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Improving Fluid Filtration to Saline Reservoir Rocks

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The paper describes the study of the peculiar features of fluid (gas, water and oil) filtration through saline rocks of the Chayandinskoye oil/gas/condensate field. As is known, the peculiar features of filtration are closely associated with the structure of voids in reservoir rocks under study and depend on the voids type (porous, porous-fractured, cavern-porous, etc.) and its parameters (porosity, sinuosity, mean radius of pores etc.).

Filtration through porous media, the parameters of which change over time, is of peculiar interest. Media can gain such a property in the process of filtration through the media of fluids reacting with the substance of the dispersed medium. In particular, during filtration of water solutions through saline reservoir rocks.

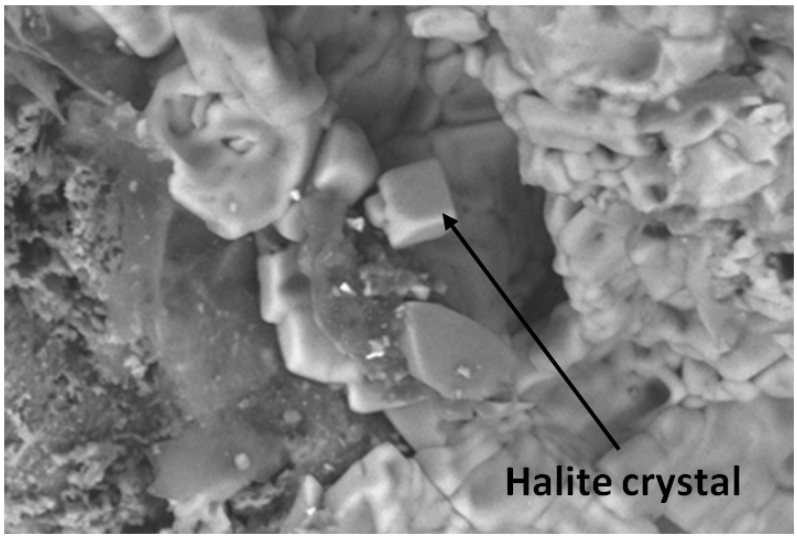


Figure 1 – Scanning electron microscopy (SEM)

Clastic deposits of producing horizons of the Chayandinskoye field suffered post-sedimentation salination as the result of different sedimentation features: change in stratal thermobaric condition during regional uplifts and erosional destruction of deposits, paleoclimate cooling and glaciation, in addition to filtration of brines through rock faults and fractured zones formed.

Complex conditions of sedimentation led to severely heterogeneous distribution of rock salination by intensity and volume of producing horizons.

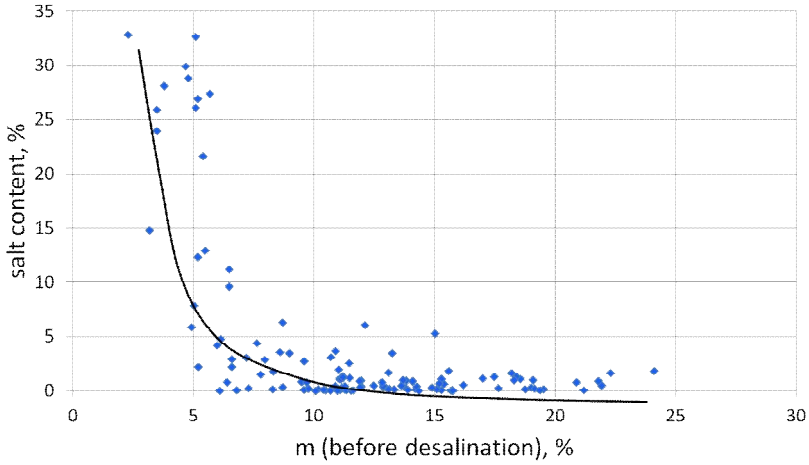


Figure 2 – Porosity dependence on salt content

The salt content in the rock pore space varies from percent fractions to 20-35%. Layers composed of coarse-grained poorly sorted clastic rock varieties are most intensively salinated (5 to 20-35%). The porosity of such saline rocks is from several percent to 8%, rarely up to 10%.

Study of Voids Structure

- Mercury porosimetry and capillarimetry were used for study of the pore space structure before and after filtration of water solutions through rock specimens.
- The results of study of the pore space structure with the mercury porosimetry method (without impact on the structure during the measurement process) and the method of a semi-permeable membrane (with partial salt washaway in the process of determination of the capillary pressure) were compared.
- After rock desalination its pore space structure changes significantly: the sizes of filtrating porous channels grow, and the distribution of pores by sizes is displaced to the area of larger pores.

