Classification of Structural Coal-Controlling Styles and Analysis on Structural Coal-Controlling Actions

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Abstract: Tectonism was the primary geologic factors for controlling the formation, deformation, and occurrence of coal measures. As the core of a new round of prediction and evaluation on the coalfield resource potential, the effect of coal-controlling structure was further strengthened and deepened in related researches. By systematically combing the tectonic coal-controlling effect and structure, this study determined the geodynamical classification basis for coal-controlling structures. According to the systematic analysis and summary on the related research results, the coal-controlling structure was categorized into extensional structure, compressive structure, shearing and rotational structure, inverted structure, as well as the sliding structure, syndepositional structure with coalfield structure characteristics. In accordance with the structure combination and distribution characteristics, the six major classes were further classified into 32 subclasses. Moreover, corresponding mode maps were drawn to discuss the basic characteristics and effect of the coal-controlling structures.

1. Introduction

Tectonism was the primary geologic factors for controlling the formation, occurrence, and deformation of coal measures. Geologists around the world have long noticed the comprehensive controlling effect of tectonism on the formation and deformation of coal measures. The tectonic coal-controlling researches on the early stage mainly focus on the controlling effect of tectonic form or tectonic parts on the accumulation and occurrence of coal by taking a static tectonic coal-controlling view. Tectonic form is merely a deformation result caused by tectonism, while the tectonic process is the substantial factor for dominating all tectonism. The concept of tectonic coal-controlling effect is gradually strengthened as the daily deepening of this concept. Moreover, the research concerning tectonic coal-controlling effect gradually developed toward the tectonic movement-controlling effect. Related researches evolve from the discussion on deformation mechanism of single tectosome, to the overall analysis on the tectonic system and group, and then to the comprehensive study emphasizing regional tectonic deformation law and geotectonic evolution; they develop from the description on the simple geometry of tectosome, to the analysis on the tectonic combination rule, and finally to the exploration on the formation mechanism of the tectonic effect. The research evolution reflects the daily expansion of the analysis methods and the deepening of the analysis level. In addition, the analysis methods are widely used in coalfield geology. A new round of national prediction and evaluation on the coalfield resource potential takes the tectonic coal-controlling effect study as the core. It tends to recover the tectonic-thermal evolution history of coal basin and analyze the late reformation and coal metamorphism of coal-bearing strata. Moreover, it reveals the aggregation and occurrence law of the coal resources under different tectonic backgrounds, so as to provide basis for the prediction and evaluation on the potential of coalfield resource.
2. Classification of the Coal Controlling Structures

Structure classification is the basis for the structure style study. T.P.Harding and J.D.Lowell (1979) proposed a classification plan of great significance in 1979. This plan was indicated as follows: firstly, by determining whether or not the basement was involved, the structure was divided into basement-involved structure and strata-covering structure; then according to the mechanical properties and stress transfer mode of deformation, the two categories were further classified into 8 basic structures. On the basis of geodynamic background, Liu Hefu (1993) emphasized the consistency of the structure with the formation dynamics of basin and concluded three major systems, including extensional structure, compressive structure, and strike-slipping structure. Subsequently, according to their involvement degree, the three systems were further divided into basement deformation and cover deformation. At present, the earth dynamics classification system has gradually become a general trend for structure classification.

The coal-controlling structure classification should focus on the consistence of structure with the formation dynamics of basin from the perspective of exploring the tectonic origin of basin and guiding the mineral resources exploration. Moreover, guided by current mainstream scheme-geodynamic classification, the coal-controlling structure was classified into four major classes, comprising extensional structure, compressive structure, shearing and rotational structure, and the inverted structure bearing superimposed and composite properties. On this basis, the characteristics of the coalfield should be reflected, such as the heterogeneity and stratification of the lithologic features of the coal-bearing strata. Since these features can lead to common sliding structures that may develop in a variety of stress environments in coalfield, it is needed to categorize the sliding structure individually. Basing on the new round of prediction and evaluation on the coalfield resource potential, this study systematically analyzed and concluded the results of previous researches and classified the coal-controlling structure into following types, as shown in Figure 1 and Table 1.
Figure 1 The coal-controlling structure mode

