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REGIONAL SIGNATURES AND METALLOGENIC MODELS OF SANDSTONE HOSTED URANIUM DEPOSITS IN NORTHERN CHINA

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INTRODUCTION

Since new century, more exploration has been focusing on the sandstone-hosted uranium deposit in northern China, which is a major industrial exploration type besides granite and volcanic rock-related uranium deposits and become more and more important. Due to metallogentic, theoretical innovation and exploration technological progresses, new deposits have been discovered and more resources/reserve expanded in Meso-Cenozoic basins, such as Kujieertai deposit in Yili basin, Zaohuohao, Nalinggou, Daying deposits in northern Ordos basin, Basaiqi deposit in Erlian basin and Qanjiadian deposit in Songliao basin from the west to the east.

Those sandstone-hosted uranium deposits form in different geo-tectonic settings and have different mineralization and regional signatures which can be used to select targets and evaluate uranium potential in exploration areas. Besides the traditional interlayered oxidation-reduction (redox) metallogenic model, some new metallogenic models have been established for the sandstone-hosted uranium deposits in north China, such as Metallogenic Superposition Model and Tectonic Activated Metallogenic Model, which have been of great importance to exploration and new discoveries of uranium resources.

REGIONAL SIGNATURES

The mineralization and regional signatures of those deposits have been generally summarized in North China.

(1) Diversity of metallogenic sedimentary basins: The sandstone-hosted uranium deposits have been found in different types of basins. The northern China basins can be generally subdivided into western, middle and eastern parts based on their tectonic dynamic mechanism. The western part is dominated by intermountain basin such as Yili and Tuha basins within the Tianshan Mountains where a number of sandstone-hosted uranium deposits discovered; the middle part foreland basin like Ordos basin with large uranium deposits and continental margin rifted basin like Songliao basin with deposits in the eastern part.

(2) Diversity of metallogenic sedimentary beds: The sandstone-hosted uranium deposits can be also found in different sedimentary beds, the major mineralization host rocks are Early to Late Jurassic sediments in age in the west, and Late Jurassic to Early Cretaceous sediments in the middle, Late Cretaceous sediments in the east. It is obvious that metallogenic sedimentary bed gets younger and younger from the west to the east, indicating higher erosion degree in the west due to stronger Himalayan Neo-tectonic movement impact especially on the northwestern China during Cenozoic era.

(3) Diversity and multiple stages of metallogenic ages: Based on the systematicly geo-chronological studies on those major uranium deposits, uranium mineralization usually shows multiple stages in one deposit and younger age in the front of one roll-shaped ore body, and different uranium deposits often have different ages in different areas, in spite of their dominating Cenozoic ones. However, it is clear that uranium mineralization age is younger than the host rocks, and in general, the mineralization age gets younger from the east to the west, being associated with neo-geotectonics, showing opposite tendency of the host rock ages. In addition, the age data of uranium deposits show their undergoing more complicated processes in the middle part like Ordos basin (1).

(4) Diversity of metallogenic fluids and processes: Uranium mineralization processes are dominated by meteoric water (fluid) to form typical redox zone controlling ore bodies in the west, and those processes are related to not only meteoric fluid but also oil-gas and hydrothermal fluids in the middle to the east, which make the formation processes and signatures of the uranium deposits more complicated such as alteration, ore bodies and compositions, e.g. pitchblende dominant in ores of the deposits in the west and both pitchblende and coffinite in the middle to the east (3)

The formation of those sandstone-hosted uranium deposits and their regional metallogenic signatures in northern China are closely related to Himalayan geotectonic movement, which is due to subduction of Indian Plate tectonics towards the northwest and leads to continental-continental collision and rise of the Qinghai-Tibetan Plateau. This process started ca.55 Ma ago and is still going on (2). That collision results in the present signatures of the basins especially in the northwestern China and Central Asia, which has great impact on the sedimentary formation, hydrogeological process, paleoclimate change and movement of oil-gas fluids during Cenozoic period. Furthermore, it has fundamental impacts on the metallogenic processes of sandstone-hosted uranium deposits in northwestern China and Central Asia, leading to formation of world class sandstone-hosted uranium province.

The role and impacts of the collision and Tibetan Rise on metallogenic processes of sandstone-hosted deposits can be generally described as below.

A Deposition and erosion in Cenozoic period: Cenozoic sedimentary deposition provides possible new uranium bearing beds, and erosion or depositional interruption enable uranium oxidized to be immigrated easily, in addition, uplifting of the provenance rocks could provide uranium source, both of them are favorable for formation of sandstone uranium deposits.

B: Formation of tectonic slope: The tectonic slope formed by the regional tectonic movement can provide a good hydrological condition for formation of the deposits, i.e., oxidized uranium-bearing meteoric fluid can move into the permeable sandstone bed and meet the reductant materials which make oxidized uranium be reduced again for uranium to precipitate in the redox zone to form deposits; the similarly formed fault in the discharge area can improve the hydrological condition and can be as channel for deep necessary reductants to come up into the potential ore bed.

C: Formation of arid and semi-arid weather: This kind of weather has been formed due to the rise of Qinhai-Tibetan Plateau especially in the northwestern China, which is favorable for uranium immigration.

D: Escape and upwards movement of oil and gas: During rising process of especially basins rich in oil and gas, they can move upwards the de-pressured areas where they act as reductants to form redox zone for possible uranium deposition; in addition, secondary reduction processes related to oil and gas can protect the existed ore body and lead to the secondary metallogenic process(4).

METALLOGENIC MODELS

The metallogenic models for the major sandstone-hosted uranium deposits have been summa-rized in the north China.

