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Coal Series Sedimentary Environment and Coal Accumulation Characteristics of Xinyuan Coal Mine in Qinshui Coalfield

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Abstract

The Xinyuan Coalfield is located in Shouyang County, northwest of the Qinshui Coalfield. The primary coal-bearing strata within the field consist of the Upper Carboniferous Taiyuan Formation and the Lower Permian Shanxi Formation. Distinct coal accumulation environments have resulted in significant differences between these two strata in lithological composition, facies characteristics, and coal-bearing properties. Both formations represent transitional environmental deposits. The Taiyuan Formation features barrier coast and deltaic sedimentary systems, with stable and substantial thickness at coal seams No.8, 9, and 15, constituting stable recoverable coal seams across the region. In contrast, the Shanxi Formation develops deltaic sedimentary systems based on pre-deltaic and deltaic foreland deposits at the top of the Taiyuan Formation. While coal seams No.3 and 6 exhibit relative stability, their thickness varies, making them locally recoverable coal seams. Through systematic analysis of the Xinyuan Coalfield's stratigraphy, age determination of coal-bearing strata, coal seam correlation, and sedimentary environment evolution, this study summarizes the coal accumulation characteristics within the field, providing geological evidence for regional coal resource exploration and development.

Keywords

Xinyuan well-field; Depositional environment; Coal accumulation characteristics; Coal-bearing strata.

1. WELL-FIELD STRATA

1.1. Regional Stratigraphy

Located in the northern Qinshui coalfield, the Xinyuan mining area features relatively intact stratigraphic exposure. The geological sequence, from oldest to youngest, comprises: the Archean Longhuahe Group, Proterozoic Hanguan Mountain Group, Paleozoic Cambrian, Ordovician, Carboniferous, and Permian, Mesozoic Triassic, and Neogene Upper Tertiary and Quaternary. Distinct stratigraphic characteristics characterize each epoch: Archean formations predominantly consist of gneiss and amphibolite metamorphic rocks, exceeding 3,000 meters in thickness; the Paleozoic represents the primary coal-bearing strata within the mining area, with the Carboniferous Benxi Formation, Taiyuan Formation, and Permian Shanxi Formation forming the core coal-bearing strata [1]; the Neogene is characterized by loose sedimentary layers of sand, gravel, clay, and loess, exhibiting significant thickness variations.

1.2. Main Strata of The Well Field

The surface of the Xinyuan Well Field is mostly covered by Quaternary loess, with local exposure of bedrock. The developed strata from old to new mainly include Ordovician, Carboniferous, Permian, Triassic, Upper Tertiary and Quaternary. The lithology, thickness and sedimentary characteristics of each stratum are as follows:

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(1) Ordovician (O):

The sedimentation of carbonate rock is the main, the middle system lower Majiagou Formation, the upper Majiagou Formation and the Fengfeng Formation, the total thickness is large, lithology is limestone, dolomite limestone, mudstone, local gypsum layer, the buried depth is large area of the fracture and karst does not develop, with the underlying strata in the contact.

(2) Carboniferous System (C):

The formation is divided into the Middle-Term Benxi Group and Upper-Term Taiyuan Group, serving as the basement and core coal-bearing strata within the mining field. The Benxi Group, with a thickness of 37.09–76.53 m (average 49 m), consists of sandy mudstone, aluminum-rich mudstone, and limestone. Its base contains Shanxi-type iron ore and bauxite, interspersed with coal seams. The Taiyuan Group, ranging from 100.92 to 150.78 m in thickness (average 123 m), comprises sandstone, sandy mudstone, limestone, and 11 coal seams, with the No.8, 9, and 15 seams being stable or more stable recoverable coal seam, four layers of limestone (K4, K3, K2, K2 lower) layer position is stable, is an important marker layer.

(3) Permian System (P):

The formation is divided into three groups: the Lower Shanxi Group, Lower Shihexi Group, and the Upper Shihexi Group with Shiqianfeng Group. The Shanxi Group serves as the core coal-bearing stratum, measuring 31.53–78.20 meters thick. It consists of sandstone, sandy mudstone, and coal seams, containing six coal seams. Seam No.3 is a stable and fully recoverable seam, while Seam No.6 is an unstable, partially recoverable seam. The remaining sections are primarily composed of alternating layers of sandstone and sandy mudstone, with occasional coal seams and limestone nodules.

