Environmental Impact Assessment of Exploration Coal Deposits and Project Constructions

— on example of Primorskiy Region (Russian Far East) —

Dr. Tatiana SELIVANOVA
Geophysical and Geoecological Chair,
Far Eastern State Technical University

Abstract

Will be use 6 graphics packages of a few coal deposits and technical constructions consisted from schematic geological, hydro-geological and technical maps.

The practical course include following:

1. Zoning of territory on man-caused environmental impact:

Will define borders of the following zones:
1) Zone of direct man-caused environmental impact;
Zone of considerable man-caused environmental impact;
Zone of zero man-caused environmental impact.

Will define the environment component has the most man-caused impact.

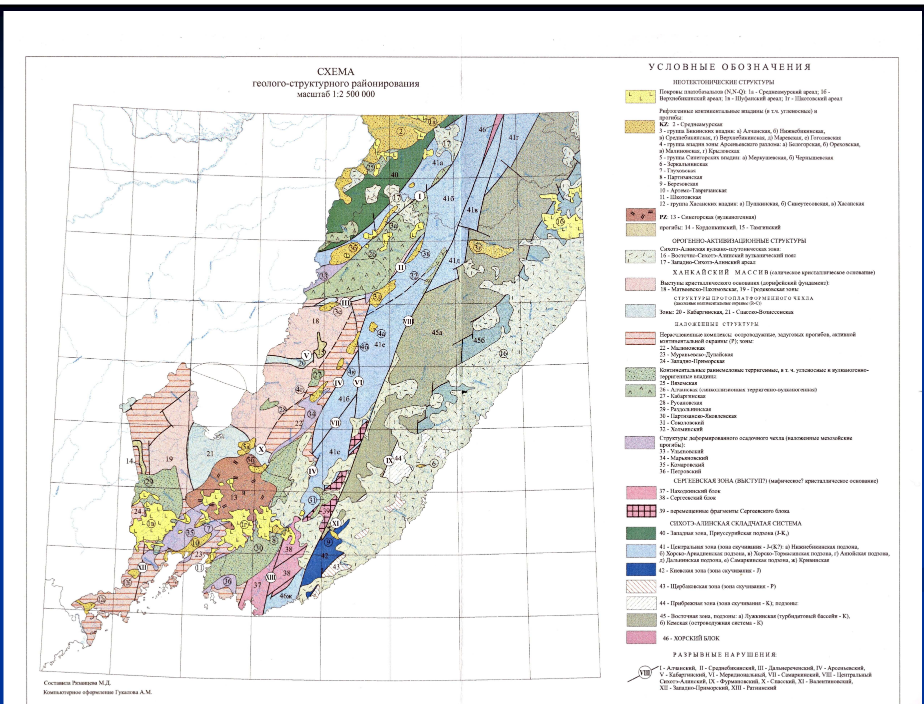
2. Environmental quality monitoring:

- Engineering-geological monitoring networking.
- Underground water quality monitoring networking.
- Surface water quality monitoring networking.
- Air quality monitoring networking.
- Soil quality monitoring networking.

3. Recreational stability impact of territory:

- Will calculate factor of a recreational development of territory (K).
- Will type of a recreational landscape.

An application of Resistivity and Induced polarization sounding methods on ground water research by the example of Primorski Krai



Hankayskiy Region

- In the tectonic meaning the Region represents the **Hankayskiy median massif;**
- The rocks submitted the **terrigene, carbonaceous, granite formations;**
- Cover rocks compose imposed **Cainozoic depressions;**
- **Paleogen-Neogen coaly-terrigene** formations are bedded in the basin of the depressions;
- The top structural horizons of the depressions are formed by **Quaternary lacustrine-marsh, polygenetic formations, alluvial sediments of the flat river.**

Underground Water Of The Hankayskiy Region

- **The water of Quanternary sediments and artesian aquifer waters** are widely distributed;
- The capacity of the water horizons is **5-20**m;
- The filtration factor changes from **3 up 50 m/day;**
- The capacity of the covered clay, loams layers is **2-3 m;**
- Chemical compound of water is **hydrocarbonate, mainly calcic;**
- The water mineralization is **75-680 mg/l;**
- The waters have **leaching aggression.**

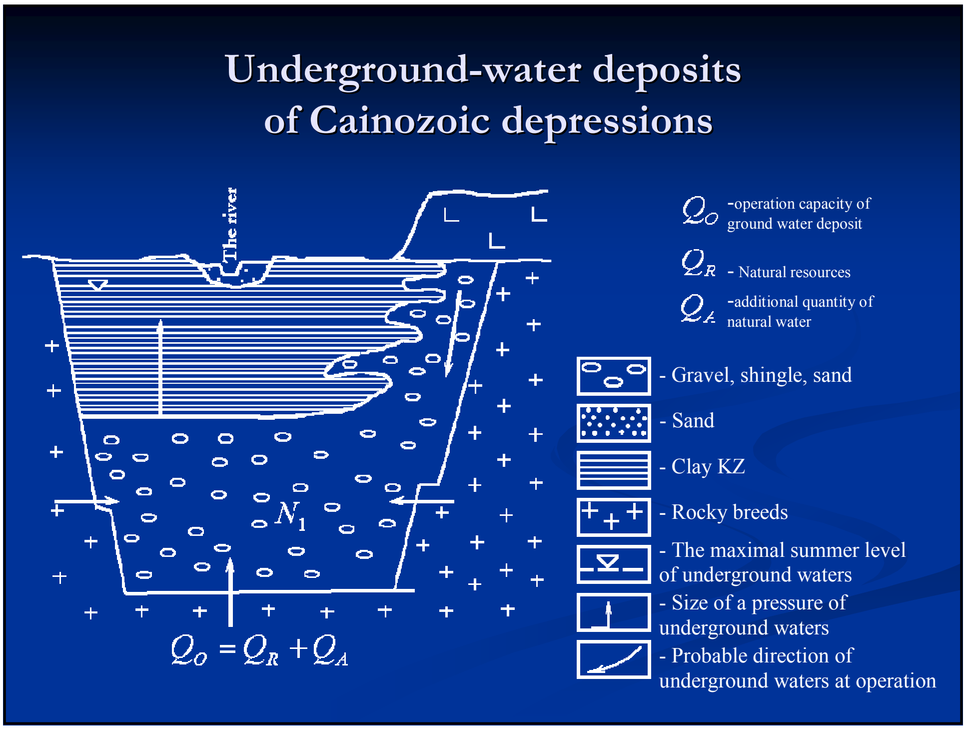
Hydrogeology Of The Piedmont Region

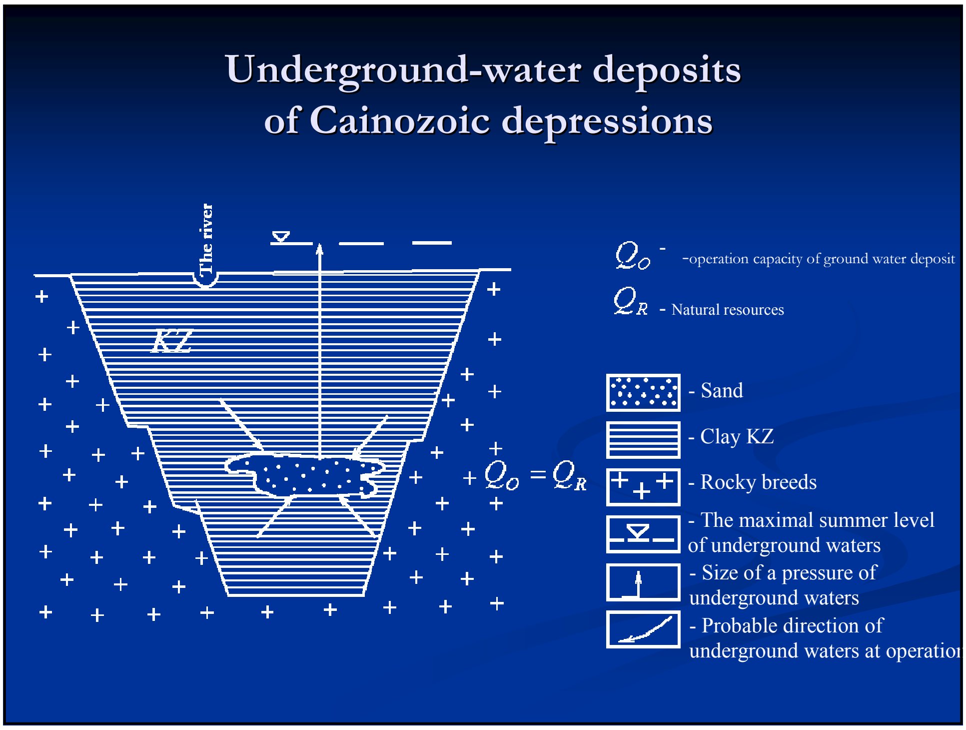
- Presence **23 small artesian basins** framing the Hankaiskiy massive;
- Presence **bedded-fractured subsoil waters neogen basalts**;
- **Alluvial water horizons** have widespread;
- **Waters of top fractured zones** have insignificant distribution;
- The water horizons are dated to **gravel, gravel-pebble, sand-gravel, sand sediments**;

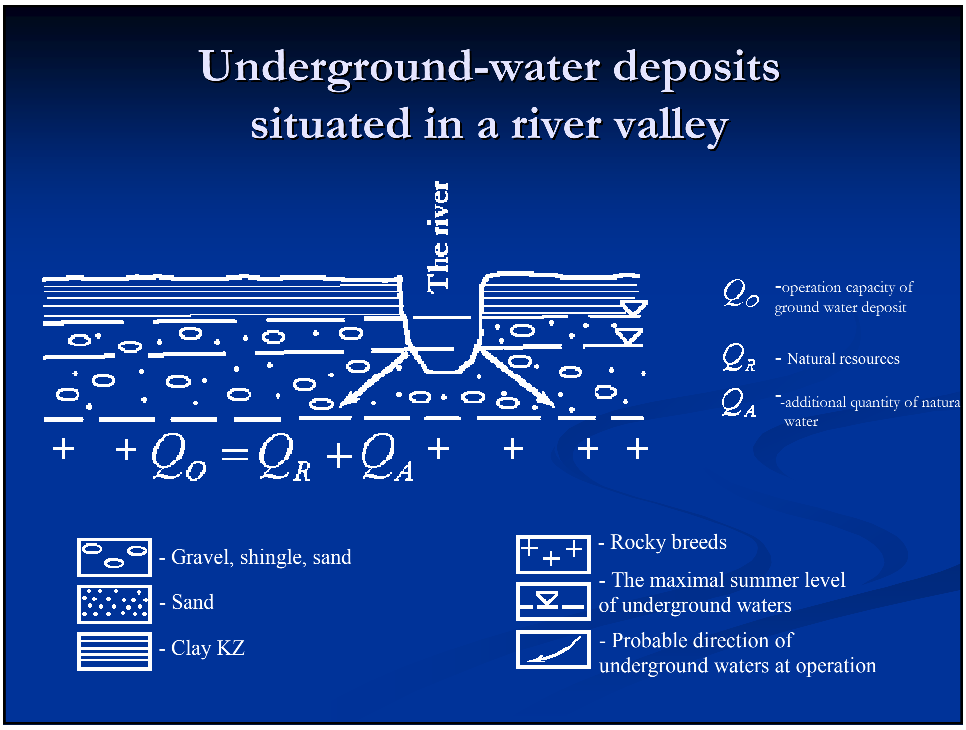
- The clay streaks causes formation several **water horizons hydraulicly connected among themselves**;
- The filtration factor is **1- 344 m/day**;
- The chemical composition is **hydrocarbonate, less often chloridical, calcic, natrium**;
- Waters have **leaching aggression**;
- The water horizons of the sea and alluvial-sea sediments located below of the sea level have **mineralization up to 25.7 g/l, acidic aggression, less often leaching aggression**

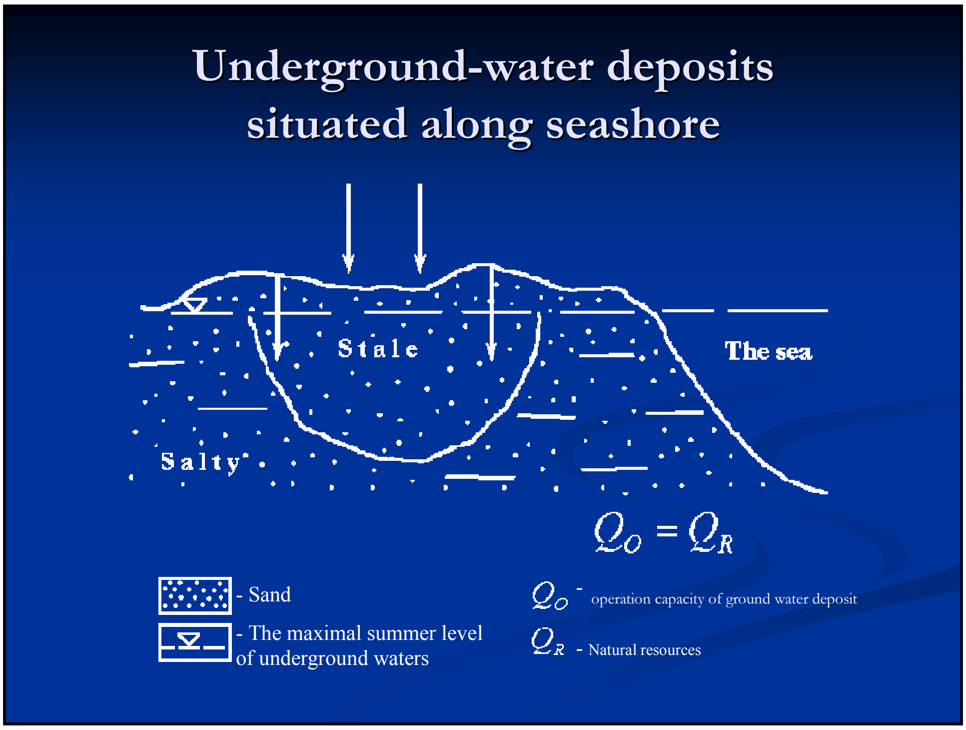
Typical hydro-geological sections of underground water deposits of Primorski krai

