Analysis on Coal-control Structural Style in Coal Regions of Northwest China

Tong Wang a,b*, Yucheng Xia c, Daiyong Cao a

a College of Geoscience and Surveying Engineering, China University of Mining & Technology, Beijing 100083, China;
b China National Administration of Coal Geology, Beijing 100039, China;
c Xi’an University of Science and Technology, Xi’an 710054, China

Abstract

Because of the weakness of studying on coal-control structural styles in coal-bearing zones in Northwest China, coal resources exploration often falls into a passive situation and survey results are affected. Through the analysis of coal basement features, late regional fault systems and distribution characteristics of coal measures, seven typical coal-control structural styles are summarized and determined, and their genetic mechanism is analyzed comprehensively and scientifically based on the structure framework “five belts” and “three blocks”. Especially the gentle slope overthrust-type structural style is a new understanding to coal structure features, expanding the scope of searching for coal. The study results have theoretical significance for guiding the exploration of coal resources and improving the effectiveness of geological exploration; practical significance for ensuring large-scale coal bases construction and speeding up westward movement of coal industry.

Key words: coal regions in Northwest China; coal-control structural style; forming mechanism; analysis

1. Introduction

It is estimated that coal reserves are about 4 trillion tons in Northwest China, accounting for about 75% of China but only 400 billion tons of proven resources, accounting for 8% of estimated reserves [1], so there is a large exploration potential in Northwest coal regions. The 12th “Five-Year” plan focuses on...
accelerating the development of coal resources in Northwest China and lists Xinjiang Region as the 14th large-scale coal base [2], which increases the urgency of finding out coal reserves.

Controlled by basement structural characteristics and basin margin fault zone, temporal and spatial differences of coal-accumulating conditions of coal measures are very obvious [3-5]. In addition, features of coal-forming period and multi-phase after that, tectonic superposition and transformation at different intensities, the original coal basin was strongly damaged which greatly increased the complexity of coal occurrence situation [6,7]. Because the lack of the systematic study on coalfield tectonic evolution, the understanding of structural style in coal regions of Northwest China is not very clear which led to coal resources exploration often into a passive situation [8,9] and affected survey results. Therefore, the study on coal-control structural style in coal regions of Northwest China have theoretical significance for guiding the exploration of coal resources and improving the effectiveness of geological exploration; practical significance for ensuring large-scale coal bases construction and speeding up westward movement of coal industry.

2. Coal-control structural style

Applied the theory of lithosphere kinetics[3], the authors analyze tectonic evolution in Northwest China combined with tectonic unit division program[10-12], and consider Northwest China coal-accumulating regions are mainly composed of 5 fold belts [the first belt (ACF-Altai Caledonian fold belt); the second belt (IVF-Irtysh Variscan fold belt, WJF-West Junggar Caledonian-Variscan fold belt, EJF-East Junggar-Variscan fold belt, STVF-South Tianshan Variscan fold belt); the third belt (NQCF-North Qilian Caledonian fold belt, SQCF-South Qilian Caledonian fold belt, EKNCF-north belt (Caledonian fold belt)); the fourth belt (EKSF-south belt (Variscan-Indosinian fold belt); the fifth belt (WKSIF-south belt (Indosinian fold belt)) and three stable blocks between them, [the first block (JB-Junggar block (basin); THB- Tuba micro block (basin); YMTM-Ili-Tianshan micro block); the second block (TB-Tarim stable block (basin)); the third block (CHB-Qaidam stable block (basin)) (Fig.1). And on this basis, summarized and determined 7 kinds of typical coal-control structural styles as follows:

2.1. Imbricated ramp style

In the fold belt especially lower Paleozoic and older strata suffered multiple superimposed deformations, the structure pattern is generally shown as closed linear double folds associated with imbricated thrust fault. The identical tendency of axial plane of duplex folds and thrust plane reflected the kinematic characteristics of fold belt stable block thrust. Imbricated thrust fault on both sides of the basin over thrusting to the basin forms the extrusion shrinkage structure pattern of imbricated ramp type [4,8]. e.g., out Juggar fold belt in northern basin over thrusting from north to south while north Tianshan over thrusting from south to north (Fig.2); Tarim Basin, Qaidam Basin, Hexi Corridor basins, and Turpan-Hami Basin, Yining Basin, Bayinbuluke Basin, Yanqi Basin etc. within Tianshan fold belt all are clamped with thrust faults .

2.2. Piggy-back nappe type

From the structural profiles between Junggar Basin and Bogda Moutain (Fig.3), there are several low-angle over thrust faults developed between fold belt and the basin.

