Student Competition on Regional Groundwater Flow

Exploration for reservoir-quality subsurface rock-bodies by mapping and interpretation of regional groundwater flow

Team： Looking at the Basin!

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CORUM CONFERENCE CENTER
43rd IAH congress

Outline

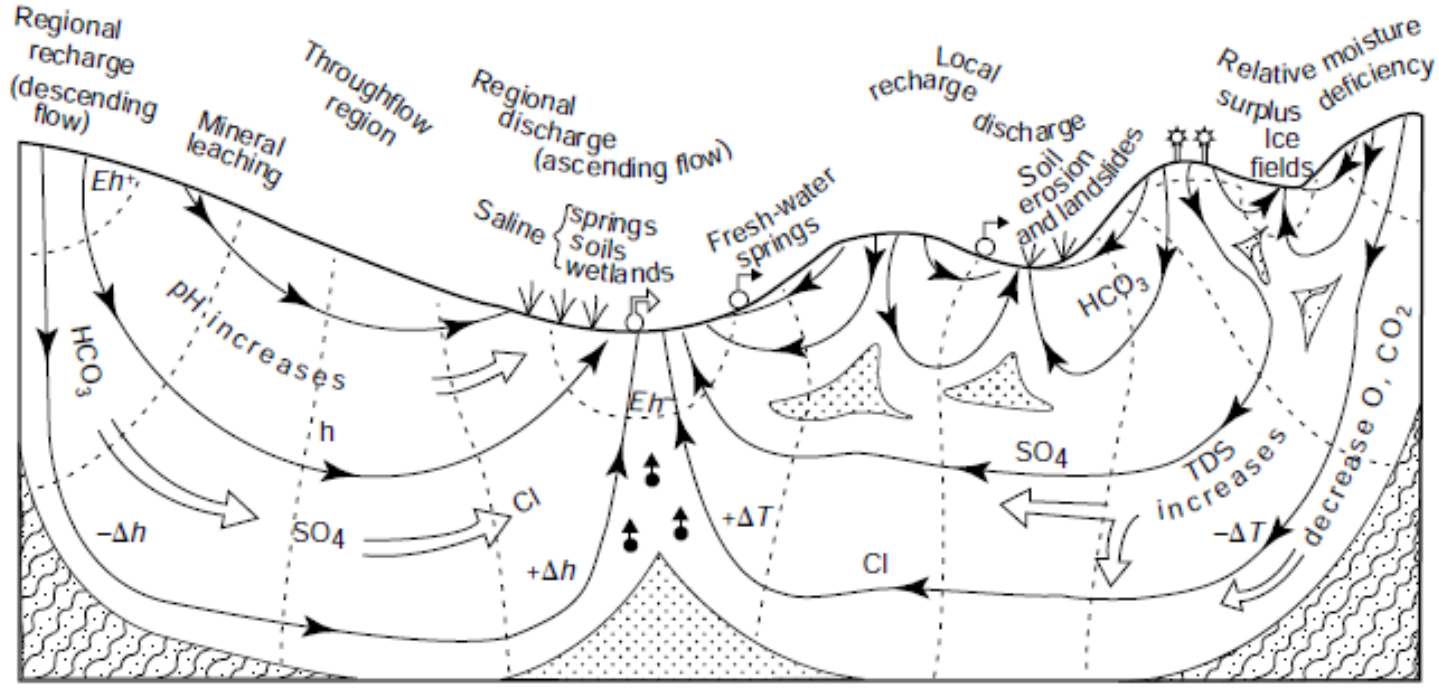
1. Introduction

2. Theoretical Investigation

3. Case study

4. Conclusion

Introduction



Regional groundwater flow system

(Toth, 1999)

