鄂尔多斯盆地聚煤规律及煤炭资源评价

COAL ACCUMULATING AND COAL RESOURCE EVALUATION OF ORDOS BASIN

中国煤田地质总局 著
China National Administration of Coal Geology

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国家Ⅰ类地质项目研究成果

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中国煤田地质总局　著
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内 容 提 要

本书是在国家计委“七五”Ⅰ类地质项目研究成果基础上的专门著述。

书中应用板块构造和现代沉积学理论，对鄂尔多斯盆地的形成、演化过程和聚煤规律进行了系统分析和全面论述。它除研究解决了以往对盆地含煤地层划分和煤层对比中存在的问题外，还首次统一了全盆地含煤地层的划分和煤层对比，并以丰富的实际资料论证了鄂尔多斯盆地为世界上特大级煤盆地。同时，本书还运用层次分析理论对盆地煤炭资源进行了综合评述，指明了有利开发区。

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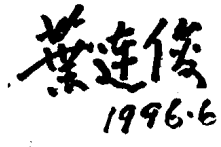
序

鄂尔多斯盆地处于中国不同构造域的交汇部位，含有丰富的煤炭资源。对它的认识不仅对中国地质特征研究具有重大的理论意义，而且也对煤炭资源分布规律研究具有重要的实际意义。由中国煤田地质总局负责，陕西煤田地质局牵头，甘肃、宁夏、内蒙古、山西煤田地质局和中煤航测遥感局、煤炭科学研究总院西安分院共同参加完成的“鄂尔多斯盆地聚煤规律及煤炭资源评价”研究工作，历时8年，在系统分析、整理现有资料的基础上，针对盆地内存在的地质问题，进行了野外及室内的深入研究。统一了全盆地含煤地层及煤层对比，有重点有目的地解决、澄清了一些疑难问题，对全区的情况有了全面了解。尤其是项目组的同志克服重重困难，解决了长期以来地质界争论不休的煤层归属问题，并在这方面有所突破。他们严肃、求实的工作态度，可以说同当年大庆初期强调地质基础工作的作风是一样的。

另外，这项研究工作还研究、利用了一些新的科学技术和手段。如利用γ测井技术划分和对比地层及煤层，为聚煤规律研究打下了良好基础；用航测遥感技术为系统地分析盆地构造格架和盆地形成的大地构造背景提供了先进手段。

其次，研究工作以丰富的实际资料和聚煤规律研究成果为基础，查明了鄂尔多斯盆地巨大的煤炭资源量，为国民经济发展和煤炭工业战略西移提供了重要依据。研究工作从多学科、多领域对一个特大型煤盆地的聚煤规律进行了完整分析，确定了煤炭资源评价的主要内容，构筑了煤炭资源评价的结构模型。根据评价结果，从整体上合理、全面地提出了这个区域的开发设想，对综合性地规划、部署这个地区的煤炭资源开发具有科学、经济的参考价值。因此，本书在理论研究和指导实践方面具有重要意义，我向参加本项工作的同志和本书作者表示衷心祝贺！



Abstract

With well—developed and huge thickness of sedimentary strata, Ordos basin can be grouped into three tectonic—sedimentary evolutional stages: Early Palaeozoic, Late Palaeozoic to Triassic and Early — Middle Jurassic to Early Cretaceous. Different stages are formed in certain geotectonic settings respectively. It is concluded that coal—accumulating process only takes place during Late Palaeozoic, Late Triassic and Early to Middle Jurassic, of which the coal—accumulating process during Early to Middle Jurassic focuses one's attention upon.

1. Early Palaeozoic, a development stage of shallow—sea basin within intraplate.

During Early Palaeozoic, Ordos area (meaning nowadays distribution scope of the Ordos basin) belongs to a party of continental plate of North China, and on the both sides of south and north is confinde by Qinling—Qilian and Xingmeng trench. An aulacogen is developed on the west side. This geological period is characterized by opposite and common development between shallow—sea basin of stable intraplate and movement belt of continental margin. During late period of Early Palaeozoic, Subduction of oceanic crust taken place one after another on the South and north sides of continental plate of North China, and Caledonian folded belt is formed along the continental margin, This compressional process of subduction of oceanic crust resulted in, as a whole, uplift of continenta plate of North China and consumption of shollow—sea basin of intraplate. Then, the area is undergone uplift and denude for long.

