The effect of sedimentary facies on coalbed methane in Binchang mining area

Kai Shao¹,²,⁴, Dongmin Ma¹, Laixin Li², Dongdong Wang³, Lin Zhang² and Gang Yang²

¹Xi’an University of Science and Technology, Xi’an 710054
²Shanxi Coalbed Methane Development Company Limited, Xi’an 710119
³Shandong University of Science and Technology, Qingdao 266590
⁴Corresponding author’s e-mail: sncbmc@163.com

Abstract. Research on geology data, drilling data, logging data of the coalbed methane drilling data in Binchang mining area, 6 sedimentary facies have been found. These sedimentary facies are: braided river facies, meandering river facies, meandering river delta facies, alluvial fan facies, fan delta facies and lake facies. By study of the CBM drilling, well cementing and hydraulic fracturing, Optimization parameter selection on the later CBM well engineering in different sedimentary facies had been summed up.

1. Background

Binchang mining area is located in Changwu county and Binzhou City, Shaanxi Province (Figure 1) and on the Yishan slope southwest of the Ordos Basin, its structural framework is wave-shaped monoclinic structure. The main structure is 3 ~ 5 ° small dip oblique structure. The faults in this area are smaller than 5 meters with relatively simple structure, and the development of strata is mainly affected by the original sediment [1, 2]. The region is rich in coal resources, coal reserves of 5 billion tons, coal bed methane reserves of 7.3 billion cubic meters.

Since 2008, 63 coalbed methane wells have been drilled by Shaanxi Coalbed Methane Development Company Limited, and the peak production reached 30323.78 m³ per day for the horizontal wells and 3300 m³ per day for the vertical wells. The total output over 50000 m³ per day.

Coalbed methane is a clean energy source. The development of this new energy is conducive to reducing the occurrence of coal mine gas accidents, and also provides an example for the development of low-rank coalbed methane in Northwest China. Gas field engineering is an important part of coalbed methane development.
However, in the process of coalbed methane development, due to drilling quality control, pipe sticking, well deviation and poor fracturing effect, the production reduction is caused. This is a serious problem affecting the engineering quality and the production of coalbed methane wells. This paper introduces the construction process and geological conditions of coalbed methane wells, and tries to find a solution to the common problems of engineering quality.

2. Stratigraphy and sedimentation
The lithological units of the formation include, from base to top, Hujiacun Formation, Anding Formation, Zhiluo Formation, Yanan Formation, Fuxian Formation, Luohe Formation, and Yijun Formation (Figure 2).

The sedimentary characteristics of Hujiacun Formation are gray to dark gray mudstone, silty sandstone mixed with thick fine-grained feldspathic sandstone, and there are current bedding and horizontal layers in the area. Hujiacun Formation is mainly delta front sedimentary facies; The quantitative analysis results show that Anding Formation and Zhiluo Formation are unconformable in contact, and the lithology is red sandy sandstone, silty sandstone and light gray sandstone [3]. From bottom to top, two sets of sediments are formed and returned to the corresponding delta facies, and delta front and front delta sedimentary facies are developed.

The Zhiluo Formation can be divided into two parts. The lower lithology is purple and violet sandy shale mixed with violet fine sandstone. The upper part is gray fine-grained sandstone mixed with violet sandy shale [4]. This formation is in unconformity contact with the underlying Yanan Formation, and the vertical lithologic changes show positive rhythm and river-dual structure. River courses and natural levees are developed by siltation in meandering rivers, and cross bedding and trough cross bedding can be seen at boreholes.

Yanan Formation is the main coal-bearing strata, and its lower lithology is grayish brown bauxite mudstone, argillaceous siltstone and fine sandstone, which is rich in pyrite, oolitic siderite and plant root fossils. Above is a thick No.4 coal seam, overlying a set of shallow dark gray mudstone and sandy mudstone, rich in plant fossils. No.4 coal seam can be mined locally in No.4, 4-1 and 4-2 layers. The upper lithology is gray mudstone, sandy mudstone, siltstone and carbonaceous mudstone, and the
bottom is thick sandstone layer, which is connected with the lower part. No.3 coal seam can be found in some areas. The results show that the delta zone is the most favorable coal accumulation area, and the coal seam is deposited in a stable place where the creation rate of accommodation space and peat/coal accumulation rate are balanced [5].

The lithology of Fuxian Formation is represented by gray, sage green mudstone and porphyry siltstone, and the bottom of breccia is often sandy mudstone of Triassic. The strata are in unconformity contact with the underlying strata. The sedimentary facies are meandering river sedimentary facies, and the deposits in Binchang mining area are mostly floodplain deposits [6].

The Luohe Formation can be divided into two parts. The upper part is represented by red thick conglomerate, and purple grain feldspar sandstone with thick conglomerate, is mainly braided river sedimentary facies, about 60-80m thick [7]. Lower part is represented by red fine - grain feldspar quartz sandstone, feldspar sandstone with thick layer of coarse grain and dark brown thin layers of mudstone, and general thickness is about 70 -100 m. It is the main aquifer with large scale cross-bedding and conformable contact with underlying YiJun Formation, representing the fan delta and braided river sedimentary facies [8].

Yijun Formation: The lithology is thick conglomerate containing gravel coarse sandstone lens. The gravel is mainly composed of granite and gneiss, with an average thickness of about 20 m, which is unconformably contacted with the underlying strata. The sedimentary facies are mainly alluvial facies, and the borehole can be divided into root fan and inner-middle fan.