Underground-water deposits of Cainozoic depressions

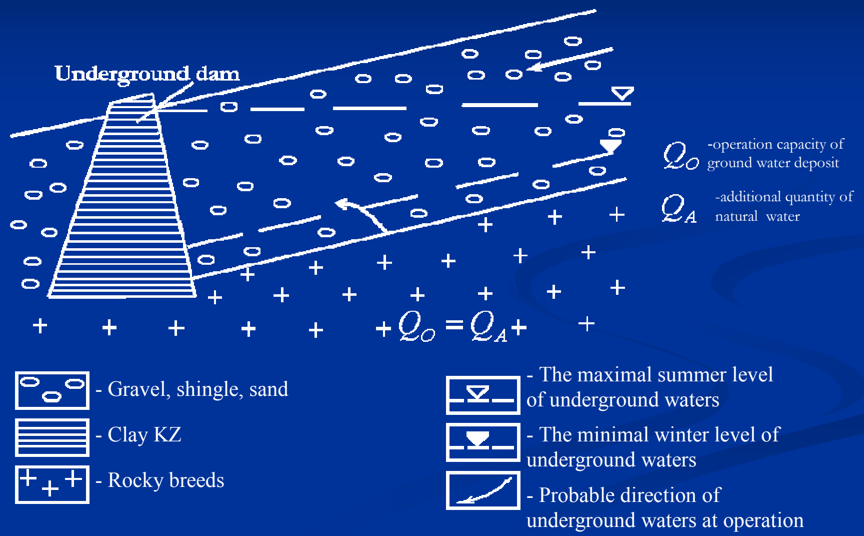

Underground-water deposits
of Cainozoic depressions
The river
N_1
$Q_O = Q_R + Q_A$
Q_O -operation capacity of ground water deposit
Q_R - Natural resources
Q_A -additional quantity of natural water
- Gravel, shingle, sand
- Sand
- Clay KZ
- Rocky breeds
- The maximal summer level of underground waters
- Size of a pressure of underground waters
- Probable direction of underground waters at operation


Underground-water deposits
of Cainozoic depressions
The river
KZ
$Q_O = Q_R$
Q_O - -operation capacity of ground water deposit
Q_R - Natural resources
- Sand
- Clay KZ
- Rocky breeds
- The maximal summer level of underground waters
- Size of a pressure of underground waters
- Probable direction of underground waters at operatio

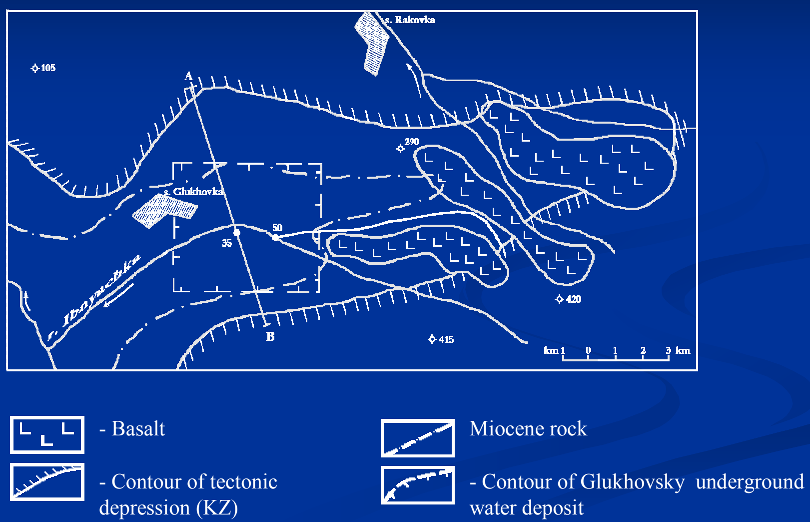

Underground-water deposits
situated in a river valley
The river
Q_O -operation capacity of ground water deposit
Q_R - Natural resources
Q_A -additional quantity of natura water
$Q_O = Q_R + Q_A$
- Gravel, shingle, sand
- Sand
- Clay KZ
- Rocky breeds
- The maximal summer level of underground waters
- Probable direction of underground waters at operation

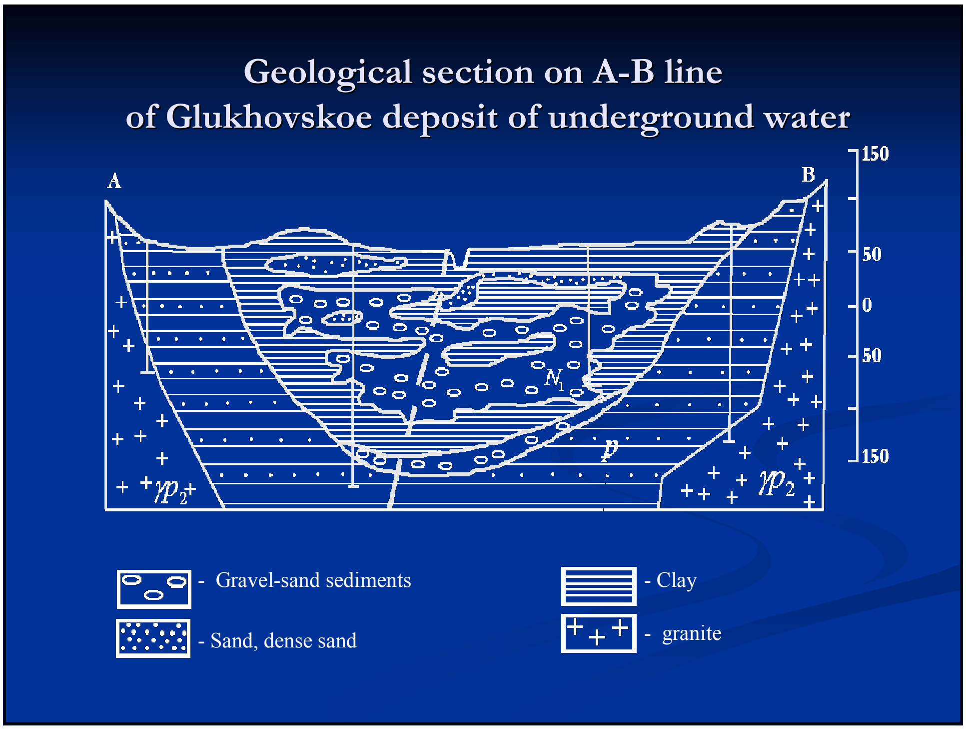

Underground-water deposits
situated along seashore
Stale
The sea
Salty
$Q_O = Q_R$
- Sand
- The maximal summer level of underground waters
Q_O - operation capacity of ground water deposit
Q_R - Natural resources

Underground water deposits concerned with all-the-year-round dewatered underground water horizon

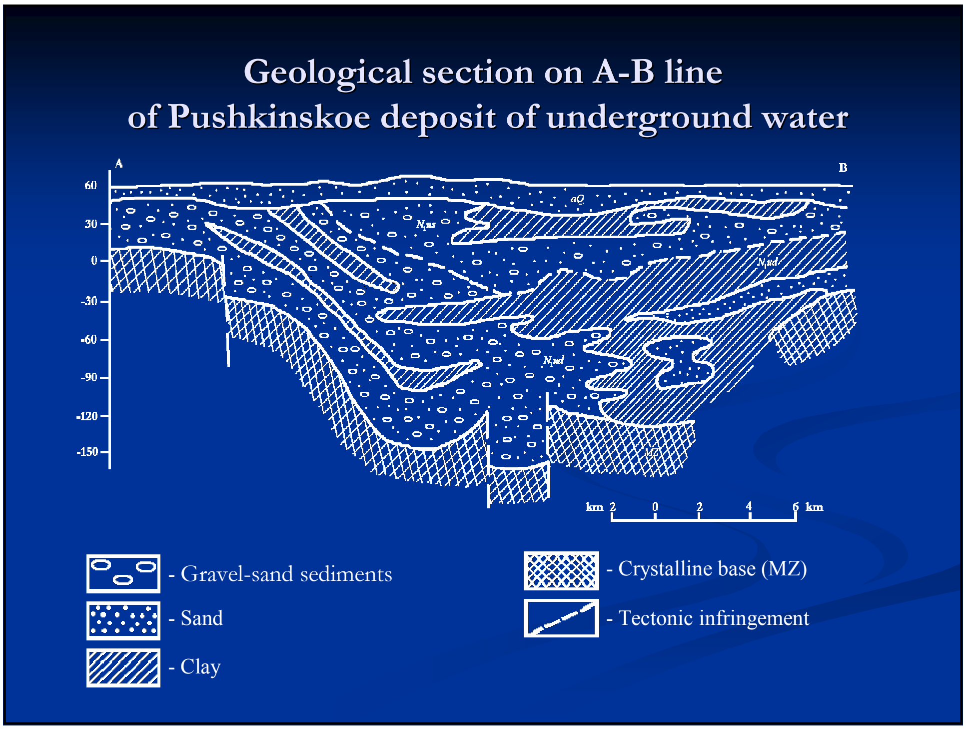


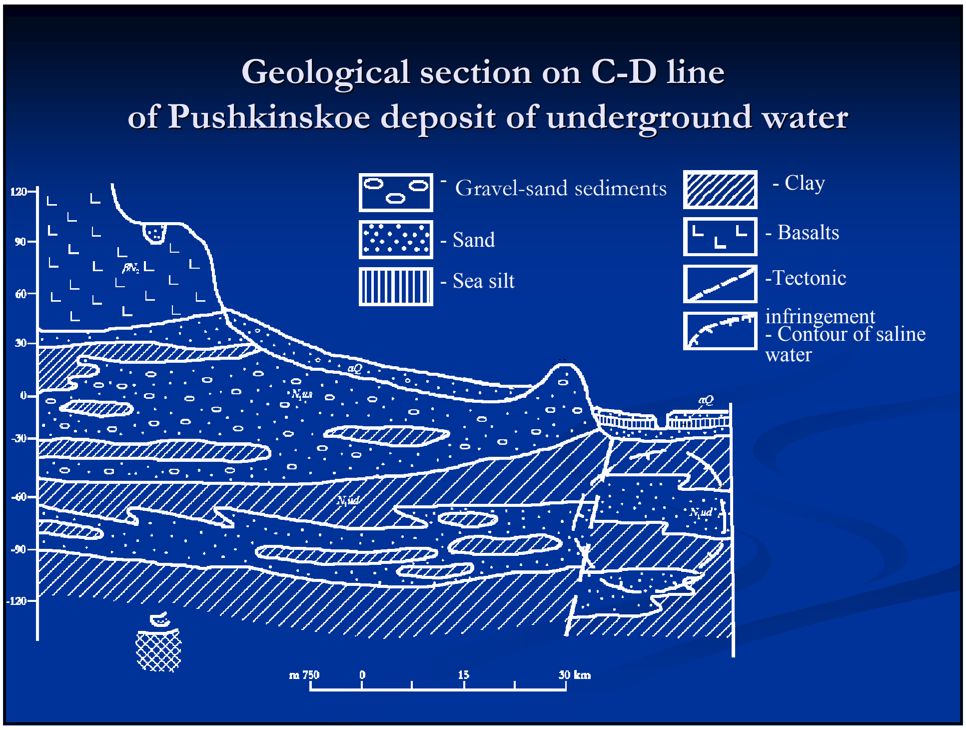
Glukhovskoe deposit of underground water