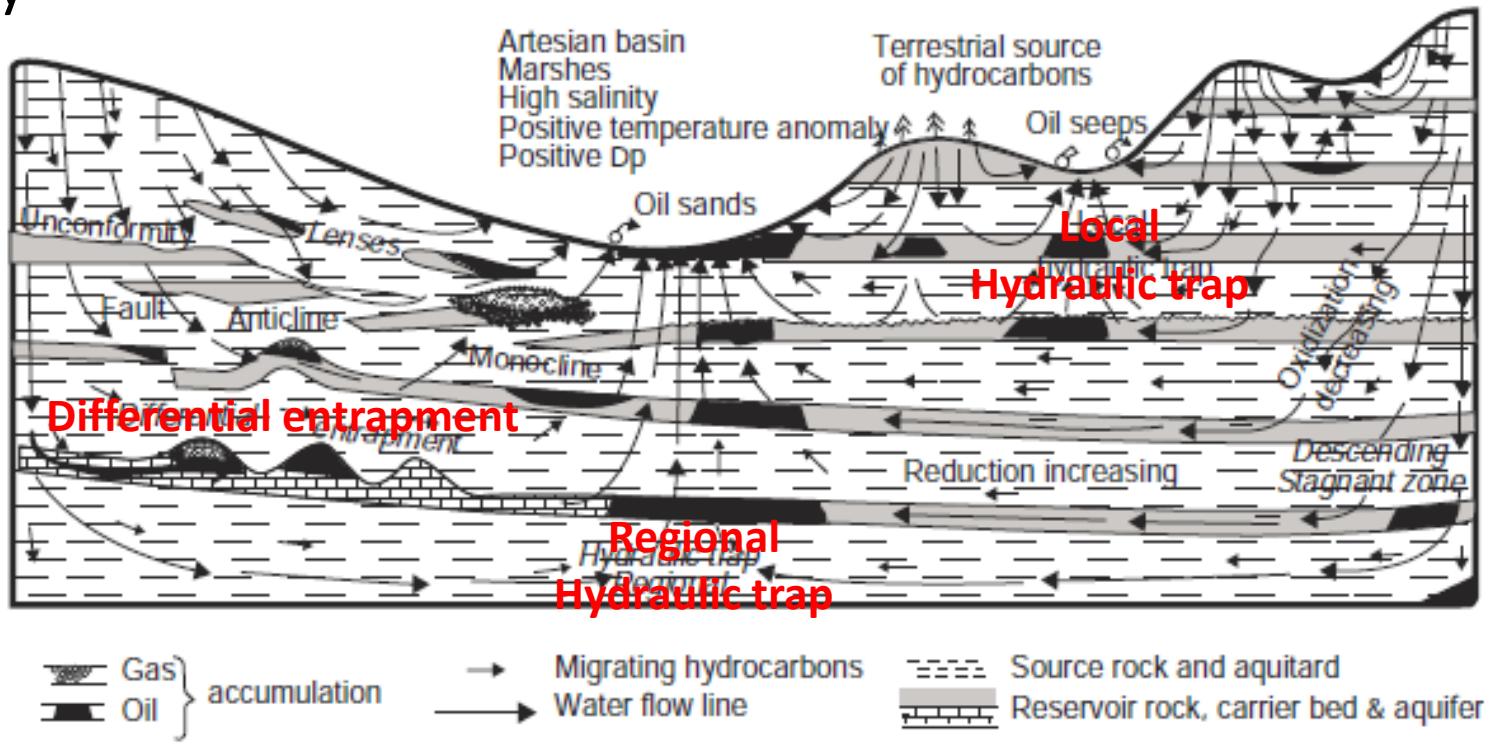
Introduction

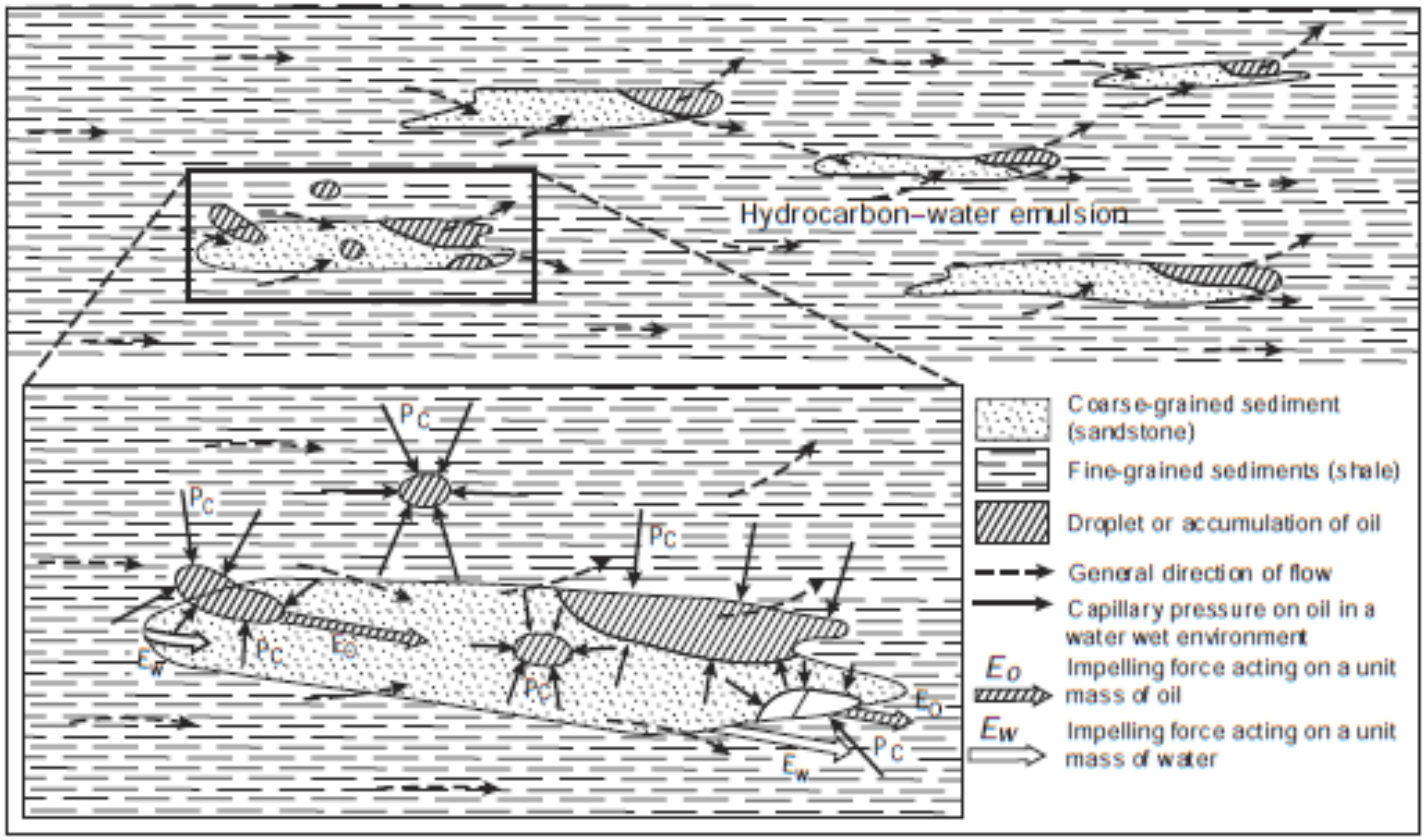
Exploration for reservoir-quality subsurface rock-bodies:

Differential entrapment;

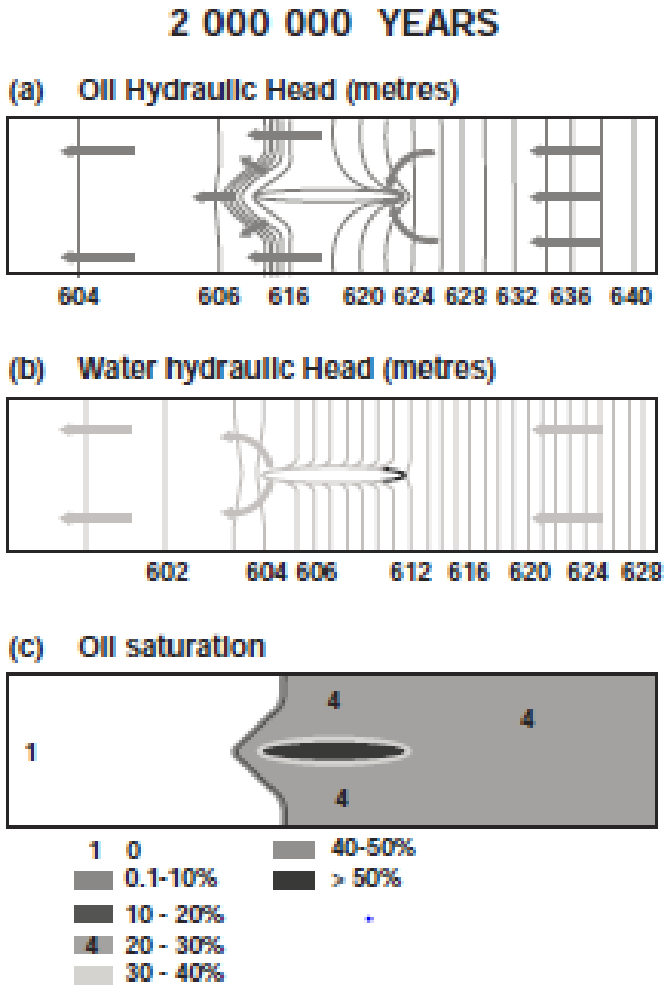
Regional hydraulic trap;

Local hydraulic trap;





(Toth, 1988)



(Rostron& Toth, 1989)

Grain-size difference between a sandstone lens and its surrounding shale matrix → a capillary barrier

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The definition of potentiometric anomalies

$$h = \frac{\Phi}{g} = z + \frac{p}{\rho g}$$

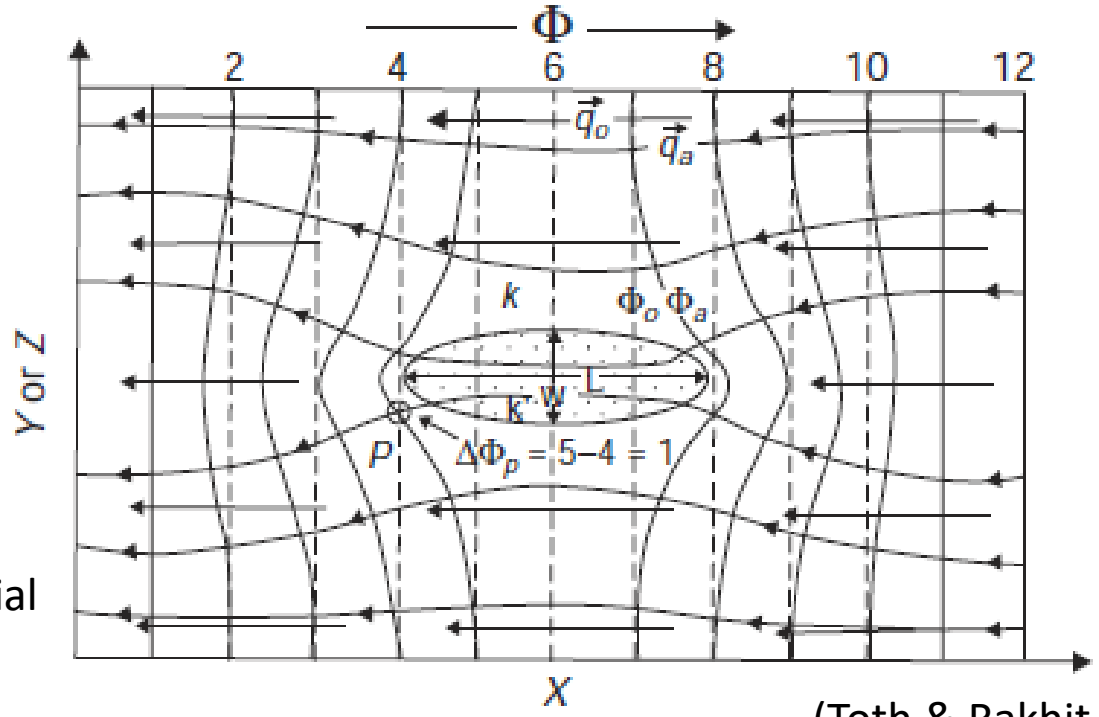
The absolute anomaly :

$$\Delta\Phi = \Phi_a - \Phi_o$$

where Φ_a is anomaly potential and Φ_o is the original potential

The limit anomaly :

$$\Delta\Phi_l = g\frac{L}{2}\frac{\partial h_o}{\partial x}$$



(Toth & Rakhit, 1988)