3. Coalbed methane drilling and production
Coalbed methane projects mainly include drilling, logging, cementing and fracturing projects. The main function of logging method is to find out the distribution and lithologic changes of coal and coalbed methane, so as to achieve the purpose of traditional coalfield geological drilling [9, 10].

3.1. Drilling engineering quality
The drilling operation methods of coalbed methane wells in different coalbed methane fields may be quite different. Drilling technology and equipment usually depend on coal seam geological conditions. According to the available data, the main problems of drilling in this area are sticking, deviation and completion.

3.2. Stuck pipe
The main part of the stuck pipe of Luohe Formation is in the upper part. Sedimentary environments are mainly braided rivers, alluvial and fluvial, the lithology beingquartz sandstone, feldspathic quartz sandstone, and gypsum minerals, which have good permeability. During drilling, the expansion of gypsum minerals in water will cause wellbore contraction, and the good permeability of sandstone will cause the loss of drilling fluid. Both will cause wellbore contraction, pipe sticking and completion.

3.3. Well deviation
Deviation will affect subsequent cementing, fracturing and production of coalbed methane wells, and serious deviation will cause failure of coalbed methane wells. The strata in the study area experienced Indosinian movement and Yanshanian movement, and the geological background is an important reason for well deviation. There are three remarkable characteristics of unconformity between Yijun Formation and Anding Formation, Anding Formation and Yanan Formation, Fuxian Formation and Hujiacun Formation. The lithology, dip angle of strata and layered structure of lower strata of unconformities are different. For example, the underlying surfaces of Yijun Formation and Anding Formation are unconformable, the dip angle of strata changes rapidly, and the lithology changes from conglomerate to argillaceous siltstone, resulting in the problem of well deviation.
Figure 2. Stratigraphic log showing the position of the formations and sedimentary facies on CBM well engineering in Binchang mining area.

3.4. Completing the Well
According to the completion experience of traditional oil wells, the completion technology of coalbed methane wells has made great progress, but it needs to be further improved to adapt to the characteristics of coalbed methane reservoirs. As stated in the existing statistics, coal seams such as the lower member of Luohe Formation, the middle and lower member of Anding Formation and the lower member of
Zhiluo Formation of Yijun Formation are the main hidden dangers of cementing quality. The sedimentary facies of the middle and lower members of Luohe Formation and Yijun Formation in the study area are alluvial fan deposits with thick glutenite and large grain size, which have typical alluvial fan sedimentary characteristics. The sedimentary facies of the middle and lower members of Yijun Formation and Luohe Formation are alluvial deposits with thick sedimentary layers and large grain size; The lithology of the lower part of the stable formation is mainly sandstone and argillaceous sandstone, and the sedimentary facies is mainly distributary channel microfacies (Figure 2).

After completion, the cementing performance, filtration performance and permeability of alluvial fan and distributary channel sediments are worse than those of other sediments. Due to these characteristics, mud and water quickly enter the stratum, which affects the smooth completion of the project. In order to further improve the completion engineering, the compatibility between cement and formation should be studied.

Due to the engineering problems of drilling, the construction period of coalbed methane project becomes longer and the cost increases. For example, the cementing of Well 05 and Well 06 occurred in alluvium. In order to improve the quality of drilling engineering, the study area should improve the drilling fluid, drilling equipment and technology according to the characteristics of sedimentary facies, and adopt waterborne drilling fluid to achieve the balance between wellbore stability and coalbed methane production.

3.5. Fracturing coal seams and production
In the reservoir, methane is adsorbed on the surface of coal seam, so hydraulic fracturing of coal seam is needed to generate economic gas flow. Hydraulic fracturing is designed to make fractures as long as possible. Although the fracturing equipment and design are the same, the fracturing effect is different under different sedimentary environments [11, 12].

The coal of Yanan Formation is deposited in delta swamp area. Distributary channel has little influence on swamp environment in some stable areas, and can provide sufficient accumulation places for thick coal seams (Figure 3). However, under the action of distributary channel and estuary dam, the coal seam in river delta changes under the influence of river movement. Coal seams are well developed in DFS-133 well area, and the sedimentary environment is more stable than that in DFS-151 well area. Because the Young's modulus and shear strength of hydraulic fracturing coal seam are lower than those of sandstone and mudstone, it is easier to form wider fracture propagation in coal area [13, 14, 15].

The results show that the output of well DFS-133 is 3300 m³, which is much higher than output of well DFS-151 is only 450 m³. It shows that sedimentary facies analysis plays an important role in coalbed methane fracturing. Therefore, in the future work, sedimentary facies are an important factor that must be considered in fracturing coal seams. The meandering river environmental well is an important way to optimize the design of fractures, and shale gas may exist in the shale of estuary dam(Figure 3).
Figure 3. The effect of sedimentary facies on CBM Fracturing in Binchang mining area.

4. Conclusion
1) The main sedimentary environments of drilled strata during coalbed methane well in Bingchang mining area are continental sedimentary environments, braided stream, meandering river, meandering river delta, alluvial fan, fan delta. Lake 6 types of sedimentary facies are found in the area, and the coal seam is mainly formed in the distributary bay facies at meandering river delta.

2) For coalbed methane wells, sedimentary facies affect well deviation, completion, cementing quality and fracturing radius. Therefore, the analysis of sedimentary facies of each coalbed methane well is very important. Attention should be paid to the influence of sedimentary facies in drilling fluid, drilling equipment and fracturing technology.

3) It ultimately affects productivity and economic efficiency. This study provides technical support for the follow-up coal-bed methane engineering, especially for the low-rank coal-bed methane engineering in northwest China.

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