Vol. 86 No. 3 pp. 547–554 ACTA GEOLOGICA SINICA (English Edition) June 2012

Uranium Metallogenic Regionalization and Resource Potential in China

LI Ziying[1,*], ZHANG Jindai[2], JIAN Xiaofei[2], CAI Yuqi[1], GUO Qingyin[2] and ZHU Pengfei[1]

1 Beijing Research Institute of Uranium Geology, Beijing 100029, China
2 Bureau of Geology, China National Nuclear Corporation (CNNC), Beijing 100013, China

Abstract: This paper is comprehensively involved in main types of uranium deposits and their general metallogenic characteristics, metallogenic fields, provinces, regions and belts, and uranium resources potential evaluation. Generally speaking, there are favorable conditions and good uranium resources potential for uranium mineralization in China.

Key words: Uranium deposit type, metallogenic characteristics, metallogenic regionalization, uranium resource potential

1 Main Types of Uranium Deposits

Classification of uranium deposits is a basis for the resource potential evaluation (Chen, 1999). There are different classification principles and methods of uranium deposits used in China. At present, the classification of uranium deposits is principally based on their origins and can be classified into magmatic, hydrothermal, continental and marine facies sedimentary ones. Furthermore, based on host rocks and metallogenic environments, uranium deposits can be traditionally classified into 4 categories, 9 types and 21 subtypes (see Table 1). Among those types, granite (vein) type, volcanic (vein) type, sandstone type, carbonaceous–siliceous–pelitic rock (black shale) type are four major types of uranium deposits in China, which account for more than 90% of the whole uranium resources discovered in China.

Table1 Classification of uranium deposits in China

category	type	subtype
magmatic	pegamatite	/
	alkaline rock	/
hydrothermal (vein)	granite	internal granitic body
		external granitic body
		overlying basin above granitic body
	volcanic rock	volcanic breccia pipe
		subvolcanic rock
		broken dense fissures
		interlayered
		volcanic clastic
continental facies sedimentary	sandstone	interlayer oxidation type
		phreatic oxidation type
		sedimentary
		polygenic
	mudstone	/
	coal	/
marine facies sedimentary	black shale	sedimentary
		epigenetic reforming
		hydrothermal reforming
		hydrothermal and eluvial
	phosphate	/

2 Regional Uranium Metallogenic Characteristics

2.1 Relationship between tectonic evolution and uranium mineralization

Compared with the ancient shields or large cratons in the world, the ancient continental blocks are usually small in size, dispersion in distribution and younger in consolidation in China, and Proterozoic uranium mineralization is much weaker in China than North America, Australia and South Africa (Zhang and Li, 2008). Up to now, the Lianshanguan uranium deposit found in the northern margin of North China platform is considered to be the oldest uranium deposit with an age of 1900 Ma. On the contrary, the tectonic belts of continental block are well developed in China, in which late magmatic activities and tectonic movements were strong and frequent. These geotectonic evolutions show the reasons why uranium mineralization occurs mainly in the Paleozoic and Mesozoic-Cenozoic period, especially in the Mesozoic-Cenozoic time.

2.2 Relationship between magmatism and uranium mineralization

Hydrothermal uranium deposits (including granite type, volcanic type, alkaline metasomatic type) in China account for major proportion of uranium resources. Those

* Corresponding author. E-mail: zyli9818@126.com

deposits are usually associated with acidic magmatism in space and time (Li et al., 2004). Intrusive magma centers and volcanic eruption belts control the distribution of uranium metallogenic zones. In fact, uranium ore fields are closely associated with magmatic centers (Li, 2006), such as the Zhuguang uranium ore fields and Ganhang volcanic mineralization belt. In addition, magmatic rocks formed in different ages from Paleozoic to Mesozoic contain high uranium contents, which provide a good uranium source for sandstone type uranium deposits formed in late ages, especially Mesozoic-Cenozoic time (Wang et al., 2011).

2.3 Relationship between tectonic faults and uranium mineralization

Tectonic faults play both constructive and destructive roles in uranium mineralization. It can be concluded that hydrothermal uranium deposits, without exception, have been controlled by the second-order structures of major tectonics. It is relatively clear that the deeply setting faults play an important role in magmatism, but their relationship to uranium mineralization should be furthermore studied. In addition, faults play also important roles in sandstone type uranium deposits. They can act as hydrodynamic discharge zones and geochemical redox barriers for interlayer oxidation uranium mineralization because they are often easy to be reluctant moving channels from the depth. It should be pointed out that strong tectonics also often reform or destruct previous uranium deposits and make it more difficult to explore for uranium resources.