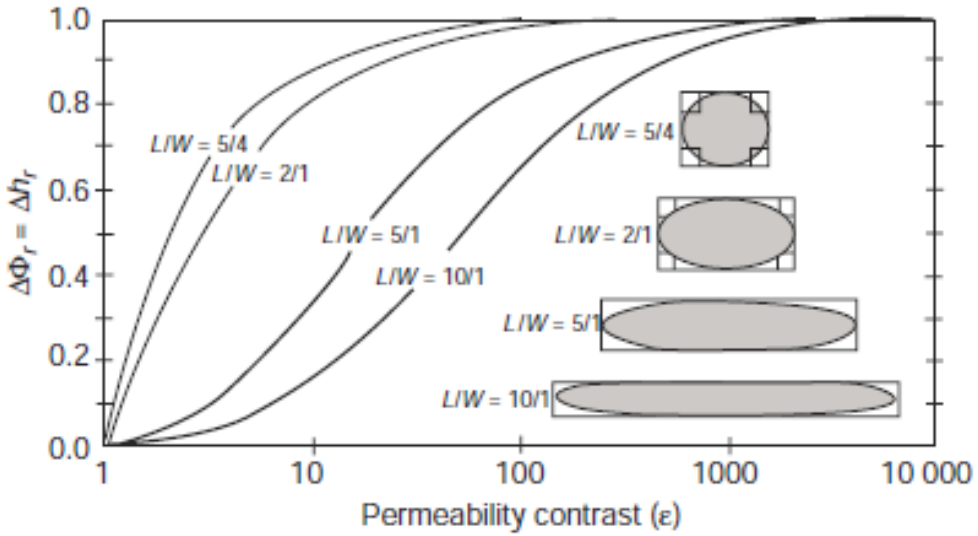
The effect of rock lens of relatively high permeability

Influencing factors of potentiometric anomalies

- Lens geometry
- Anisotropy
- The lens orientation
- Spacing and relative position of multiple lenses

Lens geometry (L/W)

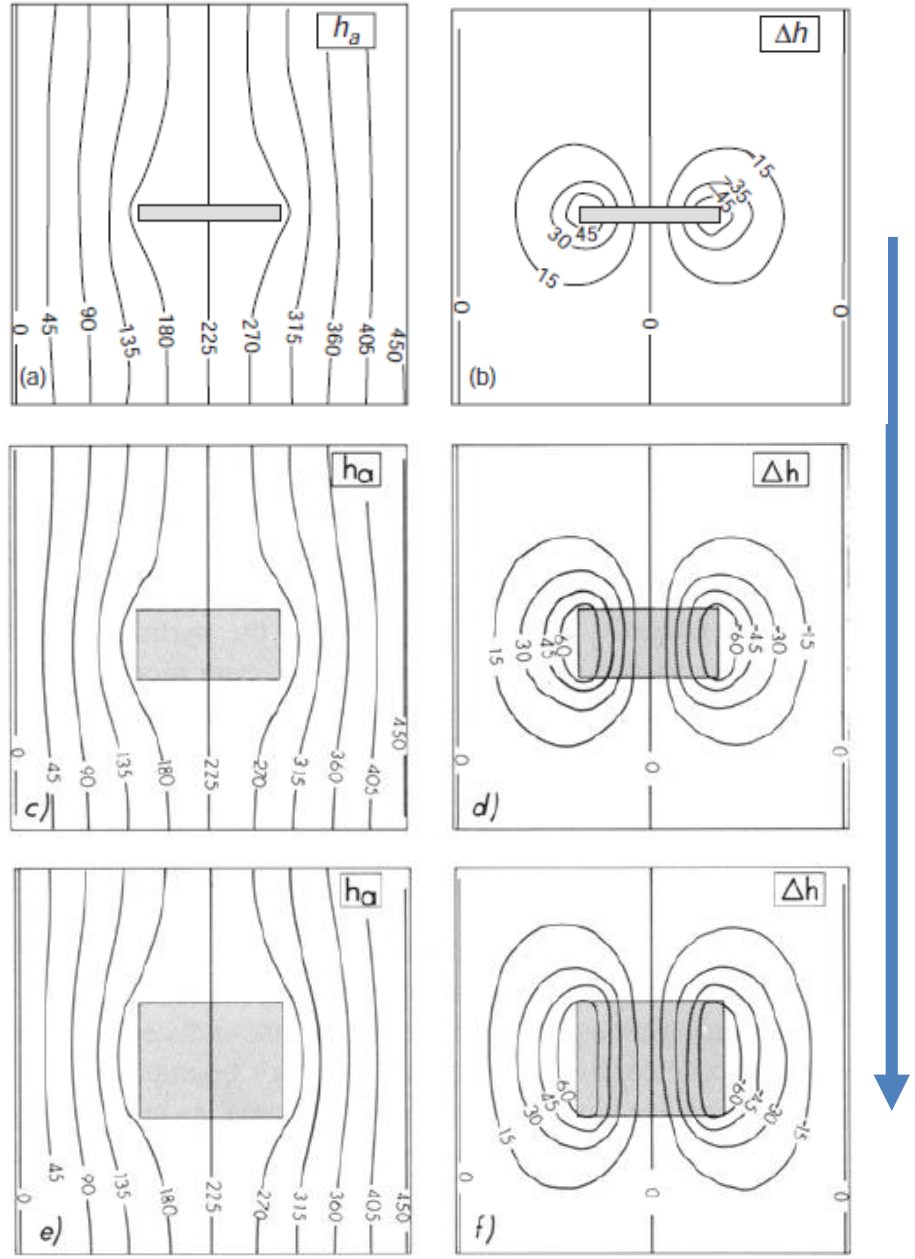
- The areal extent and the intensity of perturbation increase with the declining L/W



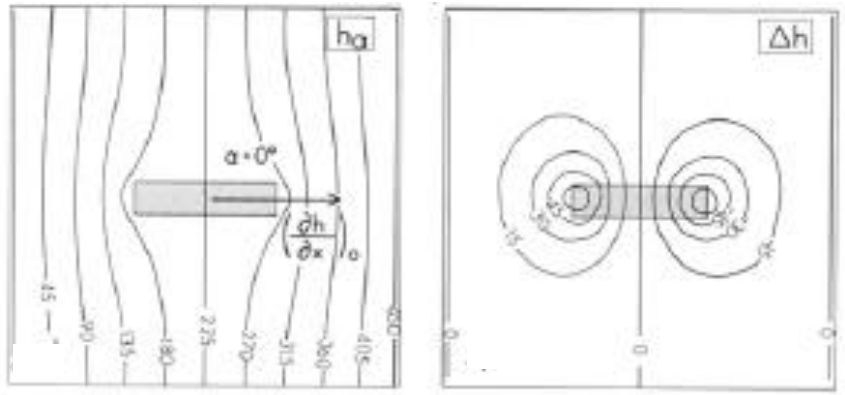
L/W=10/1

L/W=2/1

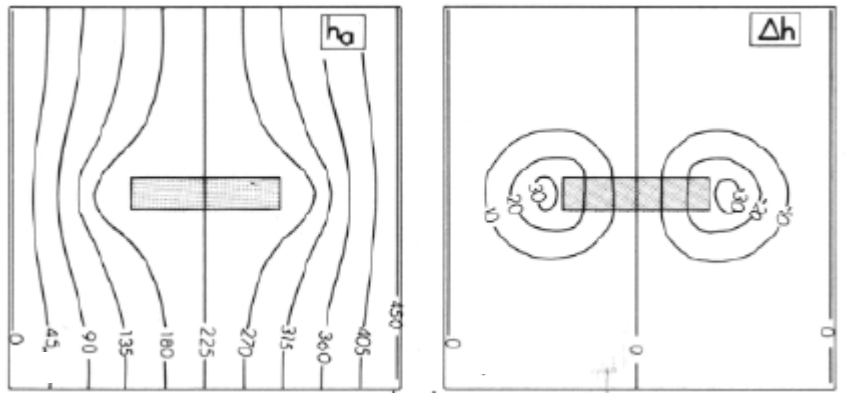
L/W=5/4



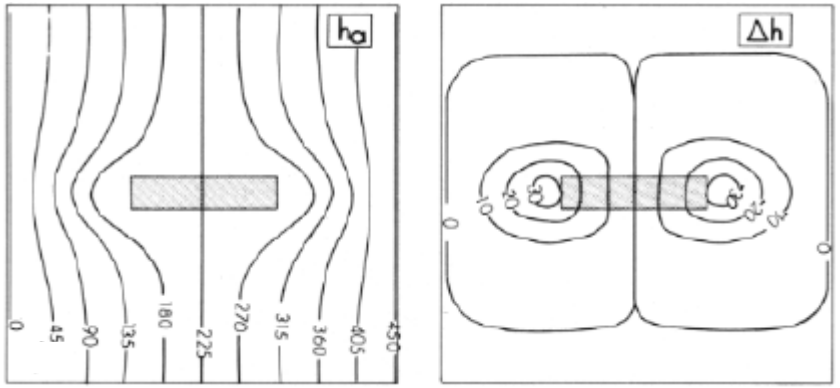
Anisotropy ($K_{h/v}$)



