Characterization of fines produced during drainage of coalbed methane reservoirs in the Linfen block, Ordos Basin

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Abstract
Coal fines produced during drainage of coalbed methane reservoirs can affect the permeability of the coal reservoir and damage production facilities such as downhole pumps, shafts, and valves. Thus, to clarify the mechanism of coal fines output is very important to high production of coalbed methane. The characteristics of coal fines can be used to identify the sources of the coal fines and to develop reasonable means of controlling coal fines output. In this study, different coal fines characteristics were investigated to reveal the output mechanism of coal fines. The coal fines samples were collected from 16 coalbed methane wells, which located in Eastern Ordos Basin of China. And the wells are in different drainage stages. The coal fines samples were analyzed by using transmission light microscopy, reflection polarized optical microscopy, laser particle size analysis, X-ray diffraction, and scanning electron microscopy with energy dispersive X. The results show that the concentration of coal fines is in the range of 3–8% (volume percent). The sizes of the coal fine particles tended to be below 200 µm. The main components of pulverized coal are vitrinite and inorganic minerals and the average content of inorganic minerals account for 50.56% and the standard deviation is 0.0685. The morphology analysis results show that the shape of coal fines is different in different parts of the coalbed methane wells. The coal fines concentration increases with the increase in the thickness of the deformed coal, and decreases with the increase in the burial depth. The concentration of coal fines becomes

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higher with the increase of casing pressure and coal fines concentration increases with the increase of the variation of bottom hole pressure.

Keywords
Coal fines, characteristics, drainage, coalbed methane, Ordos Basin

Introduction
The recovery of coalbed methane can be classified into three stages of dewatering: single water flow, gas-water two-phase flow, and single gas flow. Due to mechanical abrasion, liquid erosion and pressure fluctuations, coal fines will be inevitably produced in all dewatering stages (Singh et al., 2015a; Zhang et al., 2011, 2015; Zou et al., 2014; Wei et al., 2016). The generation and migration of coal fines during coalbed methane (CBM) production can have a detrimental effect on gas production by blocking pores and cleat flow paths in the coal strata, and through damage to downhole pumps (Civan, 2000; Liu et al., 2012; Nunes et al., 2010; Palmer et al., 2005; Singh, 2011; Wei et al., 2014). Factors that affect generation of coal fines include: (1) coal properties and the geological conditions; (2) the mechanical grinding during drilling, fracturing stimulation, and completing process; (3) the erosion of liquids flow, pressure fluctuations, and shrinkage of coal during production (Chen et al., 2009; Civan, 2007; Gentzis et al., 2009; Magill et al., 2010; Marcinew and Hinkel, 1990; Yuan and Shapiro, 2011; Zeinijahromi et al., 2011).

A lot of research works are focusing on the generation mechanisms, influencing factors and control measures of coal fines from theoretic analysis, laboratory tests and production practices. Palmer et al. (2005) summarized different coal failures during drilling, fracturing, and CBM production and concluded that failures in weak coal could cause fines generation. Chen et al. (2009) believed that the main factors that affect the output of coal fines are the properties of coal. Cao et al. (2012) proposed a system to classify coal fines as original coal fines, which generated from tectonic damage during coal forming period and secondary coal fines, which generated from mechanical destruction and pressure changes during coalbed methane exploitation period. Wei et al. (2013) showed that the formation of tectonically deformed coal is the key factor of coal fines generation. Guo et al. (2015) conducted a laboratory investigation on fines production and suggested that the main compositions of produced fines are clay minerals. Zhang et al. (2016) made gray relational analysis and concluded that the development of tectonic coal is the most critical factor. Guo et al. (2015) conducted a laboratory investigation on fines production and suggested that the main compositions of produced fines are clay minerals.

Expect the geological factors that affect the output of coal fines, the engineering processes (drilling and fracturing process) are also key factors that lead to coal fines output. Wang and Lan (2012) studied the main control factors of coal fines output in different drainage stages and believed that the drill process, erosion by flow liquid, and pressure fluctuation are the main factors in the production of coalbed methane. Zhang et al. (2011) assumed that in the process of drilling and fracturing, due to mechanical grinding, liquids flow erosion, and stress change, the strength of coal is decreased and the structure of coal is damaged, thus coal fines output. Bai et al. (2011) believed that the coal fines produced by mechanical
destruction mainly includes the lapping by drilling rig and the erosion by high-speed fracturing fluid and the grinding by proppants in the fracturing project.