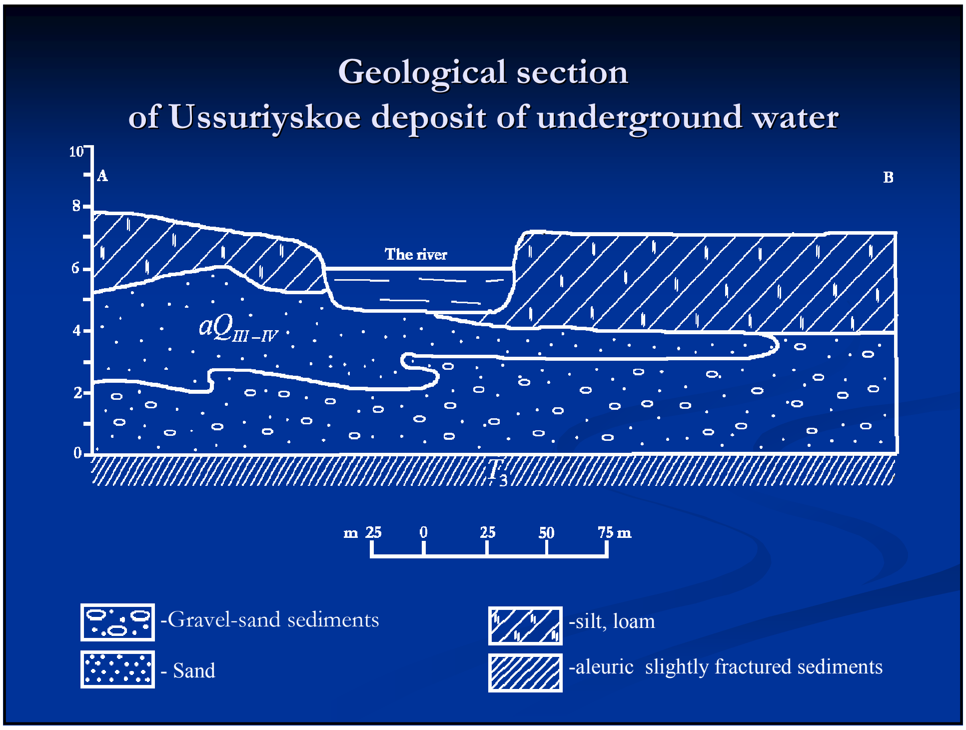


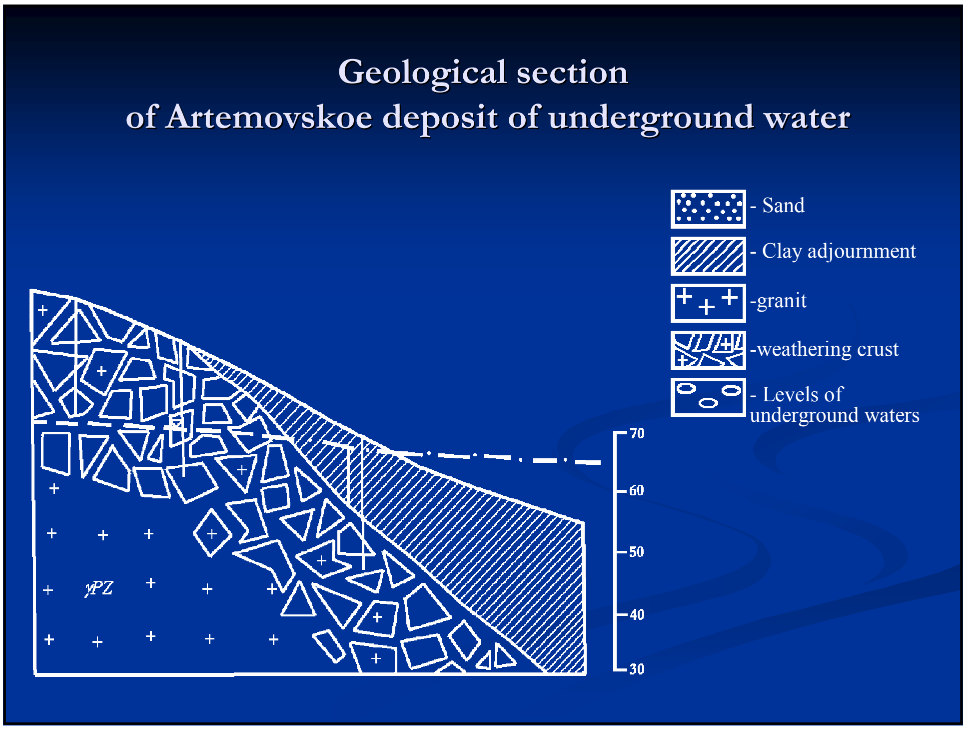

Geological section on A-B line
of Glukhovskoe deposit of underground water
A
B
150
50
0
50
150
N_1
γp_2
- Gravel-sand sediments
- Sand, dense sand
- Clay
- granite


Pushkinskoe deposit of underground water
Ussuriysk
Artyom
Vladivostok
The Amur gulf
China
MZ
I
II
- River valley
- Sand-clay sediments
- Basalt plateau
MZ
-Highlands; range of dense fractured rocks(MZ)
- mountain ridges
- Pushkinskay depression (KZ)
Contour of underground salty relic wa
- Pushkinskoe deposit of fresh underground water
I - Borisovsly section
II- Razdolnensky section

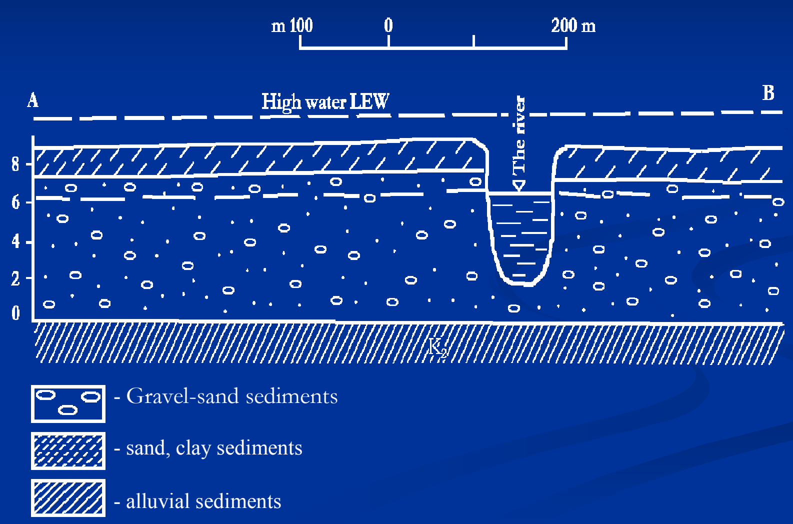

Geological section on A-B line
of Pushkinskoe deposit of underground water
A
B
60
30
0
-30
-60
-90
-120
-150
km 2 0 2 4 6 km
- Gravel-sand sediments
- Sand
- Clay
- Crystalline base (MZ)
- Tectonic infringement


Geological section on C-D line
of Pushkinskoe deposit of underground water
120
90
60
30
0
-30
-60
-90
-120
- Gravel-sand sediments
- Sand
- Sea silt
- Clay
- Basalts
-Tectonic
infringement
- Contour of saline
water
m 750 0 15 30 km


Geological section
of Ussuriyskoe deposit of underground water
10
8
6
4
2
0
A
B
The river
aQIII-IV
T3
m 25
0
25
50
75 m
-Gravel-sand sediments
- Sand
-silt, loam
-aleuric slightly fractured sediments


Geological section
of Artemovskoe deposit of underground water
- Sand
- Clay adjournment
-granit
-weathering crust
- Levels of
underground waters
70
60
50
40
30
γPZ

Geological section
of Bolshekamenskoe deposit of underground water



An application of geophysical methods for carrying out hydro-geological tasks requires:

- - To reduce field engineering saving hardware (such as chisel) as well as workloads in laboratory;
- - To monitor continuously the information of hydro-geological parameters of underground water horizons in area and depth.

An application of geophysical methods allows achieving the following geological-hydrogeological tasks:

1. Lithological stratification of a section from the surface up to the depth of the first regional aquifer;
2. Division and zonation of a section in terms of geological/hydro-geological type;
3. Determination of overall parameters of mineralization including salinity, pH and other chemical indicators in underground waters, for understanding the spatial changes in area and depth;
4. Determination of permeability parameters and their special change of water-socked rocks.

Geophysical researches on underground waters are carried out in combination with the following activities:

- - On-site borehole logging for obtaining regarding parameters;
- - Laboratory works on classification of samples and corresponding tests.

Electrical investigation measuring the resistance of direct current physics are following:

1. The intensity of electric conductivity of rocks depends on bearing free-ion content in ground water;
2. Mineralization and the degree of halomorphic featureof an aquifer are defined mainly the electric resistances of country rocks;
3. Free ions move along capillaries in rocks or soils. Therefore, the porosity influences on resistance of rocks.

The following factors influence the resistance of rocks:

- - Water content of rocks;
- - The form and structure of pore spaces of rock;
- - Temperature;
- - Granulometric heterogeneity of rocks;
- - The content and structure of clay fraction.

Mathematical expression the dependence of resistance on rocks' temperature

$$\rho_t = \frac{\rho_{18}}{1 + 0{,}025(t - 18^\circ)}$$

Mathematical expression the dependence of resistance on porosities of water-contained rocks

$$P_n = A_n / K^m$$

P_n- Parameter of porosity or relative resistance water content rocks and resistance of water contained in rocks' pories;

A_n- The constant factor changing for sandy-argillaceous rock from 0.9 up 1.3;

K_m - Average porosity of rocks;

m - The parameter connected to the form rocks' pore channels.

Interpretation of electro-prospecting data

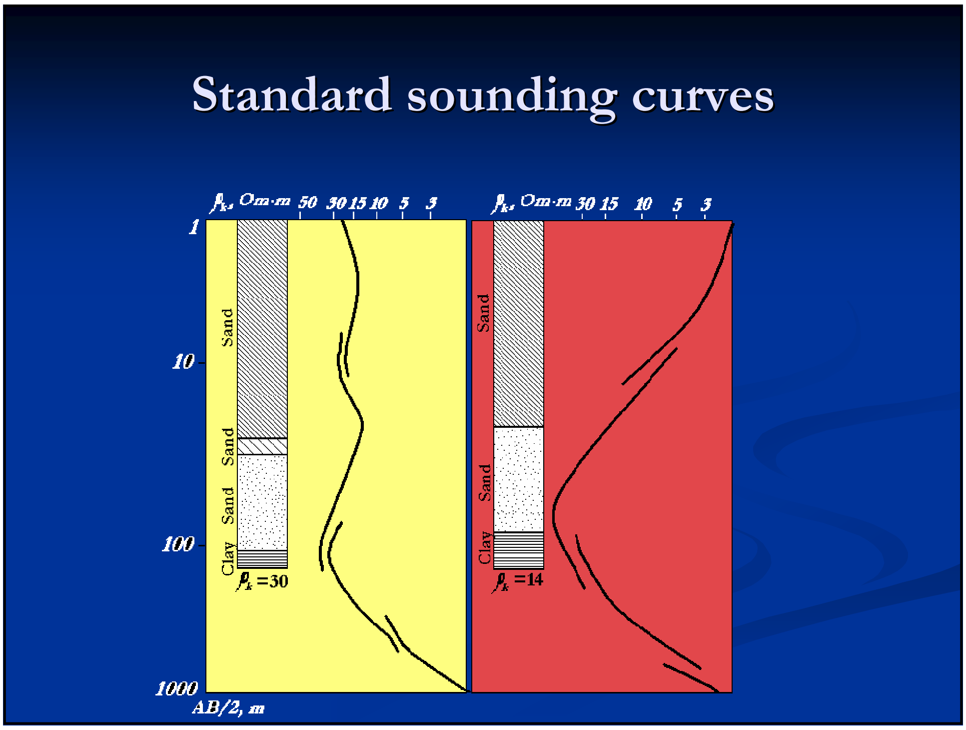
Interpretation of electro-prospecting data is carried out by two stages:

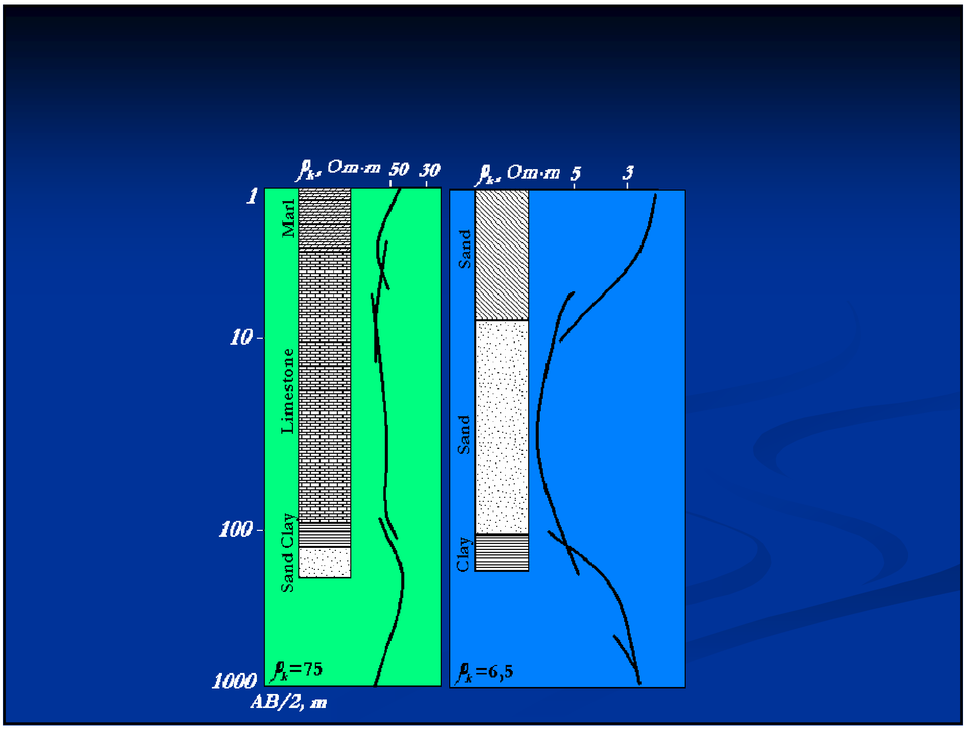
1. Qualitative interpretation

2. Quantitative interpretation

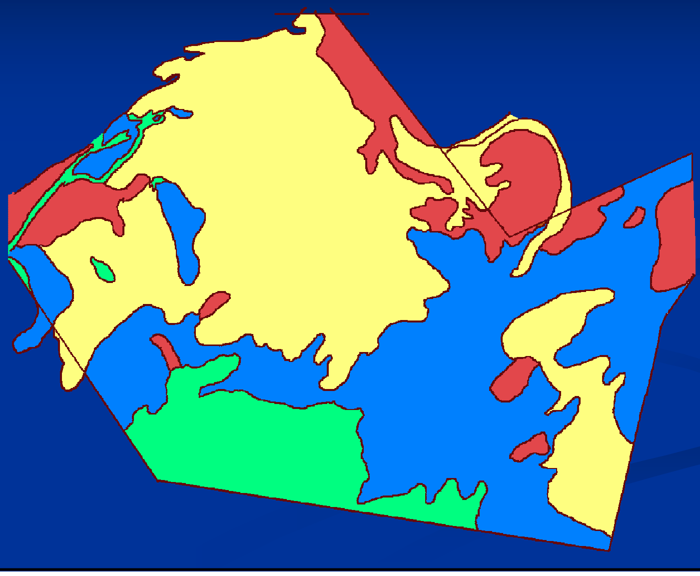
Qualitative interpretation of electro-prospecting data

