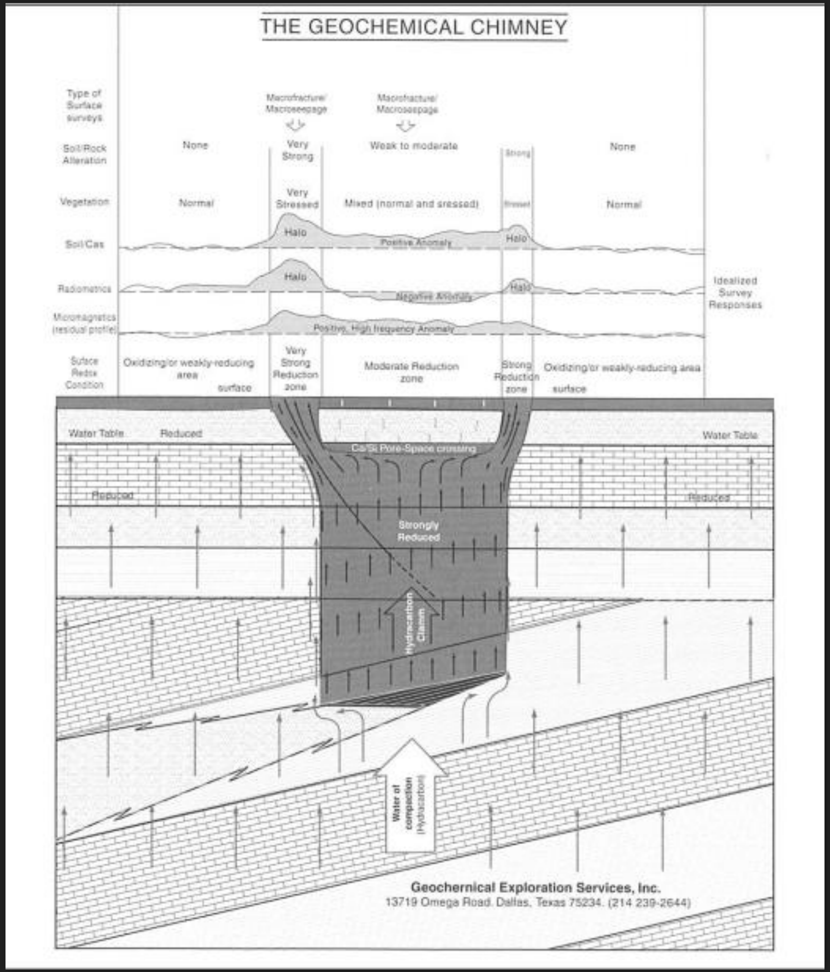




Examples, practical utilization



Tóth J. (2015)



Tóth J. (2009)

Summary

- Coexistence of: two convergent flows, fluid potential minimum, decreasing temperature and pressure and increasing salinity
    - *Unidirectional flow* *Convergence of two flows*
- In the hydraulic trap bigger water effect → more unstable oil accumultaion
- The pattern of the flow system and phenomenas on the surface can help predict the location of accumulations
- „Based on these relations and phenomena, that is, applying hydrogeological principles and techniques, the conventional arsenal of geology, geophysics, and organic geochemistry of the explorationist may be broadended by a hydrogeological approach to basin analysis and petroleum exploration to be called, perhaps,

Petroleum Hydrogeology.”

THANK YOU FOR YOUR KIND ATTENTION!

References, acknowledgement

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