From time, the age of fault formation is newer with the closer to the basin and belongs to piggy-back thrust nappe. In other words, with regional compression strengthening and thrust napping processing to
the basin, original sedimentary basin margin is covered under fold belt (generally composed of old strata) which led to sedimentary minerals covered with nappe, e.g., Karamay-Urho fracture on the west of Junggar Basin, 30° dipping slowly to northwest, downward extending about 11km, so on north of it, Zhayier Mountain is actually a nappe. That is, current location of Zhayier Mountain is not the edge of original Junggar Basin. Under the nappe, it is possible to find covered mineral resources.

Fig. 1. The sketch map of tectonic division in Northwest China

Fig. 2. The structural profiles in Junggar Basin
2.3. Gentle-slope overthrust type

In the past geological exploration, a series of imbricate thrusting were drawn in breakpoint location through drill holes according to a certain angle. The geological report on coalmine production of Urumqi County submitted by some geological team of Xinjiang Region in 1990 considered that three NW-strike imbricate thrusting strata[12] (F5-1, F5-2 and F5-3 in Fig4a) developed in the coalmine (Liu Huanggou), Urumqi County. But after years of roadway exposure and production process, at least F5-2 and F5-3 disappear. The authors find they are actually a gentle-slope thrust fault reflected in different drill holes (Fig.4b) after analyzing the breakpoints based on field observation of ground stratum structural features and data contrast of exploration and roadway; Line F5-1 in the report is actually surface outcrop of the nappe structure. With the new understanding, we can not only solve the contradictions between geological report and geological facts, but also explain the causes of the high stress phenomena, such as the minefield borehole burst, etc.

Fig. 4 The ramp over thrust-like structure

2.4. Asymmetric linear fold
Because of continuous acting of strong compressive tectonic stress, coal-bearing strata occur asymmetric linear fold [13]. e.g., Urumqi mining area is located in the northwest limb of Bogda Mountain anticlinorium, the north of Urumqi Dong Shan thrust fold (F1). Main structure is a NEE asymmetric linear overturned fold (Fig.5) composed of Mesozoic strata with axial plane dipping southeast, two-wing dip angle 50°—90°. This is a common overturned stratum.

2.5. Longitudinal bending fold

The kind of coal-control structural style is developed mainly in Moeller mining area, northeast Muli coalfield, Qinghai. Because of uneven NNE and SSW horizontal compression (stronger in north), the mining area west of Meiyaogou forms wide and gentle double fold with two symmetric limbs of main syncline, even deformation, about 50° dipping angle, no strike thrust fault associated. Affected by translational thrust fault in southeast, dipping angle has tendency for steeper gradually (Fig.6).

2.6. Compressive block

The kind of coal-control structural style is seen at Xuehuoli, front edge of western and Riganshan, northern Qilian Mountain [14,15]. Xuehuoli area overall is a near east-west monoclinic structure.
Compressed strongly by Tuolaishan, the northern area formed north-dipping thrust fault which napping Changcheng system and Permian under Jurassic coal-bearing strata and small synclines and anticlines are developed. Riganshan, north of the studied area, presents north dipping monoclinic structure because of napping by northern thrust fault.

2.7. Plane “S-”and reserve “S-”shaped structure

The kind of coal-control structural style is seen in Muri mining area, peripheral Haider mining area. The plane “S” structure was formed based on X–type shear rift by south-north ramp compression (stronger in south) . Regional coal basin was sheared and caused Jurassic strata of Haider mining area and Moeller mining area apart.

3. Genetic analysis of coal-control structure style

3.1. Dynamic mechanism analysis

According to the theory of plate tectonics and lithospheric dynamics, above 7 kinds of coal-control styles compressed extrusion-contraction structure control [6,8,14,15-17] corresponding with Northwest coal regions compressed repeatedly in south-north direction since Late Jurassic [6,8,17-20]. Earth tectonic role of Northwest regions has been in another more active period from the Late Mesozoic: strong subduction of ancient Pacific plate, eastern early ancient Eurasian plate; the breakup of Gondwanaland; subduction and extinction of Tethys oceanic crust; increasing land mass convergence activity [6,8,10]. Late Jurassic to Early Cretaceous, the collision of Lhasa-Tengchong micro-plate and Eurasian plate collision formed late ancient Eurasian plate. From Eocene to Oligocene, the collision of Indian plate and late ancient Eurasian plate formed modern Eurasian plate [10,11]. After continent-continent collision, southern block compressing north, stress gradually transmitted and accumulated. Therefore, since Late Jurassic, tectonic stress of coal-accumulating region in Northwest China has character of NS-trending compression in the whole region and increasing tendency of compressive stress as time passed. Even today, modern tectonic stress in coal regions of Northwest China remains still near NS-trending horizontal compression [18-20] (Fig.7).