Qualitative interpretation is based on zoning of sounding curves contained hydro-geological section information


Standard sounding curves
Om·m 50 30 15 10 5 3
Om·m 30 15 10 5 3
1
10
100
1000
Sand
Sand
Sand
Clay
=30
Sand
Sand
Clay
=14
AB/2, m


Om·m 50 30
Om·m 5 3
1
10
100
1000
Marl
Limestone
Sand Clay
=75
Sand
Sand
Clay
=6,5
AB/2, m

Zoning map of sounding curves



As resistance of rocks is influenced simultaneously by some factors,

the functional dependence between resistance of rocks and hydro-geological parameters can be established only by correlation method

Quantitative geological/hydro-geological interpretation is based

on the correlation between geophysical and geological/hydro-geological parameters

Many experimental researches with many parametrical measurements taken in

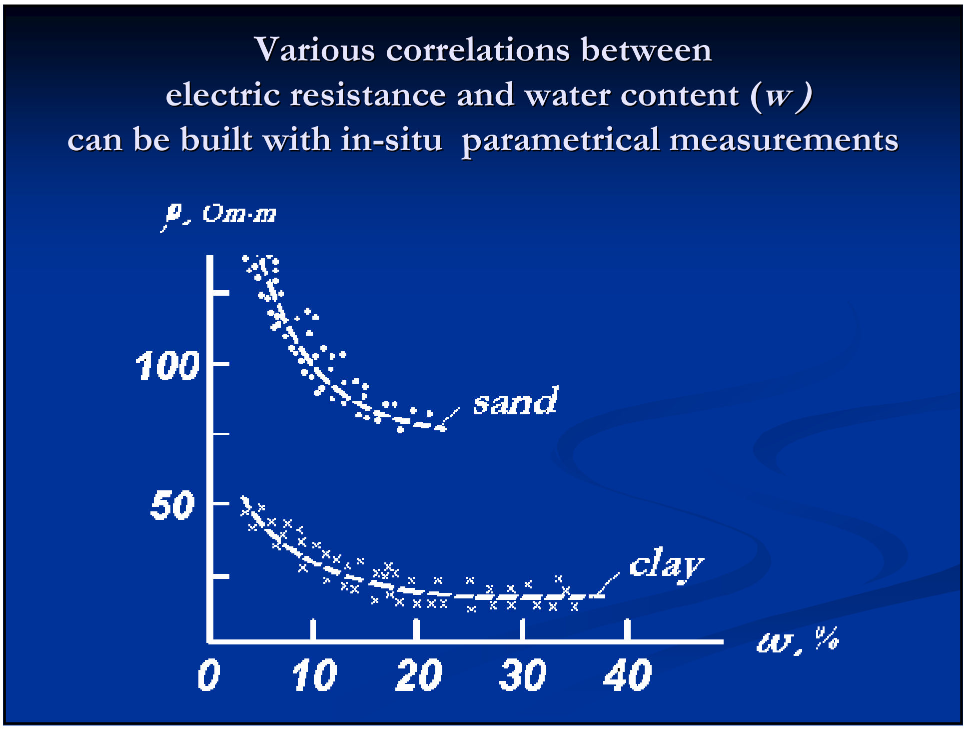
prospecting shafts, drill holes, ground surface, and also laboratory,

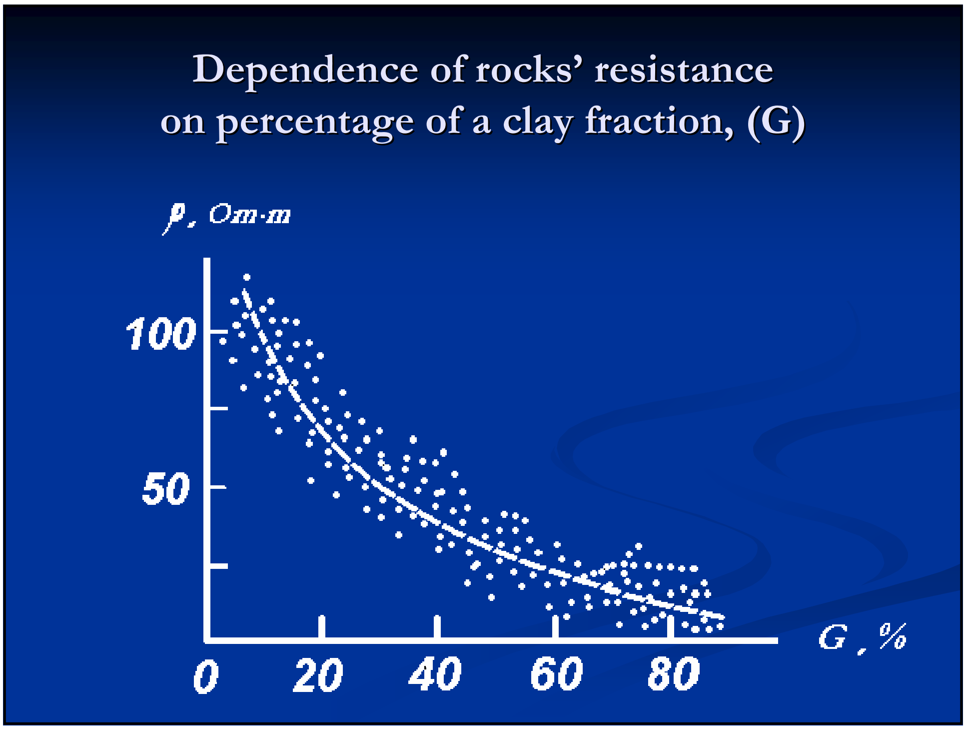
from which correlation between

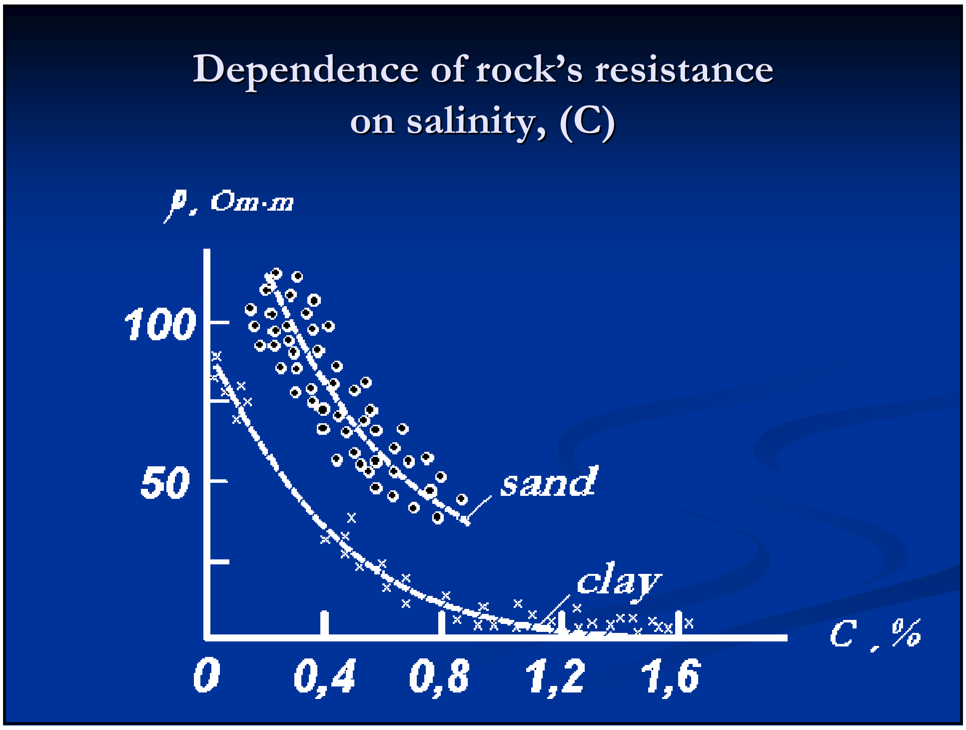
specific electric resistance and

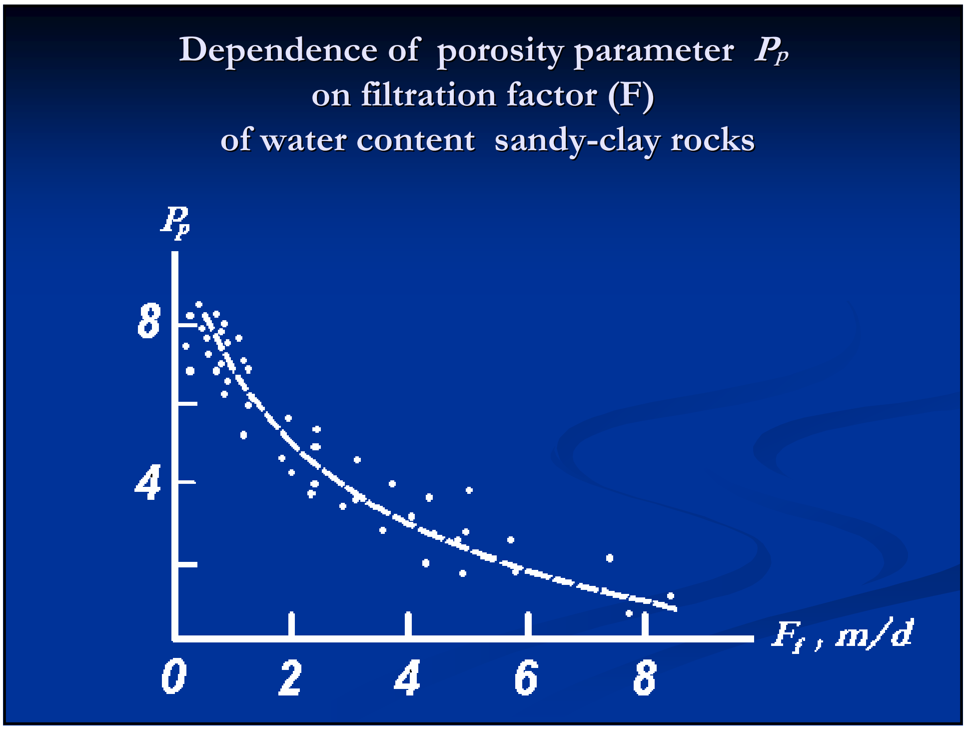
rocks' hydro-geological parameters

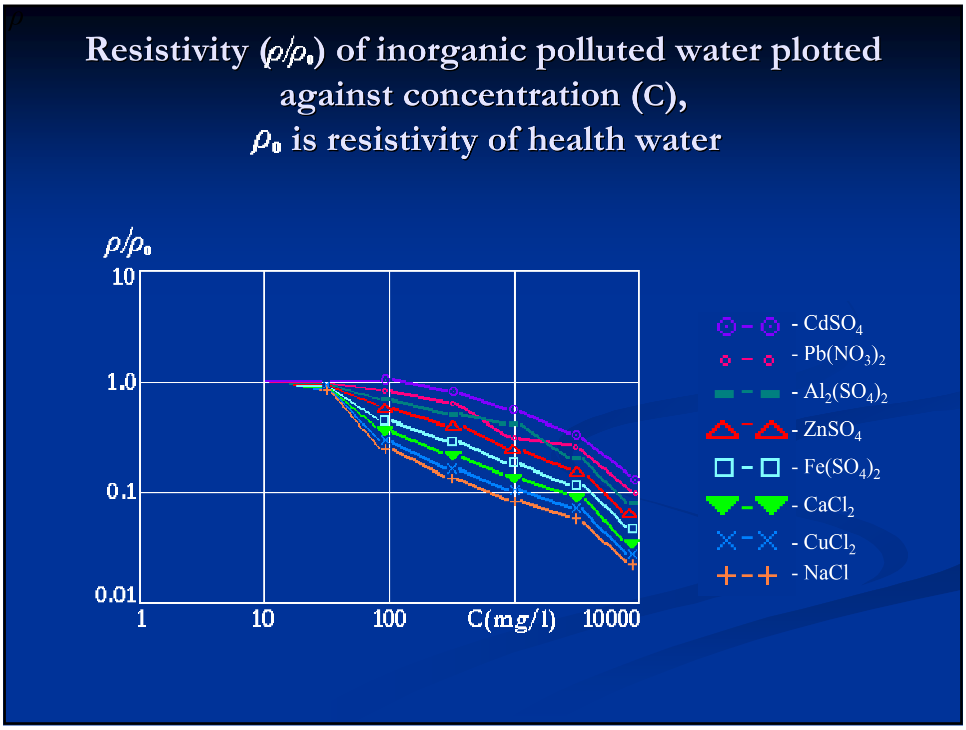
have been established and statistically proved