2.4 Complexity of geological tectonic setting and diversity of uranium metallogeny

China's continents undergo multiple regional geological events during a long-term geological evolution; therefore, geological and tectonic features are quite complex, and correspondently lead to complicated uranium mineralization. Uranium deposits show multiple mineralization phases and varieties of features. This is the reason why diverse types of uranium deposits exist in China (see Table 1). Furthermore, the same type of uranium deposits also presents different signatures. The uranium mineralization ages range from Proterozoic to Cenozoic, but being concentrated in Mesozoic. The deposits have composite origins superposed by both endogenetic and exogenetic processes.

2.5 Major sedimentary formation and uranium mineralization

Black shale is an important sedimentary formation in China, which is rich in uranium. The Upper Sinian series and Lower Cambrian series are widely distributed at the both margins of the Jiangnan uplift ancient continent of the Yangtze block and the southern margin of the North China Platform. The Silurian shale formation is distributed in southern Qinling and Late Paleozoic shales in the South China fold belt. And in these formations many carbonaceous-siliceous-pelitic rock type (black shale) uranium deposits have been discovered. Jurassic, Cretaceous and Paleogene sedimentary formations are developed in continental sedimentary basins, which are main ore beds producing sandstone-type uranium deposits, and the Upper Triassic should also be worthy prospecting. The large sandstone type uranium deposits are mainly found in large inter-mountain basins or stable craton basins. They are usually formed in the geodynamic transitional stage and controlled by uranium source, paleoclimate, sedimentary facies and late epigenetic transforming conditions and so on. It is pointed out that interlayer oxidization sandstone-type uranium deposit should be main exploration target type, then paleo-phreatic oxidization type.

Uranium mineralization characteristics are generally in accordance with the regional geotectonic background in China.

3 Major Metallogenic Units

Based on the above mentioned classification and uranium metallogenic background, the metallogenic field, province, region and belt can be furthermore classified in China, namely, four fields (Ancient Asian, Qin-Qi-Kun, Pan-Pacific and Tethys metallogenic fields), ten provinces (Altai-Junggar, Tianshan, Tarim, Qilian-Qinling, Daxinganling, Jihei (orogenic belts), North China Continental Block, Yangtze Continental Block, Southeastern China, Gangdisi-Shanjiang) and 49 regions and belts (see Fig. 1 and Table 2).

4 Uranium Resource Potential

4.1 Exploration degrees

In general, exploration degree for uranium resources is relatively lower in China. The exploration degree can be classified into four categories (Zhang and Li, 2008):

The first category means areas with the highest exploration degree, in which a lot of uranium deposits have been explored, being only about 100,000 km^2 in size.

The second category indicates areas with high exploration degree, marked by metallogenic provinces and belts, about 1.4 million km^2.

The third category means areas more than 2.3 million km^2 with a certain exploration degree, in which geological

