# Polyanskii O.P. Flux models of porous fluid with the phase transition vapor-liquid at thermal influence of stratified magmatic bodies.

Institute of Mineralogy and Petrography, Siberian Branch of RAS, Novosibirsk, pol@uiggm.nsc.ru

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Sedimentary basins of Eastern and Arctic Siberia with the flood magmatism are gigantic reservoirs of carbonic compounds. There is an idea that the flood magmatism was the event which initiated a migration of hydrocarbons and resulted in formation of industrially significant deposits. In this connection, it is interesting to investigate by means of mathematical models the regimes of filtration of the pore fluid, considering the vapor-liquid phase transition near intrusions (sills and dykes) in a sedimentary basin.

A geometry and physical parameters of the two-dimensional model were chosen on the basis of the natural Enisey-Khatanga rift sedimentary basin, which is situated on the north of the Siberian platform. Two types of models were regarded: 1) intrusion of a horizontal sill into the basement of the basin, under the layer-collector and between two collectors; 2) the same situations with the vertical dyke and branched sill (Fig. 1, as one of the variants). The non-stationary boundary problem includes a determination of the thermal and baric fields and velocity vectors of movement of gas and liquid, which are consistent with the equation of preservation of energy, moment, and mass inside the given region, boundary and initial conditions, shown in Fig. 1. The calculations were carried out using the numerical algorithm of the consequent upper relaxation with the Newton-Rathson itterational procedure on the basis of the Newton-Rathson Haar-Galakher-Kyle finite difference scheme. In dependence on a phase state, which varies during heating/cooling of the host rocks, the uni or bi-phase (vapor-liquid) flux of sub-critical or over-critical fluid is modeled. An equation of Haar-Galakher-Kyle describing the aqueous fluid at the critical point was used as an equation of state.

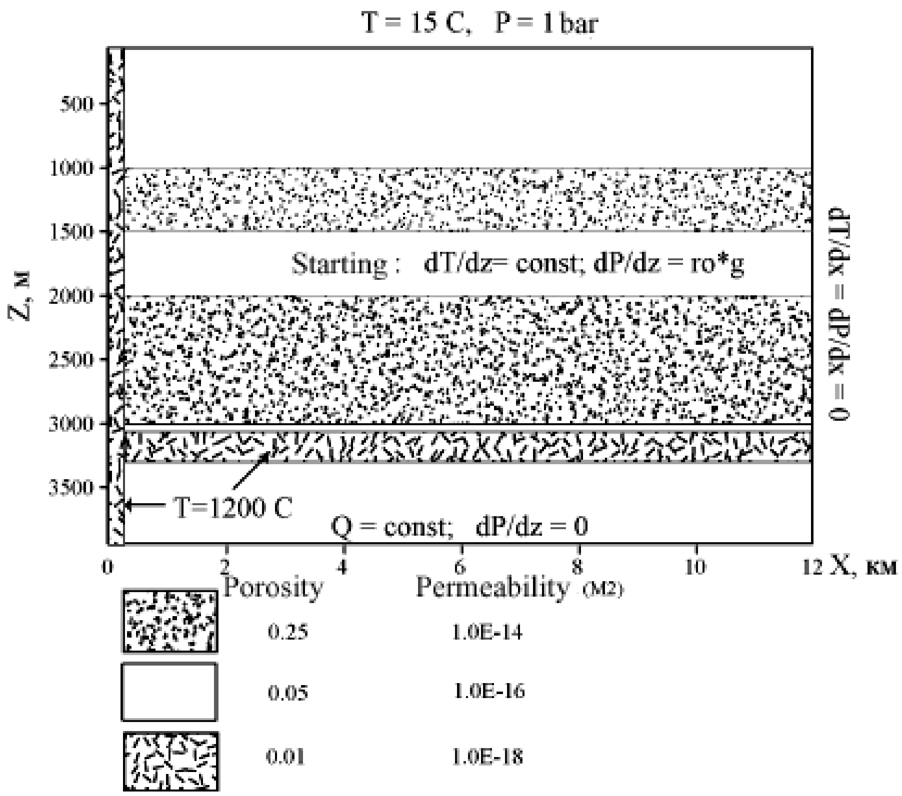


**Fig. 1.** Geometry of the calculated region, the model parameters, boundary and initial conditions of filtration of the pore fluid in the inhomogeneous stratified rock sequence, including fluid-resisting layers (light areas), collectors (dotted areas), and magmatic intrusions (hatched area). Legend and porosity and permeability values for the each rock type are shown below the figure.