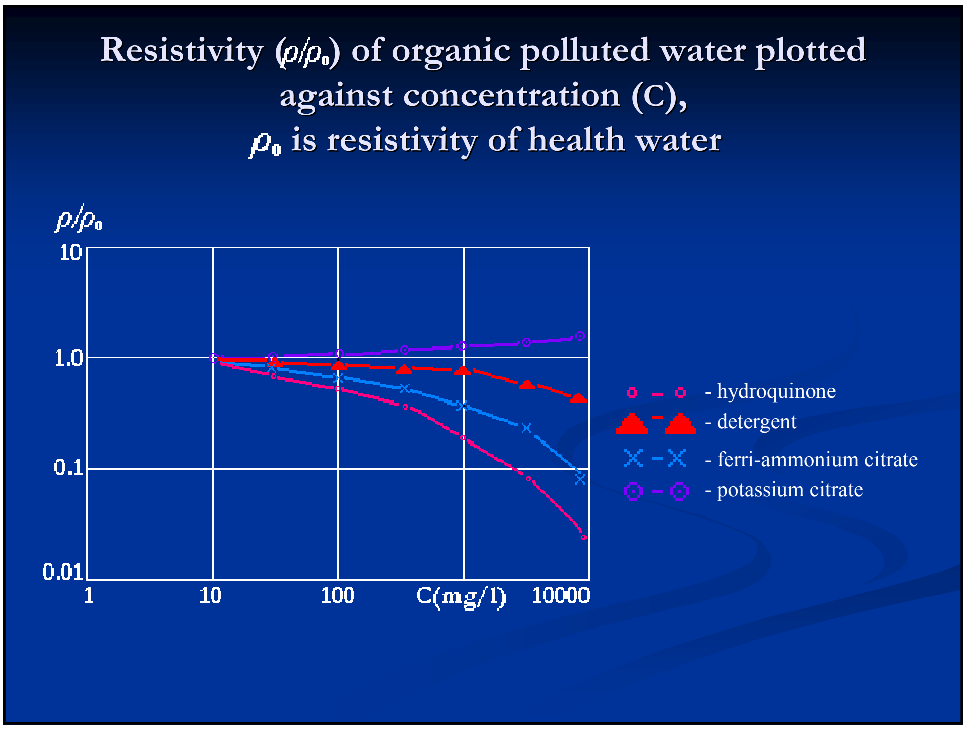

Various correlations between
electric resistance and water content (w)
can be built with in-situ parametrical measurements
ρ, Om·m
100
50
sand
clay
0
10
20
30
40
w, %


Dependence of rocks' resistance
on percentage of a clay fraction, (G)
ρ, Om·m
100
50
0
20
40
60
80
G, %


Dependence of rock's resistance
on salinity, (C)
ρ, Om·m
100
50
sand
clay
0
0,4
0,8
1,2
1,6
C, %


Dependence of porosity parameter P_p
on filtration factor (F)
of water content sandy-clay rocks
P_p
8
4
0
2
4
6
8
F_f, m/d


Resistivity (ρ/ρ₀) of inorganic polluted water plotted
against concentration (C),
ρ₀ is resistivity of health water
ρ/ρ₀
10
1.0
0.1
0.01
1
10
100
C(mg/l)
10000
- CdSO4
- Pb(NO3)2
- Al2(SO4)2
- ZnSO4
- Fe(SO4)2
- CaCl2
- CuCl2
- NaCl


Resistivity (ρ/ρ₀) of organic polluted water plotted
against concentration (C),
ρ₀ is resistivity of health water
ρ/ρ₀
10
1.0
0.1
0.01
1
10
100
C(mg/l)
10000
- hydroquinone
- detergent
- ferri-ammonium citrate
- potassium citrate

Electrical investigation by a method of the induced polarization

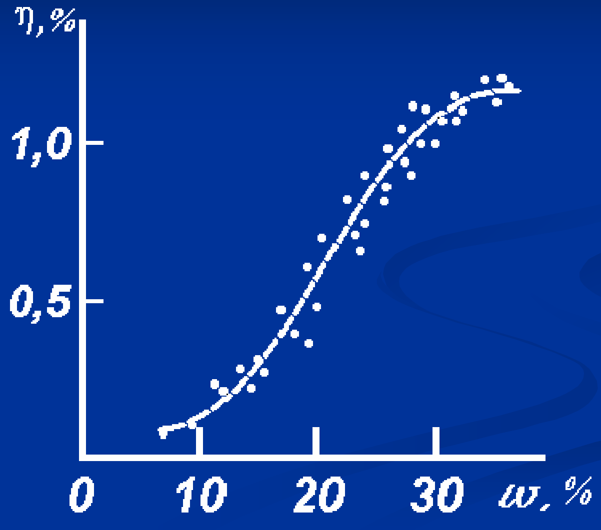
For quantitative estimation on the effect of induced polarization, the factor of polarizability is used

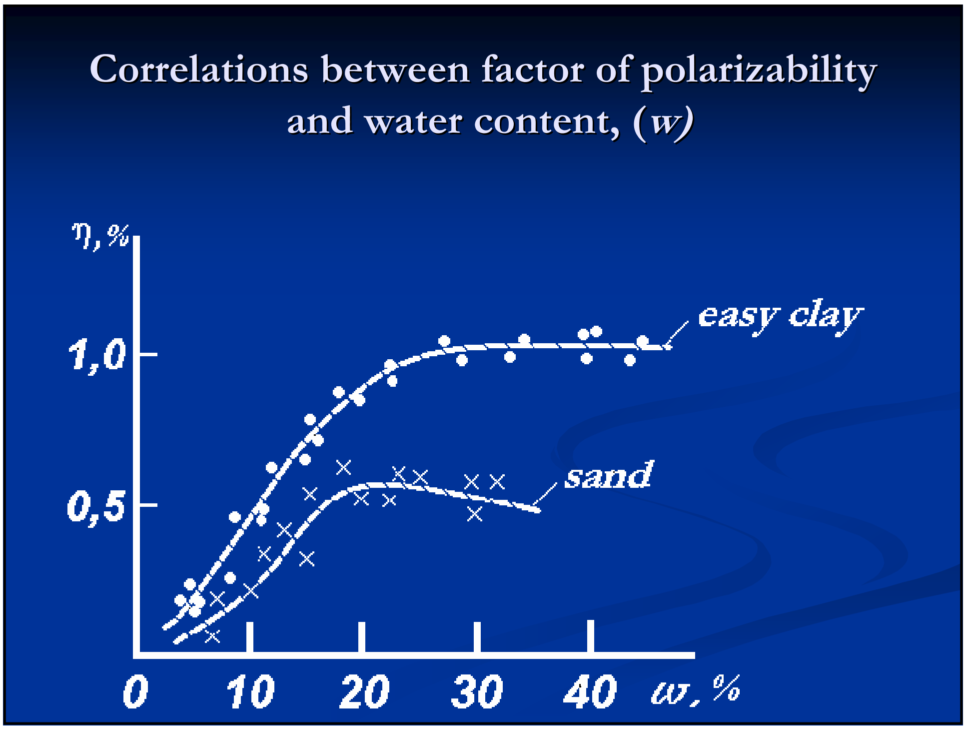
$$\eta = \Delta U_{VP}(t) / \Delta U_{pr}$$

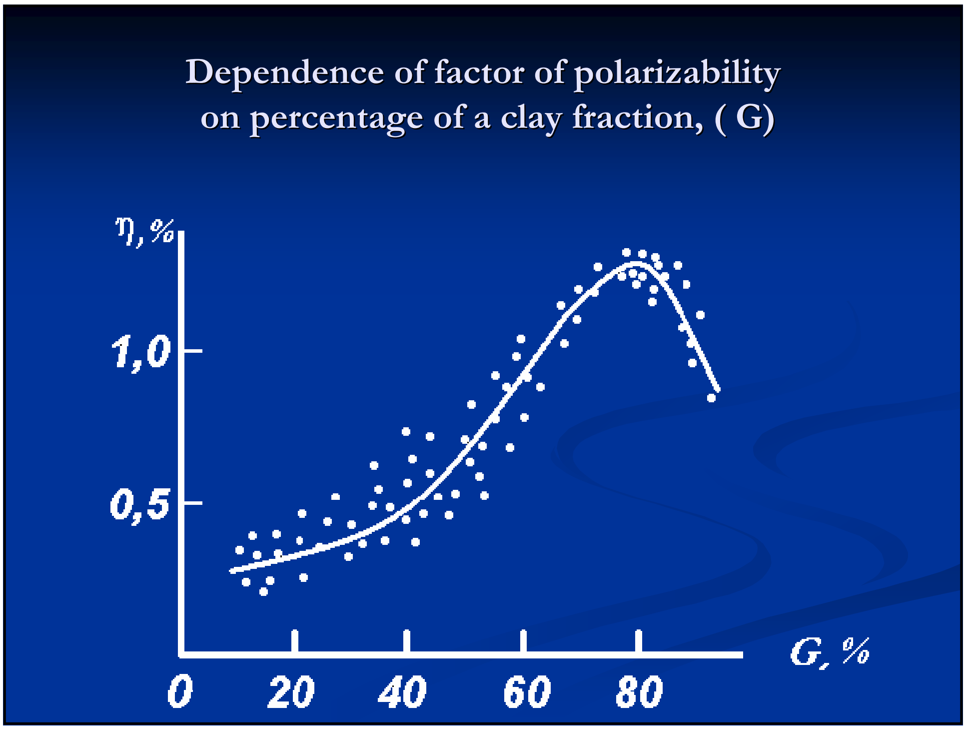
Where U1 is potentional defference of the first field,
while U2 is potentional defference of the second field.

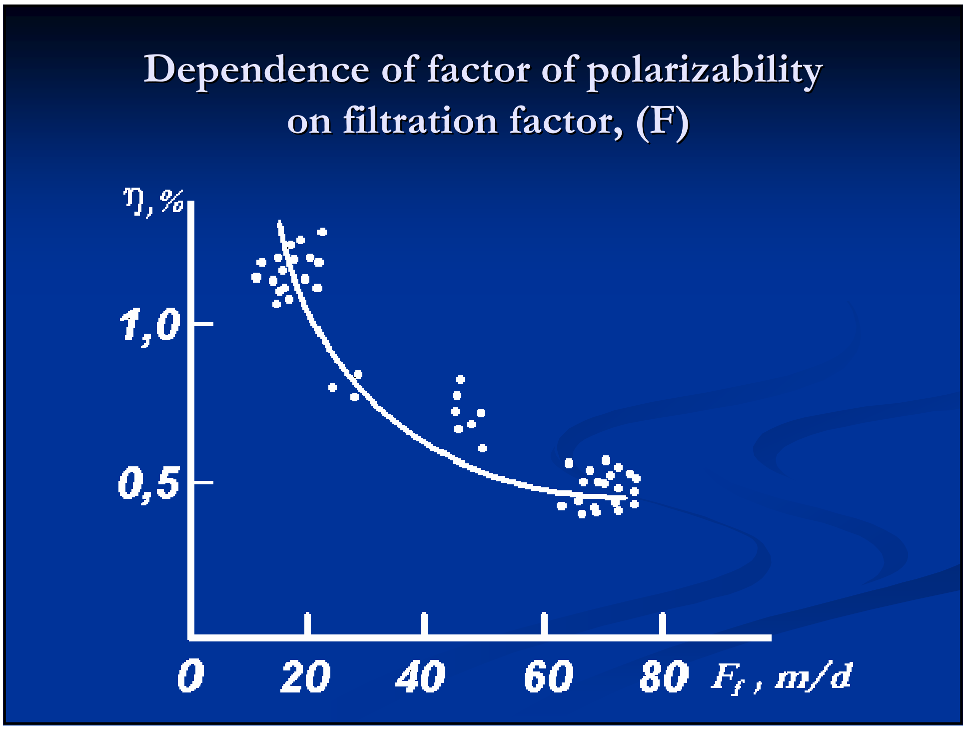
n is amplitude characteristic of depolarization effect