(4) Lower Triassic Liujiagou Formation (T1l):

The sandstone is mainly composed of brick-red fine-grained feldspar sandstone, interbedded with purplish-red sandy mudstone. The sandstone has developed horizontal bedding, and is exposed incompletely due to weathering and erosion. The residual thickness is about 150m.

(5) Upper Tertiary, Upper Neogene (N2):

The rock is red, dark purple clay, fine sand and light gray gravel. The clay is compact, 3.00~25.00 m thick, average 13.69 m.

(6) Quaternary (Q):

The formation is composed of reddish-brown, earth-yellow clay, sub-clay and gravel, and is a loose sedimentary layer with a thickness of 27.60~85.10 m, and an average thickness of 51.99 m.

2. CHRONOLOGICAL DIVISION OF COAL-BEARING STRATA

The boundary between the Sinian Well-field Carboniferous and Permian has always been controversial. The traditional division is based on the K7 sandstone at the bottom of the Shanxi Formation. In order to align with the international stratigraphic division standards, the boundary has been redefined through paleontological fossil analysis.

Due to their widespread distribution, abundant fossil deposits, and rapid evolutionary history, toothed spines fossils have become a key reference for the International Commission on Stratigraphy in defining the Carboniferous-Permian boundary. The emergence of Streptognathodus isolatus is recognized as the starting point of the Permian period [2][3]. Previous surveys in this region and surrounding areas have yielded extensive paleontological fossil data. Through macroscopic stratigraphic correlation analysis, it has been demonstrated that the K2 limestone and underlying No.15 coal seam in this area align with the standard

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section of Lingchuan Fucheng in southeastern Shanxi, both representing the lower boundary of the pseudo-Hispanian Wagian belt.

Re-examination of fossilized tooth-shaped spines has identified the previously designated S. gracilis in the Taiyuan Formation's multilayered limestone as S. isolatus. Based on sedimentary discontinuity markers, the Carboniferous-Permian boundary in southeastern Shanxi should be established between the base plate of Coal Seam No.15 and the root soil rock beneath the K2 limestone where S. isolatus first appeared [4, 5]. Following this standard and the updated Carboniferous bifurcation and Permian trichotomy scheme from the International Stratigraphic Table (2008-2009), the core coal-bearing strata in this region are classified into the Upper Carboniferous Taiyuan Formation and the Lower Permian Shanxi Formation.

3. COAL SEAM COMPARISON

The coal seam comparison is based on the drilling data of the area and the surrounding area and the data of the mine shaft exposure, and the marker layer method, the layer spacing method and the coal seam structure and combination characteristic method are used to identify the coal seam comparison.

3.1. Marking Layer Method

The selection of the marker layer is based on the principle of stable stratigraphic position, obvious lithologic characteristics and regional contrast significance. The Shanxi Formation and Taiyuan Formation in this area are the core marker layers of the developed sandstone and marine limestone, and their characteristics and contrast significance are as follows:

(1) K7 sandstone:

The sandstone at the bottom of Shanxi Formation is the boundary marker between Shanxi Formation and Taiyuan Formation, and also the old bottom of No.6 coal seam. The lithology is gray-white coarse/fine-grained quartz sandstone with siliceous cementation, often containing gravel at the bottom, and the interbedded bedding is well developed. It is an important basis for comparing No.6 and No.8 coal seams.

(2) Taiyuan Formation marine limestone:

The K4, K3, and K2 limestone layers are stable and serve as reliable marker layers. K4 limestone (Hou limestone) forms the direct roof of Coal Seam 11, with a thickness ranging from 1.15 to 4.83 meters and an average of 2.63 meters. K3 limestone (Qian limestone) serves as the direct roof for Coal Seam 13, measuring 0.25 to 6.10 meters thick with an average of 2.70 meters. K2 limestone, containing animal fossilized remains, forms the direct roof of Coal Seam 15, with a thickness of 0.40 to 4.04 meters and an average of 1.78 meters. These three layers are key markers for coal seam correlation within the Taiyuan Formation.

3.2. Layer Spacing Method

The sedimentary strata in the inner part of the new well field are relatively stable, especially the thickness of the coal-bearing strata (the bottom of Shanxi Formation, Taiyuan Formation) and the variation range of the interlayer distance between the coal seam and the marker layer are small. Combining the interlayer distance method with the marker layer method can effectively improve the accuracy of the coal seam contrast, which is an effective auxiliary method for the coal seam contrast in this area.