Table 1 Classification of the coal-controlling structure

| Major class            | Subclass                  | Major class            | Subclass                                                                 |
|------------------------|---------------------------|------------------------|--------------------------------------------------------------------------|
| Extensional structure  | Uniclinal block           | Shearing/rotation      | Translational fracture                                                   |
|                        | Graben and hors           | al structure           | Positive-translational and inverse-translational fracture                |
|                        | Half graben               |                        | En echelon folds                                                         |
|                        | Tilted fault blocks       |                        | Brush structure                                                          |
|                        | Imbricate stretching      |                        | Planar “S” and inversed “S” structure                                    |
|                        | structure                 |                        |                                                                          |
| Compressive            | Imbricate thrust          | Inverted structure     | Positive inversion                                                       |
|                        |                           |                        |                                                                          |
3. The Coal-Controlling Structures’ Characteristics and Effects

Extensional Structural Coal-Controlling Styles: As a common structure in coalfield, the extensional structures formed under horizontal tensile effect is mainly characterized by normal faults and the extensional fault block combinations among the normal faults. In accordance with the planar distribution and combined features, extensional structure is divided into 5 subclasses.

Compressive Structural Coal-Controlling Styles: The compressive structure deformation combinations yielded under lateral extrusion deformation effect contain the thrust faults-dominated structure, the combination of thrust fault and fold, the fold-dominated structure. The three types are in transitional form. Therefore, according to the planer distribution and characteristics of thrust(or fold) and the combinations, the compressive structure is classified into the following subclasses below:

Shearing and Rotational Structural Coal-Controlling Styles: Shearing structure is widespread in coalfield structure and greatly affects the spatial distribution of coal seam. The shear structure is available in many coalfield structures and is an indispensable structural characteristic. Strike-slip faults can be extended into a long straight line form or diagonal form on a plane. Therefore, according to the planar distribution and combination characteristics of shear and rotational structure, the following 5 types are concluded.

Inversion Structural Coal-Controlling Styles: During the alternative process of “opening” and “closing” of Chinese crust, the coal basin in each era has undergone strong or weak structural inversions. Therefore, according to the appearance order and combination characteristics of extensional and compressive structures, the inverted structure can be divided into the following 5 subclasses.

Sliding Structural Coal-Controlling Styles: The sliding structure is the tectonic deformation developed from the sliding of the shallow rock mass in the crust along the slip surface. Since the coal measure and coal seam provide the lubrication layer and decollement surface for the sliding, the sliding structure is widely developed in coalfield and is provided with coalfield features. According to the planar distribution and combination characteristics of the sliding structure, 4 subclasses are summarized.

Synsedimentary Structural Coal-Controlling Styles: It is also known as growth faults and is mainly located on the edge of sedimentary basin. During the development process, the sedimentary basin subsides constantly. The subsidence is conducive to burial preservation of coal. As the ongoing of subsidence, the outside of the basin is continuously uplifted. In general, synsedimentary faults are normal fault on strike. On the profile, they are generally in spoon shape with steep upper part, gentle lower part, upward concave surface, and the apparently thickened strata on hanging wall (downthrown side), which are the basic characteristics and recognition mark of synsedimentary faults. The synsedimentary fault has significant influences on the formation and variation of coal measures. The
contemporary coal measures on the two sides of the fault are significantly different in aspects of thickness and lithology, such as the Xutong well field in Huaibei coalfield.

4. Summary
The study on structural coal-controlling effect serves as the core for the new round of prediction and evaluation on resource potential nationwide. In the case of insufficient coalfield geological exploration data, the study on tectonic patterns can be employed to recognize the possible tectonic pattern, reveal the law of geological tectonic development, establish geological structure model, and conduct structure and coal-finding prediction. Determination on the coal-controlling structure is of great significant for profoundly recognizing the development law of coalfield structure and guiding the coal resource evaluation and coal resources exploration and practice. On the basis of the current mainstream plan-geodynamic classification plan and the achievements of the new round of prediction and evaluation on resource potential nationwide, this study classified the coal-controlling structure into 6 major classes and 32 subclasses and draw corresponding mode maps. Subsequently, it gave detailed discussion on the origin, morphology, combination characteristics, and coal-controlling effect of each structure and listed the developed coalfield or mine area of each structure.

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