2. Late Palaeozoic to Triassic, a development stage of huge intracontinental basin. the connection of shollow—sea basin within intraplate of North China during Late Palaeozoic with outplate ocean basin is separated by the Caledonian folded belt, as a folded orogenic terrain of continental margin of North China. Thus, a sedimentary basin, represented by the epicontinental sea, is formed, which takes Caledonian folded belt as boundary of south and north, and converges westwards and links Qilian sea, as well as opens eastwards. The Ordos area belongs to western section of the basin, and the pattern of stable continental plate against movement belt of continental margin trend toward united. During late period of Late Palaeozoic, Sedimentary basin of intraplate epicontinental sea is turne to continental deposit, and this sedimentary — tectonic patter is basically inherited during Triassic. Western and Southwestern margin of the area come to uplift intensively because of ocean crust subduction within Tethys tectonic domain, and more than 3000m in thickness, coarse clastic sediments are formed in front of the margin. At this time, Ordos basin belongs to a party of huge intracontinental basin, which takes Caledonian folded belt as sedimentary boundary of south and north, and western side of the area features well — developed of

thrust fold. A system discussion on the huge intracontinental basin is made by Liu Shaolong (1986), and he considered that there exsit an united giant basin, range close to $9\times10^5km^2$, in north China at that tinme. Zhao Chongyuan (1990) considered that the giant basin is a result of convergence westwards during early period. In late period of Late Triassic, development history of the basin, influenced by Indosinian movement, came to and by means of uplift and denude.

3. Early—middle Jurassic to Early Cretaceous, a formation and development stage of the Ordos basin.

After indosinian movement, Chiness geotectonics went into a new period of tectonic development, that is to say, an intesively active period of marginal—Pacific tectonic domain and Tethys tectonic domain. Under compressional stress derived from Pacific direction, a left—lateral Shear close to SN trending, and right—lateral shear close to SN trending from WS direction, Ordos area is in a down—warped stage of relative stable, and results in formation of the Ordos basin. By way of analysis lithologic character and thickness of Jurassic and Cretaceous System of western margin of Ordos, it seems that formation and evolution of the basin is considerably influenced by Tethys tectonic domain. It can be recognized that the basin nowadays is result of succeeding reform based on analysis distributed characters of strata during Jurassic and Cretaceous, and that initial depositional scope is more than that of nowadays.

3.1 Scope and boundary of the basin

3.1.1 Northern boundary of the basin

Northern margin of the Ordos basin is neighbouring Hetao fault depression. A great amount of exploration have been carried out by changqing Bureau of Petroleum Exploration in the fault depression. Up to now, it has been found that lamellibranch fossil of late Jurassic to Early Cretaceous in Linhe, Huhe and Jilantai depression. By virtue of the discover, it cannot be denied that there exsit Lisangou Fm. and Guyang Fm. (After Guo Guangming et al, 1980). No geological proof that is convinced has been found yet, although some one takes the down—warped above mentioned as an alone basin. According to strata of Middle—Lower Jurassic within northern section of the Ordos basin is overlaped and changed coarse—grained north wards, north boundary of the basin is approximate to Ula Mts. to Daqing Mts.

3.1.2 Southern boundary of the basin

Southern margin of the basin is neighbouring Weihe fault depression. Due to the fact that there is no a drill hole through Cenozoic Erathem in Weihe fault depression, Southern boundary of the basin is only determinated by means of analysis data of earthguake exploration here. It has been illustrated by the data that there is obriously difference in basement tectonic at both sides of the Weihe fault, that is, south side belongs to a party of Qiling orogeny belt, and north side to a party of Weihe uplift. By way of analysis the fact that strata thickness of Early—Middle Jurassic in Binxian, Xunyi and Jiaoping is decreasing,

coarse—grained and poorly—sorted, southern margin of the basin might be limited to north of the Weihe fault.