During the dewatering process, due to the fluctuation of flow velocity caused by production disruption and pressure fluctuation, the coal fines deposited and block the flow channel to reduce the permeability of coal reservoir. Chen et al. (2009) believed that the output of coal fines is affected by the intensity of the drainage, the higher the intensity of the drainage, the more coal fines output. Cao et al. (2013) concluded that the fluid velocity and the confining pressure influenced the output of coal fines on the basis of physical simulation experiment. Ma et al. (2013) believed that the output of coal fines is less in early drainage stage, then the output of coal fines increased gradually and reached the maximum. In the single gas flow stage, there is little coal fines production. Zhang et al. (2013) believed that the output of coal fines will be increased with the increase of flow velocity. Also, the greater the flow, the easier it is to move large particles of coal fines. Due to the output of coal fines, the pressure drawdown distribution formed by the drainage cannot be fully unfolded. On the other hand, the coal fines that flow into the drainage system are deposited in the pump, which will affect the pump efficiency (Cao et al., 2012; Wei et al., 2014; Zhao et al., 2013). However, there are few studies for quantitative correlation analysis between production conditions and fines generation. Because of the complexity of coal and its difference with rock, it is important to analyze the characteristics of coal fines that generated from raw coal and study the relationship between produced fines and the influencing factors.

Predecessors have done a lot of works in the study of coal fines. These works have proposed the main controlling factors, generation mechanisms, and control measures of coal fines on both laboratory tests and actual production process. There is a lack of long-term and continuous samples collection, detailed test data, and quantitative analysis between the characteristics and influence factors. Based on the continuous collection of large number samples and detailed test data (concentration, particle size, composition, and morphology), this paper presents a detailed description of the coal fines and analyzed the quantitative relationship between concentration of coal fines and factors. This provides a theoretical basis for the study of the generation mechanisms of the output of coal fines and more accurate output predictions of coal fines and a better drainage system.

Methodology

We collected coal fines at the wells’ separators of 16 vertical and deviated CBM wells in Linfen blocks of the southeastern Ordos Basin, China. Each well had a history of producing significant volumes of coal fines. All CBM wells in this study had perforated completions. The wells intersect two main coal seams: the Permian aged 5# seam with $R_{\text{max}}$ ranges from 1.34% to 2.09%, and the carboniferous 8# seam with $R_{\text{max}}$ ranges from 1.49% to 2.12% (Wang, 2011). Some of the wells also intersect the 4# and 9# seams (Figure 1). We also collected blocks of coal from mines in the same region.

Coal fines were collected with 1 L containers from the wells’ separators over a period of 2 year (totally 370 water samples were collected from June 2013 to June 2015). The concentration of solids in each water sample was measured with a MFB-II coal fines concentration monitor. The solids were filtered, dried in a vacuum oven for 2 h at 50°C, and then stored in sealed plastic bags for further analysis in the lab. The particle size distributions of coal fines were measured using a British Malvern 2000 Laser Particle Size Analyzer. Optical micrographs were collected with an OR-THOPLAN polarized light microscope.
Inorganic components were analyzed using a Rigaku D/max -2500 PC X-ray diffractometer (XRD). Scanning electron microscope (SEM) images were collected with a Hitachi S-3400 SEM with IE 250 X-ray energy spectrometer.

**Results and discussion**

**Composition of coal fines**

According to the quantitative analysis of the micro-components of raw coal (Table 1), the vitrinite content of the main recoverable coal seam in Linfen coalbed methane block is more than 70% and the inorganic mineral content is below 15%. Compared to the result of raw coal, the analysis of the coal fines composition shows that vitrinite and inorganic mineral have the opposite trend. The vitrinite content accounted for an average of 31.75% and the standard deviation is 0.0552 while the inorganic mineral content has reached 50.56% and the standard deviation is 0.0685. The experimental results show that the nature of coal is the basis of coal fines generation and the vitrinite is more easily broken than other components, which is the main cause of coal fines output. The inorganic mineral particles have poor adhesion with the skeleton and weak binding force between mineral crystals (Singh et al., 2015b). Under high-speed fluid shear stress, the mineral aggregate is easy to fall off from the skeleton into fragments, which form fine-grained coal fines that easy to migrate and discharge. The Throat is the small part connecting the pores. The main throat types are

