Core acid treatment influence on well reservoir properties in Kazan oil-gas condensate field

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Abstract. The research involves investigation of the influence of hydrochloric acid (HCI-12%) and mud acid (mixture: HCl – 10 % and HF – 3 %) treatment on the Upper-Jurassic reservoir properties in Kazan oil-gas condensate field wells. The sample collection included three lots of core cylinders from one and the same depth (all in all 42). Two lots of core cylinders were distributed as following: first lot – reservoir properties were determined, and, then thin sections were cut off from cylinder faces; second lot- core cylinders were exposed to hydrochloric acid treatment, then, after flushing the reservoir properties were determined, and thin sections were prepared. Based on the quantitative petrographic rock analysis, involvin 42 thin sections, the following factors were determined: granulometric mineral composition, cement content, intergranular contacts and pore space structure. According to the comparative analysis of initial samples, the following was determined: content decrease of feldspar, clay and mica fragments, mica, clay and carbonate cement; increase of pore spaces while in the investigated samples- on exposure of rocks to acids effective porosity and permeability value range is ambiguous.

1. Introduction

Bottom-hole formation zone treatment in oil-producing wells is performed to eliminate low production problems. Alternative treatment methods for bottom-hole formation depends on the physico-chemical rock properties and fluid-saturated reservoir.

The research goal is to investigate how hydrochloric acid (HCl – 12 %) and mud acid (mixture of hydrochloric acid HCl – 10 % and fluoric acid HF – 3 %) treatment influences porosity-permeability in reservoir formations. The research tasks involved the multi-analysis of cores before and after rock acid treatment and further comparison of obtained results.

2. Source data

Investigated layers are located within the coal-overlaying thickness of Vasugan suite (U_1^1, U_1^2 b). These layers are composed of fine-grained and medium-grained sandstones with clay and carbonate cement embracing visible traces of authigenic calcite and siderite [2] being to different extents both porous and sometimes oil-saturated.

Samples were taken from three wells 14 and 16 (layer U_1^1) and 673 ($Ю_1^2$ b) in Kazan oil-gas condensate field, located in Parabel region, Tomsk Oblast, Russian Federation. Tectonically, the field is related to local elevations involving the N-W Kalgachsk meso-protusion. Geologically, this field is related to West -Siberian petroleum province.

The sample cores were prepared in the following way: cores from one and the same depth were being cut into three cylinder lots, each of which was 30cm. in diameter and 45cm. in length. The cylinder faces of the first lot were cut off and impregnated with colored resin in a vacuum, and these faces were further made into thin sections. Porosity and permeability in the first cylinders were determined according to the standard method [4, 3]. The second lot of cylinders were inserted into a vessel with 12 % hydrochloric acid solution for 1.5 hours. The third lot of cylinders were exposed to mud acidizing, which is a mixture of hydrochloric acid (HCl)– 10 % and fluoric acid (HF) – 3 %. In this case the samples were exposed to the solution for 5 minutes, where dissolution reaction proceeds violently and, as a result, the solution was discolored to brown. After the samples were flushed, the faces were cut off and then thin sections were made; and porosity and permeability were determined in the cylinders. Therefore, based on the results obtained from 42 cylinders and 42 “colored” thin sections of initial samples (14) after hydrochloric acid and mud acid treatment, the reservoir rock properties were determined. Further, the quantitative petrographic rock analysis in thin sections (before and after acid treatment exposure) was conducted [1, 5]. The above-mentioned results comparable to initial sample data were organized as diagrams, respectively to different colors

3. Research results and discussion

Based on the investigation of the mineral composition, the feldspar content (figure 1) in sandstones after acidizing is significantly different from those in the initial samples. However, the quartz content after acidizing is not different from those in the initial samples. Quartz does not dissolve in hydrochloric acid, while the quartz reaction with fluoric acid (as a constituent of mud acid) proceeds quite slowly.

After the acid treatment a significant change in the rock cement is observed (figure 2). In comparison with clay cement content in the initial samples, the content in above-mentioned samples decreases during the reaction with both hydrochloric acid and mud acid, where a more intensive aggression is closely related to the latter. It is the quick reaction of fluoric acid (HF) (as a constituent of mud acid) which dissolves aluminosilicate, a constituent of clay mineral cement.