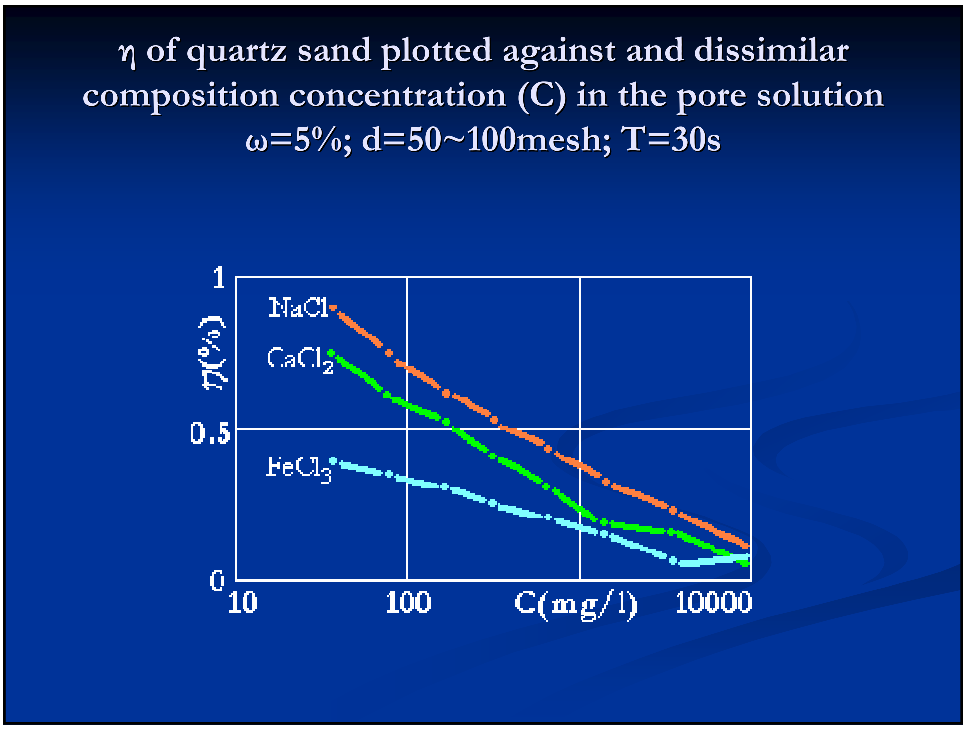
Correlations between factor of polarizability and water content (*w) for loam*




Correlations between factor of polarizability
and water content, (w)
η, %
1,0
0,5
easy clay
sand
0
10
20
30
40
w, %


Dependence of factor of polarizability
on percentage of a clay fraction, (G)
η, %
1,0
0,5
G, %
0
20
40
60
80


Dependence of factor of polarizability
on filtration factor, (F)
η, %
1,0
0,5
0
20
40
60
80
F_f, m/d


η of quartz sand plotted against and dissimilar
composition concentration (C) in the pore solution
ω=5%; d=50~100mesh; T=30s
η(%)
1
0.5
0
NaCl
$CaCl_2$
$FeCl_3$
10
100
C(mg/l)
10000

Integrated factor A is used for characterizing the speed of hydro-geolocal-dependent depolarization effect

$$A = \frac{\Delta U_{VP}(1) - \Delta U_{VP}(11)}{\Delta U_{pr}} \cdot 100\% = \eta(1) - \eta(11)$$

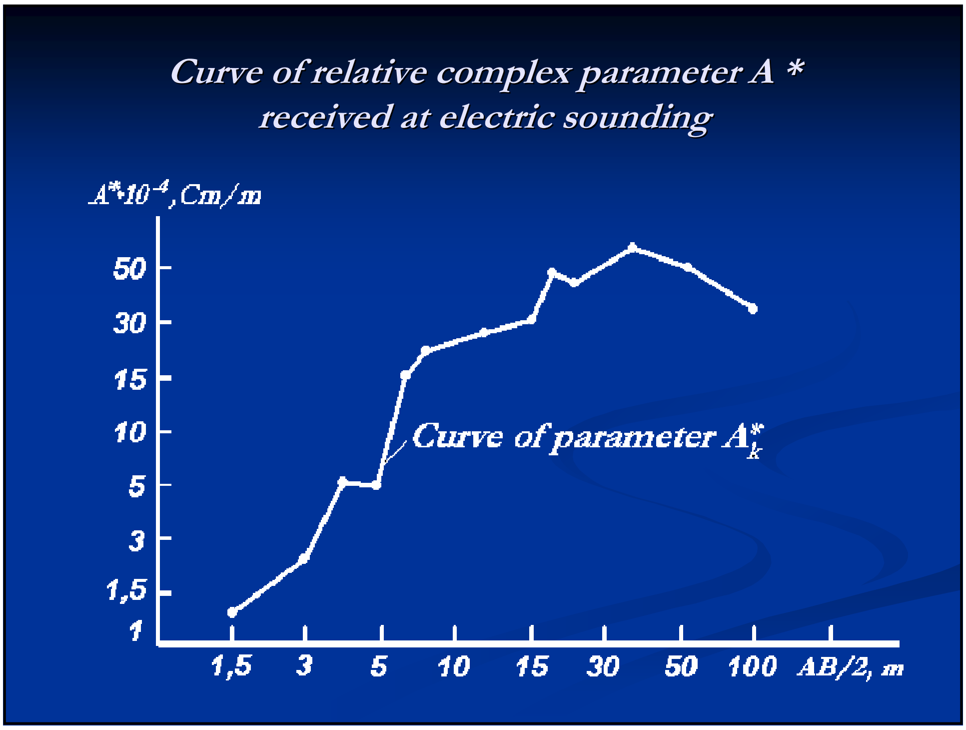
where U1 is polarizability after 1-st second electricity is cut off,
U11 is polarizability after 11-n second electricity is cut off

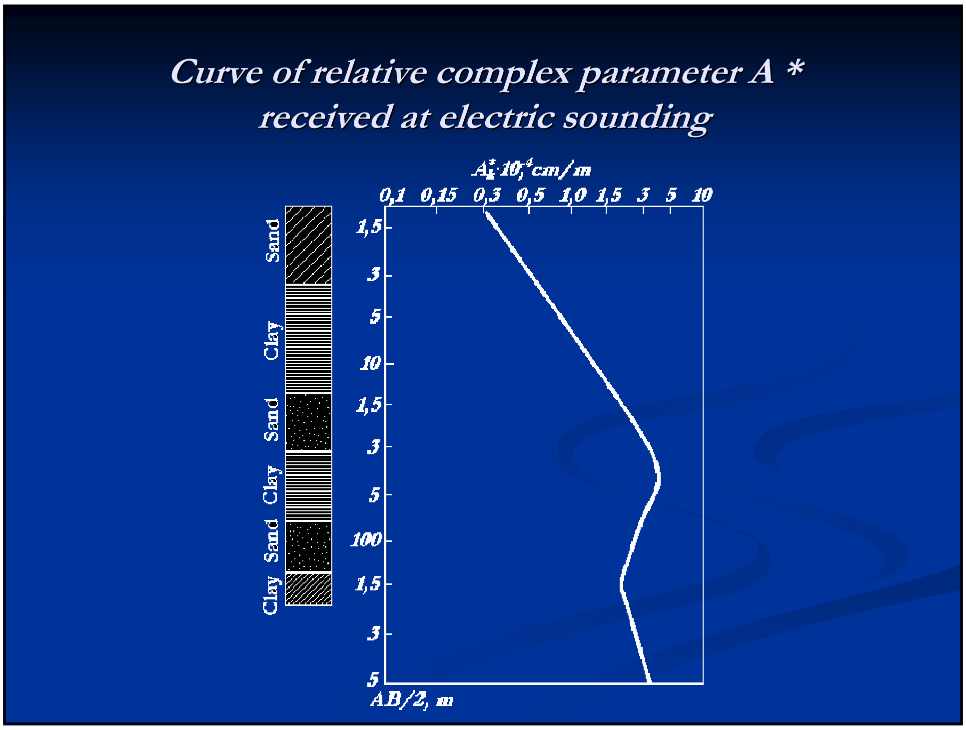
Effect of induced polarization depends on resistance of rocks

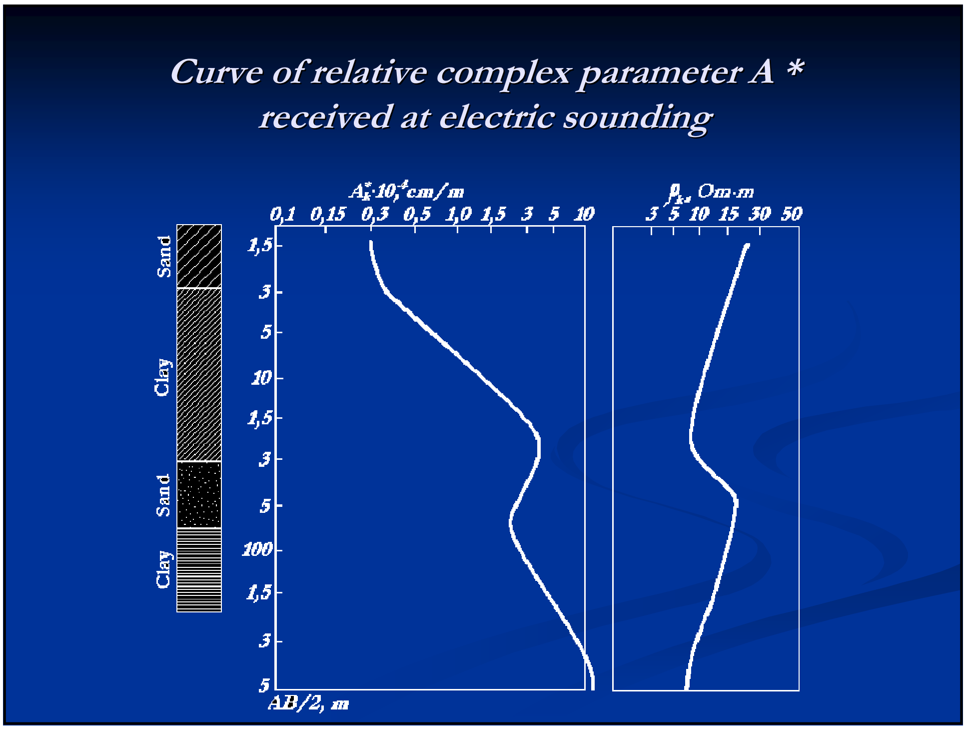
Relative integrated index A *

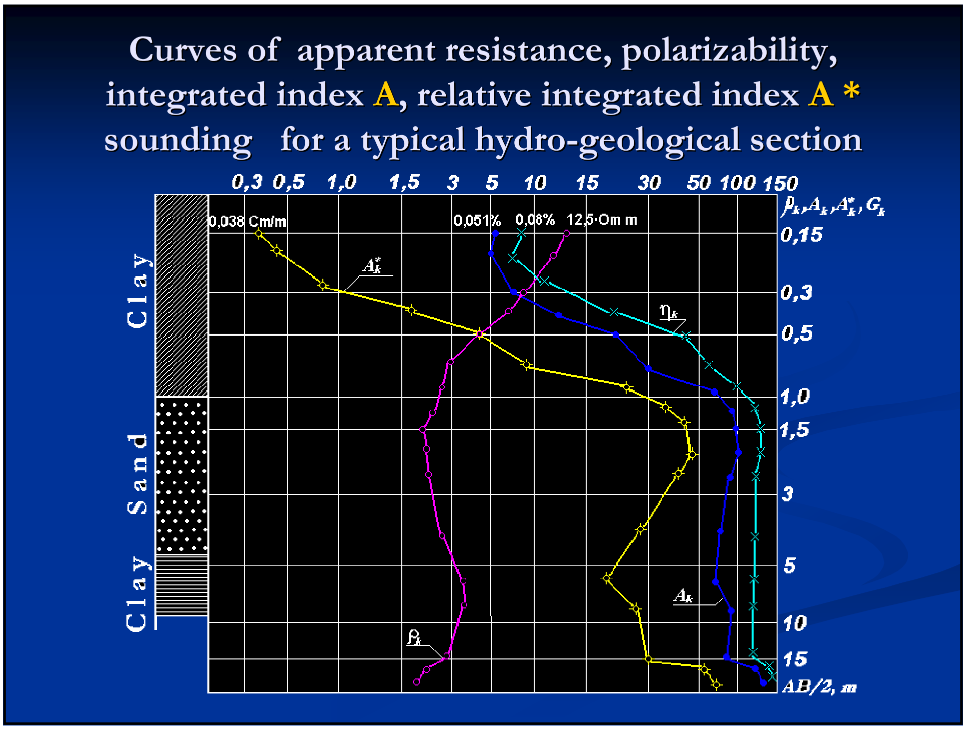
$$A^* = A / \rho$$

Relative integrated parameter A *
has the big comprehension for hydro-geological parameters determination

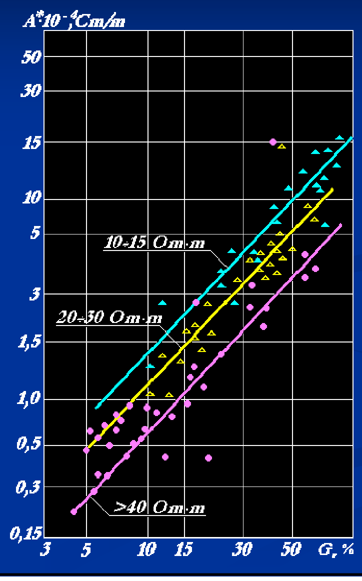

Curve of relative complex parameter A *
received at electric sounding
A*·10⁻⁴, Cm/m
50
30
15
10
5
3
1,5
1
1,5
3
5
10
15
30
50
100
AB/2, m
Curve of parameter A*k


Curve of relative complex parameter A *
received at electric sounding
A*k·10⁻⁴cm/m
0,1 0,15 0,3 0,5 1,0 1,5 3 5 10
Sand
Clay
Sand
Clay
Sand
Clay
1,5
3
5
10
1,5
3
5
100
1,5
3
5
AB/2, m