![Figure 1. Coal bearing strata integrated vertical litho-log of Ordos Basin.](image-url)
reduced throat, constricted throat, flaky throat, curved throat, and tube bundle throat (Liu, 2009). The movement of inorganic mineral fines in the cleat is easily plugging the throat and reduce the permeability of coal reservoirs. In particular, if the proportion of clay minerals is high, their cohesiveness, and agglomeration constitute an important factor of pump-block. As shown in Figure 2, the inorganic minerals account for an average of 54.35% of the coal fines, which are discharged by the wells that exploit 4 + 5, 8 + 9 # coal seam, and the vitrinite account for an average of 33.52%. While the inorganic minerals which are discharged from 5, 8# coal seam account for an average of 42.89% and the vitrinite account for an average of 29.88%. The experimental results show that the content of inorganic minerals which are discharged from the coal seam of 4 + 5, 8 + 9 # is higher than that of 5, 8# (Table 2).

5 # Coal seam in this area is mainly continental deposition, which is formed in the delta plain distributary channel and diversion bay depositional environment. In the sedimentary environment of the eastern delta, the thickness of the coal seams decreases but the sand bodies develop. As the twists of the river phase, which turns to most of 5 # coal seam containing gangue. In addition, when the coarse clastic material is deposited, since the brine solution in the depositional environment is already in the supersaturation state, the clastic deposition rate is much higher than that of the crystalline debris due to the presence of clastic minerals (Singh and Singh, 2012, 2015c; Zhang et al., 2014). Thus, the sediment contains a small amount of gypsum. 8 # Coal seam in this area is mainly formed in the shallow water barrier coastal environment, which is a marine deposition. Marine sedimentary environment makes the sulfur content of 8 # coal seam relatively high (Zhang et al., 2014). In the XRD test analysis, it is found that all the samples contained pyrite.

It is because the content of anhydrite and pyrite content is high, resulting in part of the coal-bed methane wells in this region producing sticky coal fines. This type of coal, fines sticks in the wellbore wall or paste in the bottom of the pump cylinder and attaches to the screen cloth resulting in reduced pump efficiency and pump sticking.

### Table 1. Comparison of composition between raw coal and coal fines (a) raw coal composition and (b) coal fines composition.

| Well identifier | Well type | Target coal seam | Composition |
|-----------------|-----------|------------------|-------------|
|                 |           |                  | Vitrinite   | Inertinite | Minerals |
| W8 Vertical     | 5, 8      | 22.99% 16.09%    | 60.92%      |
| GS3 Vertical    | 5, 8      | 33.33% 25.36%    | 41.30%      |
| GS1 Vertical    | 5, 8      | 33.33% 23.33%    | 43.33%      |
| GS2 Vertical    | 4 + 5, 8 + 9 | 31.78% 15.50% | 52.71%      |
| GS2 Vertical    | 4 + 5, 8 + 9 | 29.37% 15.38% | 55.24%      |
| GS2 Vertical    | 4 + 5, 8 + 9 | 22.63% 19.71% | 57.67%      |
| WX10 Deviated   | 5, 8      | 39.86% 17.48%    | 42.66%      |
| WX9 Deviated    | 5, 8      | 37.18% 19.71%    | 43.11%      |
| GSX2 Deviated   | 4 + 5, 8 + 9 | 37.59% 8.51%    | 53.90%      |
| GSX2 Deviated   | 4 + 5, 8 + 9 | 29.45% 15.75% | 54.79%      |
| Raw coal / Coal seam | / | 73.90% 13.10% | 13.00%      |

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Morphology of coal fines

Figure 3 shows the SEM image of the coal fines sample produced at the wells’ separators. Two images are magnified 3000 times and 2100 times after the microscope observation and it can be seen that the coal fines particles are spherical, and the edges and corners are not obvious. It is analyzed that the original coal fines are mostly generated in the coal formation and the tectonic movement process. It is a slow and long process. Due to the effect of this process, the original coal fines become smaller and have good roundness. Therefore, it is concluded that the main coal fines output from the wells’ separators is original coal fines.

Figure 4 shows the SEM image of the coal fines samples in workover. It can be seen that the coal fines are massive, angular and the surface adhere of impurities is roughness. It is analyzed that the output of angular coal fines is mostly influenced by the drilling process, reservoir renovation and drainage process and so on. Therefore, it is concluded that the secondary coal fines are the main factors that cause the pump sticking in the production of coalbed methane wells.

