



Research on Lowstand System Tract from Its Characteristics, the Environment of Coal Formation and the Model of Coal Accumulation

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Abstract: *The coal bed in the lowstand system tract plays a increasingly significant role in the study of sequence division and the model of coal formation has become key issues. In this study, the theory that coal formation environment, whether it is a littoral environment or terrestrial environment, is generally the area of shoaly depression of the corradng stream or stream terrace has been proposed through analysis of coal formation sedimentary environment of marine lowstand system tract and nonmarine faulted basin lowstand system tract coalseam, space characteristics of lithology. Coal formation of marine lowstand system tract in coastal area mainly occurred in Neopaleozoic, its coal bed lesser and its progradation is marine deposit (limestone or claystone). While, in the nonmarine low stand system, coal formation are mainly found in Mesozoic and the sedimentary particles of coal roof is coarser, this pattern is common in braided river, alluvial fan or fan delta. The coal seam in the lowstand system tract with complex structure, great difference in thickness and the quality of coal seam is poor. Based on the swing of Lake Basin water and the change of structural, there are high sulphur and ash in coastal area, high ash and more branch in the continental rift basin.*

Keywords: *Lowstand system tract, coal formation environment, coal-accumulation model*

1. Introduction

It has been a research hot topic that the theory and model of coal-accumulation since the sequence stratigraphy were used to study the coal bearing-succession. Three systems tract can be identified, which are lowstand system, transgressive system, and highstand system tracts. Many experts (Li et al., 2000; Dissel, 1992; Shao et al., 2001) [1-3] found coal beds can be formed in transgressive and highstand system tract. There are many studies on coal formation in the above two system tracts due to many large coalfields in the world belongs to coal formation in highstand system tract or coal formation in transgressive system tract. Coal formation in this two system tracts are based on uniformitarianism theory. The theory of coal formation in the transgression events that based on the theory of catastrophe theory also believe the coal beds is formed in the transgression system tract, but the essence of coal formation have a certain essential difference with coal formed in transgression process. Nowadays, many large coalfields in the world are formed in the high system tract and transgressive system tract but the coal formed in the low system tract is less studied. Many coal beds formed in lowstand system tract has been found with the geological exploration of coalfield in China [4-8]. But the characteristics of coal formation, the environment of coal formation and the mechanism of coal formation in the lowstand system tract have been unclear. This is related to the basic theory that identify sequence boundary of coal bearing strata and coal

beds division. So, it is necessary to study and discussion the mechanism of coal formation in the lowstand system tract. Therefore, this paper discusses the environment and characteristics of coal formation in the lowstand system tract by the view of sequence stratigraphy. This is great significance to enrich the coal formation theory and strengthen the study of coal formation mechanism in sequence stratigraphic framework.

1.1. Depositional environment of coal formation in lowstand system tract

The researches about coal formation in the lowstand system tract are not a lot, Yuan Bo et al. (2008) [8] research the formation mechanism of the Middle Jurassic coal beds at the Hongtai area in Turpan-Hami basin and find that some coal beds are formed in the lowstand system tract. Yang Rongfeng et al. (2001) [9] research sequence stratigraphy and coal accumulation regularity of jurassic coalfield in Beijing area and found that the coal beds in the lowstand system tract is developed on the natural embankment and the local bay on both sides of the river, The continuous of coal beds are better in the distributary channel, but the coal beds are poor in stability and does not have industrial value. Jiang Ye et al. (2001) [5] research the coal formation mechanism of Ordos middle east Zizhou town Chuanbao area and found that some coal beds in this area were formed in incised valley of lowstand system tract. In addition, the coal beds in the epicontinental

sea coal bearing strata in the eastern part of the North China plate are also formed in the transgressive system tract or the highstand system tract. From the above study, coal formation in lowstand system tract has less research and research on coal formation environment, coal formation characteristics and coal formation mechanism is still unclear. Therefore, this paper focuses on analysis, characteristics and discusses the mechanism of coal formation environment in lowstand system tract, so that provide some basics of division of sequence stratigraphy for coal geological workers.

