Research on geological structure characteristics of Lubanshan mine field

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Abstract. Mine geological structure is an important geological factor that affects coal mine safety production. Based on detailed underground geological observations and surface geological survey data, starting with the study of structural traces and structural stress field, the Lubanshan mine field's geological structural characteristics and structural stress field distribution are analyzed. The research results show that the structural profile of the Lubanshan mine field is mainly controlled by the NE-directed Xunsi anticline. The geological structure at the edge of the minefield is more complicated and the internal geological structure is relatively simple. The development of small faults and layer-slip faults, often in groups of coal seams or coal seam roof and floor, has become one of the biggest obstacles restricting coal mine safety production.

1. Introduction

Geological structure refers to the shape left over by the deformation and displacement of the rock layers in the earth's crust due to the action of the crustal movement [1-2]. Its scale is as large as thousands of kilometers, as small as millimeters or even micrometers. Mine geological structures mainly include folds, faults, joints, interlayer sliding, etc., which are important geological factors that affect coal mine safety production [3-5]. Therefore, studying the geological structure characteristics of coal mines is of great significance for preventing coal mine geological disasters, improving coal mine safety production capacity, and ensuring coal mine safety production.

Lubanshan mine field is located in Junlian County, Yibin City, Sichuan Province. It belongs to the Junlian mining area, with a designed production capacity of 900,000 t/a and a minefield reserve of 235.47 million tons. The mine field is divided into two pairs of mines--Lubanshan South Mine and Lubanshan North Mine. Due to the complex geological structure of the minefield, small and medium folds and faults are generally developed, which makes the coal seam unstable and seriously affects the safety of coal mine production. Therefore, the study of the geological structure characteristics, development law and evolution of the Lubanshan mine field will provide a reference for the daily safe mining of the mine field.
2. Geological background
The Lubanshan mine field belongs to the Junlian mining area. The Junlian mining area is located in the western section of the southern Sichuan coalfield. It is adjacent to the Sichuan-Guizhou and Sichuan-Dunnan structural belts on the east and west sides, and is connected to the third subsidence zone of the New Cathaysian System in the north-the southern margin of the Sichuan Basin which is a component of the Yanjin-Weixin East-West Tectonic Belt.

A general retreat occurred in this area during the Dongwu Movement at the end of the Maokou Formation. Along with the continuous uplift of the ancient land of Sichuan and Yunnan, there were extensive and strong Emeishan basalt eruptions. The coastline continued to move southeast and then the land area is enlarged. In the late Permian, this area underwent an extensive transgression, and the coastline moved from southeast to northwest. The area around Junlian became coal-bearing construction in the coastal plain environment. In short, due to the control of the paleogeographic environment in the southern Sichuan area in the Late Permian, the sedimentary zoning phenomenon is obvious, and the mineable coal seam gradually rises from east to west as the ancient coastline goes westward. Therefore, the lower part of the Xuanwei Formation and the Emeishan Formation in this area are equivalent to the Longtan Formation in the eastern region.

The coal-bearing strata is the Xuanwei Formation of the Upper Permian, with a thickness of 139.44 meters. The main coal-bearing section is the upper section of the Xuanwei Formation, which is a coastal plain coal-bearing construction, with an average thickness of 42.72 meters, 7 to 9 layers of coal, and a total thickness of 7.32 meters. There are 4 layers of mineable or partially mineable coal seams, from top to bottom. The bottoms are No.2, No.3, No.7, and No.8. The total thickness of the mineable coal seams is generally 5.54m. Among them, the 2nd and 7th coal seams are partially mineable and are unstable coal seams. The 3 and 8 coal seams are basically available in the whole area. It is a relatively stable coal seam. The inclination angle of the coal seam is 7°~21°. The average minable thickness of the coal seam is 0.95m~2.31m, and the average distance between the coal seams is 3.7m~18.43m. It is a gently inclined thin and medium-thick close-range coal seam. The roof of the coal seam is mostly a combination of argillaceous rock and sandstone, and the floor is argillaceous rock and sandstone.