The surface features of the coal fines are determined by their own composition. According to the energy spectrum test (Figure 5), the main elements of the coal fines with smooth surface are C and the main elements of the coarse particles are O, S, and Fe. It is

![Figure 2. Comparison of composition between coal fines from different wells that intersect and produce from coal seams (4 + 5 and 8 + 9) or seams 5 + 8.](image)

| Wells | Kaolinite | Illite | Quartz | Barite | Gypsum | Anhydrite | Pyrite | Siderite | Calcite |
|-------|-----------|-------|--------|--------|--------|-----------|--------|----------|--------|
| WX6   | 20%       | 9%    | 56%    | 15%    |        |           |        |          |        |
| GS1   | 7%        |       | 73%    | 3%     | 17%    |           |        |          |        |
| GS2   | 11%       | 12%   | 4%     | 13%    |        |           |        |          |        |
| WX8   | 6%        | 17%   | 51%    | 26%    |        |           |        |          |        |
| WX9   | 13%       | 50%   | 6%     | 31%    |        |           |        |          |        |
| GS2   | 5%        | 23%   | 28%    | 44%    |        |           |        |          |        |
| GSX2  |           |       |        |        |        |           |        |          |        |
| GSX2  | 56%       | 17%   | 7%     | 20%    |        |           |        |          |        |

Table 2. The inorganic components of coal fines from different CBM wells.

Morphology of coal fines

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considered that sulfate, Fe$_2$O$_3$, and FeS$_2$ are the main particles adsorbed on the surface of particles. Coal particles with smooth surface are mainly organic matter. Coal particles with rough surface may be pyrite accumulated in the coal particle.

**Concentration of coal fines**

The monitoring results of concentration (volume fraction) of coal fines in water samples collected in the 16 wells are shown in Table 3, which lists the coal seams, well orientation, and completion depth of each of the 16 wells. It can be seen from Table 3 that the concentration of coal fines is varying among different coalbed methane wells. The average value of the concentration is range from 3.6% to 5.9% and the standard deviation is range from 0.52 to 1.22. The minimum value of the concentration of coal fines in water samples is 3.1% while the maximum value is 8.1%. It is analyzed that the concentration of coal fines is influenced by the drainage stage, characteristic of producing coal seam and tectonics conditions and so on. When turn to the relationship between concentration of coal fines and different drainage stage, there is a large gap among the initial gas production stage and gas rising stage (Figure 6).
Table 3. Summary of coal fines samples collected from wells in Linfen Block, Ordos Basin over a 1 year period.

| Well identifier | Well type | Depth of completion zone (m) | Target coal seams | Concentration (Vol%) | Minimum | Maximum | Average |
|-----------------|-----------|------------------------------|-------------------|----------------------|---------|---------|---------|
| W1 Vertical     | 990       | 5, 8#                        |                   | 3.3                  | 5.9     | 4.7     |
| W2 Vertical     | 1120      | 5#                          |                   | 3.1                  | 4.3     | 3.6     |
| G1 Vertical     | 991       | 5, 8#                       |                   | 4                    | 4.8     | 4.4     |
| GS1 Vertical    | 955       | 5, 8#                       |                   | 4.2                  | 6.7     | 5.5     |
| GS2 Vertical    | 935       | 4 + 5#, 8 + 9#              |                   | 3.8                  | 8.1     | 5.3     |
| WX1 Deviated    | 1030      | 5, 8#                       |                   | 3.6                  | 6.2     | 5       |
| WX2 Deviated    | 1020      | 5, 8#                       |                   | 3.4                  | 5.9     | 4.8     |
| WX3 Deviated    | 1010      | 5, 8#                       |                   | 4.2                  | 7.8     | 5.5     |
| WX5 Deviated    | 1050      | 5, 8#                       |                   | 4.6                  | 5.8     | 5.2     |
| WX7 Deviated    | 1025      | 5, 8#                       |                   | 4.7                  | 6.3     | 5.3     |
| WX8 Deviated    | 1200      | 5, 8#                       |                   | 3.1                  | 5.3     | 3.8     |
| WX9 Deviated    | 1230      | 5, 8#                       |                   | 3.4                  | 5.5     | 4.2     |
| GX2 Deviated    | 1030      | 5#                          |                   | 3.6                  | 5.2     | 4.4     |
| GX3 Deviated    | 1045      | 5, 8#                       |                   | 3.9                  | 5.4     | 4.9     |
| GSX3 Deviated   | 1030      | 4 + 5#, 8 + 9#              |                   | 3.5                  | 5.7     | 4.7     |
| GSX2 Deviated   | 1020      | 4 + 5#, 8 + 9#              |                   | 5.2                  | 7       | 5.9     |

The annual mean is an arithmetic mean of concentrations of all samples collected from the well during the survey period.