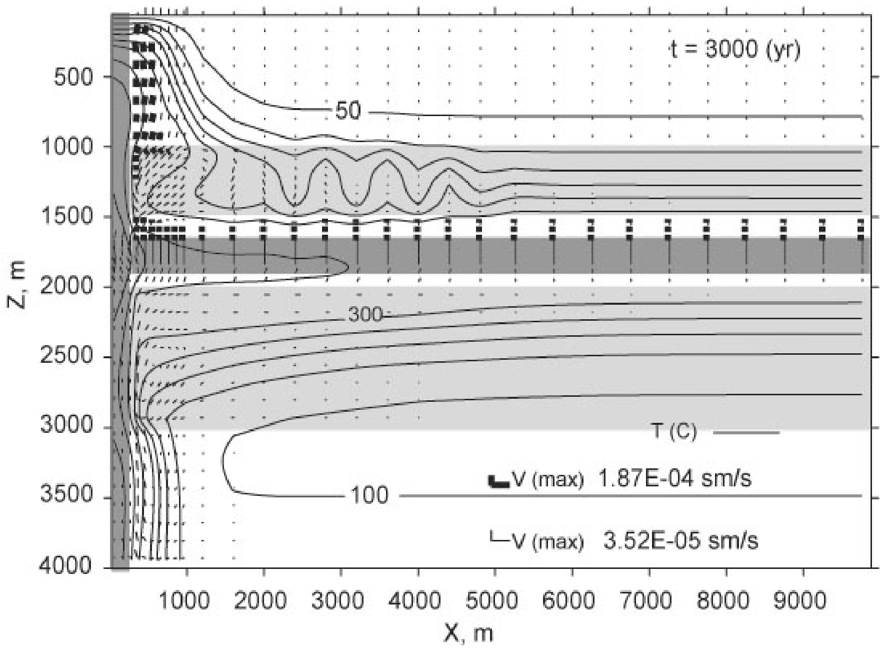


**Fig. 2.** The beginning of convection (after 3 thousands of years), triggered by emplacement of the vertical dyke (left) and the sill between the collectors. Intrusions are shown in dark-gray, collectors are light-gray. The position of isotherms and vectors of velocities of steam and liquid (scale in cm/sec). Interval between the isotherms from 50 to 300$^O$C is 50$^O$C, further, is 100$^O$C. Fluid transforms into gas above the upper contact of the sill and at the contact with the dyke on low depths. The boiling region is indicated by solid rectangles.

A number of numerical experiments were conducted in order to investigate an influence of the individual sill or the dyke simultaneously with the sill intruded into the sedimentary rock sequence on the convection of the pore fluid. In all variants with the dyke, the free convection is triggered by simultaneous heating from below and from aside. Figure 2 shows the initial stage of convection in time of 2 thousands years after the magma intrusion. The sill of 250 m in thickness intrudes the layer between two collectors. In the upper collector, which is heated from below and aside, the shape of isotherms is oscillating and a wave of thermal perturbations expands in time from the vertical intrusion. This process does not occur in the lower collector. Heating from aside results in formation of one cell at the cooling wall of the dyke. Owing to the active circulation of the fluid, the more intensive cooling occurs here, and isotherms, which were initially parallel to the dyke contact, are displaced to the left, close to the symmetry axis. A boiling of the pore fluid occurs above the upper contact of the horizontal sill. These regions are shown by thick dashes (Figs. 2 and 3). The boiling of the aqueous fluid is possible on the depths not more than 2-2.5 km, then pressure does not exceed the critical pressure.