3.3. Structure and Combination Characteristics of Coal Seam

The coal seams in this area exhibit significant variations in thickness, number of interbedded rock layers, and structural characteristics, serving as key indicators for seam correlation. Specifically, the No.6 and No.8 seams feature relatively thin profiles with pronounced variations

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and simple structures. The No.9 and No.15 lower seams show substantial thickness fluctuations, with structures ranging from simple to complex. In contrast, the No.3 and No.15 upper seams possess thicker profiles, containing 0-3 or 0-4 interbedded rock layers respectively, and demonstrate stable stratigraphic positions. These inherent characteristics alone provide reliable correlation markers.

The results of the stratigraphic correlation of the No.3, No.6, No.8, No.9, No.15 and No.15 lower coal seams in the well field are reliable, which lays a foundation for the analysis of the subsequent sedimentary environment and the characteristics of coal accumulation.

4. SEDIMENTARY CHARACTERISTICS AND ENVIRONMENTAL EVOLUTION OF COAL-BEARING STRATA

The core coal-bearing strata of the Xinyuan Well Field are the Taiyuan Formation of the Upper Carboniferous and the Shanxi Formation of the Lower Permian, both of which are formed in transitional sedimentary environments, but their sedimentary characteristics and environmental evolution processes are significantly different. The Taiyuan Formation is a marine-terrestrial transitional cycle sedimentation, while the Shanxi Formation is a deltaic cycle sedimentation, and there is continuity in their sedimentary evolution.

4.1. Upper Carboniferous Taiyuan Formation (C3t)

The Taiyuan Formation, which forms a consolidated contact with the underlying Benxi Formation, is one of the primary coal-bearing strata in the mining area. It ranges from 103.93 to 150.56 meters in thickness, averaging 128.63 meters. The lithology consists of black carbonaceous mudstone, dark gray sandy mudstone, limestone, and 6 to 14 coal seams. Coal seams 8, 9, 15, and 15′ are considered recoverable. The K2′, K2, K3, and K4 limestone layers are stable and serve as regional stratigraphic reference markers, with the base composed of K1 conglomerate quartz sandstone. Based on lithologic and facies combination characteristics, the Taiyuan Formation is divided into three sections from bottom to top, each exhibiting distinct sedimentary features and environmental evolution as follows:

4.1.1. The Following Paragraph (C3t1)

With a thickness ranging from 29.80 to 56.58 meters (average 43.41 meters), this formation consists of K1 sandstone, sandy mudstone, and the No.15,15b, and 16 coal seams, representing deposits formed in a barrier island-lagoon and tidal flat environment. Following the Ordovician large-scale marine transgression, crustal subsidence slowed. Weathering and erosion processes were followed by Benxi-period deposits that filled and completed the Ordovician erosion surfaces, creating a flat coastal plain environment for Taiyuan-period sedimentation. River-borne clastic materials, eroded by waves and redistributed by seawater, formed a closed lagoon in the shallow tidal channel behind the barrier island. This lagoon deposited mudstone containing pyrite nodules. As the lagoon was filled and silted, the coastal plain developed into forest swamps, which later transformed into the stable, recoverable No.15 coal seam across the region. The coal seam exhibits high sulfur content due to tidal influences.

4.1.2. Middle Section (C3t2)

With a thickness ranging from 35.52 to 67.71 meters (average 49.07 meters), this formation consists of limestone, sandstone, mudstone, and non-minable coal seams numbered 11,12, and 13, representing a terrace-lagoon tidal flat environment. The area experienced sea retreat following large-scale marine transgression of K2 limestone, forming two deltaic cycles: K2-K3 and K3-K4, with the K2-K3 cycle being well-preserved and typical. After K4 limestone formation, intense river erosion cut through the lower strata, replacing the reverse-grain sequence of K3-K4 deltaic deposits with a normal-grain sequence, resulting in an incomplete cycle structure.

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Located at the delta's leading edge with deep water coverage, peat swamps developed only briefly at the river mouth sandbar and higher interbay areas. Due to subsequent river erosion, the coal seams became thin and unstable, rendering them economically unviable for mining.

