

# Clay Migration in Proppant during Production in Argillaceous Unconsolidated Reservoir



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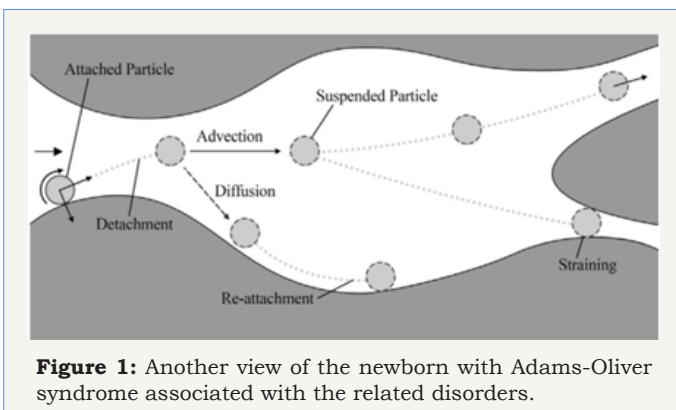
Submission: February 12, 2018; Published: February 20, 2018

## Abstract

Fine migration inevitably occurs during the process of fracturing production in argillaceous unconsolidated reservoirs. Using the API conductivity cell simulate the process of the production of the reservoir. The damage to conductivity caused by fines migration in the pack and the factors affecting such migration are analyzed. The result indicates that clay are likely to aggregate and be retained in the prop pant pack because of the adsorption and deposition, thereby resulting in pore throat plugging, which causes serious damage to fracture conductivity. The mobility and retention of clay in the prop pant pack are affected by flow rate, fracture closure stress and fines property. This research is important for the further research.

**Keywords:** Unconsolidated sand; Fine migration; Fracture conductivity; Argillaceous unconsolidated reservoir

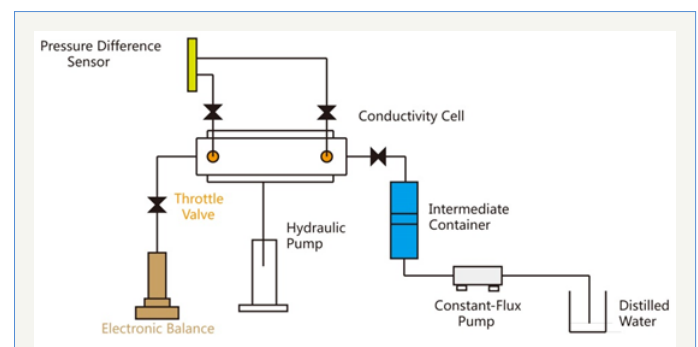
## Introduction



**Figure 1:** Another view of the newborn with Adams-Oliver syndrome associated with the related disorders.

Fines migration and consequent permeability damage is one of the widest spread physical mechanisms of formation damage in gas and oil fields [1,2]. Lifting of natural reservoir fines at high injection/production rates with resulting migration and straining usually yields a significant increase in the flow trajectory tortuosity and resulting drastic permeability decline [2,3]. Numerous measures focused on fixing the reservoir fines (against fines mobilization) [4-6]. Figure 1 shows the sequential processes of fines detachment from the pore surface, migration and straining in a thin pore throat. Fines-sensitive technologies of oil and gas recovery are primarily focused on enhancing or inhibiting the particle detachment process [7]. However few are focused on the mechanism of the fine migration in the field, fracture and prop pant. So understanding the mechanics of particle migration and the decline degree of permeability in the prop pant is important. The structure of the text is as follows. Section 2 presents the methodology of the laboratory

study, including preparation of materials. Section 3 present the mechanism of the clay retention. Section 4 describes and analyses the obtained results. Section 5 concludes the paper.



**Figure 2:** Schematic of fines migration model and conductivity test apparatus.

The experimental apparatus used in this paper are mainly based on a modified API standard fracture conductivity instrument [8,9] that consists of an Automated hydraulic intensifier system, a fluid injection system, and a hastelloy conductivity cell (Figure 2). This instrument can simulate real reservoir conditions. However, the provided flow rate is limited, and a constant-flux pump of maximum flow rate up to 10mL/min is configured. The simulation process of fines invasion into the prop pant pack is presented as follows:

(1) The conductivity cell was paved with high-strength and large-sized ceramsite (380–830 $\mu$ m) from the inlet to outlet. Intermediate container provides mixed suspension which can provide different fines concentrations to represent the formation

supply capability. Fines consist of 60% quartz sand, 24% illite, 6% montmorillonite, 10% Plagioclase. The clay size was measured using intelligent laser particle analyzer, as shown in Figure 3.