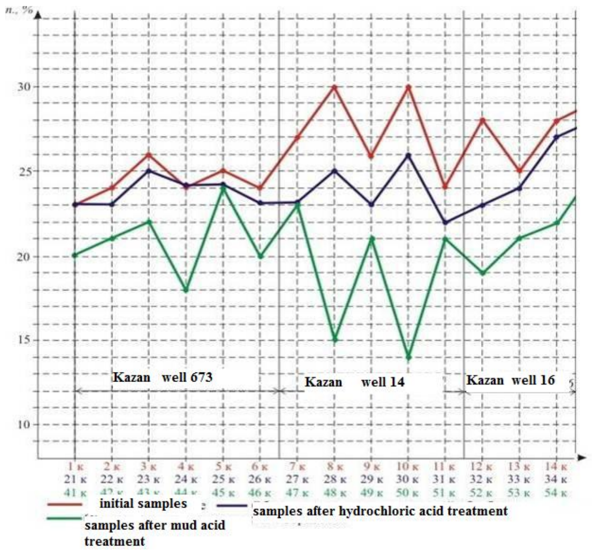


Figure 1. Feldspar content in sandstones according to thin sections.

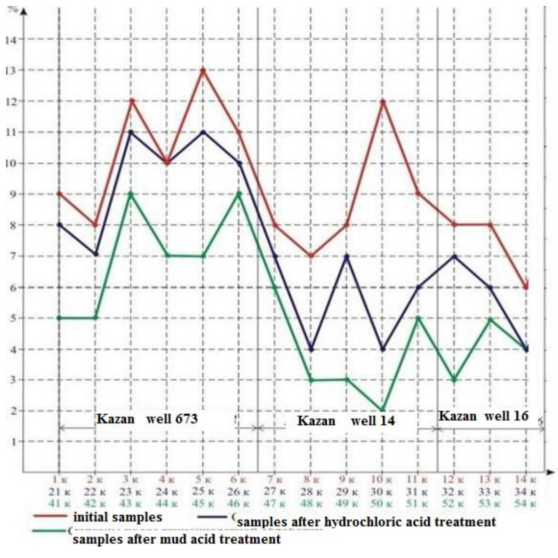
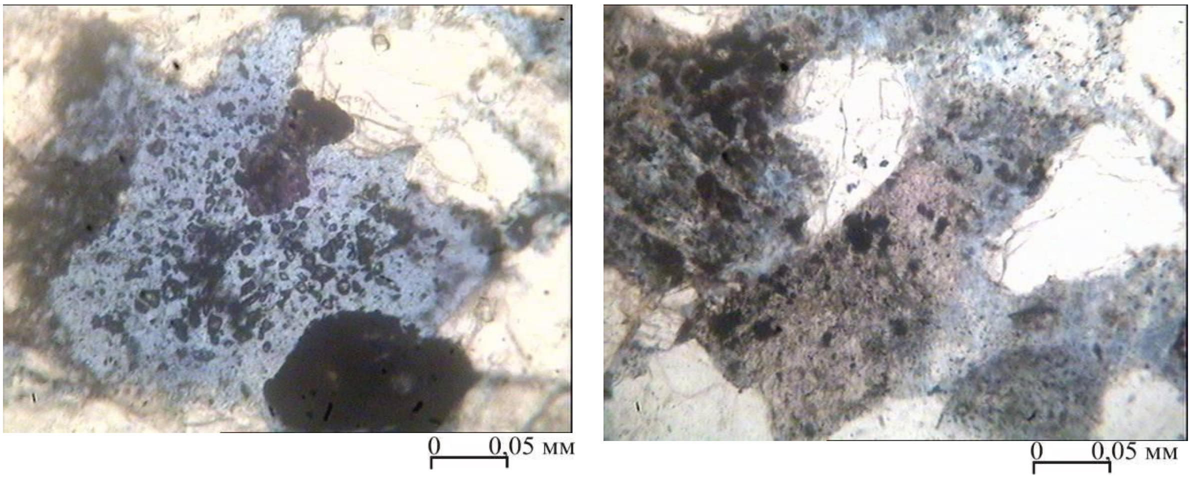


Figure 2. Clay cement content in sandstones according to thin sections.

In rocks with carbonate cement, the cement content decrease is a response to the active hydrochloric acid reaction which dissolves calcite and possibly siderite. On exposure to hydrochloric acid carbonate cement is sometimes preserved as a film around the grains or as filling in small pores. Although mud acid exposure results in the decrease of carbonate cement content, it is less than in the case of hydrochloric acid exposure.