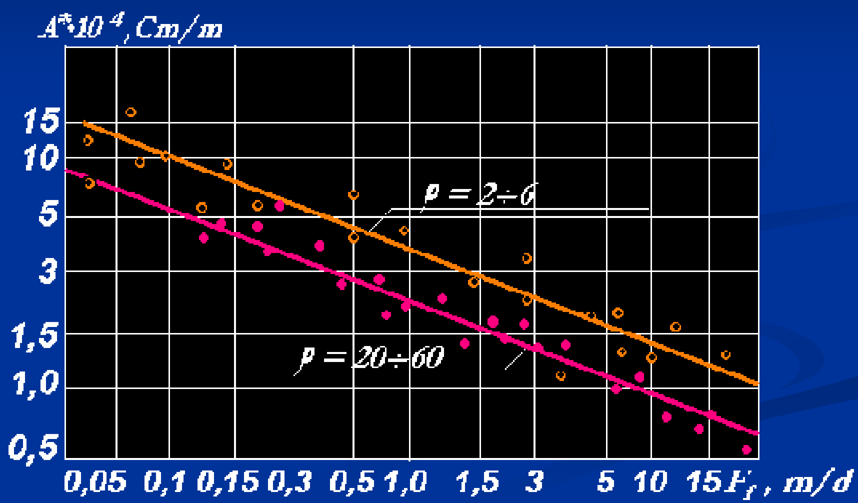

Curve of relative complex parameter A *
received at electric sounding
Sand
Clay
Sand
Clay
AB/2, m


Curves of apparent resistance, polarizability,
integrated index A, relative integrated index A *
sounding for a typical hydro-geological section
0,3 0,5 1,0 1,5 3 5 10 15 30 50 100 150
0,038 Cm/m
0,051% 0,08% 12,5·Om m
Clay
Sand
Clay
AB/2, m

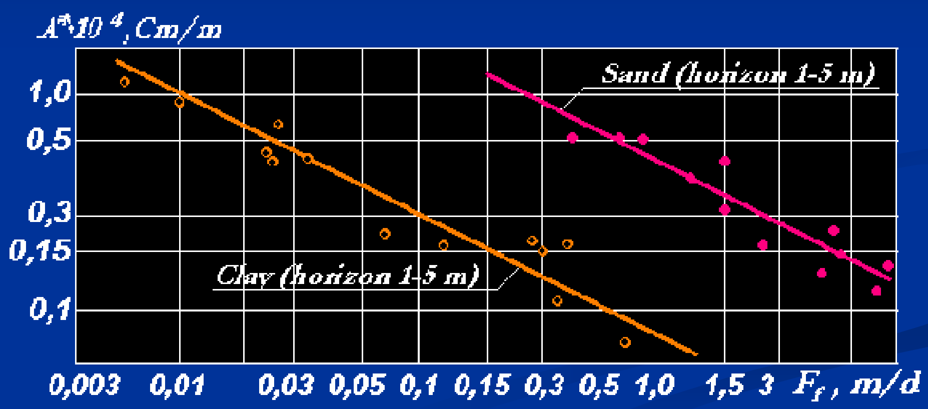
Dependence of Relative integrated index A * on percentage of a clay fraction ,(G)



Dependence of Relative integrated index A * on filtration factor, (F)



Dependence of Relative integrated index A * on filtration factor (F) for various aeration zones



Tumangan River Basin

(Russian part)

- The Tumangan River Basin 25.8 sq. km in area and 16 km long
- 0.1 % of the reservoir area are Russian territory
- Rivers flow throught the Hasanskaj Plain, forming lagoons offshore
- Hasanskaja Plain is located in a modern low land in subsidence at a rate of 1 mm/a
- In the area of the river basin, sandy and fertile soil cover is wide-spread cover in 1-6 m thick
- In the river valleys, cobble, pebble, and sandy deposits dominate

Deformation of the Tumangan River channel are:

- In narrow part of the river route, deep erosion is observed;
- Average depth on the river channel are 4-4.5 m;
- As a result of deep erosion, the depth of the river channel increased up to 12-15 m;
- Lateral erosion widened the river channel, moving a channel of the river across a valley in the left party.

Tumangan River channel migration

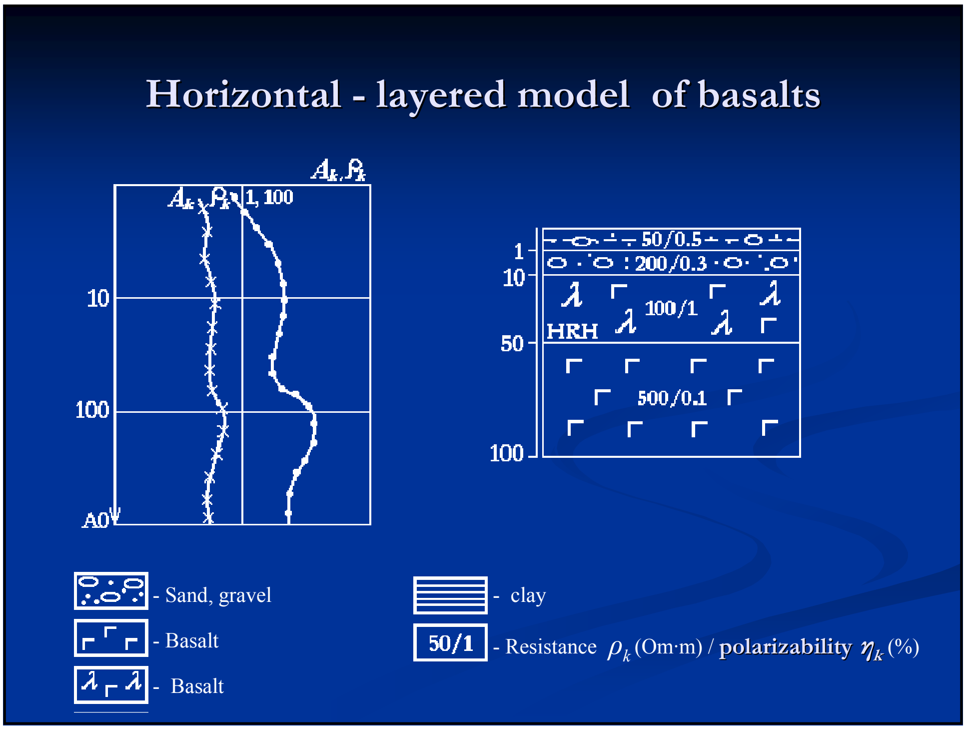
- The average rate **river channel migration** of for the river during the period of 1950-2002 is 2.04 m/a;
- As a result of lateral erosion, in the Russian side, 1.21 hectare of land were washed away every year;
- The displacement of coastal edge of the river in 2000 is 60-70 m for high water.

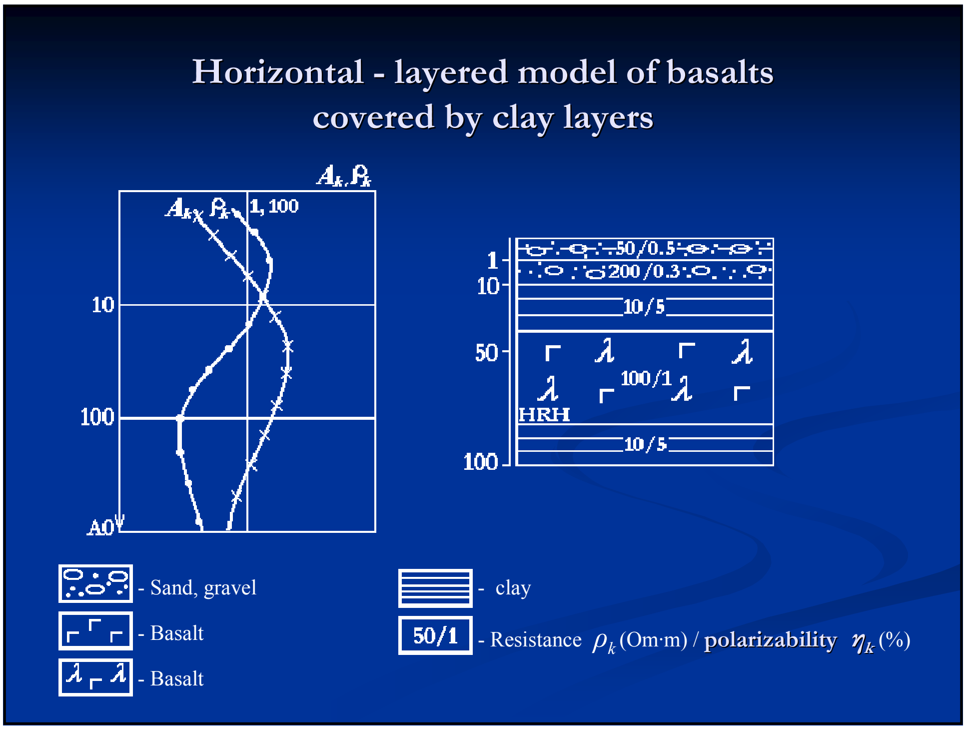
The underground water beneath the Tumangan River Basin features:

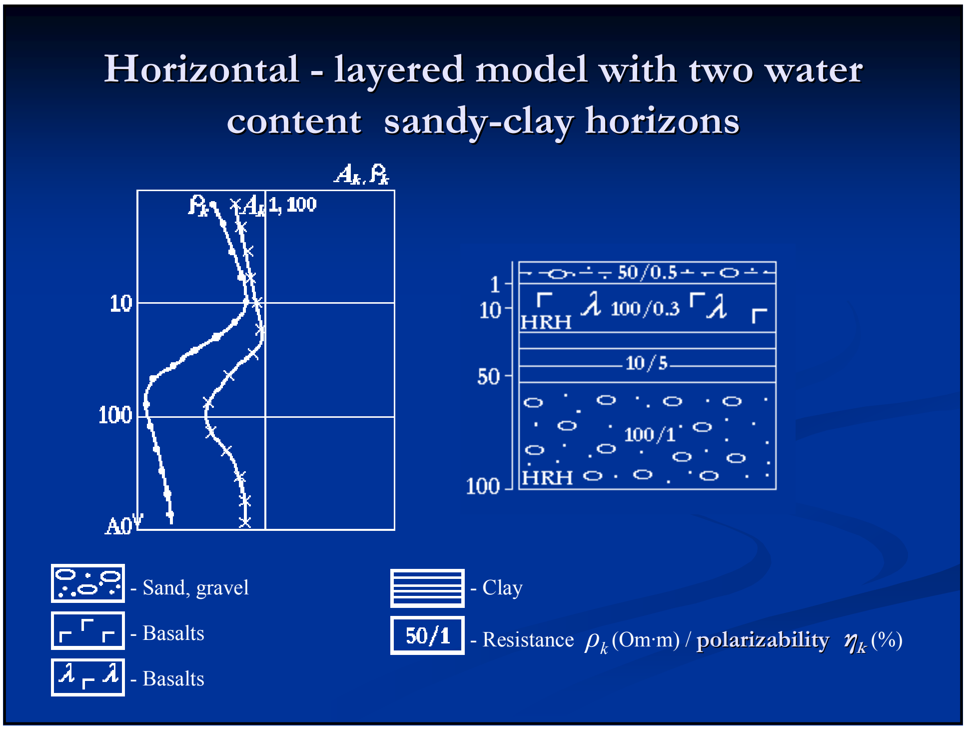
(Russian part)

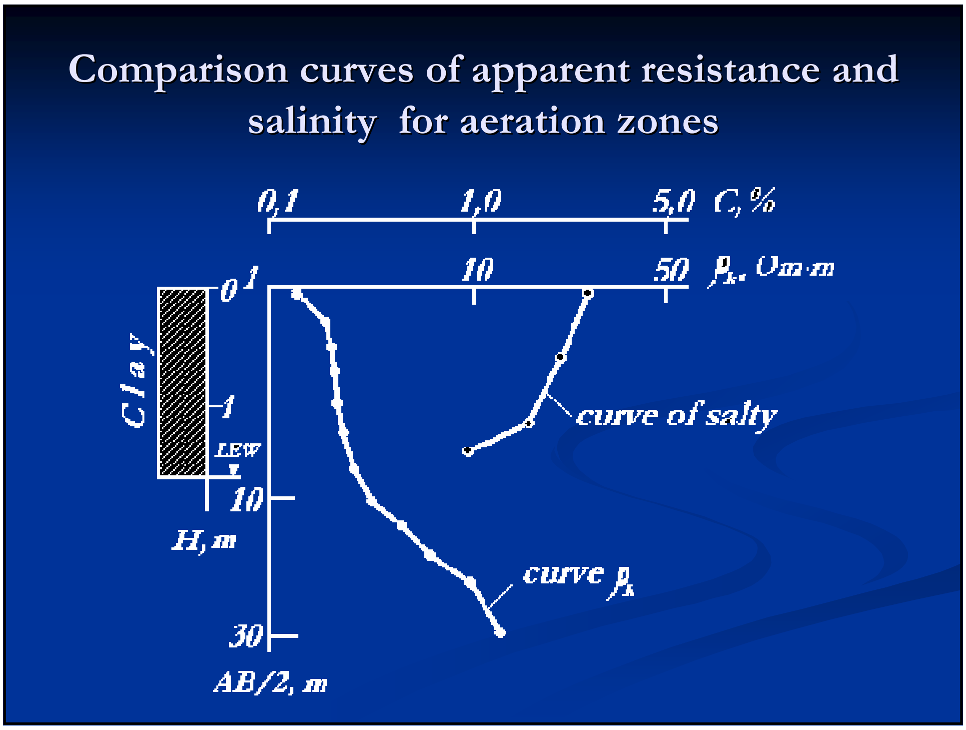
- free flow; flow through porous and water-socked rocks made of very coarse-grained gravels and pebbles;
- few are fractured zones of basalt, limestone, and granite;
- the underground water horizons alternate with clay layers levels between 1 up to 10 m. Sometimes, these clay layers build up pressures in underground water;
- Altitude of underground water varies from 0.5 to 15 m;
- The thickness of water-socked complex changes from 10 to 60m;