The traditional thought of sequence stratigraphic is produced in that study on sedimentary sequence of passive continental margin basin, therefore, the traditional definition of lowstand system tract refers to a basin with a continental slope break, the depth of the water is shallow when deposition developed, the sedimentary system is distributed at the low-site of the basin in sedimentary system. The major sedimentary facies with low water fan, slope fan, low water level wedge and filling deposition of incised valley, the sediment is dominated by coarse particles. Lowstand system tract is often due to the sea level fall to low which result into the incision recovery of the fluvial depositional system in the continental sedimentary environment, this resulting in a river deposition system and Common in the continental margin of the region. From the above point of view, there are three typical types of depositional systems in the lowstand system tract: alluvial deposits, the coastal plain and the near shore deposition, the deep water slope and the basin block flow deposition. The coal beds are derived from the peat swamp accumulation, and the peat swamp is mainly developed in the land and water transitional form. In view of this, in situ coal beds occurred in deep water slopes and the basin block flow deposition are few; therefore, partial deposition in alluvial plain, littoral plain and nearshore areas may become a good place for peat swamp accumulation or the zone for coal accumulation [6].

1.2 Depositional environment of the coastal plain and near shore lowstand system tract

The research shows that coastal areas easy to form accumulation of peat swamp, the main principles of the specific depositional environment about the accumulation of peat swamps are consistent that in low-lying areas, there are zones, better plant growth, not easy to surface water seepage; groundwater buried shallow, high humidity, prone to peat swamp accumulation. The previous researches on peat swamp in coastal area is mainly coal formation in transgression system tract or coal formation in highstand system tract, there is little research on coal formation in lowstand system tract, generally speaking, there is river incision in lowstand system tract and it is not easy to accumulate plant remains, and unfavorable development of peat swamp in the river due to strong hydrodynamic conditions and there

are a lot of clastic materials. The study found that the peat swamp accumulation in coastal plain generally occurs in the river incised valley; generally speaking, there is a lot of river incised valley due to the sea level fall relatively in the coastal region. And there grow some plants in the incised valley due to the underground phreatic water supply or sea waters intersection at coastal sea level so that it becomes a good source of peat swamps. For example, there are a large number of lowstand system tracts in the late Paleozoic Taiyuan formation sedimentary period in the western part of North China, Qiaotou sandstone found in Taiyuan formation sedimentary period in Taiyuan, Shanxi province, it formed in the Zisong period, corresponding to a wide range of Ordos transgression period, Jiang Ye et al. [5] research of Ordos basin Zizhou town Chuanbao area found the area near the Qiaotou sandstone, the underlying limestone sandstone subjected to cutting, is the sandy river deposition from the Qiaotou sandstone. It is found that Qiaotou sandstone is phase transition of limestone in the transgressive system tract with the stratigraphic contrast. Qiaotou sandstone connected with coal beds limestone on vertical is superposed and contact with limestone on lateral, especially the coarse clastic sandstone exist in the zone that limestone development and there is clear boundary with limestone, it is low down-cutting channel filling (Fig.1). Some of the coal beds are developed in the down-cutting channel around the cutting, and the distribution of the coal beds are limited, subsequent transgression terminates its development and formed the roof of marine deposition.

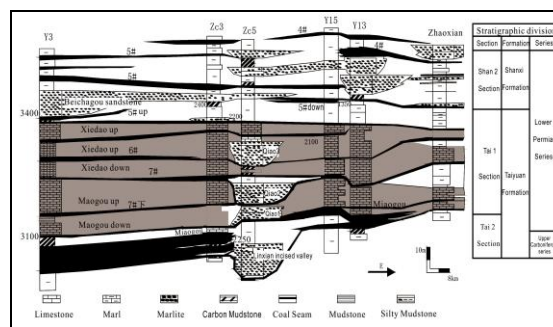


Fig. 1: The Correlation of Early Permian between east and west of Chuanbao Area in Zizhou, Middle East Area of Ordos (Jiangye, 2001, modified)

In short, the coal beds formation environment in the coastal area is associated with the river incised valley, coal beds distribution location represents the place of peat swamp developed on both sides of the river, It can be distributaries bay or the river terraces, but the distribution of coal beds is limitation affected by the swing of the river.

1.3 The coal formation environment of lowstand system tract in continental lake basin

In the nonmarine fault basin, especially the basins in meso-cenozoic of China, because of the basin

structural evolution cycle phases are obviously, there is slope break near the lakeshore area. In the early period of low water level, there is a lot of down-cutting streams of river during the period of lake level decline relatively and a large amount of terrigenous clastics material was taken to below the new shoreline in this area. In period of lowstand system tract, smaller lake basin is mainly developed plain of fan-delta and the area is generally deposited with large amounts of organic matter, such as the Yishen 1 - Ning-2 - 93-4 well in south of Yining depression, Yili basin, its extremely thick coal seam is formed in the central uplift region where a large amount of organic matter is deposited and slipped to the center of the depression(Fig.2) [10].In view of coal formation case in lowstand system tract found in China's continental fault basin [11], it is found that the lake surface change, tectonic subsidence and groundwater level are the main controlling factors that affecting the development of peat swamps. During the period of lowstand system tract, it developed a lot of fluvial facies back swamp or depression between wetland fan etc in lakeshore area because of lake regression. The channel not easily diverted due to the apparent downcutting action and it lead to the back swamp and depression between wetland fan become to a good place for coal accumulation, So a large number of peat swamps were developed.