3.1.3 Western boundary of the basin

Western margin of the basin is characterized by strong chang of succesing tectonics. So, there are arguments about determination of the western margin, and point at issue is the ownership of Rujigou coal field. In Rujigou coal field, not only lithologic characters, sedimentary environment and underlay srrata of Jurassic as well as inside of the basin can be compared all about, but also palaeoflow direction at both sides of synclinal points at all to centre of the Ordos basin. It is showed that sedimentary strata of Rujigou, Early to middle Jurassic, belongs to a party of the Ordos basin, and western boundary might locate at the western foot of Helan Mountains to Qingtongxia to Guyuan.

3.1.4 Eastern boundary of the basin

Most of Jurassic strata within the east basin have been denuded, Yan'an area, which is mainly composed of lake sediments except for sediments of stream system in bottom, and , obviously, it is not boundary of depositional basin. During Jurassic, Lüliang Mountains has not been formed based on analysis regional tectonics. At that time, depositional system around the basin opens eastwards, and centripetal pattern is not formed, a ccording to analysis.

By virtue of coal-bearing features of yan'an Fm. , seam is symmetrically developed on both sides of the basin centre within sedimentary section through the basin SN strending.

But, in sedimentary section, EW trending, Seam is only developed on west side of the basin centre.

It has been illustrated obove that coal-bearing strata of Jurassic in Datong and Ning wu, east of Lüliang mountains together with jurassic sediments of Jiyuan. Henan Province might be a party of the Ordos basin. Coal—bearing rock series of jurassic, from Datong to Ningwu, are traslated clastic rorck series of coal—bearing into laka sediments that are poor coal—bearing or Without coal. Those characteristics are similar to that of Shenmu to Yan'an, west of Lüliang Mountains. Deep—seated lake facies and Sediments of profundal gravity flow are found in Jurassic strata of Jiyuan. They might take together with lake sediment nearby Yan'an to form a subsidence centre of the basin, On that score, eastern boundary of the Ordos basin might be east of Datong and Yima, Shanxi Province.

3.2 Evolution and development of the basin

Ordos basin, marked by bearing obvious stages, as respects formation and evolution, can be divided into four epoches based on geological boundary, types and sedimentary thickness as well as location of depositional centre. First epoch after Indosinian, coal—bearing sediments which is formed during late period of Early Jurassic to early period of Middle Jurassic, and represented by unconformity before lst episode of Yanshan movement, are inserted between Yan'an Fm. and Zhiluo Fm. , In the epoch, depositional system of alluvial, delt and lake is well—developed within the basin. Sedimentary in stratigraphi-

cally ascending order can be divided into three stages: Initial, overlap and offlap filling based on plane matching features of three depositional systems above mentioneal. Sediments of the initial stage are obviously controlled by rolling morphology of palaeo—structural plane in Indosinian. Sandy—argillaceous sediments within shallow—lake are mainly developed in palaeo—swale separated each other, and sandy—gravelly fluvial sediments are mainly developed in palaeo—valley. There is not deposition in palaeohighland. In the overlap stage, lake is developed to the utmost extent except for a few districts of the basin margin, and palaeohighland disappearance. Fluvial and delta systems have been shrunk to margin area of the basin, and lake centre situated at Yan'an and east of Yan'an. An accumulation pattern of strata is typically presented in the form of overlap. The rock type is mainly Sandston(41.97%), Secondly argillite (26.81%)and siltstone (24.78%). In the offlap filling stage, lake is shrunk towards centre of the basin, and fluvial and delta deposition is advanced towards centre of the basin. Thus, a typical progradational accumulating pattern is formed, in which is main sandston (51.62%), secondly siltstone (21.85%)and argillite (21%). The drill hole data showed that variation of strata thickness in range of 200000km^2 is limited in numbers. In general, the variation range is 180 to 300m, and mean accumulated velocity is about 20m/Ma. This is a good response to structural condition of relative stable, and to slowly subsidence of earth crust. Depositional centre is situated at Lingwu to Weizhou based on strata thickness delineation, and depression direction is NE 35°.