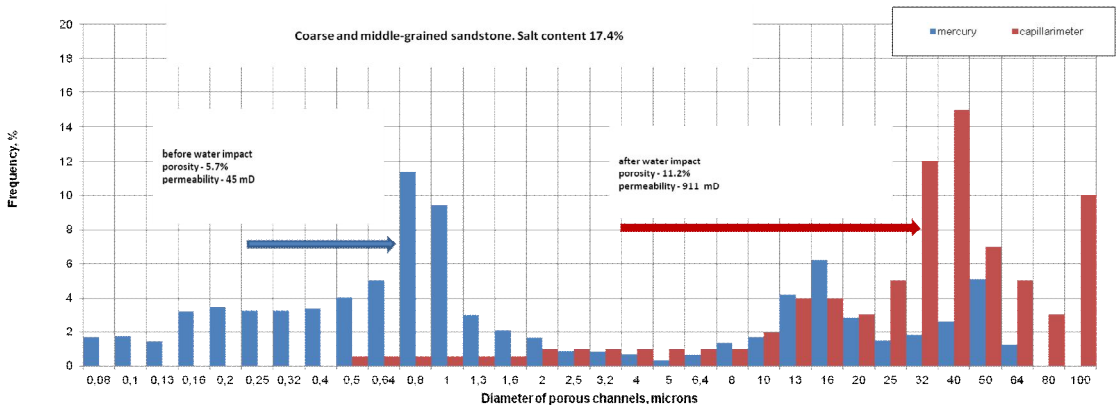


Figure 3 – Changes of pore space after of water impact

Impact of Salt Washaway on Rock Permeability and Porosity

A significant volume of poorly mineralized water (up to 10 porous volumes and above) was pumped through the porous medium.

With increase of the salt quantity in the rock the degree of change of porosity and absolute permeability grows. This agrees well with the fact that in the rocks, the porosity of which is reduced due to salination, permeability and porosity are improved (porosity and absolute permeability grow) by means of salt washaway.

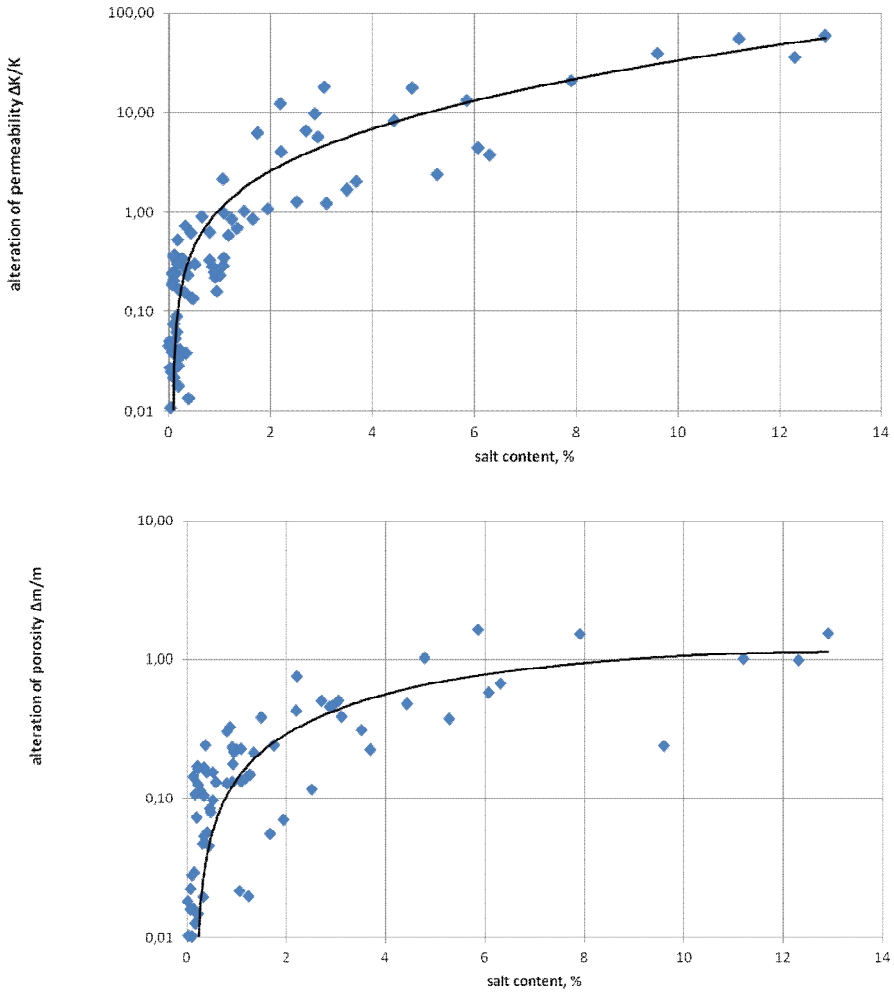
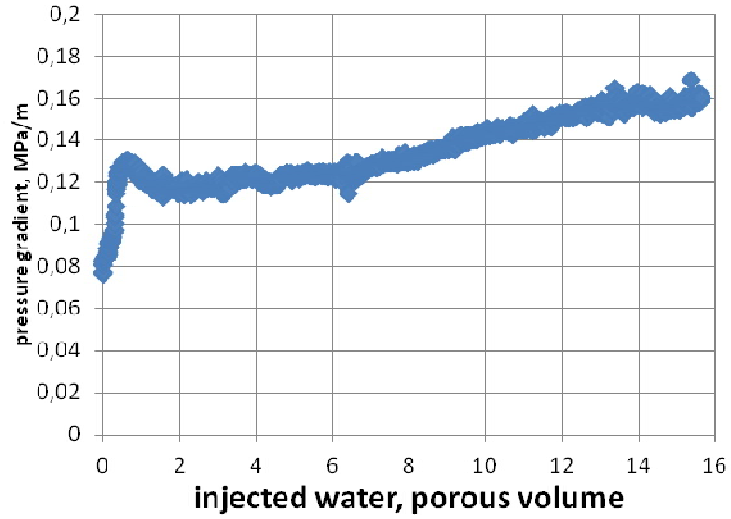