4.1.3. Upper Section (C3t3)

The formation ranges from 21.66 to 53.23 meters in thickness, averaging 36.15 meters. It consists of sandstone, sandy mudstone, and coal seams including No.8 and No.9. The No.9 coal seam is relatively stable and mostly recoverable, while the No.8 seam is unstable and partially recoverable, indicating deltaic environmental deposition. During the early Middle Carboniferous, the area experienced uplift and erosion. In the late period, crustal subsidence allowed seawater to intrude from the southeast, gradually forming a lagoon. Iron-aluminum materials accumulated on the Ordovician weathering surface, creating the Shanxi-type iron ore at the base. Northwestward clastic materials, reworked by seawater, formed the K1 barrier island sand body, creating a closed, strongly reducing environment in the lagoon. After the lagoon became shallow, coastal swamps developed, forming the No.15 coal seam. Following the K2 limestone marine transgression, frequent seawater advances and retreats created multiple deltaic cycles. After the formation of the No.9 coal seam, intense river activity led to significant variations in lithology and thickness between this seam and the K4 limestone. Post-marine retreat, the upper Taiyuan Formation and the overlying Shanxi Formation together formed a complete depositional deltaic cycle.

4.2. Lower Permian Shanxi Formation (P1s)

The Shanxi Formation is bounded by the K8 sandstone base boundary, with a thickness ranging from 40.36 to 90.97 meters (average 56.32 meters). Its lithology includes gray to light gray sandstone, dark black sandy mudstone, and coal seams, comprising the No.1, 2, 3, 4, 5, and 6 coal seams. The No.3 coal seam is stable and mostly recoverable, while the No.6 coal seam is unstable and partially recoverable. Formed on the upper sedimentary foundation of the Taiyuan Formation, this group develops a complete accretionary deltaic cycle—progressing from a pre-delta to the delta's leading edge and finally to a delta plain—forming a continuous sedimentary evolution sequence with the Taiyuan Formation.

4.2.1. Sedimentary Characteristics

The Shanxi Formation's sedimentary processes were predominantly driven by fluvial activity. Coal seams 3 and 6 formed in post-embankment peat swamp environments, while coal seam 4 developed in deltaic interfluvial bay sediments. The K7 sand body at the base measures 1.36–12.35 meters thick (average 4.90 meters), consisting of quartz sandstone with mica and black minerals. The base is coarse-grained, often containing gravel, and exhibits well-developed cross-bedding. Overall, this formation developed in a relatively enclosed water environment, influenced by multiple rotational filling processes at the delta's leading edge. The leading edge slope is gentle, with limited sedimentary thickness in the foredelta and deltaic leading edge. The K7 sand dam area, situated at a lower elevation, shows significant tidal influences [6].

4.2.2. Environmental Evolution

The sedimentary environment of Shanxi Group has experienced a complete process of construction-period-abandonment-period-construction-period, each of which consists of several small sedimentary cycles, and the overall evolution is a deltaic accumulation.

1) On the basis of the late Late Carboniferous Gulf environment deposits, the K7 sandstone developed into an early deltaic cycle, and the deltaic continuous accumulation deposited the pre-deltaic mud and deltaic foreland sand in the shallow basin, which formed the upwardly coarsening underwater sequence;

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2) The diversion channel continued to advance, and the area shifted to the lower delta plain sedimentation, where the post-shore environment developed into peat marshes, forming the discontinuously distributed No.6 coal seam. Subsequently, the river migrated and changed its course, and the delta entered a period of abandonment. Differential compaction and dome subsidence created a bay environment connected to the sea.

3) The bay was filled with sediment and leveled to form a bay marsh, where vegetation flourished, forming the recoverable No.3 coal seam in the whole area. Subsequently, the diversion channel advanced to this area again, initiating the late delta construction period. The environment of the upper delta plain diversion channel was deposited, with lithology changing from coarse to fine from bottom to top.

4) The K8 sandstone at the top boundary of the Shanxi Formation marks another sedimentary cycle of the divergent channel, indicating that the deltaic deposition in this area has entered a new stage.