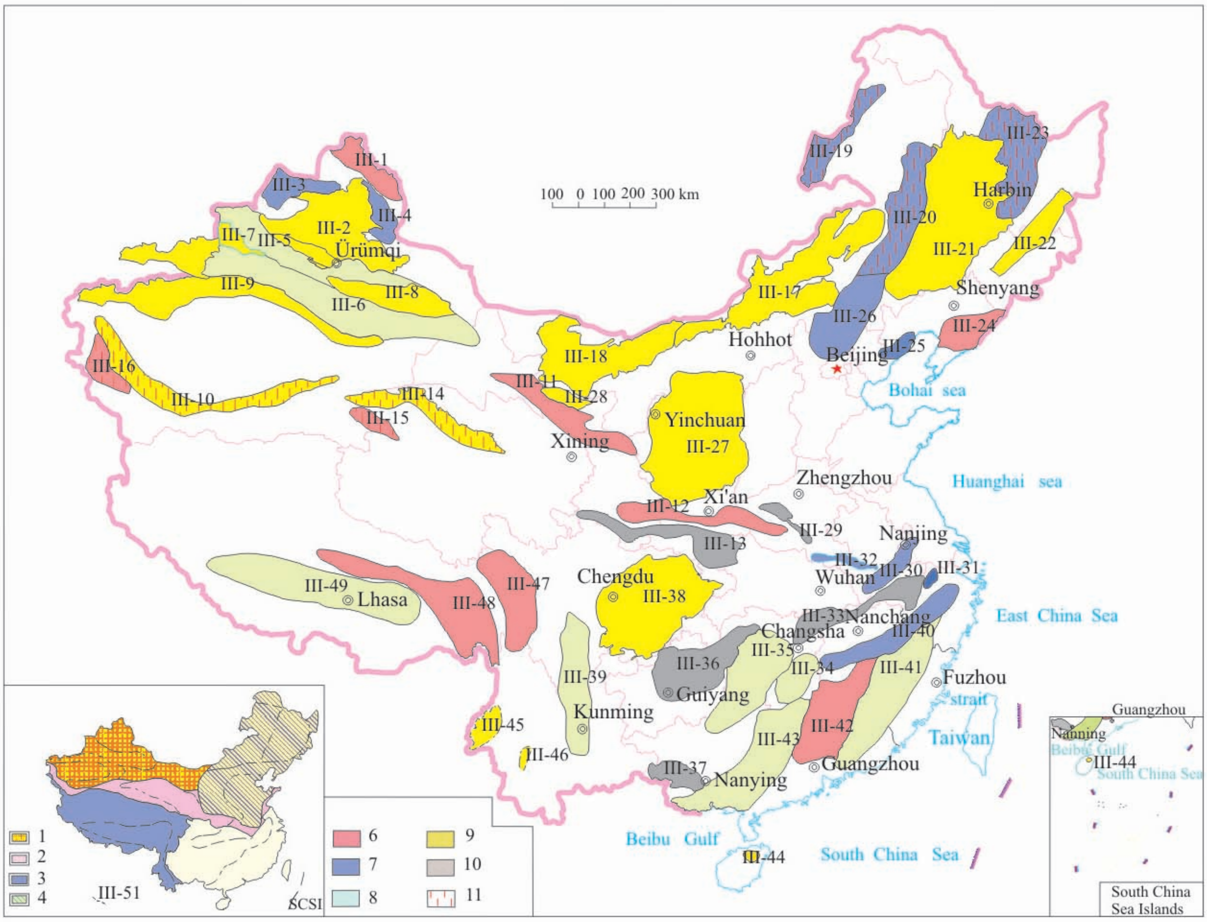

Fig. 1. Sketch map showing the distribution of China uranium metallogenic region and belts.
1, Ancient Asia field; 2, Qin-Qi-Kun field; 3, Tethys field; 4, Pan-Pacific; 5, border of the metallogenic province; 6, granite type; 7, volcanic rock; 8, mixed type; 9, sandstone type; 10, black shale; 11, prospect belt.
Metallogenic region and belt: III-1, Altai belt; III-2, Junggar region; III-3, Xuemisitan belt; III-4, Wulunguhe belt; III-5, North Tianshan belt; III-6, South Tianshan; III-7, Yili region; III-8, Tuhe region; III-9, North Talimu Margin; III-10, South Talimu Margin; III-11, Longshoushan-Qilianshan belt; III-12, North Qinling belt; III-13, South Qinling belt; III-14, Qaidam region; III-15, Qimantage belt; III-16, West Kunlun belt; III-17, Erlian region; III-18, Badanjilin-Bayingebi region; III-19, Erguna-Manzhouli belt; III-20, Zhalantun belt, III-21, Songliao region; III-22, Dunhua-Mishan belt; III-23, Yichun belt; III-24, Eastern Liaoning belt; III-25, Xingcheng-Qinglong belt; III-26, Guyuan-Hongshanzi belt; III-27, Ordos region; III-28, Chaoshui region; III-29, South Margin belt of North China Continental Block; III-30, Yangtz Mid-Down Stream belt; III-31, Tianmushan belt; III-32, Jinzhai belt; III-33, Xiushui-Ningguo belt; III-34, Middle Hunan belt; III-35, Xuefengshan-Motianling belt; III-36, Middle Guizhou-West Hunan belt; III-37, Damingshan belt; III-38, Sichuan region; III-39, Kangdiandizhou belt; III-40, Ganghang belt; III-41, Wuyishan belt; III-42, Taoshan-Zhouguang belt; III-43, Chenzhou-Qinzhou belt; III-44, Leiming region; III-45 Tengchong region; III-46, Lincang region; III-47, Changdu belt; III-48, Bange-Jiali belt; III-49, Cuole-Nanmulin belt.

investigation and regional evaluation of uranium resources with the scales 1:200000 (or 1:250,000) to 1:500000 have been carried out.

The fourth category represents areas more than 5.8 million km^2 with very low exploration degree or even blank places, and in fact, only 3.9 million km^2 among them can be explored for uranium resources.