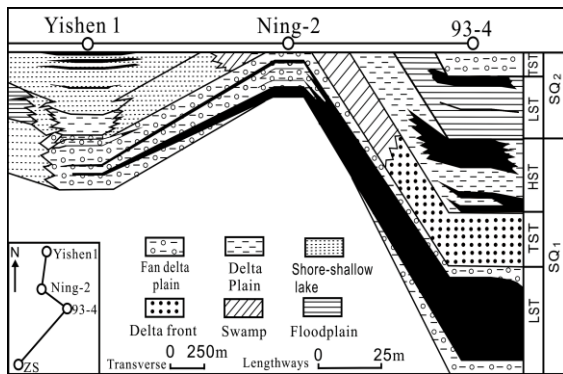


Fig. 2: North-south section of Xishanyao Formation in Yili basin (Ma Shuai et al., 2012, modified)

For example, Huangxian coalfield in eastern Shandong, the primary mineable coal bed of 4# coal bed was formed in lowstand system tract [12](Fig.3), which is coal formation in late lowstand system tract, the coal bed floor is coarse plastic deposit of alluvial fan-fan delta on sedimentary sequence, mainly superimposed in alluvial depositional system, coal beds distribution is limited and coal thickness changes greatly and the distribution and accumulation of coal beds affected by the ancient landform. Therefore, the coal formation environment of lowstand system tract in terrigenous lake basin is mainly occurred in the area that the location closes to the provenance, such as fan delta deposition environment, anastomosed stream-lake deposition environment, and so on, these areas have a greatly topographic relief.

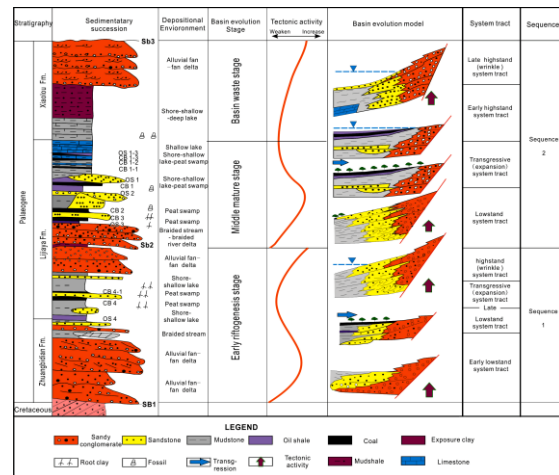


Fig. 3: The sequence division and fault active characteristics of basin margin of Huangxian faulted basin (lv et al., 2015, modified)

2. Coal-accumulation model and coal beds characteristics in lowstand system tract

2.1 Coal-accumulation model in lowstand system tract

The accumulation and save of peat in coastal area is related to the river channel or delta distributor channel, generally speaking, in deposition period of lowstand system tract (Fig.4), river is more stable because of the down cutting of the river, peat swamps are developed and preserved due to good place that suitable for plant to growth with the lateral accretion of channel. Therefore, some local areas are formed good coal beds of low system tract.

There have lowstand system tract in area of terrigenous lake basin, the development and preservation of peat swamp have great relationship with the variation of lake level, there are good space for growth of peat swamp in environment of continental deposit (alluvial fan, river or fan delta) during period of lowstand system tract, such as distributary bay, wet depression in middle of fan or deltaic deposit in little scale etc., and plant grow well in this areas, (Fig.5). It immersed in the local space of the land and it also can form a relatively good space which is good for plant to growth during lake level rise relatively in the late of lowstand system tract, the end of lake transgressive system tract shut down the growth of peat swamp.