5. COAL ACCUMULATION CHARACTERISTICS OF RECOVERABLE COAL SEAMS

The recoverable coal seams in the Xinyuan well field are mainly the No.8, No.9 and No.15 coal seams of Taiyuan Formation and No.3 and No.6 coal seams of Shanxi Formation. These coal seams were formed in different coal accumulation environments and were controlled by factors such as sedimentary environment, material source and hydrodynamic conditions. There are obvious differences in thickness distribution and coal quality characteristics (ash content and sulfur content). The coal accumulation characteristics of each coal seam are as follows:

5.1. Coal Seam No.15

The No.15 coal seam is located in the first cycle of the bottom of Taiyuan Formation, formed by the marshification of tidal flat and mudflat, is a typical representative of tidal flat coal formation, the coal seam thickness is 0.83~5.24 m, except for the western edge of the local thin than 2.15 m, the thickness of most parts is more than 3 m, the thick coal belt is distributed in the northeast, parallel to the ancient coastline, the coal seam has the tendency of branching westward and thinning.

In terms of coal quality, the ash yield ranges from 8.22% to 48.83%, indicating it is medium-ash coal. The sulfur content is 0.79% to 6.03%, classifying it as medium-to-high sulfur coal. The high-sulfur zone is located in the northeastern part, aligning with the distribution directions of the thick coal belt and high-ash zone. These zones are parallel to the ancient coastline, which is a prominent feature of tidal flat coal formation.

The coal-forming tidal flats in this region exhibit the following common characteristics: The coal seams are formed by marine regression-type terrestrial tidal flat deposits beneath them, overlain by marine transgression-type subtidal carbonate rocks, and located at the peak of the regression. The coal seams are widely distributed with stable stratigraphic positions. Extensive marshification over prolonged periods results in thick coal seams (e.g., No.15), while short periods lead to thin seams (e.g., No.11, 12, 13). The coal seams run parallel to the ancient coastline, gradually branching and tapering in both marine and terrestrial directions. The underlying bedrock consists mainly of mudstone and sandy mudstone. Peat accumulation is influenced by periodic seawater cycles, and marine sediments protect the coal seams but increase sulfur content [7, 8].

5.2. Coal Seam No.9

The No.9 coal seam, formed during the fourth cycle of the Taiyuan Formation, is deposited on the abandoned deltaic lobe. With a thickness ranging from 0 to 3.6 meters, it exhibits a

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westward-thickening and eastward-thinning pattern. The delta's abandonment process began in the western region, where the flood basin developed marshes first, yielding coal deposits of 0.9 to 3.6 meters. In contrast, the eastern region experienced later marsh development and the formation of divergent channels, leading to erosion-induced thinning or even complete loss of coal seams, with thicknesses of 0 to 2.46 meters.

The coal quality characteristics are distinctly controlled by the depositional environment: The ash yield ranges from 10.51% to 42.58%, indicating medium-ash coal with a higher concentration in the eastern and lower in the western sections. When the roof consists of medium-grained sandstone, the ash content consistently exceeds 34.38%, directly reflecting river erosion. The sulfur content ranges from 0.24% to 1.07%, characterizing ultra-low-sulfur coal with a lower eastern and higher western trend. The eastern section is significantly influenced by freshwater from divergent river channels, while the roof predominantly consists of non-marine sediments, resulting in minimal exposure to seawater sulfates. The Sr/Ba value of 0.14 in the coal seam roof further corroborates this feature [9]. Additionally, the erosive effect of S2 sandstone is a key factor contributing to the occurrence of thin coal seams and coal-free zones in the No.9 coal seam of this region.

5.3. Coal Seam No.8

The No.8 coal seam is located in the fifth cycle of Taiyuan Formation, formed in the marsh environment of the diversion channel, the thickness of the coal seam is 0~3.24 m, the distribution is thick in the east and thin in the west, the formation of the thin coal belt is closely related to the scouring effect of the diversion channel and the breach fan.

In terms of coal quality, the ash yield ranges from 9.20% to 48.3%, classifying it as medium-ash coal. The ash content shows a north-to-south gradient, with higher levels in the northern regions due to closer proximity to continental source areas and abundant clastic material replenishment. The sulfur content ranges from 0.35% to 1.76%, indicating ultra-low sulfur coal. This is primarily attributed to the freshwater-dominated environment during peat swamp formation, with minimal seawater influence.

5.4. Coal Seam No.6

The No.6 coal seam is located in the sixth cycle of the bottom of Shanxi Formation, which is also formed in the marsh environment between the diversion. The thickness of the coal seam is 0~2.01m, and the thickness is thicker in the west and thinner in the east. The coal seam in the east is thin and varies greatly, which is mainly affected by the difference of sedimentary micro-environment and the influence of the later river channel.