3. Overview of regional structure
The geological structures in the area can be roughly summarized into two directions according to their distribution morphology: east-west and north-east. The east-west structure is mainly represented by the Luomurou anticline, Mu'ai syncline, and Yejiaba-Leyi anticline. Its structure is characterized by wide and gentle syncline, symmetrical two wings, and mostly chalk and Chuluo strata on the axis. The anticline is compact, the rock formations are steep in the south and gentle in the north, asymmetrical, the core strata are Cambrian and Ordovician, and the two wings are Silurian, Permian, and Triassic. The north-east trending structure mainly includes Xunsi anticline, Xinjie syncline, Dalantian Wujiawan anticline, Shenjiawan syncline, Wude syncline, Laopaifang anticline, Tiechanggou syncline, three subcontractors anticline and Guantianwan syncline. The fold axis is northeast. The anticline is compact, the syncline is open, and it is a partition type fold.

The structures in the above two directions are the products of the Yanshan movement, but the order of formation is sequential. Since the east-west structure affects the stratum and is larger in scale, it is considered that the east-west structure precedes the north-east structure. The Lubanshan mine field is located within the north-east trending structure.

4. Geological structure characteristics of the mine field
The Lubanshan mine field is located on the north side of the Xunsi fault, east of the Xinjie syncline, and the Xunsi anticline runs through the entire Lubanshan mine field. The Xunsi anticline is a broad and simple northeast-trending anticline structure, accompanied by secondary folds and faults consistent with the axial direction. The overall appearance is that the edge of the well is more complicated, the inside of the well is simple, the larger faults are distributed in the boundary of the well, and the inside of the well is only affected by small faults.
4.1. Fold structure
The Xunsi anticline runs diagonally across the entire mine field, from the vicinity of Xunsi in the south, passing through Gaodi and Miaoping at the southern foot of the Luban Mountain to the north of Zhujiagou. The total length is about 13 kilometers. The axis changes from N70°E to N30°E to the north (mostly around N40°E in the minefield), and the axis is slightly inclined to the northwest with an inclination angle of 85 to 90 degrees. The hub dips to the northeast with a dip angle of 5-10 degrees. The oldest stratum exposed at the core is the Maokou Formation. The two wings are mainly Middle and Lower Triassic and Upper Permian. The northwest wing has a slightly larger dip angle of 20~25 degrees, the southeast wing is slightly slower at 10~20 degrees.

The Xinjie syncline is the boundary structure of the eastern part of the minefield, and the secondary folds associated with the Xunsi anticline and the Xinjie syncline are mostly distributed around the edge of the minefield. They are small in scale and have little impact on the coal seams. The folds in the minefield are not well developed, and there are only a few microwave fluctuations. In the periphery of the minefield, in the Leikoupo, Jialingjiang, and Tongjiezi formations on the axis of the anticline and on the two wings, there are some small-scale interlayer folds. These folds only affect the shallow strata and have no effect on the coal seams.

4.2. Fault structure
Faults are the main geological factors affecting the mining of the Lubanshan mine field. According to the conditions of geological exploration and mine production, there are developed faults in the minefield, but most of the large-scale faults are distributed around the edge of the minefield, which will have little impact on coal mining in the future. During the mining process, a large number of small faults were discovered and identified. The preliminary analysis showed the following characteristics:

(1) Large-scale faults are mostly developed around the edge of the minefield, or as the boundary of the minefield, such as the regional east-west fault with a drop of more than 100m. In addition, there are coal-cutting normal faults F54 and F86, which are distributed north-east. The drop of F54 is 20~25 meters, and the drop of F86 is 10 meters. They are respectively distributed near the coal outcrop at the west end of the minefield and the Fujia area at the southern end of the minefield, which has a certain impact on the mining of shallow coal seams.

(2) The large coal-cutting fault in the minefield is only the F100 reverse fault, with a drop of 20~25 meters, which has a greater impact on coal mining. The following figure is a cross-sectional view of F100, as shown in Figure 1.

![Figure 1. Sectional view of F100 fault](image-url)
(3) Most of the medium-sized faults are developed near the axis of the syncline. The faults tend to have the same stratigraphic tendency. Normal faults are mostly developed near the axis of the anticline, and reverse faults are mostly developed near the axis of the syncline.