It should be noted that fluoric acid and aluminosilicate and carbonate reaction results in the formation of salts- fluoride silica and fluoride calcite as sediments which are partially removed from the pore spaces during flushing (figure 3). In this case the reaction products are intensively removed during hydrochloric acidizing, pores are decontaminated and the intergranular contacts are clearly defined.



a b

Figure 3. Inclusions of black substance in pores and on grain surfaces (thin sections of samples after mud acid treatment): a) Kazan well 14- thin sections 50к, depth: 2487.0 m. 1 nH; b) Kazan well 16 – thin sections 53к, depth: 2497.8 m.1 nH.

The dissolution of rock components during acidizing resulted in the increase of the pore spaces. The following graphically illustrates the changes of effective porosity and permeability (figures 4, 5).

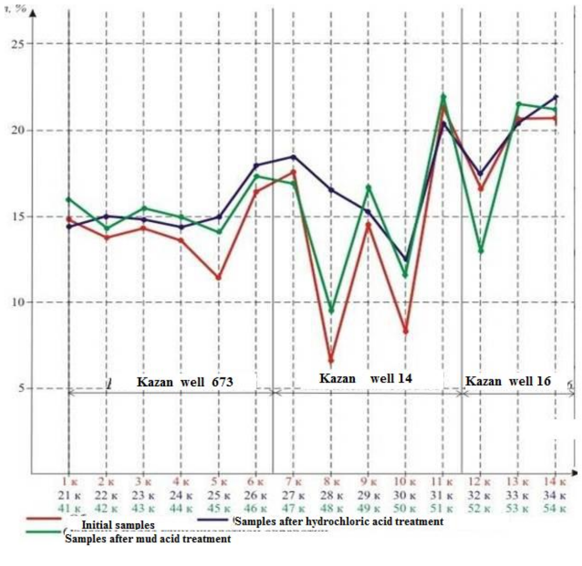


Figure 4. Changes of effective porosity in

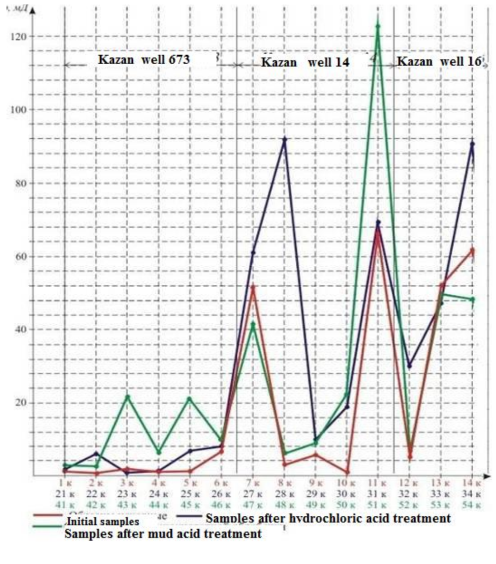


Figure 5. Changes of permeability in samples.

samples.

The increase of effective porosity value is observed, mainly, after mud acid treatment, while the permeability value- after hydrochloric acid treatment. In this case the effective porosity value range is less than the permeability value range. Graphically, it is obvious that in medium-grained sandstones (samples 7k and 12k) the effective porosity value range decreases on exposure to mud acid; while in the samples-7k and 14k- the permeability value range decreases only after mud acid treatment.

During acid treatment the aluminosilcates are dissolved and form salts (fluoride silica and fluoride calcite) in relatively high porosity medium-grained sandstones. These salts precipitate as a black viscous substance in the pore spaces and on grain surfaces, which, in its turn, certainly destroy the reservoir properties.

4. Conclusions

Thus, the above-mentioned research indicated the fact that hydrochloric acid and / or mud acid treatment is highly effective for terrigenous reservoirs, where both clay and carbonate cements are predominate. After mud acid and hydrochloric acid treatment the content of feldspar, clay and mica fragments, carbonate and clay cement decreases in the sandstones, and, consequently, effective porosity and permeability increases.

Based on the samples of medium-grained sandstones with carbonate, as well as argillaceous-silt sandstone and carbonate-argillaceous cement (layers U_1^1 wells 14 and 16 in Kazan field) it was established that hydrochloric acid treatment is more effective in enhancing the reservoir properties.

In relatively high porosity medium-grained sandstones during acid treatment the aluminosilcates are dissolved and form salts (fluoride silica and fluoride calcite), which precipitate as a black viscous substance in the pore spaces and on grain surfaces, and certainly destroy the reservoir properties.

Based on the samples of fine-grained sandstones with carbonate, as well as argillaceous-silt sandstone and carbonate-argillaceous cement (layers U_1^1b well 673 in Kazan field) it was established that both hydrochloric acid treatment and mud acid treatment are effective in enhancing the reservoir properties.

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