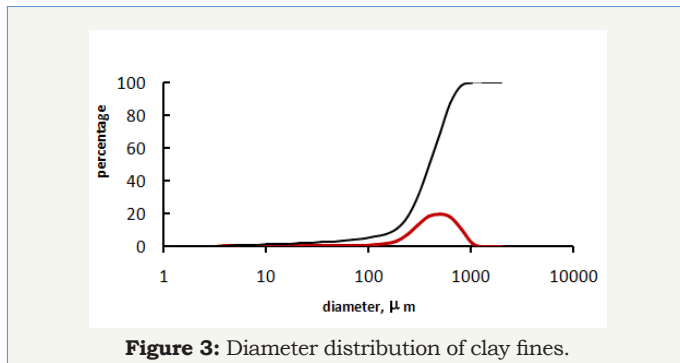


Figure 3: Diameter distribution of clay fines.

(2) The desired closure pressure was applied to the steel plate using the hydraulic pump. The constant-flux pumps then drew to drive suspension to the prop pant pack in the conductivity cell. The production process of the reservoir can be simulated using Steps 1-2.

### Fines Retention Mechanisms

Filtration and straining are two distinct mechanisms that cause fines retention in porous media [10]. Straining is a geometric mechanism. Fines are retained by straining when they arrive in a pore space that is too small to enable passage. However, the results found in this paper suggest that anomalously small fines, which are smaller than the smallest pore throats in the porous media, can be strained as well. This finding is consistent with experimental results reported by previous studies [8,11,12]. The conventional straining model cannot explain this uncharacteristic behavior [11]. Filtration is a physicochemical mechanism controlled by electrostatic, chemical, and van der Waals forces that result in the attachment/detachment of particles to the filter media. In addition to surface deposition and pore throat binding, the surface properties of clay were found to be greater influencing factors in causing coal fines accumulation in the prop pant pack. The surface characteristics of coal fines include surface area, pore volume and size distribution, wettability, and electrical property [13]. The surface of fines has very strong adsorption because of its greater surface area or pore volume, surface roughness, and surface energy, which cause coal fines to aggregate [14-18].

### Results and Discussion

Experiment results show that clay invading into the prop pant pack would plug the pore throat of the prop pant pack and would cause a sharp decline in fracture conductivity [19-21]. There is a linear relationship between closure pressure and conductivity. This invasion could decrease the conductivity by 50% when the concentration of coal fines is 3% and the closure pressure is 16MPa. Moreover, the damage would rapidly worsen with increasing fines concentration. When fines concentration reaches 5%, the pore throat of the prop pant pack would be completely blocked, and no conductivity would be available under 16MPa (Figure 4 & 5). Different damage degree can be seen from Figure 6. This finding indicates that when the qualities of fines retention in the prop pant

pack increase, propped fractures conductivity would decrease. In order to mitigate conductivity damage, few fines should be allowed to enter prop pant pack. The effects of flow rate and clay concentration on conductivity damage are shown in Figure 5 & 6, respectively. The discharge of fluid at different rates and the measurement of the corresponding conductivity are shown in Figure 5. Under a 16MPa closure pressure, flow rate changed from 3 to 10mL/min much more clay are retained in the pore throat at higher fluid rate because of their strong adsorption property, thereby causing an inevitable decrease in conductivity, as shown in Figure 5. The prop pant pack with higher clay concentration has more retention (Figure 6). In addition, the formation of effective flow path scan is seen during the experiments, which provide and retain effective fracture conductivity as shown in the Figure7.