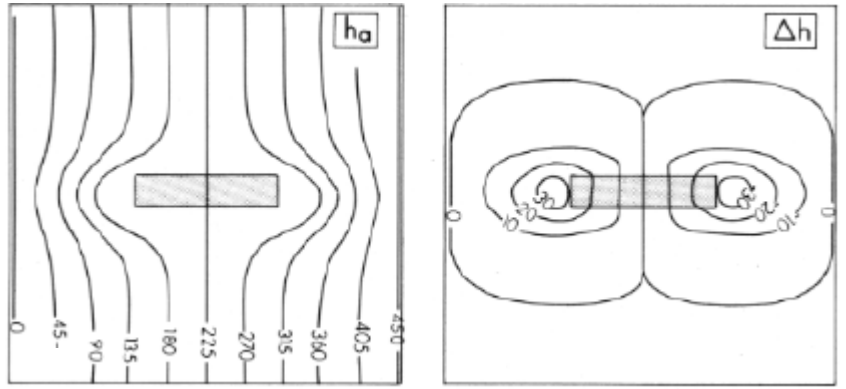
$K_{h/v}$=1



$K_{h/v}$=2



$K_{h/v}$=5



$K_{h/v}$=10

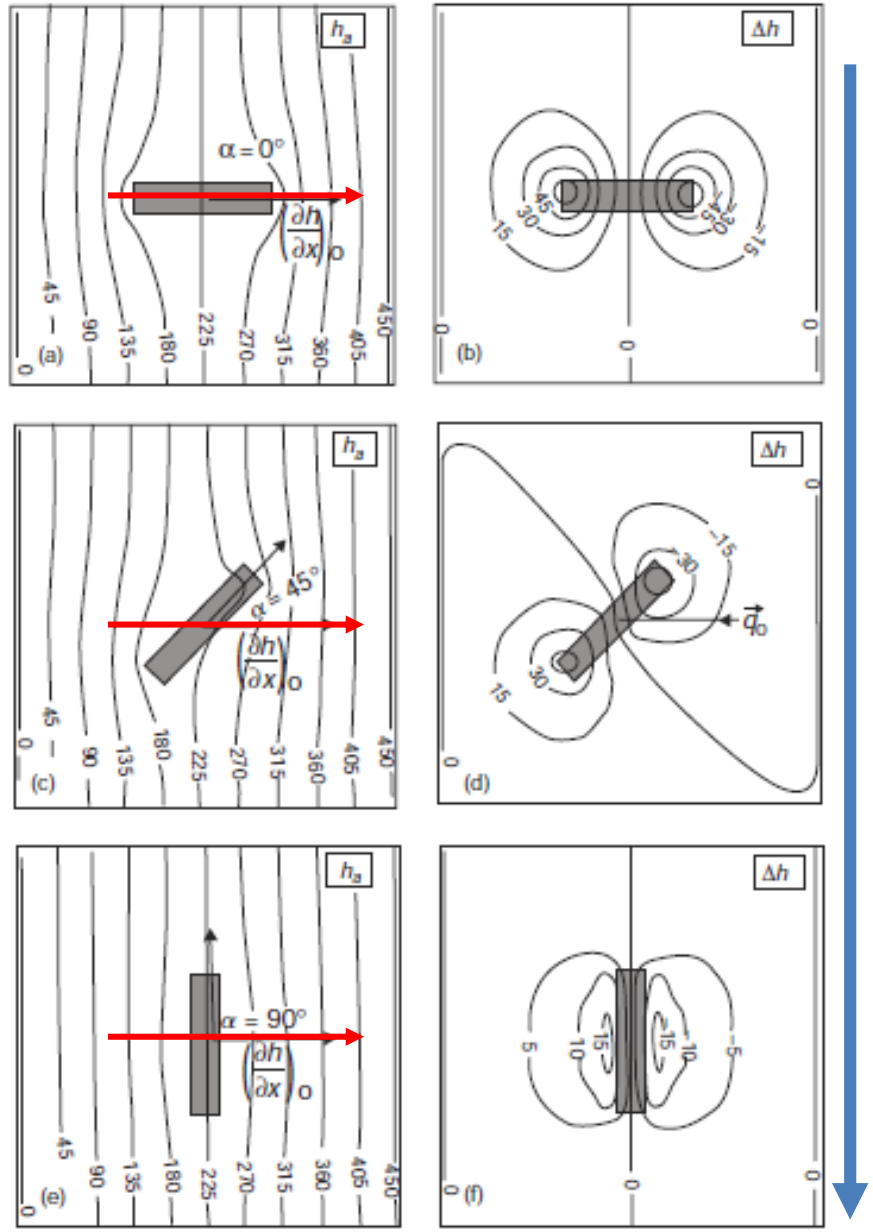
The Lens Orientation

- The areal extent and the intensity of perturbation decrease from increasing α.

α=0°

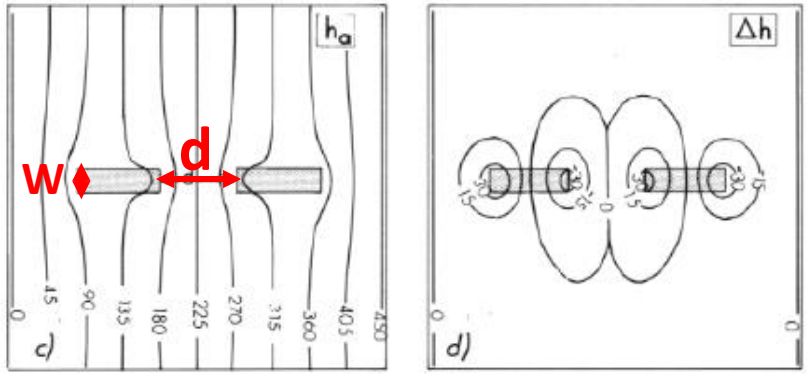
α=45°

α=90°

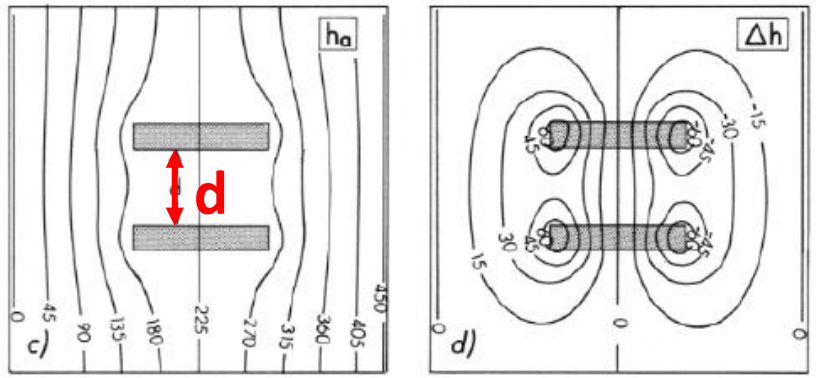


Spacing and relative position of multiple lenses

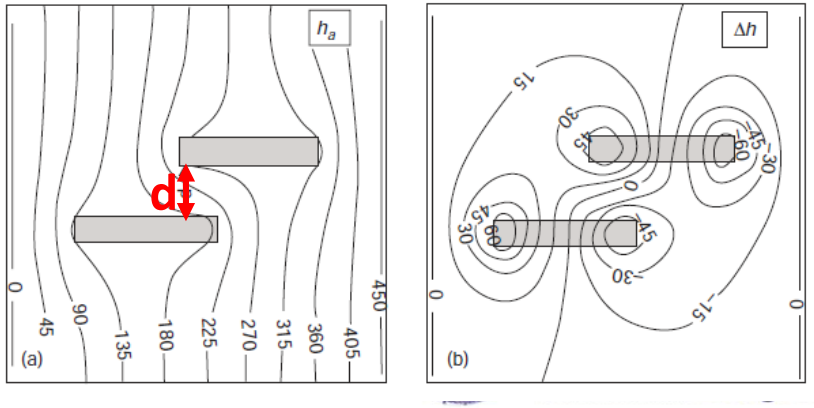
- Two identical lenses in tandem



- Two identical lenses in parallel position, perfect overlap laterally



- Two identical lenses in parallel position, partial overlap laterally



Summary

- The potentiometric anomaly is negative at the upstream end and positive at the downstream end of a highly permeable lens;

- The value of the anomaly increases with increases in permeability contrast, length, width, and L/W.