4.2 Uranium resource potential

China is located at the intersection places of the well-known world mineralization belts. Eastern China is geologically an important component of the world circum-Pacific uranium metallogenic belt, northern China is an important component of Eurasia rectangular uranium metallogenic belt, and southwest China is part of Tethys metallogenic field (Zhai, 2004). Many large, super-large uranium deposits have been already found in countries located in those metallogenic belts, and a large number of uranium deposits also found in China. Therefore, there are favorable metallogenic conditions for uranium mineralization, which are of different geotectonic backgrounds favorable for different types of uranium deposits. Although the super-large uranium deposits discovered are few in China, uranium deposits are of more types, multiple mineralization periods from Proterozoic to Cenozoic and exist as group of small to medium-sized deposit, showing unique signatures and another advantage uranium resource potential.

Table 2 China uranium metallogenic field, province, region and belts

metallogenic field No.	metallogenic field name	metallogenic province No.	metallogenic province name	metallogenic region and belt No.	metallogenic prospective region and belt name
I-1	Ancient Asia	II-1	Altay-Junggar	III-1	Altay belt
				III-2	Junggar region
				III-3	Xuemisitan belt
				III-4	Wulunguhe belt
		II-2	Tianshan	III-5	North Tianshan belt
				III-6	South Tianshan
				III-7	Yili region
				III-8	Tuhe region
		II-3	Tarim	III-9	North Tarim Margin
				III-10	South Tarim Margin
I-2	Qin-Qi-Kun,	II-4	Qilian-Qinling	III-11	Longshoushan-Qilianshan belt
				III-12	North Qinling belt
				III-13	South Qinling belt
				III-14	Qaidam region
				III-15	Qimantage belt
				III-16	West Kunlun belt
I-3	Pan-Pacific	II-5	Daxinganling	III-17	Erlian region
				III-18	Badanjilin-Bayingebi region
				III-19	Erguna-Manzhouli belt
				III-20	Zhalantun belt
		II-6	Jihei（orogenic belts）	III-21	Songliao region
				III-22	Dunhua-Mishan belt
				III-23	Yichun belt
		II-7	North China Continental Block	III-24	Eastern Liaoning belt
				III-25	Xingcheng-Qinglong belt
				III-26	Guyuan-Hongshanzi belt
				III-27	Ordos region
				III-28	Chaoshui region
				III-29	South margin belt of North China Continental Block
		II-8	Yangtze Continental Block	III-30	Yangtz Mid-Down Stream belt
				III-31	Tianmushan belt
				III-32	Jinzhai belt
				III-33	Xiushui-Ningguo belt
				III-34	Middle Hunan belt
				III-35	Xuefengshan-Motianling belt
				III-36	Middle Guizhou-West Hunan belt
				III-37	Damingshan belt
				III-38	Sichuan region
				III-39	Kangdiandizhou belt
		II-9	Southeastern China	III-40	Ganghang belt
				III-41	Wuyishan belt
				III-42	Taoshan－Zhouguang belt
				III-43	Chenzhou-Qinzhou belt
				III-44	Leiming region
I-4	Tethys	II-10	Gangdese-Shanjiang	III-45	Tengchong region
				III-46	Lincang region
				III-47	Changdu belt
				III-48	Bange-Jiali belt
				III-49	Cuole-Nanmulin belt

(1) Good resource potential in the depth: Up to now, exploration is mainly restricted to 300 m to 500 m in depth because of both economic and technical reasons. Now there are some arguments about good uranium resource potential in the depth between 500–1000 m or even bigger depth. On the one side, many uranium deposits at even more than 2000 m have been found in the countries like Russia, Canada and Germany, on the another hand, recent exploration progresses have been made in Jiangxi, Guangdong provinces in China, and uranium mineralization found in depth between 500 m and 1000 m, and some deposits such as the famous Zhoujiashan uranium deposit even more than 1000 m. In addition, new uranium metallogenic theories indicate that uranium mineralization can be found in the depth more than 2000 meters. So, it is generally believed that there should be good uranium resources potential in the depth (Li, 2006).

(2) Potential around the known deposits: Recent exploration progresses indicate that there is good uranium resource potential around the known deposits, more exploration investments can lead to new discoveries, in fact, those areas show similar metallogenic conditions to

the mineralized ones, and statistic data and prognosis results show that those areas should be of 1.5–2.5 times uranium resource potentials as much as the discovered resources (Xiao et al., 2006; Ye, 2004).

(3) Great potential in the areas with low or blank exploration degree: As discussed above, there is a big area with low or blank uranium exploration degree. However, the area has been geologically investigated and explored for other poly-metallic mineral resources. A number of poly-metallic mineralization belts have been discovered, and in which there are good mineral resource potential. According to geotectonic and metallogenic theories, uranium is genetically associated with the poly-metallic deposits, controlled by the similar geotectonic conditions. Therefore, it can be concluded that there is also good uranium resource potential in those areas.