Depositional strata of the second epoch is Zhiluo and Anding Fm., which is formed during middle and late period of Middle Jurassic. Due to the fact that structural variation of the first episode of Yanshan movenent within the basin is very weak, and its basic structural plane combined with scopt are not essentially changed. During middle period of middle Jurassic, the basin is filled with sediments of all depositional systems. In late period, the basin is mainly filled with sediments of fresh lake system, and sediments of delta system is only developed in margin of the basin. Red clastic rock series are widespreadly developed, as influenced by palaeo—climate, and coal—accumulating process disappears. Total thickness of the second epoch depositional strata is 240 to 650m, and mean accumulated velocity is 12m/Ma. Depositional centre is situated at Huanxian based on stratigraphic isopach, and depression direction is NE 25°.

Structural variation, which is the second episode of Yanshan movement during late period of Middle jurassic, resulted in withering and disappearance of the basin of second epoch. During Late Jurassic, depositional basin of the third epoch is formed, and which is basically under compressional stress just like other basin of eastern area of China. Depositional basin of the third epoch, represented by Fengfanghe Formation, is converged westwards into a banding depression along east foot of Zhuozi Mountains to Pingluo to Qianyang. Depositional strata derived from paroxysmal talus of the west structural acfive area. Those talus are composed of wedges, a kind of red conglomerate, difference in thickness at SN trike. Its maximum thickness is 2000 m, minimum 109 m, and angular uncon-

formity with underlying strata is obvious. This showed that the third epoch of the Ordos basin with respects of structure is not guiet when it formed.

Depositional basin of the fourth epoch is formed during initial period of Cretaceous, influenced by principal episode of Yanshan movement. Just like the third epoch basin, settlement is obvilusly developed in fore margin of thrusting and napping systems within margin of the basin. Gravelly talus, derived from structural active region, is laterally filled in the basin with SN stretching. At the same time, superposition and overlap of strata took place, expanded eastwards, and its eastern boundary might be in west of Yellow River. After development stage of alluvial plain, sediments of lake depositional system are filled. Total thickness of depositional strata in the fourth epoch is 600 to 1200 m, and mean accumulated velocity is 33m/Ma. , Depositional centre is situated at west of Huanxian, and depression direction is close to SN . During late period of Early Cretaceous, Ordos basin is finally withered away, and then all area is in state of slow uplift.

3.3 Process and regularity of coal—accumulating

There exsit three units of coal—accumulating rock series, that is Carboniferous and Permian, Triassic and Early—Middle of Jurassic in the Ordos basin, and total resources of coal is close to 2×10^{12} tons. It is an exceptionally large coal—bearing basin in the world. In fact, Ordos basin is formed after there exist coal—bearing rock series of Carboniferous, Premian and Triassic. The present paper does not deals in detail with the process and regularity of coal—accumulating before the basin. In stratigraphically ascending order, five units of seam in coal—bearing rock series during Early to Middle Jurassic are formed within the basin, and except that there is not accumulation seam in central basin with lake deposition for long, that is, Yan'an, Yanchang and Yanchuan .

The overall distribution of the seam is controlled by morphology of the depression, and coal—accumulating area around subsidence centre of the basin where it is seamless, takes the form of ring. The number ,thickness and lateral changed regularity of the seam vary with different position of the basin. Only, one major minable seam is developed in the south basin, and situated at lowest position in coal—bearing rock series. Plane distribution scope, thickness and structural of the seam are obviously controlled by palacotopography before coal — formation. It can be recognized that the seam, with maximum thickness, most simple in structure and being lowest in ash, is situated at axial palaeodepression, and, thinning and pinching out towards palaeo—highland.