Figure 5. The spectrum analysis on different surface of coal fines.
Granularity of coal fines

The particle size of 133 coal fines samples is analyzed by laser particle size analyzer. Figure 7 shows that the average particle size of 90% of the coal particles of the sample is less than 128 μm. We can see from Figure 8 that the average size of coal fines is under 200 μm and the standard deviation is 23.54. But, the maximum value of coal fines size is various among different coalbed methane wells. It is concluded that in the area of coal-bearing strata that affected by tectonic movement, due to the influence of multistage tectonic movement, the raw coal is crushed by stress extrusion, tensile or shearing, and the coal particle size is smaller than that generated by undeformed coal. But, the size of output coal fines is also affected by the stage of drainage. During the initial stage of coal production, secondary coal fines are mainly produced by mechanical abrasion, fluid erosion, proppant abrasion and stress fluctuation during drilling and fracturing. As the undeformed coal has more hardness than tectonic coal. When the undeformed coal is damaged by external force, the output coal fines are mainly large particles. Therefore, the granularity of the coal fines in the undeformed coal development area is larger than that of the tectonic coal area. But, with the proceed of drainage, as the secondary coal fines influenced by drilling, fracturing and other

Figure 6. Comparison of output coal fines concentration in different conditions. (a) Average of coal fines concentration from wells that extract 5#, 5&8#, and 4&5, 8&9#. (b) Average of coal fines concentration from wells in different drainage phase.

Figure 7. The distribution trend of particle size and the particle size is the average value of the 16 CBM wells.
engineering factors have been discharged, the output of coal fines are from original coal fines in this stage. In this stage, the output of original coal fines of undeformed coal is mainly dominated by the coal forming process and the coal matrix shrinkage after gas desorption while the tectonic coal is mainly produced by the destruction caused by tectonic movement. Thus, the size of the coal fines of tectonic coal is larger than that of undeformed coal.

By analyzing the particle size distribution curve of the test sample, we can see that the coal particle size distribution curve is basically two kinds (Figure 9). The first is the bimodal, namely a curve of coal particle size distribution with two peak. It is analyzed that the formation of the first peak mainly is original coal fines and most of this type of coal fines are formed in the coal-forming period and the particle size is relatively small. The second peak is mainly made up by secondary coal fines, which are influenced by mechanical erosion during drilling and fracturing process and erosion action of the flow liquid and pressure fluctuation. For the unimodal particle size distribution curve, there are only one main peak and a wide distribution range. It is analyzed that the original coal of this kind of coal fines is of little hardness or the coal maybe influenced by the tectonic movement. The particle size of coal fines has little differences, as most of the coal fines are concentrated in a certain range.

Quantitative analysis of coal fines
Tectonic coal. By analyzing the distribution characteristics of coal concentration and the development of regional tectonic coal, we can conclude that tectonic coal is still the key factor of coal fines output. According to the geological conditions of Linfen block, the logging interpretation data of CBM wells and the monitoring data of coalbed methane concentration in coalbed methane wells are statistically analyzed. The regression analysis shows that the coal fines concentration is exponentially related to the thickness of tectonic coal (Figure 10), the relationship is

\[ C = 2.8229e^{0.1778T} \] (1)

where \( C \) is the concentration of coal fines, %; \( T \) is the thickness of tectonic coal, m; the correlation coefficient is 0.8497; the number of statistical points \( N = 9 \).
As Figure 10 shows that the coal fines concentration increases with the increase in thickness of tectonic coal. The results show that the tectonic coal has low strength and is easy to break. Compared with the undeformed coal, tectonic coal produces coal fines more easily. Thus, with the increase of the thickness of the structure coal, the output of the coal fines is increased.

**Depth of coal seam.** The research area is inclined from south east to northwest and the depth of coal seam is gradually increased from south to north. The coal seam is a natural reservoir, which is very sensitive to the crustal stress. The effective stress around the CBM well is redistributed during the coalbed methane drainage. The results show that the concentration

![Figure 9. Particle size distribution (a) bimodal type and (b) unimodal type.](image)

![Figure 10. Relationship between coal concentration and thickness of coal seam.](image)
of coal fines decreases with the increase in coal seam depth from 900 to 1300 m. The relationship between the coal concentration and the depth of coal seam is analyzed (Figure 11)

\[ C = 20.377e^{-0.001H} \]  \hspace{1cm} (2)

where \( C \) is the concentration of coal fines, %; \( H \) is the depth of coal seam, m; the correlation coefficient is 0.8734; the number of statistical points \( N = 11 \).