(4) Potential of non-conventional uranium resource: So-called "non-conventional uranium resources" refer to "those of low grade, is not of economic significance or uranium only as a secondary by-product recovery from uranium associated resources at present." "non-conventional uranium resources" has considerable potential in China, e.g. resources which were not calculated with ore grades between 0.03% and 0.01%, uranium resources in phosphate rock with potential economical value, in brown coal uranium deposits (lignite-related), in mudstones with low permeability in sedimentary basins of north China, low-grade uranium resources in carbonaceous-siliceous-pelitic rock (black shale), remained uranium resource in tailings of uranium ore mines and other uranium resources such as in salt lake etc.

(5) Economic evaluation of deposits varies with time. Economic values of mineral resources should be evaluated based on important factors of both space and time, especially price change in time. Some mineral resources can not be used economically in the past, but they will be turned into economic values now or in the future. Resources of the same quality can not be used economically in this country, but used in another country or region. According to the present and future economic development trend in China, more and more uranium resources which were not economical becomes economical, which means to increase uranium reserves in equivalent way.

More and more investments have been given on uranium exploration in China recently, and a large progress made, new deposits discovered, such as sandstone type deposits in Xinjiang, Turpan - Hami and Inner Mongolia etc., some of them being large scale or super large scale in size; new more uranium resources of hydrothermal deposits also discovered in bigger depth in southern China. Uranium resources discovered increase rapidly. All of these indicate that there are great potential uranium resources and broad exploration perspective in China, and it is believed that more deposits and new resources will be discovered certainly through more investment and exploration.

5 Dongsheng Sandstone-Type Large Uranium Deposit in the Ordos Basin as an Example of Recent New Exploration Progress

The Dongsheng sandstone-type uranium deposit is a large one recently discovered in the Jurassic Zhiluo Formation of northeast Ordos Basin.

5.1 Geologic setting

The study area is located in the northeastern part of the Ordos basin (Fig. 2). The Dongsheng deposit is located at the southern margin of Yimeng Uplift and its adjacent Hetao graben at the northern margin. The Ordos basin is a large Meso-Cenozoic depression basin developed in North China Platform, with its size of approximately 250,000 km^2 and is well known as an important “energy resources basin” because of abundance of coal, oil and gas deposits.

The pre-Jurassic basement of the basin can be divided into two parts: one is the crystalline basement consisting of Archean and Proterozoic highly metamorphic rocks and migmatic granites, and the another is Paleozoic lightly metamorphic rocks (Fig. 2).

The Mesozoic sedimentary covers of the Dongsheng area are of Upper-Triassic, Jurassic and Lower-Cretaceous ages. The Upper-Triassic Yanchang Formation is composed mainly of gravel-bearing sandstone with siltstone and mudstone interbeds that are oil-gas and coal-productive. The Jurassic System can be divided into three series: (1) Fuxian Formation, the Lower Jurassic, mainly

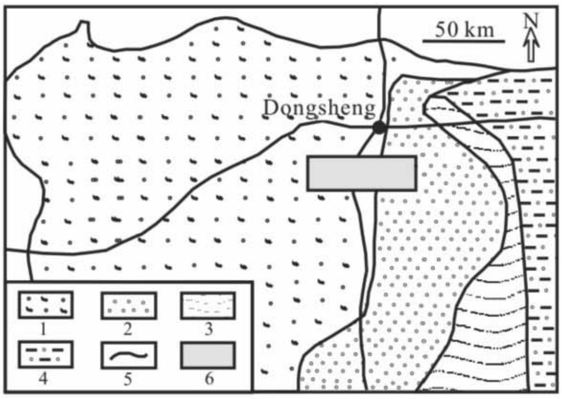

Fig. 2. Simplifies geological map of the Dongsheng area in the Ordos Basin.
1, Lower Cretaceous series; 2, Jurassic System; 3, Triassic System; 4, Paleozoic Erathem; 5, road; 6, study area.

composed of siltstone and arkosic sandstone, with a parallel unconformity to the underlying Yanchang Formation. (2) Yanan Formation, coal-productive beds with arkosic sandstones, siltstone and mudstone interbeds, in which uranium anomalies have been found, being one of uranium target horizons; Zhiluo Formation, the Middle Jurassic, composed of gray, greenish sandstone, siltstone and mudstone, which is separated by a parallel, and locally angular, unconformity from the underlying Yanan Formation; Anding Formation, the Middle Jurassic, mainly composed of fine-grained red or brownish red siltstone and mudstone, with a parallel unconformity to the underlying Zhiluo Formation. The lower section of Zhiluo Formation is the main target horizon of Dongsheng deposit. It belongs to braided stream depositional system (Fig. 3). (3) Fenfanghe Formation, Upper Jurassic, poorly developed in the study area, mainly composed of brown-red conglomerate, with an angular unconformity to the underlying Anding Formation. The Lower Cretaceous series is mainly composed of red and gray sandstone and mudstone of alluvial, fluvial and eolian origins, which has angular unconformities with overlying and underlying horizons. In general, Upper Cretaceous and Lower Tertiary series are poorly developed in the study area. Quaternary sands and soils are scattered through the region and can reach tens of meters thick.