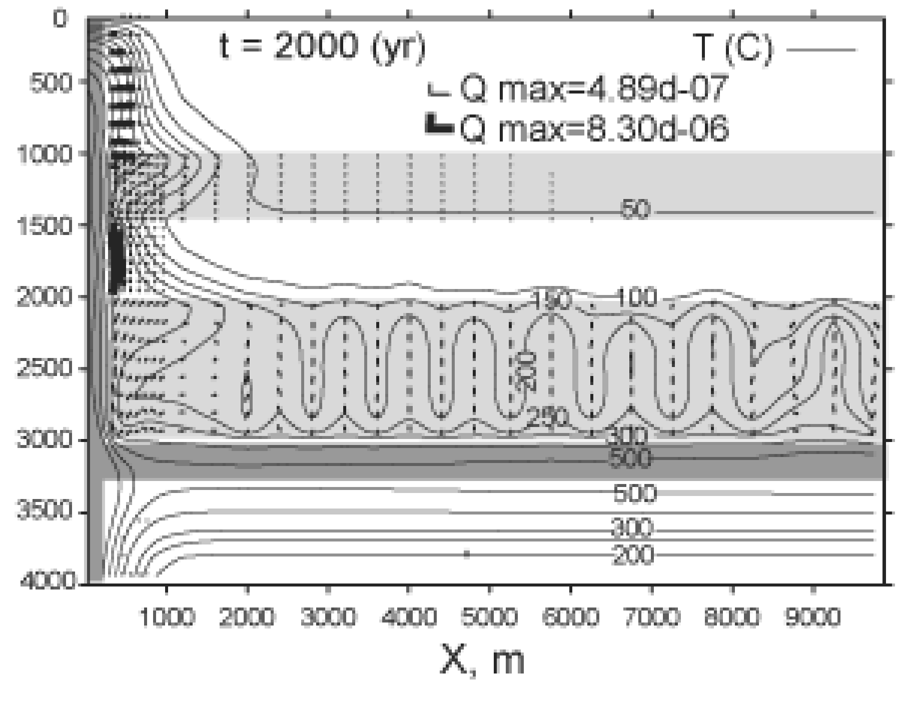


**Fig. 3.** Development of convection in the model of the intrusion of the dyke and the sill of 250 m in thickness at the direct contact with the lower collector for the time of 2 thousands of years after the intrusion. The fluxes are in g/(sec cm$^2$). The periodicity of the thermal field in the lower collector is caused by the sill influence. Boiling occurs at the contact with the dyke.

The periodical structure of convection forms under influence of even heating by the sill (Fig. 3). In the upper collector, one cell with a localized uprising flux at the vertical dyke and wide sinking flux forms. The periodicity of the structure is not observed in it because of remoteness of the sill. The region of the overheated steam forms at the contact with the dyke above and below the upper collector. In the zone of contact with the collector, the vaporization is not durable, since heat is removed from this region by the vertical fluid flux, and cooling is more effective. In contrast to the previous model, cells form along the whole length of the layer. Only one cell exists in the upper collector, but they are numerous in the lower collector. In time, the left cell is developed at expense of other cells.

The calculation show that if the dyke creates the horizontal temperature gradient, that results in instability of the fluid in the layer beyond the dependence of the sill emplacement. The sill provides conditions then the temperature gradient becomes higher than some value, and the Raleigh similarity criterion Ra for the porous layer becomes higher than the critical value.

The possibility of convection in dependence on the type of intrusion, its position in the basin, initial temperature, and physical parameters of rocks is demonstrated. The patterns of an evolution of the phase state, the temperature field, and velocities of the fluid flux in the sedimentary sequence around the cooling intrusion are obtained. In contrast to the conductive heat transfer, convection in the condition of highly permeable layers-conductors can create wide zones of heating and boiling above stratified intrusions and near vertical magmatic bodies. The existence of the region of small thermal gradient in the collector, where convection is developed above the magmatic intrusion, is predicted. Being modified, the problem can be applied to the prediction of the behavior of the hydrocarbon fluid in sedimentary basins with the flood magmatism.

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