Figure 4 – Influence salt content to porosity and permeability

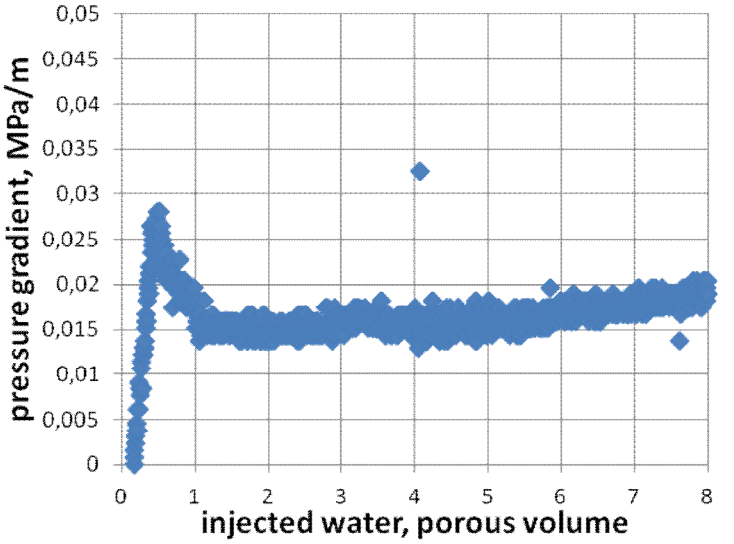
Dynamics of Multi-Phase Filtration in Saline Reservoirs

- Permanent washaway of salt will occur in the process of single-phase or multi-phase filtration with the participation of water. Respectively, permeability and porosity will change as well due to alteration of the voids structure.
- Physical modeling of oil displacement by water was used for study of the peculiar features of filtration properties in saline reservoir rocks of the Chayandinskoye oil/gas/condensate field.

- Tests were performed on core material presented by various lithological types of reservoirs of the studied producing deposits in the double-phase filtration unit, under reservoir thermobaric conditions of the Chayandinskoye field.



salt content
C = 0.03%
before displacement:
Kabs = 861 mD
m = 11.1%
after displacement:
Kabs* = 941 mD
m* = 11.3%



salt content
C = 0.2%
before displacement:
Kabs = 595 mD
m = 14.4%
after displacement:
Kabs* = 641 mD
m* = 15%

Figure 5 – The displacement dynamics (alteration of the hydraulic resistance depending on the water volume pumped through the rock) is different depending on the salt content

- Abrupt reduction of pressure differential in the core model during the after-fracture period and its slower reduction during the following periods were observed in intensively salinated rocks (with high salt content in the rock C from 1% to 10% of the model mass).

- Either monotonous growth of pressure differential or its short-term reduction with further slow growth was observed in poorly salinated rocks (with salt content in the rock C below 0.5% of the model mass) during the period after the displacement front outreached the core model.
- Growth of filtration resistance observed during water filtration through saline oil saturated reservoirs is explained by migration of solid particles and plugging of some filtration channels - colmatage of pores. After rock extraction and drying the particles are removed from pores, and porosity and absolute permeability turn to be higher than before rock salination.

Conclusions

1) Multiple tests showed that during single-phase or multi-phase filtration, with water present, permeability and porosity are improved by means of change of the voids structure (salt washaway from the rock), on the one hand, and filtration properties are improved by means of colmatage (growth of filtration resistance and water permeability fading in the presence of residual oil), on the other hand.

2) These effects shall be taken into account for selection of the methods of impact on the reservoir (in particular, for improvement of the efficiency of oil displacement by means of water injection in the reservoir), and for numeric modeling of multi-phase filtration with stratal water present.

3) Rock salination makes it necessary to correct a complex of standard and special studies of the core material. For example, it is feasible to take core with the use of water-free drill mud in order to reduce salt washaway from the core material, and prepare and study a collection of specimens without the use of water, if possible.

References

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