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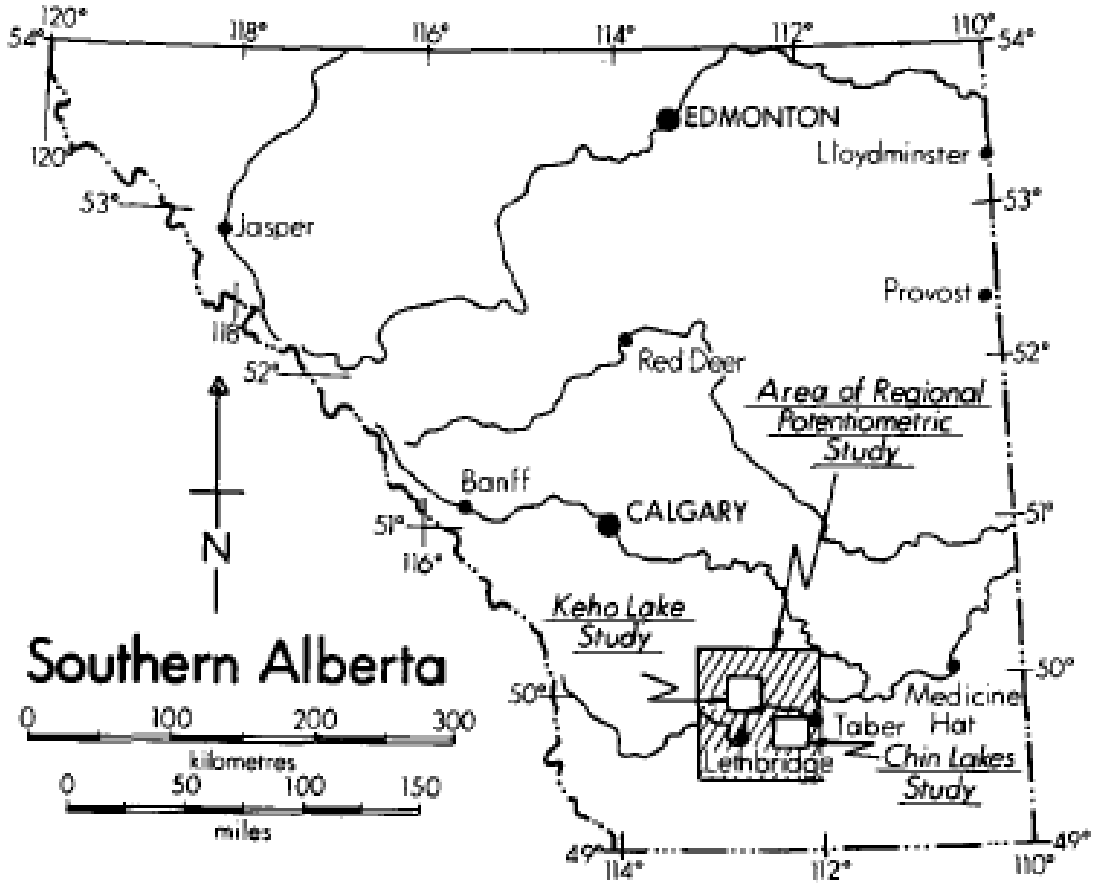
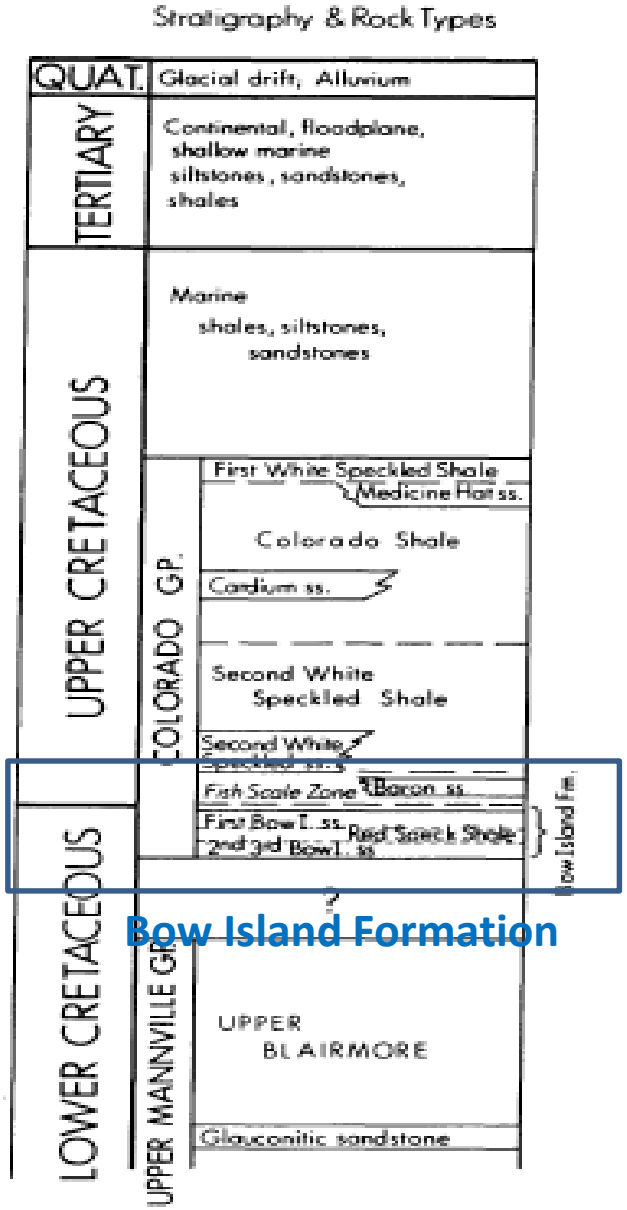
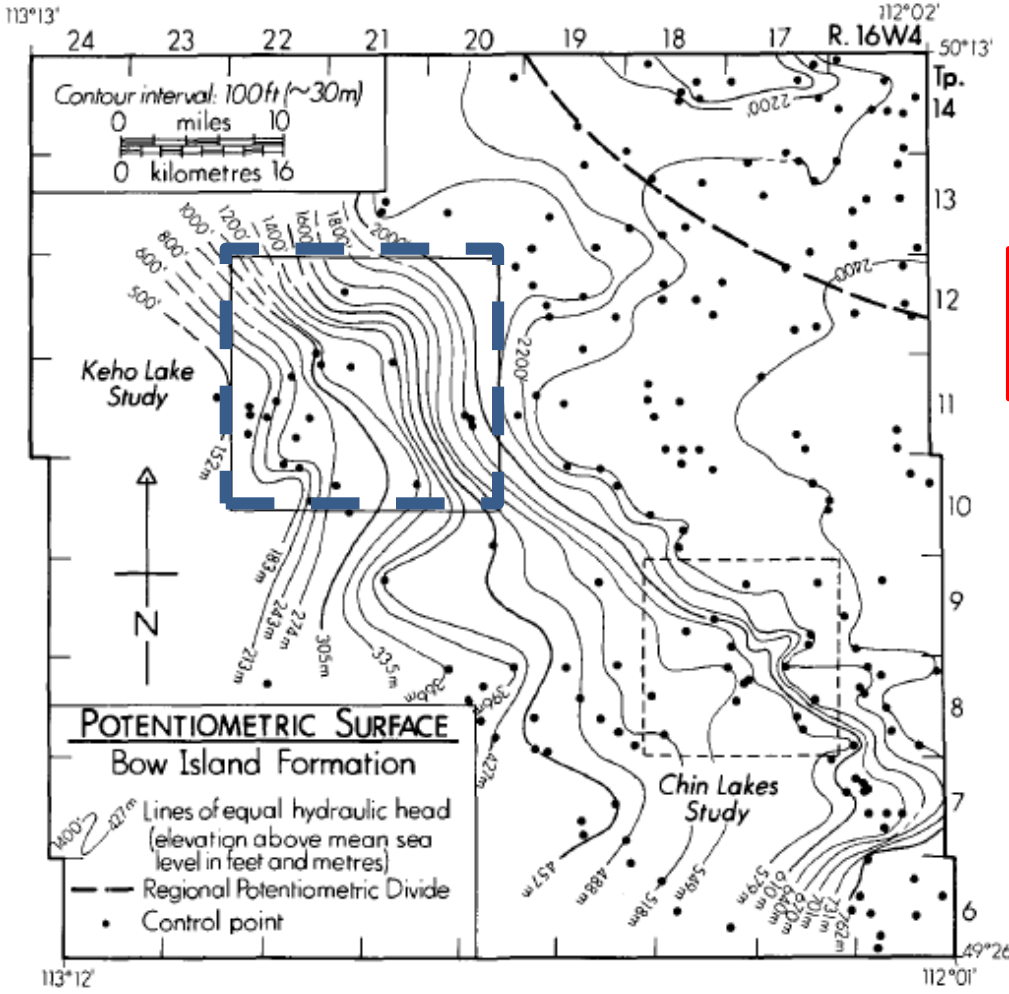
Study Area