World—famous mining area of Shenfu, is justly situated at the north basin. Here five units of seam is well—developed. Major minable seam with maximum thickness, is located on upper of coal—bearing rock series. and characterized by widespread distribution, stable thickness and low ash. The seam is diverged and pinched out when thick—coal area transited towards margin and centre of the basin. The west basin is characterized by lots of seam, small thickness of single layer and diverging combined with merging.

3.4 Major factors controlled accumulation of seam

There are various factors controlled accumulation of seam, e. g. palaeoclimate, palaeotectonics and intensity of organic sedimentation, with regard to overall features of the Ordos basin.

Palaeoclimate, a key factor controlled seam, provided environment in favour of plant growth and breeding. It is usually by documents considered that the moist and warm climate is in favour of coal—formation, and that determines properties of palaeoclimate based on the face of plant community. But, it is showed by sporopollen data that there is *Classopollis*, represented drying temperate ot subtropical zone by its primordial plant, in Fuxian Formation and in Yan'an Formation. Combined with analysis for formation and distribution of modern Earth's surface peat, the authors consider that climate, when coal—bearing rock series formed during Early to Middle Jurassic within the Ordos basin, belongs to an alternative type which is warm and moist climate in favour of plant rapid growth together with drying and cold climate resulted in died out of plant. The judge above mentioned is supported by inertite thin bed of widespread ditribution in coal.

It is showed by space—time distribution features of seam in the Ordos basin that the seam is controlled by tectonics to display in two respects, that is, coal—accumulating period and coal—accumulating area. In detail, the coal—accumulating period is usually controlled by structural transition period, represented by coal—bearing rock series of Early to Middle Jurassic, which is formed in transitional process from Indosinian with lift to Early—Yanshan with subsidence. Also, five major minable seams in Yan'an Fm., which bears very similar features to that above mentioned, that is to say, fluvial and delta depositional system, marked by lift tectonic setting, are usually under the seam; lake depositional-system, marked by subsidence setting, is usually over the seam. Coal—accumulating area is usually controlled by tectonic transitional position. For example, overall plane morphology of seam in Yan'an Fm. is in the form of ring, and the ring is in turning position from lift area of the basin margin to subsidence area of the basin centre. In the process of formation and evolution of the Ordos basin, southwest margin of the basin is continuous in tectonic active area. Just in the area, seam thickness in maximum, represented by Huating mining area.

The intensity of organic sedimentation is controlled by palaeoclimate and geotectonice setting. The palaeoclimate can produce a great amount of plant remains, and provide organic sedimentation with material. The geotectonic setting can result in abandonment of organic sedimentation, and provide transportation and deposition of the plant remains with condition. This tectonic setting only occures in tectonic turning period. Such being the case, perfect match of palaeoclimate with tectonic turning period is a key factor determined intensity of organic sedimentation, and the intensity is also a key factor determined coal forming or not, and determined inorganic contents in coal. On that score, it is reputed that the efficacious ways of strategic coal—hunting might be palaeoclimate restoration, by means of palaeomagnetic research, combined with tectonic settings analysis.

Assessment for coal resources is based on coal-accumulating process. On the basis of suggestions from geology, coal mine design, capital construction, mining and adiministrative departments of coal industry production, and in accordance with present coal technique policies of coal industry, the main contents of coal resource assessment is determined, including four aspects of resource condition, mining technique condition, exploitation condition and exploitation result, and 17 items and 19 parameters. By means of the theory and method of stratified analysis, structural mode for assessment is constructed, and the assessment scheme is divided into 15 pairwise comparison matrixs. After separately seeking and statistically processed written opinions from 30 senior experts in coal production, reseurach, design and government departments, and also evaluating 15 pariwise comparison matrixs through maximum characteristic value method in computer, importance sequence and value of various assessment parameters and quantitative comparison of different assessment contents have been worked out. On the foundation of resource assessment, present profitable exploitation zones, future exploitation zones and long-range exploitation process are differentiated, which possesses significant consulting values for coal industry strategic westward tranfer.

谨将此书献给
第三十届国际地质大会

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