(4) The faults in the minefield are dominated by small faults, the drop is mostly less than 3m, and they often appear in groups. They develop near the roof and floor of the coal seam, and the displacement is small, resulting in the phenomenon of repeated coal seams or "continuous top and bottom faults and continuous bottom faults". In places where small faults are dense, the thickness of the coal seam changes complex, the structure is broken, and it is easy to form structural coal.

(5) Layer slip structure. Layer-slip structure is a kind of geological structure commonly found in coal mines, which refers to a special structure type limited to a certain interval or layer [6]. The layer-slip structure can thicken or thin the coal seam, or even pinch out, and lose mining value. It can also lead to the destruction of the coal seam structure and the formation of structural coal soft layering. For example, in the 2836 coal exploration uphill, a layer-slip fault was found, causing the coal seam to move, as shown in Figure 2.

![Figure 2. Sketch map of 2836 coal exploration uphill](Image)

5. Analysis of wellfield tectonic stress field

From the analysis of regional sedimentary data, it can be seen that the strata in this area are relatively well developed and well exposed, except for the lack of Tertiary, Carboniferous, Devonian and Upper Silurian, the Cambrian and above are all exposed. The Permian and Triassic are the most widely distributed, and the Jurassic, Ordovician, and Silurian Middle and Lower Systems surround the region. The Cambrian is sporadically exposed on the axis of some large anticlines in the periphery, the Cretaceous is scattered in the core of the large syncline, and the Quaternary is not very developed, and is mostly scattered on both sides of the flat dam and the river valley.

Previous studies have shown that the formation of an anticline is often the result of multiple long-term effects [7]. According to the geological structure characteristics of the minefield, combined with regional structural analysis, the Lubanshan mine field structure was formed during the late Yanshan movement, and the action process was slightly sequential. The large east-west wide and gentle folds in the adjacent area of the minefield were formed by the north-south compressive stress on the basis of the early basement uplift zone, forming the primary structure of the regional caprock structure. At the same time, a series of near-east-west faults appeared. The north-east-trending fault characterized by leftward twisting is also a product of the deformation in this period, and the corresponding matching northwest-to-right twisting fault is not developed inside the minefield. The northwest-trending folds and north-south-trending folds in the neighboring area of the Lubanshan mine field may be involved in the Himalayan tectonic movement. A series of low-amplitude NE-trending wide gentle fold structures in
the Lubanshan mine field and its adjacent areas were mainly formed under the compressive stress of the NW–SE direction in the Yanshan period.

6. Conclusion

(1) The structural profile of Lubanshan mine field is mainly controlled by the Xunsi anticline in NE direction. The geological structure at the edge of the minefield is more complicated, and the internal geological structure is relatively simple. Large faults are not developed within the minefield. There are only four major coal-cutting faults, among which the Xunsi fault is the southern boundary of the minefield. F54 and F86 are respectively distributed near the coal seam outcrop at the west end of the minefield and near the coal seam outcrop near the Fujia area at the southern end of the minefield. They only have a certain impact on the mining of shallow coal seams. The reverse fault F100 has a greater impact on coal mining.

(2) Small faults and layer-slip faults are developed, often in groups of coal seams or coal seam roof and floor. Make the coal seam thicker or thinner, and the coal seam will be repeated, which will cause the roof and floor of the coal seam to be broken, causing the coal structure to be broken and forming a soft layered structure. According to the development law of the small faults in the mining area, it provides a reliable basis for the prediction of the structural division of the unmined area.

(3) The geological structure of the Lubanshan mine field is far more complex than recognized during the resource exploration stage, and the small faults encountered during the production process have become one of the biggest obstacles restricting production. Therefore, studying the characteristics of small structures in the Lubanshan mine field, summarizing the formation and development of structures, and predicting and evaluating structures are the primary tasks for building a safe, high-yield, and efficient mine geological support system.

Acknowledgments

The study was supported by National Science and Technology Major Project (2016ZX05067004-006), Key Projects of the Chongqing Research Institute's Independence (2020ZDXM06).

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