Keho Lake areas in southern Alberta. Canada

Study Area

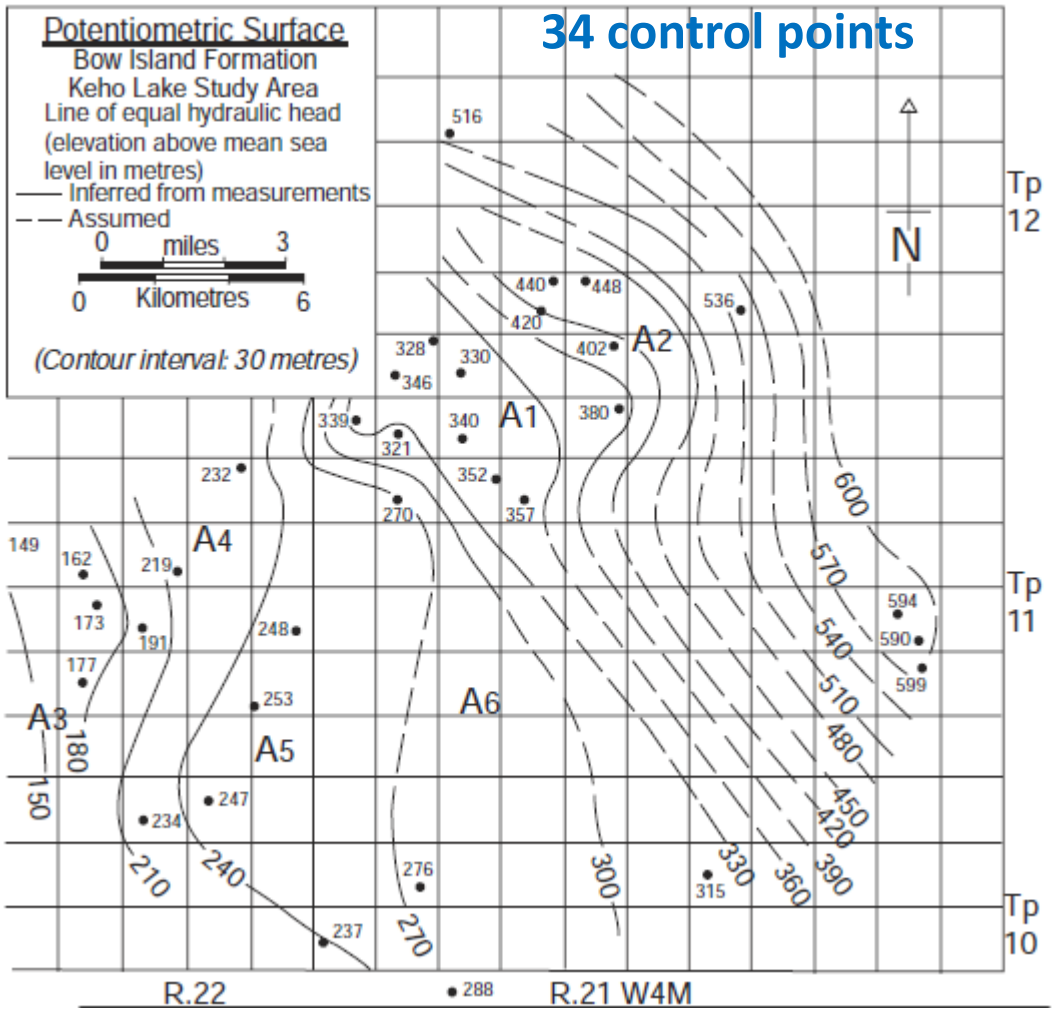




- Lenticular
- Gas and/or oil bearing

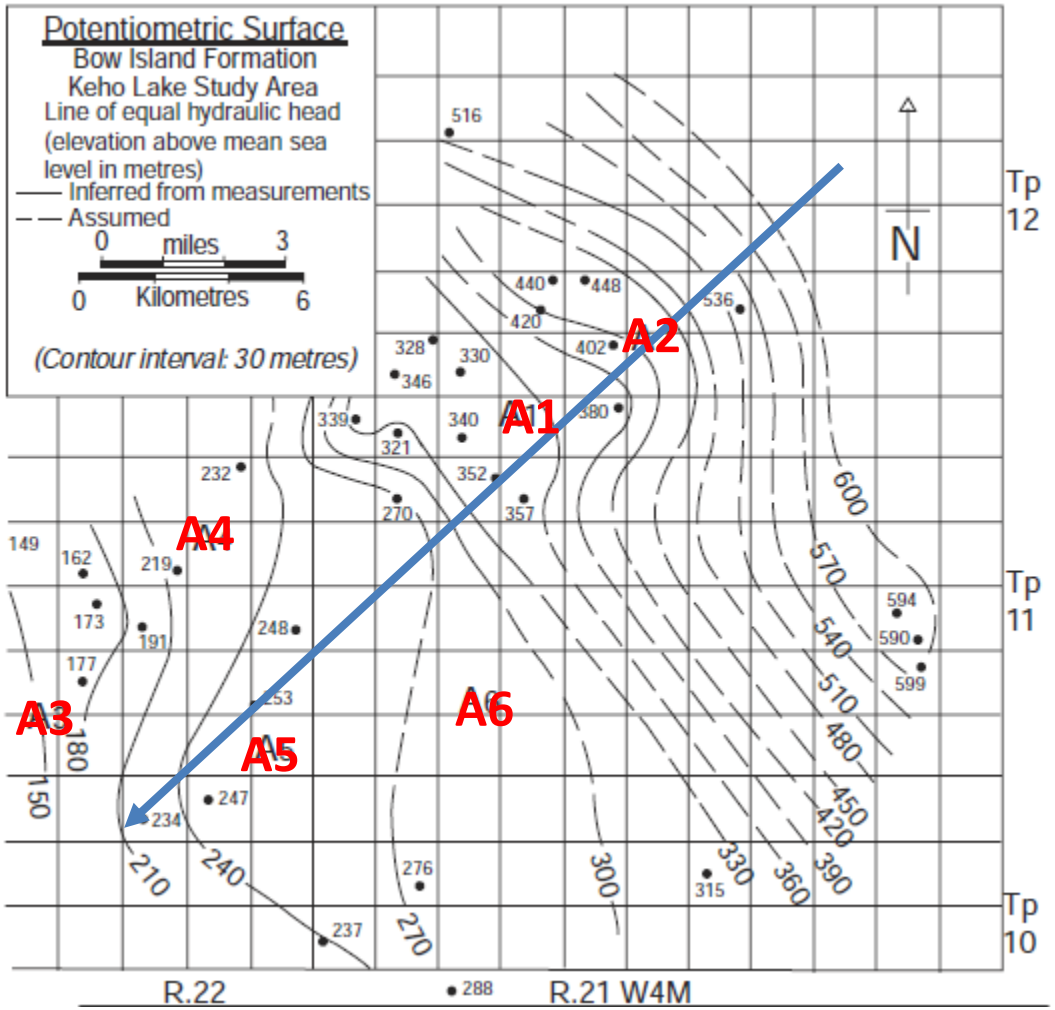
- A good database
- Dominantly lateral flow fluid
- Sufficiently large hydraulic gradient