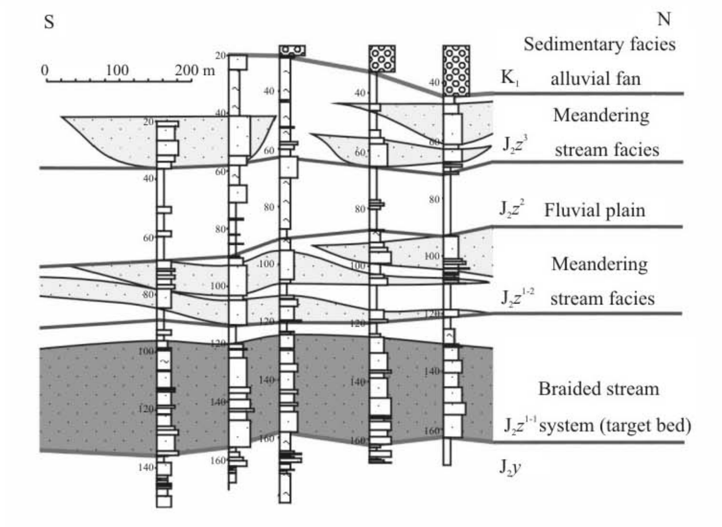

Fig. 3. Construction of Middle Jurassic Series (ore bed) and their sedimentary facies.

The Dongsheng area underwent multiple tectonic events, leading to changes of contact relations between sedimentary strata, sedimentary facies, hydrological conditions and erosion etc, having close relationship to uranium mineralization.

5.2 Petrology of ore bed sandstone

The ore bed is a graded horizon with rhythmical change in grain size and cross-stratification. The rocks are loosely cemented; the clastic grains are both poorly rounded and sorted, mostly sub-angular to sub-rounded in shape. It is composed mainly of gravel-bearing grit, medium-coarse grained sandstone, coarse-grained sand bearing medium-grained sandstone, medium- and fine-grained sandstone. The mineral compositions are mainly quartz, feldspar, debris and mica.

The contents of different matrix in the sandstones are usually less than 10%, and carbonates less than 0.5%. Contact cementation way dominates and then the porous cementation in the matrix. Some sandstones are strongly altered by carbonatization, the contents of the carbonates range from 10% to 20%, in cases of basal cementation, the carbonate even up to more than 50%, forming “psammitic limestone”. Almost all of the carbonates exist as calcite. The calcite usually shows form of large bright crystal grains, in some cases micro-crystal aggregates ranging from 0.002 mm to 0.005 mm in diameters, and sometimes also spherulites.

5.3 Uranium mineralization

When uranium bearing fluids flow to the places where physical and chemical conditions change, stable and complex compounds become unstable，and gets precipitated. The important factor in changing conditions of the uranium bearing fluids is the organic matter, which plays the reduction and absorption role.

In reducing conditions, adsorption by organic matter is related with humic and fulvic acids. The absorption of UO_2^{2+} is determined by both enrichment of UO_2^{2+} ion and the agglomeration degree of uranium organic complex compounds. In the acidic condition of pH=3.4, the adsorption of uranium is at the highest.

Nearly all solid bitumen and many kinds of coal (with humic acid) have ability to reduce uranium. The materials which can reduce uranium are plant debris formed during sedimentation process, and bitumen and oil migrating into ore beds after diagenesis. The rate of reducion depends on the organic matter character and reaction temperature.

The study area has undergone a tecto-thermal event after uranium mineralization. Because of high temperature, the thermal fluids have strong migration ability and are rich in U, Mo, Re, V, Se, Si, Ti, P, REE etc. These fluids are usually alkaline. Under condition of strong oil reduction, fluid feature changes from alkaline to acidic and uranium precipitates from the fluids.

Dongsheng deposit occurs in the redox zone, i.e.