(1) Interlayered redox metallogenic model

This model is very popular like roll-front model and represented by Kujieertai deposits in the southern margins of Yili basin. The basement of Yili basin has a binary structure, i.e. Precambrian crystalline and Late Paleozoic clastic basement with relatively high uranium content of 4-14 ppm as source. The cover sedimentary strata are dominated by Triassic to Jurassic with undeveloped Cretaceous and younger rocks. The uranium ore-bearing bed mainly is Jurassic coal-bearing clastic formation with good mudstone(coal)-sandstone interbedded structure and usually located in fluvial and delta phase sediments with thickness of 25-40 meters. The favorable host rock is medium-coarse grained debris arkose with good permeability. Uranium mineralization can be found in 7 different sequences of the ore bed, extending ca. 10 kilometers in length. The deposit shows complicated roll-front shape with the ore grade changing from 0.01% to 0.2%. Uranium exists as dominant pitchblende and a few coffinite as well as absorbent forms; the associated elements are V, Se, Mo and Re etc.; metallogenic age is determined by multiple stages of 19Ma, 12Ma, 5Ma, 2Ma and 1Ma (1).

(2) Metallogenic superposition model

This model is represented by Zaohuohao sandstone-hosted sandstone type uranium deposit in north Ordos basin, it is located at the southern margin of Yimeng uplift block and its adjacent Hetao graben at the northern margin. Mesozoic sedimentary strata are mainly exposed, the Upper-Triassic Yanchang Formation is mainly composed of gravel-bearing sandstone interbeds with siltstone and mudstones, bearing oil- and coal-deposits, The Lower-Middle Jurassic Yanan Formation is mainly composed of coal-productive arkose, mudstone and siltstone. The Middle Jurassic Zhiluo Formation is the uranium-bearing ore bed, composed of gray, gray-green sandstone and mottled siltstone and mudstone, which is parallelly or locally angularly unconformably underlain by the Yanan Formation. The Upper and Tertiary strata are absent. Sedimentary strata show that the

study area underwent multiple times of tectonic events, which were closely related to uranium mineralization (3).

Zaohuohao deposit is a superlarge one . It is a special kind of sandstone-hosted uranium deposit, different from other ordinary sandstone type deposits because of itsis a newly discovered one The uranium deposit is of own unique signatures. It is generally controlled by a transitional zone between greenish and grayish sandstones, both of those two kinds of sandstones now indicate reduced geochemical environments. The greenish color of the paleo-oxidized sandstones mainly results from chloritization and epidotization related to oil and gas secondary reduction processes (4). The deposit genetically is different from ordinary sandstone uranium deposits, which is of more complex origin, undergoing not only paleo-oxidization mineralization process, but also oil-gas fluid and hydrothermal reworking processes. The metallogenic superposition model for this kind of uranium deposit has been established, i.e., the deposit underwent multiple mineralization processes and stages, such as tectonic multi-periodic "dynamic-static"coupling movements, superposition of paleo phreatic oxidation and interlayer oxidation mineralizations and composite transformation of oil-gas and thermal fluids. The metallogenic stages can be identified: A Preliminary enrichment stage at 170 Ma; B Paleo-phreatic oxidation stage at 160-135 Ma; C Paleo-interlayer oxidation stage at 125-65 Ma; D Oil-gas reduction +thermal modification at 20-8 Ma. Analytical data show that thermal modification of the deposit happened after the deposit formed. It is probably due to the modification that coffinite, selenium, sulfide minerals formed under relatively high temperature, leading to the superposed enrichments of elements like P, Se, Si, Ti and REE over uranium (3).

(3) Paleo-channel metallogenic Model

This model is represented by Bayinwula sandstone-hosted sandstone type uranium deposit in Erlian basin, it is located in Early Cretaceous paleochannel. The exposed crystalline rocks with high content uranium of 8-11 ppm to the north of the mineralization area can provide good uranium source for the deposit. The ore-bearing bed is characterized by braided paleochannel sedimentary system and the ore controlled by both interlayer and phreatic oxidation processes. The favorable host rocks are debris sandstone and arkose with a certain content of organic and sulphur materials. The ore body usually shows roll-front or tabular in shape with average thickness of 6.38 meters and ore grade ranging from 0.0113%-0.2477%. uranium exists in dominant absorbent form and pitchblende, associated with Re, Se, Mo, Sc and V etc. Metallogenic processes also show three major stages of 95 Ma with preliminary sedimentary enrichment (I), 65 Ma with dominant phreatic oxidation process (II) and 45Ma with phre-atic+interlayer oxidation process (III)(5).

(4) Tectonic Activated Metallogenic Model

This model is represented by Qianjiadian sandstone-hosted sandstone type uranium deposit in southwestern part of Songliao basin, it is located in both of the anticline wings which are formed by late activated tectonic event called Renjiang at the Late Cretaceous. The anticline structure plays a very important role in the formation of uranium deposit, which is also called "window structure". The host beds are Late Cretaceous Yaojia Formation with dominant fine-grained sandstone. The provenance rocks like Mesozoic granites and acidic volcanic rocks with uranium content of 7-15 ppm can provide good uranium sources for mineralization. The late metallogenic processes are characterized by both oxidized infiltrating and reduced effusion fluids with oil-gas through the fault from the depth to form large tabular ore body. Qianjiadian deposit is also reformed by the hydrothermal fluid related to basic dykes at the age of 53Ma. Uranium mainly exists as absorbent form and pitchblende, the average ore grade is 0.0265%. The metallogenic age is also determined to be multiple stages of 96Ma, 67Ma, 53Ma, 40Ma (1).

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Country or International Organization

China

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