Target geological unit



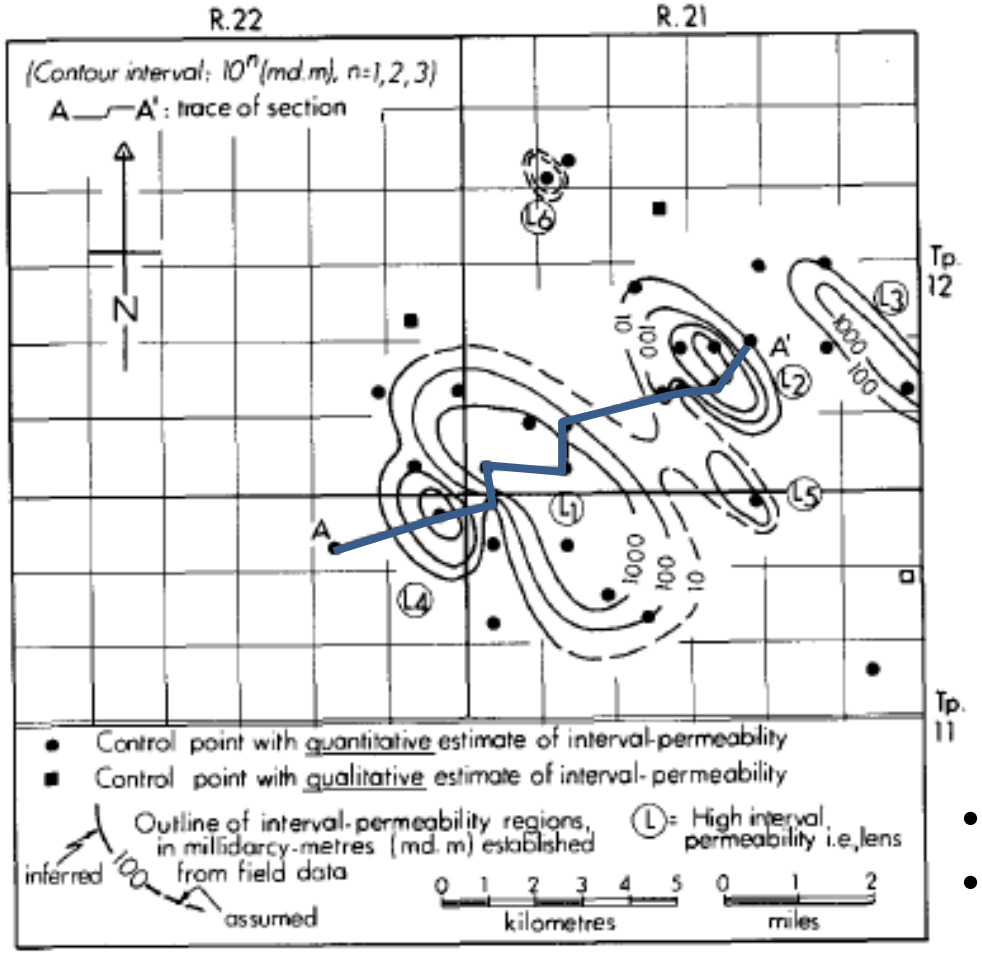
- A local area of potentiometric perturbations was selected from a large map reduced from DST(drill-stem testing)measurement of formation pressures.

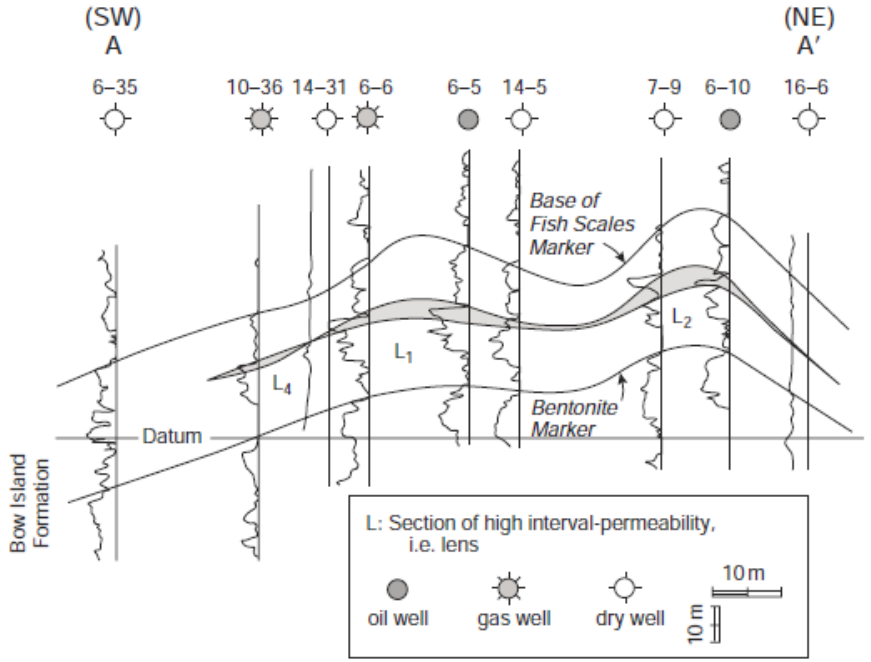
Selection of target anomalies



- Monoclinal pattern → anomalies (A1-A6)