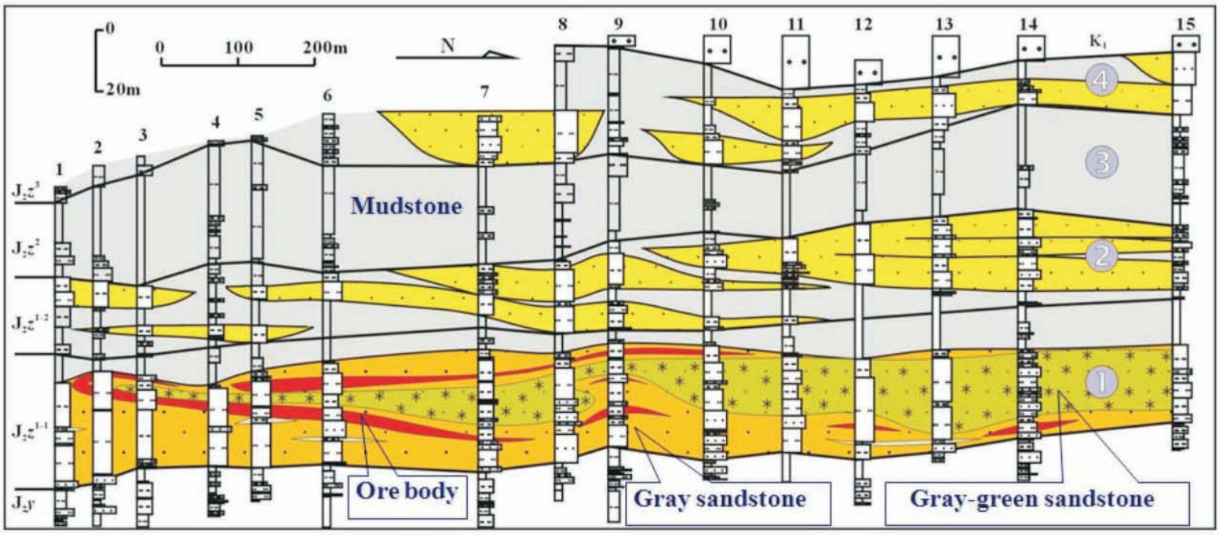

Fig. 4. Cross section showing ore body, gray and gray-green sandstone in the Dongsheng deposit.

transitional zone between oxidation and reduced zones. The redox transitional zone was formed by both paleo-phreatic and interlayer oxidation processes. The paleo-oxidized sandstones show grey-green in colour which is a unique signature different from ordinary sandstone uranium deposits (Fig. 4). The origin of greenish sandstone is due to the second reduction process related to oil and gas activation after uranium formation. The paleo-phreatic and interlayer oxidation processes can be evidenced by both vertical and horizontal zonations, which are also under pinned by geochemical and mineralogical zonations. Analytical data for U, Se, Mo, V, Re and S show systematic increase from oxidation to original zones in both vertical and horizontal sections and their close association. Goethite, kaolinite, hemitite are typical in the oxidation zone, in contrast with pyrite in the original zone. The ore bodies show roll-front shape with long tails (Fig. 4).

Uranium exists dominantly as coffinite (Fig. 5) and absorption form, which is also different from ordinary sandstone deposits as pitchblende. Coffinite usually show colloidal texture and locally column or needle forms. It is often associated with pyrite and distributes around it, and the pyrite can be metasomatized by coffinite. There is also close relationship between coffinite and organic matters. Sometimes, coffinite is also associated with clausthalite and anatase. In addition, coffinite distributes inter-grains or around the fragments of ores.

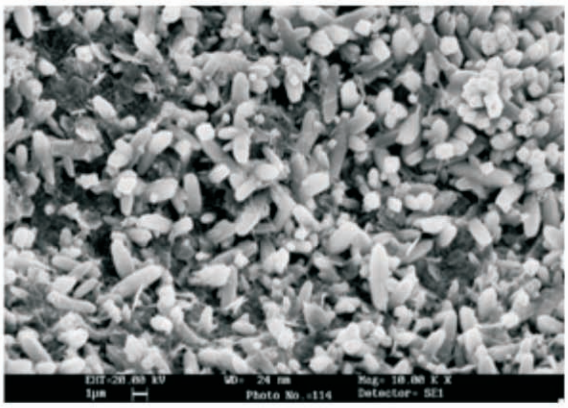

Fig. 5. Coffinite crystal found in uranium ore sample.

Uranium mineralization is dominantly formed within the ages from 65–125 Ma.

5.4 Metallogenic exploration model

The formational conditions, controls and mineralization mechanism of the sandstone type uranium deposit in the northeastern Ordos Basin are very complicated. It underwent multiple mineralization processes, such as tectonic multi-periodic “dynamic-static” coupling movements, superposition of paleo phreatic oxidation and interlayered oxidation and composite transformation by oil-gas and thermal fluids. Therefore, a new metallogenic superposition model has been put forward for the deposit in the northeastern Ordos Basin.