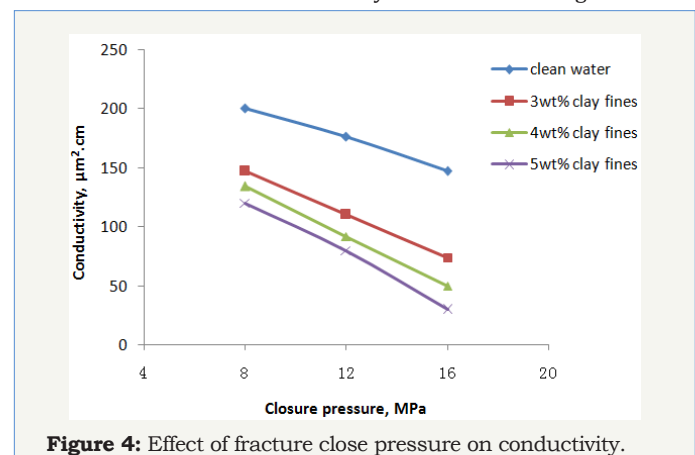


Figure 4: Effect of fracture close pressure on conductivity.

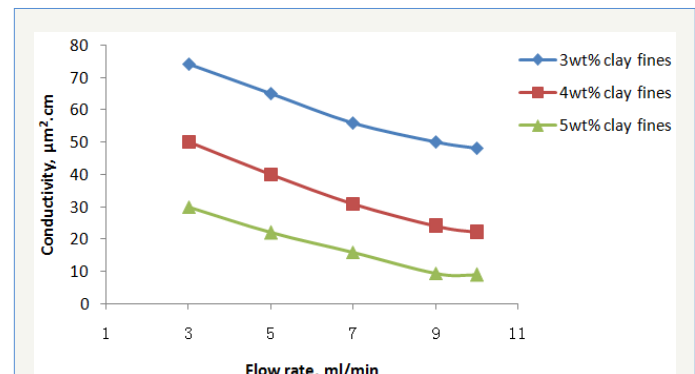


Figure 5: Effect of coal fines concentration on conductivity.

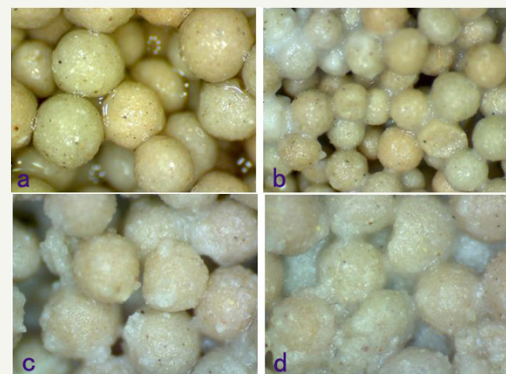
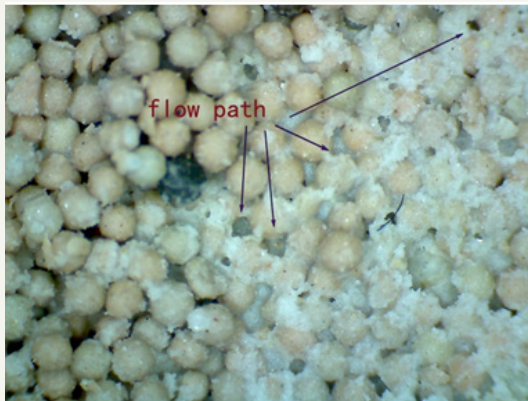


Figure 6: High-magnification view of proppant pack invaded by fines. a: clean water; b: 3wt% clay; c: 4wt% clay; d: 5wt% clay.



**Figure 7:** The formation of flow paths.

## Conclusion

1. An effective experimental method that could simulate the process of fine migration in the proppant pack was proposed.

2. Fines retention seriously damages fracture conductivity. The damage significantly worsens with increasing clay concentration and fracture closure pressure. Only 3% clay can decrease conductivity by 50%, whereas 5% fines can cause the fracture to lose conductivity completely.

3. Flow paths form in the flow of the plugging, which is the main reason that keeps the permeability of the reservoir. Flow path can keep a steady condition while a constant flow and concentration is steady during a long period.

4. Formation clay should not be allowed to enter the proppant pack. Injecting non-fluids into reservoir should be suggested to take into consideration.

## Acknowledgment

This research is supported by the National Natural Science Foundation of China (Project no.51374229).

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