The coal is of medium ash content with ash yield of 15.04-39.11%, and the ash content is higher in the north and lower in the west and east. The northern and western parts of the coal are close to the source area and are well-supplied with clastic material. The sulfur content is 0.22-1.77%, which is very low, and it is closely related to the fresh water environment during the formation of the coal seam, and the seawater has little influence.

5.5. Coal Seam No.3

The No.3 coal seam, the core recoverable seam of the Shanxi Formation, measures 0.5–4.32 meters in thickness with an average of 2.27 meters. Formed in a deltaic interbay swamp environment, it is one of the region's most significant recoverable coal seams. Its coal accumulation process is closely linked to environmental evolution during the delta's abandonment period: after the river channel breach and course change, the delta's original construction phase entered an abandoned stage. Differential compaction and uneven crustal subsidence created low-lying terrain, forming a deltaic interbay connected to the sea. Over time, continuous sediment deposition and siltation transformed this interbay into a broad terrace

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and swamp, fostering lush vegetation and ultimately forming the extensive, relatively thick No.3 coal seam [10, 11].

The thickness variation of the No.3 coal seam is governed by multiple factors, with the primary determinant being the development stage of underlying sandstone formations. A negative correlation exists between coal seam thickness and the thickness of underlying sandstone bodies such as the K7 sandstone: thicker sandstone bodies result in thinner coal seams, while thinner sandstone bodies lead to thicker coal seams. The structural framework of sandstone formations establishes the environmental foundation for coal accumulation. Additionally, the equilibrium compensation between crustal subsidence and plant fossil deposition, along with the development status of interbay swamps, also influences coal seam thickness. Although post-eruptive river erosion may cause localized thinning of coal seams to the extent of unminable conditions, this is not the primary influencing factor. Such erosion typically occurs locally and is associated with the position of main river channels, hydrodynamic conditions, and their duration.

6. CONCLUSION

1) The Xinyuan Well Field is located in the northern part of the Qinshui Coalfield, where the regional strata are well exposed. The core coal-bearing strata consist of the Upper Carboniferous Taiyuan Formation and the Lower Permian Shanxi Formation. Based on the distribution characteristics of the tooth-shaped spines Streptognathodus isolatus, the Carboniferous-Permian boundary is defined as the interface between the bottom plate of the No.15 coal seam underlying the K2 limestone and the root soil rock, aligning with the international stratigraphic classification standards.

2) The results of the stratigraphic correlation of No.3, No.6, No.8, No.9, No.15 and No.15 down coal seams in the mine field are reliable, which provide the accurate basis for the analysis of the sedimentary environment and the characteristics of coal accumulation.

3) Both the Taiyuan Formation and Shanxi Formation were formed in transitional sedimentary environments, demonstrating continuous sedimentary evolution. The Taiyuan Formation represents typical interfacial marine-terrestrial cycloidal deposits, featuring barrier coast-delta sedimentary systems that evolved from barreled islets-lagunas to tidal flats, ultimately developing into complete delta systems. The Shanxi Formation, built upon the pre-delta and delta-front deposits of the Taiyuan Formation, represents a fully developed accretionary delta system. Its environmental evolution progressed through three distinct phases: delta construction, abandonment, and subsequent reconstruction.

4) The coal accumulation characteristics of recoverable seams within the mining area are significantly influenced by depositional environments. Coal seams formed in different accumulation environments exhibit distinct differences in thickness distribution and coal quality features. The Taiyuan Formation No.15 coal seam, formed in a tidal flat environment, features stable stratigraphic position, high sulfur content, and parallel distribution along the ancient coastline. No.8 and No.9 coal seams, formed in a delta environment, are controlled by interflow marshes and abandoned delta lobes respectively, showing significant spatial differentiation in thickness and coal quality. The Shanxi Formation No.3 and No.6 coal seams, formed in delta plain interflow bays/marshes, are dominated by freshwater environments and produce ultra-low sulfur coal. The thickness of No.3 coal seam is significantly influenced by the development degree of underlying sandstone bodies.

5) The coal seam development is dominated by the sedimentary environment and tectonic movement, and is also affected by the distance of the source area, the position of the river channel, the hydrodynamic conditions, the balance of the crustal subsidence and the peat

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accumulation, etc. These factors control the thickness distribution, the stability of the seam and the characteristics of the coal quality.

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