Fig. 7. The tectonic stress field in Northwest China
3.2. Structural style genetic analysis

Since the Late Mesozoic, the general characteristics of the intraplate tectonic in Northwest coal-accumulating regions are summarized as mountain-basin evolution under the control of crust basement. So above 7 kinds of coal-control structural styles different from the Middle Jurassic have their intrinsic necessity:

(1) Multi-stages, inheritance and direction of tectonic stress field. The Northwest coal-accumulating region is more active in geologic history tectonic movement through multiple extensional cracking and compressive fold deformation [6,15,17]. But significantly different from other areas of China, the direction of structure line is basically the same, near EW or NWW in Lower Paleozoic, Upper Paleozoic and Mesozoic and Cenozoic [18,19,20]. The direction of tectonic principle stress remains near SN in the region through multiple tectonic stress transformation which reflects the multi-phase, inheritance and direction of tectonic stress field.

(2) The ancient basement of the stable block has a significant control to structural deformation. In the regional compressive stress field, tectonic differentiation between stable blocks with different crust basement and fold belt increased greatly. The fold belt is shown as intensive uplift, fold, crack, thrust napping to neighboring stable block; crust shortening and thickening while stable block is shown as relative settlement [3]. Basins formed earlier converted from extension to compression such as Junggar Basin, Turpan-Hami Basin etc. Some separated basins formed in the stable block earlier experienced expansion and onlap, and connected to form new compressive basins such as Tarim Basin, Qaidam Basin etc.

References

[1] ZHANG Fulai. Proved coal reserves of Northwest six provinces accounts for 80% of estimated reserves in China[N]. Coal Net. Jul.8, 2009. http://www.coal.com.cn/Gratis/2010-7-8/ArticleDisplay_239089.shtml.
[2] WANG Yinchun Xinjiang became the 14th large-scale coal bases[N]. Xinhua Net. Jan.10, 2011.
[3] DING Guoyu, et al., Introduction to lithospheric dymanics of China[M].Geological Publication House, 1991.
[4] MAO Bijie, YU Hui-long. Prediction and evaluation of coal resources in China[M]. Beijing:Science Publication House, 1999.
[5] XIA Yucheng, HOU En-ke. Regional geology of China[M].Beijing: The Journal of China Mining University, 1996.
[6] ZhANG Hong, LI Hengtang, XIONG Cun-wei, et al. Jurassic coal-bearing strata and coal-accumulating regularity in Northwest of China[M]. Beijing: Geological Publication House, 1998.
[7] ZhANG Hong, JI Xianglan, LI Guihong, et al. Comparison of coalfields and coal-mining geological conditions of the main coal-producing countries in the world[J]. Coal Geology & Exploration, 2007, 35(6): 1-9.
[8] HUANG Jiqing, et al. Plate opening-closing tectonics and accordion movement in Xinjiang and its adjacent regions. Xinjiang Geology and Science.(the first series). Geological Publication House,1990.
[9] HU Junqiu. Retrospect of “the 11th five-year plan” and prospect of “the12th five-year plan”of Xinjiang coal industry[J]. China Coal, 2011(4).
[10] REN Jishun, WANG Zuoxin, CHEN Bingwei, et al. China tectonics from the globe—a brief structural map description of China and its adjacent regions[M]. Beijing: Geological Publication House, 1997.
[11] WAN Tianfeng. Outline of China tectonics[M]. Beijing: Geological Publication House, 2004.
[12] No.161 prospecting team of Xinjiang bureau of coal geological exploration. Geological report of coalmine production at Urumqi county [P]. 1990.
[13] Xu Kaili, Zhu Zhicheng. Structural Geology(2nd edition)[M].Beijing: Geological Publication House, 2006.
[14] FENG Yiming, HE Shiping. Tectonics and orogenics in Qilian moutains [M]. Beijing: Geological Publication House, 1996.
[15] TANG Liangjie, JIN Zhijun, et al. Regional fault systems of Qaidam Basin and adjacent orogenic belts. Earth Science-Journal of China University of Geosciences. 2002, 27(6): 676-682.
[16] WANG Yunshan, MA Yong-quan. Characteristics of tectonic system and evolution in Qinghai province[C]. Geological Society of China Coal, Geology of Qinghai-Tibet Plateau (14)-Qinghai album.
[17] XIAO Xuchang, et al. Tectonic in northern Xinjiang and its adjacent regions[M]. Geological Publication House, 1992.
[18] WANG Suyun, ChEN Pei-shan. Numerical simulation of tenconic stress field in China and its adjacent regions[J]. Chinese Journal of Geophysics. 1980. 1.
[19] LI Yanxing, LI Zhi, ZHANG Jinghua et al. Horizontal strain field in the Chinese mainland and its surrounding areas[J]. Chinese Journal of Geophysics. 2004, 2.
[20] XU Zhonghuai. A present-day tectonic stress map for eastern Asia region[J]. Acta seismologica sinica, 2001, 5.