Geological evaluation of chosen anomaly sites



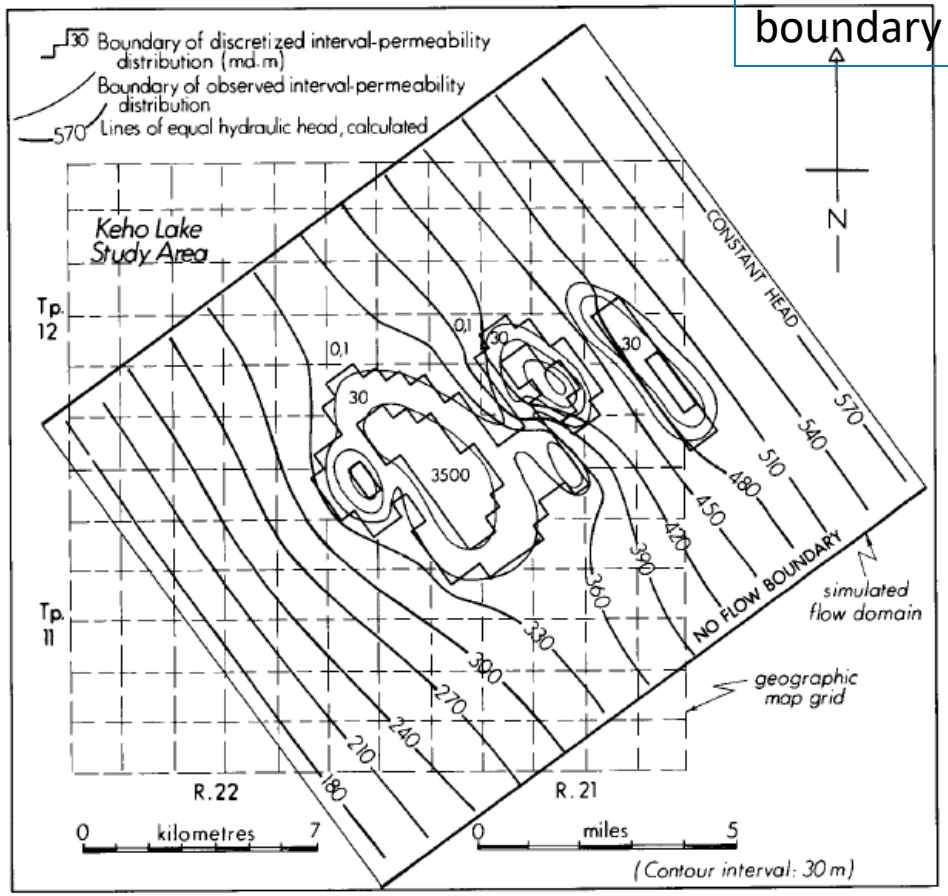


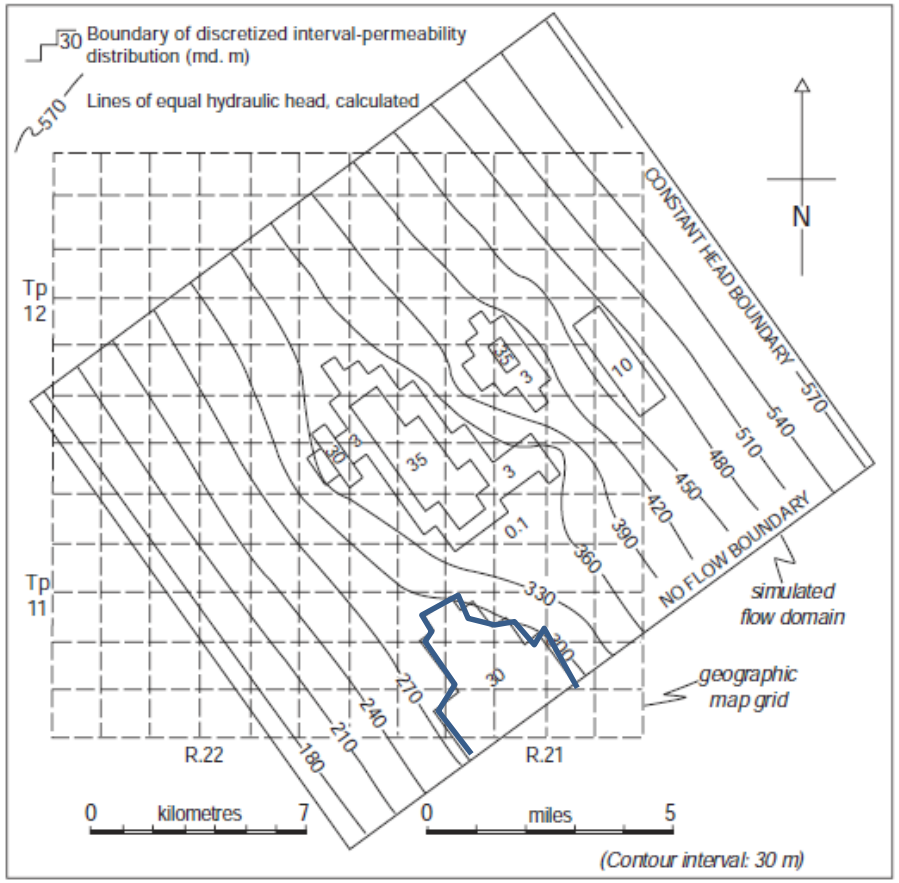
- Calculating the interval-permeability (DST and core analyses)
- The section of structure and interval permeability through lenses conforms the validity (A4 A1 A2)

Verification and refinement of the prediction by numerical modelling

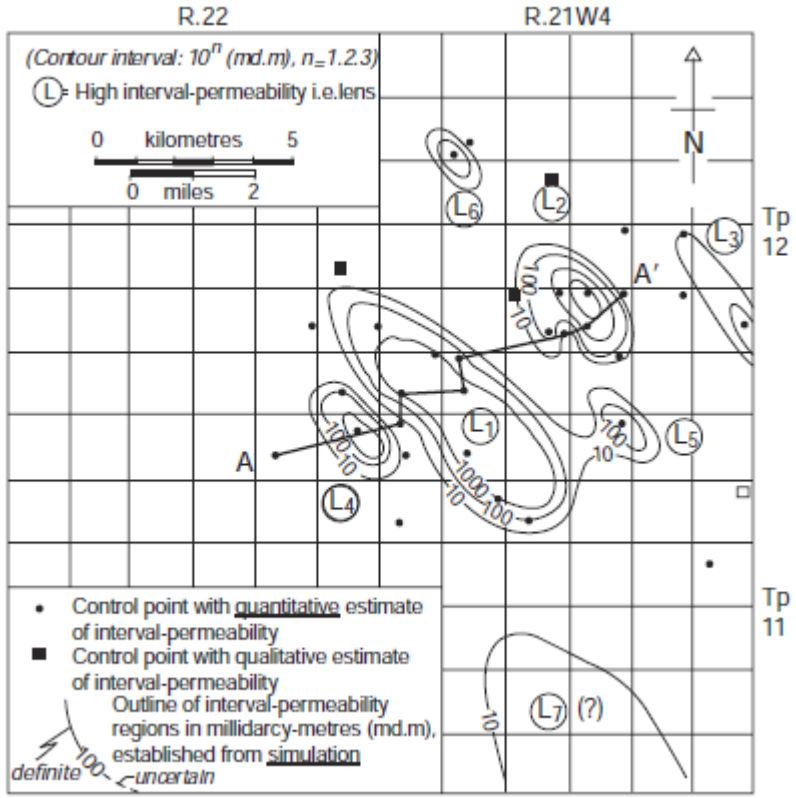
Modflow

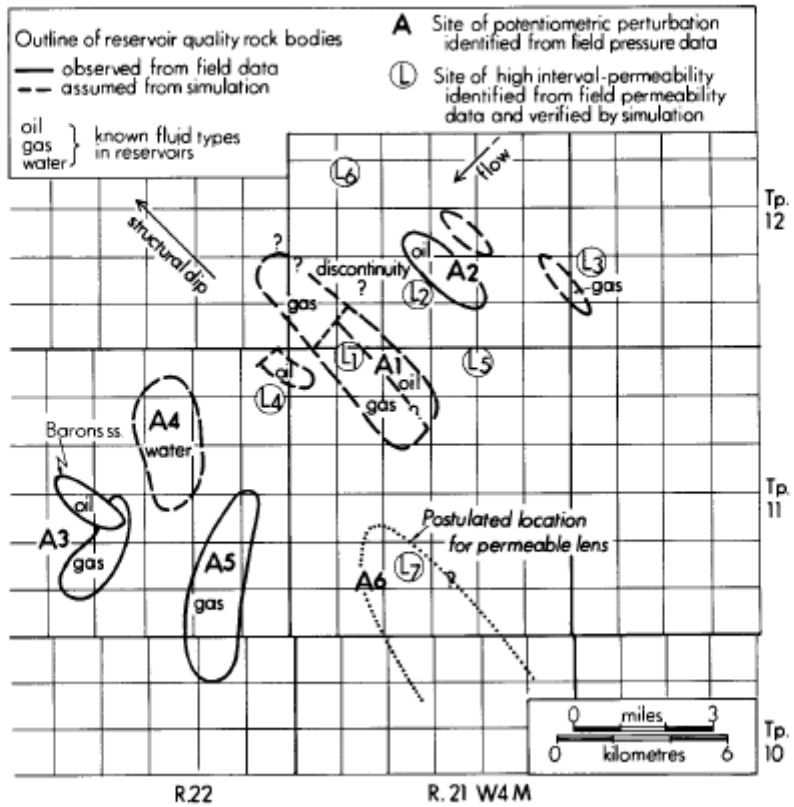
Constant head boundary





Simulation Vs. Observation



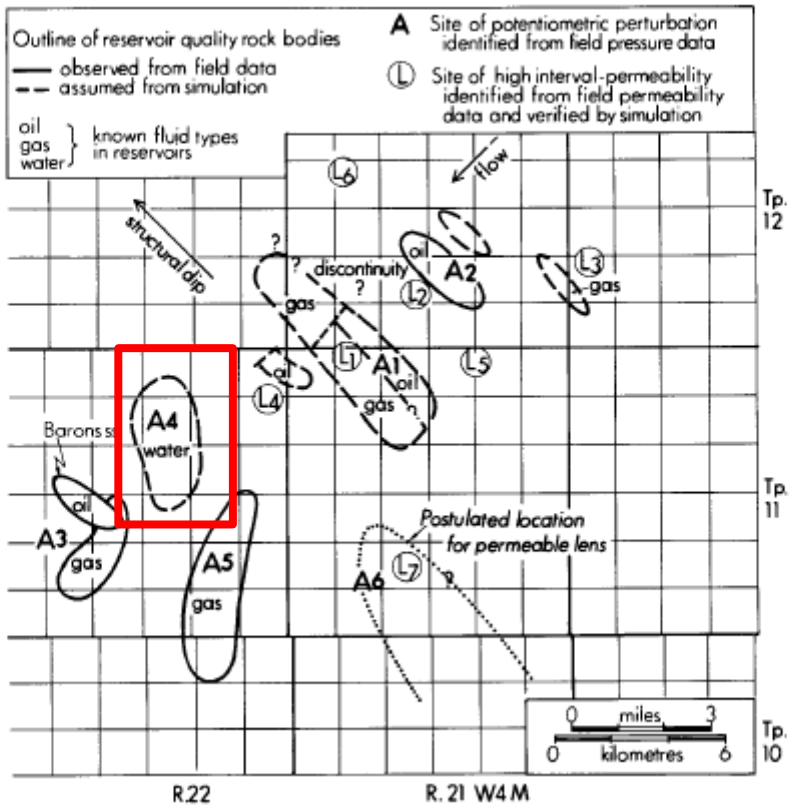


Problem

1) Database

2) Formation-fluid types

↑ × **? More data**



Conclusion

Lens-induced perturbations of the potentiometric surface is usefully employed in exploration, provided that a sufficient database exists.

Thank you for your attention!