The grey sandstones of Zhiluo Formation are the host for uranium mineralization. They were deposited in humid condition favorable for development of reducing materials and initial uranium enrichment. The initial uranium enrichment of ore beds is one of important sources for uranium mineralization, which was formed at the age of approximately 170 Ma.

Paleo-phreatic oxidation process took place in middle and late Jurassic after the deposition Zhiluo Formation. This was due to up-lift of the basin and inclined movement coupled with paleoclimate change from humid to dry and semi dry, which is favourable for surface and vertical oxidization processes to develop, and uranium enrichment and mineralization began in the ore bed, which took place during 160–135 Ma.

Paleo-interlayer oxidation process occurred in the late Jurassic to early Cretaceous. Uplift of the study area exposed to surface most part Zhiluo Formation, promoting weathering and oxidizing processes. When the paleoclimate was dry, oxygen- and uranium-bearing moved into the ore beds and interlayered oxidation process led to development of uranium mineralization, which should be major uranium mineralization processes during 125–65 Ma.

The multi-stage oil-gas reduction in the mineralized zones have been infered from the many oil-gas inclusions, indicating its role in the uranium mineralization. Post mineralization tectonic movements, uplift and decompression lead to multiple oil-gas diffusions, which in turn promoted second reduction of ore beds, and transformed earlier oxidation zone to grey-green.

Analytical data show that thermal modification of the deposit happened ca 20–8 Ma after the deposit formed.. It is probably due to this modification that coffinite (Fig. 5), selenium, sulfide minerals formed under relatively high temperature, leading to the superposed enrichments of elements like P, Se, Si, Ti and REE over uranium. The complex uranium mineralization and modification processes make this deposit unique, different from other sandstone type uranium deposits. The presence of coffinite indicates that uranium mineralization formed at relatively higher temperature and more reducing environment than those of the other deposit., The higher temperatures are also evidenced from inclusion studies on vein carbonates ranging from 70°C to 170°C, and the salinity from 8% to 20%, which also indicate that Dongsheng area has be imprinted with hydrothermal events, which should take place during 20–8 Ma.

The discovery of Dongsheng sandstone-type uranium deposit shows great uranium resource potential and a good example to explore a similar type of uranium deposit in oil-gas and coal productive basins.

6 Conclusion

Uranium deposit types have evolved considerably from the Archean to the Present, and uranium deposits can be classified into magmatic, hydrothermal, continental and marine facies sedimentary ones. The geotectonic conditions and large area with low exploration degrees indicate that there are great potentials of uranium resources in China, which is also evidenced by recent exploration progresses such as the discovery of Dongsheng sandstone uranium deposit in Ordos Basin.

Acknowledgments

This paper work is within the framework of the project Evaluation on Uranium Resources Potential in China funded by the Chinese Government and many thanks to Prof. Chen Yuchuan, Prof. Ye Tianzhu, Prof. Wang Ruijiang, Mr. Wang Quanmin, Mr. Lü Xiaoming and Mr. Wang Yuqing, etc. for their supports.

Manuscript received Nov. 12, 2011
accepted Mar. 12, 2012
edited by Fei Hongcai

References

Chen Yuchuan, 1999. *Mineral resource evaluation of major metallogenic belts of China*. Beijing: Geological Press.

Li Ziying, Huang Zhizhang, Li Xuezhen and Lin Jinrong, 2004. Regional indications for uranium mineralization in south China. *World Nuclear Geosciences*. 21(1).

Li Ziying, 2006. Hotspots related uranium metallogensis. *Uranium Geology*, 22(2): 65–69 (in Chinese).

Wang Xiang, Williams L. Griffin, Chen Jie, Huang Pinyun and Li Xiang, 2011. U and Th contents and Th/U Ratios of Zircon in Felsic and Mafic Magmatic Rocks: Improved Zircon-Melt Distribution Coefficients. *Acta Geologica Sinica* (English edition), (1): 164–174.

Xiao Keyan, Wang Yongyi, Chen Zhenghui, Zhu Yusheng, Xue Qunwei, Yang Yonghua, Li Jingchao andYang Yiheng, 2006. *New Evaluation Technology and Models of Mineral Resoiurces in China*. Beijing: Geological Press.

Ye Tianzhu, 2004. *Prognosis and Evaluation Techniques of Solid Mineral Resources*. Beijing: China Land Publishing House.

Zhai Yusheng, 2004. Regional metallogenic research methods. Beijing: China Land Publishing House.

Zhang Jindai and Li Ziying, 2008. Uranium potential and regional Metallogenic characteristics in China. *Acta Geologica Sinica* (English edition), 82(4): 741–744.