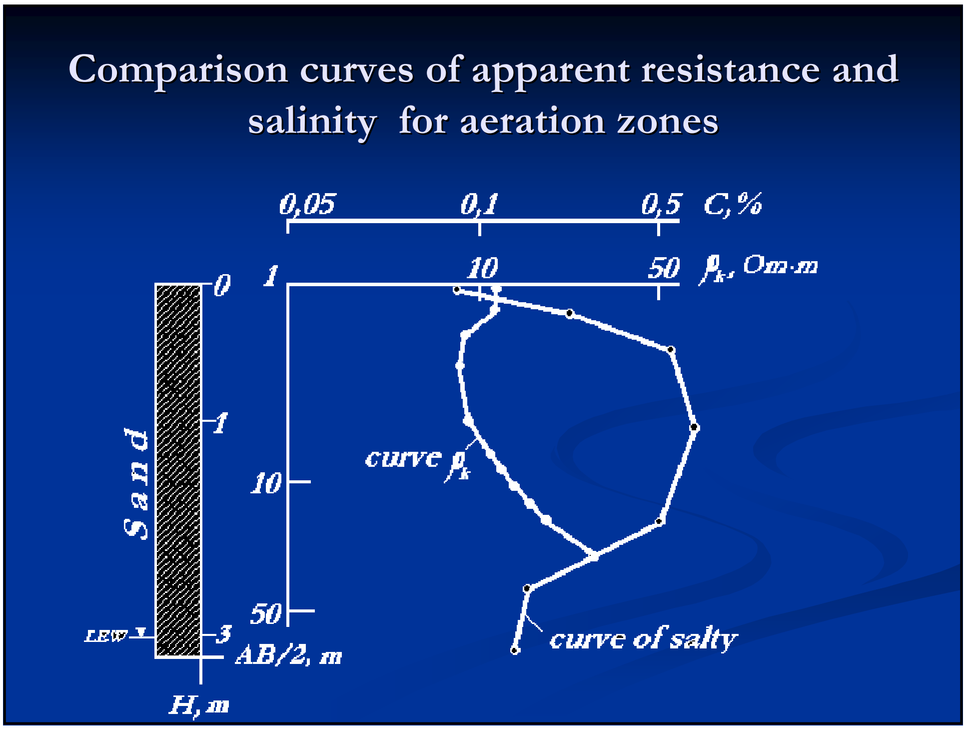
- a replenishment of underground waters is by atmospheric precipitation;
- gravity unloading of underground waters occurs in the sea, in reservoirs, and in underlaying horizons.
- undergroud waters have not been protected from ground surface pollution.
- the mineralization of underground waters changes from 75 to 500 mg/l.
- the increase in a mineralization of underground waters is possible due to penetration of sea waters and relic sea waters from deep horizons.

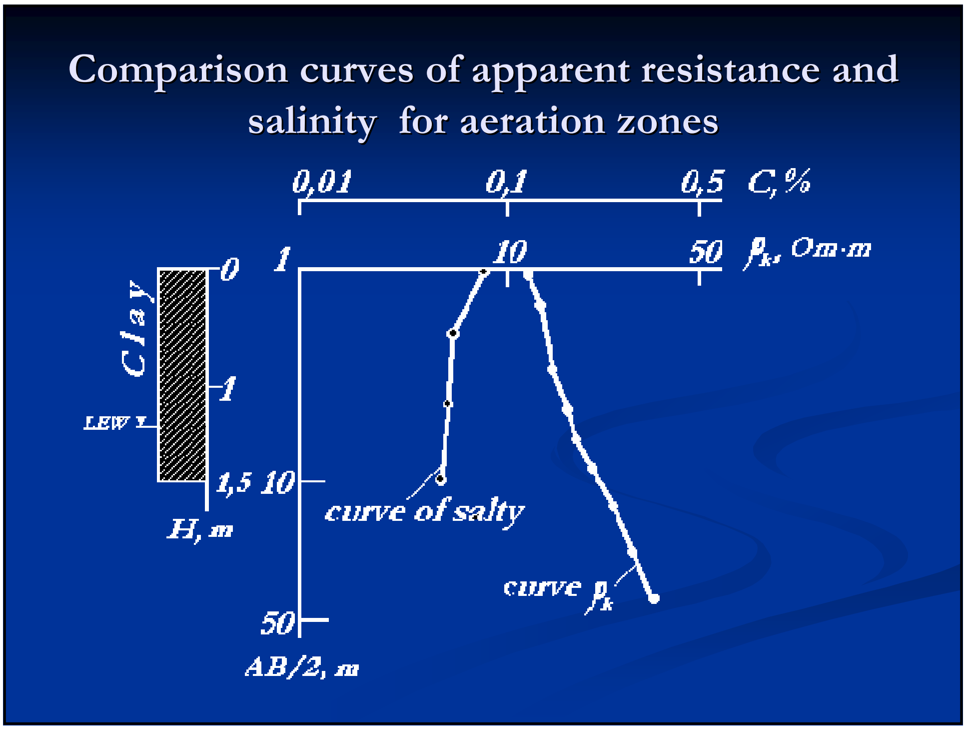

Horizontal - layered model of basalts
A_k, ρ_k
1, 100
10
100
A0
1
10
50
100
50/0.5
200/0.3
100/1
HRH
500/0.1
- Sand, gravel
- Basalt
- Basalt
- clay
50/1
- Resistance ρ_k (Om·m) / polarizability η_k (%)

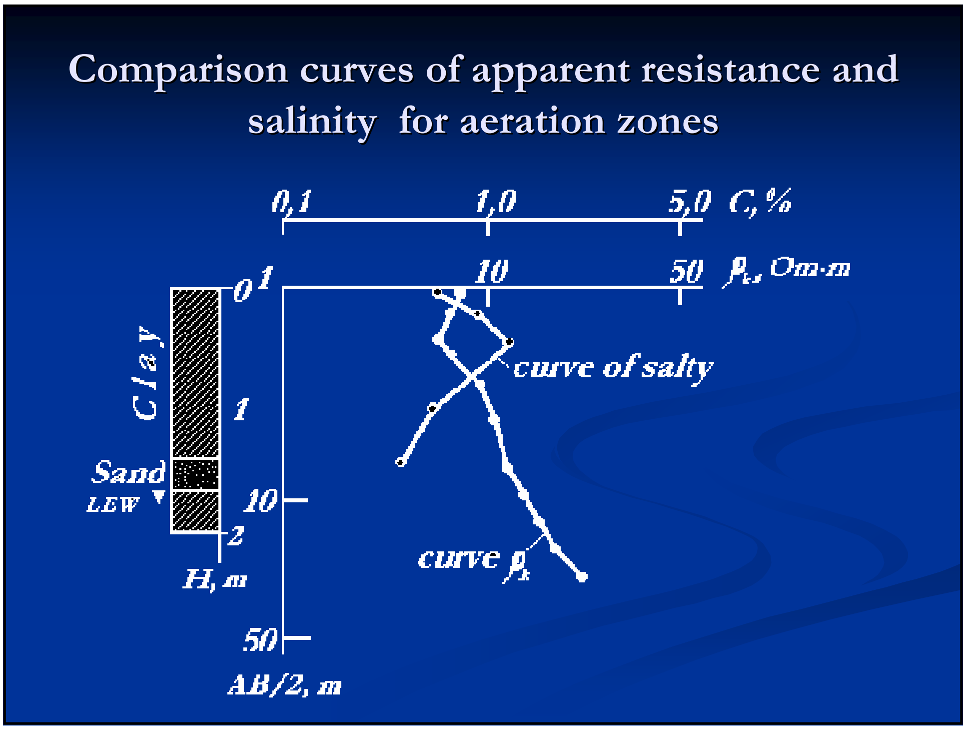

Horizontal - layered model of basalts
covered by clay layers
A_k, ρ_k
1, 100
10
100
A0
1
10
50
100
50/0.5
200/0.3
10/5
100/1
HRH
10/5
- Sand, gravel
- Basalt
- Basalt
- clay
50/1
- Resistance ρ_k (Om·m) / polarizability η_k (%)

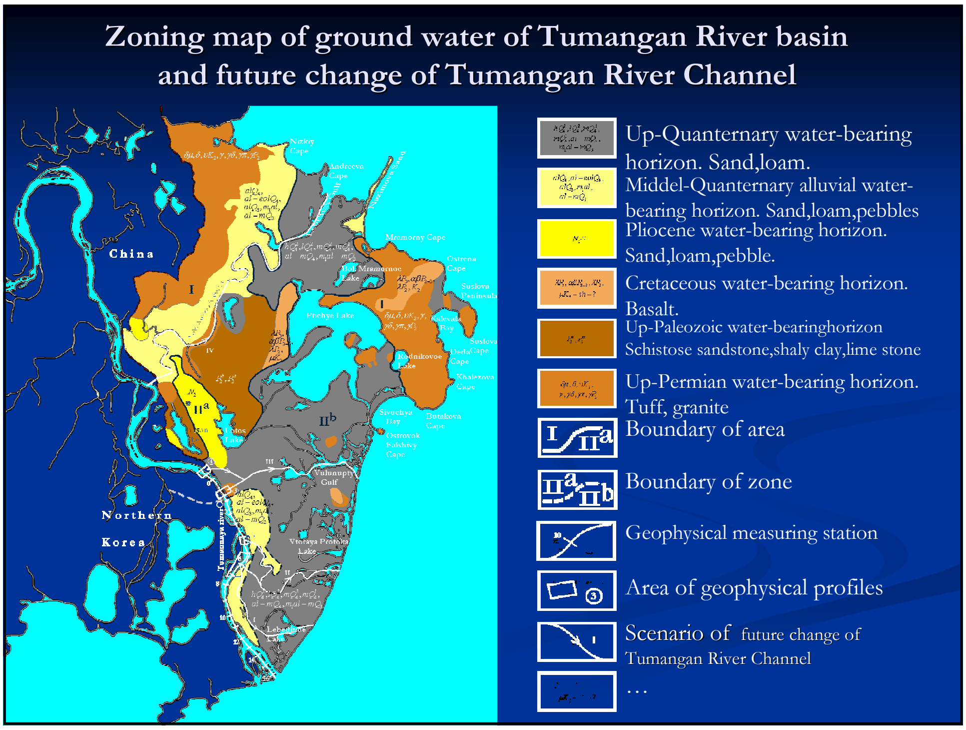

Horizontal - layered model with two water content sandy-clay horizons
10
100
A0
1
10
50
100
50/0.5
100/0.3
HRH
10/5
100/1
HRH
- Sand, gravel
- Basalts
- Basalts
- Clay
50/1
- Resistance ρ_k (Om·m) / polarizability η_k (%)


Comparison curves of apparent resistance and salinity for aeration zones
0,1
1,0
5,0
C, %
10
50
Om·m
Clay
0
1
LEW
10
H, m
curve of salty
30
AB/2, m


Comparison curves of apparent resistance and salinity for aeration zones
0,05
0,1
0,5
C,%
1
10
50
ρk, Om·m
0
1
3
Sand
LEW
10
50
AB/2, m
H, m
curve ρk
curve of salty


Comparison curves of apparent resistance and salinity for aeration zones
0,01
0,1
0,5
C,%
1
10
50
ρk, Om·m
0
1
1,5
Clay
LEW
H, m
10
50
AB/2, m
curve of salty
curve ρk


Comparison curves of apparent resistance and salinity for aeration zones
0,1
1,0
5,0
C,%
10
50
Om·m
Clay
Sand
LEW
0
1
2
H, m
10
50
AB/2, m
curve of salty
curve


Zoning map of ground water of Tumangan River basin and future change of Tumangan River Channel
China
Northern Korea
Up-Quanternary water-bearing horizon. Sand,loam.
Middel-Quanternary alluvial water-bearing horizon. Sand,loam,pebbles
Pliocene water-bearing horizon. Sand,loam,pebble.
Cretaceous water-bearing horizon. Basalt.
Up-Paleozoic water-bearinghorizon Schistose sandstone,shaly clay,lime stone
Up-Permian water-bearing horizon. Tuff, granite
Boundary of area
Boundary of zone
Geophysical measuring station
Area of geophysical profiles
Scenario of future change of Tumangan River Channel
…

The future change of Tumangan River Channel is predicted:

- Scenario 1

The river will go with a channel of River Swan, through Lake Swan and then run into the sea.

In this case, Russia will lose 22 sq. km of land.

- Scenario 2

The river will choose a new direction to the channel of the First Channels and sharply turn eastwards.

In this case, Russia will lose 35 sq. km of land.

- Scenario 3

The river will develop on an ancient paleo-channel and run into gulf Pigeon, and then go to the sea. Russia will lose 100 sq. km of land.

- Scenario 4

The river on ancient paleo-chennel will run to the River Lebedinka, then to the Gulf Swan and the Expedition Bay.

400 sq. km will be lost for Russia.