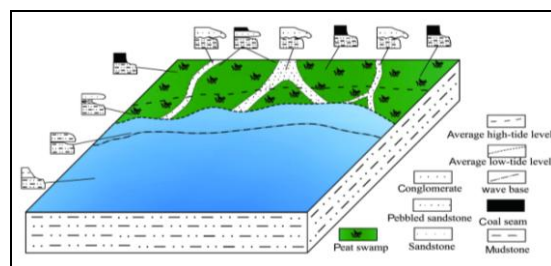


Fig. 4: The Coal-accumulation Model of Lowstand system tract in the Area of Littorine Area

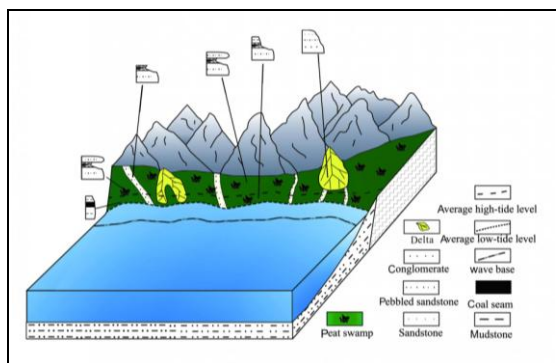


Fig. 5: The Coal-accumulation Model of Lowstand system tract in the Nonmarine Lake Basin Area

2.2 Coal beds characteristics in lowstand system tract

The coal beds in lowstand system tract are affected by depositional environment and the spatial conversion [13-15], generally speaking, coal formation in the lowstand system tract is formed in the late stage of lowstand system tract, and some conglomerate is formed in the low system tract after the progradation normally. The coal beds floor are coarse particle pebbled sandstone formed in the subfacies of river bed deposition. It formed river valley on both sides of the river due to the lateral accretion of the river with the progress of the progradation, peat swamp to be accumulated and saved due to the late stage of the progradation system tract occurred retrogradation in wet areas of natural levee on both sides of river and distributary bay etc in the period of the late lowstand system tract. Therefore, the coal beds have the following characteristics:

- The coal bed distribution is localization, only distributed in the two sides of the river (channel of anastomosed stream, meander channel or distributary channel, etc), the continuity of coal bed is better along the direction of the river, the coal bed occurs phase transformation to channel sandstone in vertical of channel.
- The characteristics of coal beds are poor quality, complex structure, quite different thickness and high index of bifurcation. Generally speaking, the coal beds of lowstand peat swamp in the coastal area is characterized by high sulfur content and larger ash due to the seawater and phreatic water underground. The coal beds of lowstand peat swamp in the faulted basin which have higher ash and more bifurcation, it is related to the water body turbulence and tectonic movement change of Lake Basin (Zengxue Li et al., 2000).
- The coal bed roof consist of the sediments in the transgressive system tract, coastal area is generally dark mudstone, coal bed or limestone formed in the transgressive system tract and nonmarine faulted basin is thick layer mudstone formed in water rises period. The coal bed floor is different with the depositional environment, coastal area generally is marine sediments, such as limestone or sandstone,

nonmarine faulted basin is coarse lag deposit of river bed and the sediment is thick. Therefore, the massive lowstand sandy-conglomerate associated with coal roof and floor is an important sign to identification. This is one of the important differences with the highstand coal bed (generally associated with mudstone and shale).

3. Conclusions

The coal formation of lowstand system tract is generally located in the coastal area or the continental area close to the provenance. Whether the environment is coastal or continental the environment of coal formation always located in shallow water depression or river terrace that the area near the river incised valley. Most of the terrigenous clastics material was taken to below the new shoreline due to the relative sea (lake) level fall or base level fall lead to form a large area of the lakeside or coastal plains caused river incision action. Peat swamps can be developed in the homogeneous terrain area that has less clastics and climate is moist and the environment suitable for plant growth. The coal bed generally corresponds to the marine layer in the coastal area, that is, phase transition occurred in the coal bed and the limestone etc, the continental environment is generally in the braided river, alluvial fan or fan delta and so on, sediment particles of the coal roof and coal floor are coarse in this area.

The coal bed in lowstand system tract quality is poor, its structure is complex and the thickness is quite different, the coal bed in coastal area with higher sulfur content and larger ash and the nonmarine faulted basin which is high ash and more bifurcation, it is related to the water body turbulence and tectonic change of Lake Basin. In general, the coal bed of lowstand peat swamp in the coastal area is characterized by high sulfur content and larger ash due to the affect of seawater and phreatic water underground. The coal bed roof consist of the sediments in the transgressive system tract, coastal area is generally dark mudstone, coal bed or limestone formed in the transgressive system tract, faulted basin is thick layer mudstone formed in water rises period. The coal bed floor is different with the different environment of depositional, coastal area generally is marine sediments such as limestone or sandstone, nonmarine faulted basin is coarse river bed lag deposit and the sediment is thick.

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