It is concluded that with the increase of the coal seam depth, the effective stress increases and the coal reservoir skeleton is more vulnerable to destruction due to the low Young’s modulus and high Poisson’s ratio. On the other hand, due to the increase of effective stress of coal seam, the reservoirs are compressed and the micro-pores in the reservoir are closed and the height of fractures is reduced. Thus, most of the coal fines is accumulated in the coal reservoirs and cannot discharge with gas-water flow. Therefore, the concentration of coal fines decreases with the buried depth of coal seam.

**Casing pressure.** The casing pressure is that the pressure on the ground is applied to the casing in the well. The casing pressure and the depth of the liquid surface are the pressure parameters, which reflect the gas production. Reasonable control of the casing pressure can maintain a good dynamic liquid surface thereby obtain the high and stable production. Through continuous monitoring of the output of coal fines in the study area, the statistical results show that with the increase of casing pressure, the concentration of coal fines becomes larger. The relationship between the concentration of coal fines and the casing pressure is logarithmically related (Figure 12)

\[ C = 0.9104\ln(P_T) + 5.5042 \]  \hspace{1cm} (3)

where \( C \) is the concentration of coal fines, %; \( P_T \) is the casing pressure, MPa; the correlation coefficient is 0.8116; the number of statistical points \( N = 89 \).

**Bottom hole pressure.** The analysis of the variation of bottom hole pressure in sampling wells shows that all the coalbed methane wells with rapid decline in the initial flowing pressure
have poor gas production and the output of coal fines is serious, and the problems caused by coal fines are much more. In view of the fact that the bottom hole pressure of CBM wells is controlled artificially, reasonable control of bottom hole pressure can effectively control the output of coal fines. In the process of coalbed methane production, the bottom hole pressure decreased with the drainage process. And the pressure gap between the coal seam far away from bottom of the well and the coal seam near the bottom of the well becomes larger. The uneven distribution of pressure in the transverse will result in the failure of coal seam and the output of coal fines. On the other hand, with the decrease of bottom hole flow pressure, the pressure drop funnel will be expanded and the reservoir pressure will be decreased accordingly. With the reservoir pressure reduced, the pressure of the overburden bearing on the coal skeleton becomes larger so that the coal reservoirs will be deformed under high pressure. Then, the coal fines will be produced.

Through the statistical analysis of the variation of bottom hole pressure and the coal concentration data of the sampling wells, we can see that the larger the gap between the bottom hole flow pressure and the original formation pressure, the greater the concentration of the coal fines. There is a linear relationship between the coal concentration and the variation of bottom hole pressure (Figure 13)

$$C = 0.3363P_L + 3.1528$$  (4)
where $C$ is the concentration of coal fines, $\%$; $P_L$ is the variation of bottom hole pressure, MPa; the correlation coefficient is 0.9604; the number of statistical points $N = 10$.

Based on the above understanding, in the CBM drainage process, we should try to extend the single water stage to expand the pressure drop area. In single water phase, we should control the bottom flow pressure changes slowly, smoothly, and continuously. On the other hand, due to the tensile and compressive strengths are weak, too fast pressure changes will lead to the destruction of coal structure, which will result in output of coal fines and plug the flow channel and reducing the permeability. If coal fines move into the drainage system, it will also have an impact on the drainage equipment and destruction continuous production process of coalbed methane wells and then generate additional workover costs.

**Conclusion**
1. The vitrinite and inorganic minerals are the main components of the coal fines, and the average content of inorganic minerals accounted for 50.56%. The inorganic mineral is mainly composed of anhydrite and the average content is 58%.
2. The shape of the coal fines is varied in different parts of the CBM wells and the coal fines in the bottom of the wells is relatively large and the roundness is poor.
3. The coal fines concentration is varied in different regions and different drainage phase and the concentration is generally in the range of 3–8%.
4. The particle size of the coal fines is mostly below 200 $\mu$m and there are two kinds of particle size distribution curves of coal fines.
5. The coal fines concentration increases with the increase in the thickness of the tectonic coal and decreases with the increase in the burial depth. The concentration of coal fines increases with the increase of casing pressure and increases with the increase of the variation of bottom hole pressure.

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