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Global Uranium Resources in Sedimentary Basins and the Characteristics of Oil, Gas, Coal and Uranium Coexisting in one Basin

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1 Sedimentary-type and Sandstone-type Uranium Resources

Over the past three decades, with the success in in-situ leach (ISL) mining of sandstone-type uranium deposits(SUD), the quantity, resources and production of SUD increased in China and the world, and it have leapt to the first in all types of uranium deposits.

Based on the statistics for the latest database of IAEA, 1520 uranium deposits have been found worldwide, and 887 uranium deposits are sedimentary-type uranium deposits, accounting for 58% of the total number of uranium deposits; SUD have the largest number of 639, accounting for 71% of the sedimentary-type uranium deposits, accounting for 42% of the total number of uranium deposits in the world. The world has identified uranium resources (RAR+IR, <\$130/kgU) 532.72×10^4 tU by 2011, of which sedimentary-type uranium deposits accounts for 44%, and sandstone-type uranium accounts for 32%. The two percentage will be 65% and 49% if not including Canada and Australia due to their monopolistic character.

The amount of global uranium production increased by 64% from 2003 to 2013, 86% of which is from ISL mining. The amount of ISL production has leapt to the first since 2009, and the production from SUD accounts for about 56% of global total production in 2012. More than 350 uranium deposits and 272500 tU resources in China have been identified(OECD-NEA/IAEA, 2016), Sandstone-type uranium deposit accounts for 43% of the resources and has become China's the maximum amount of resources and resource potential in all types of uranium deposit.

As can be seen from the above, most of the global uranium resources occur in sedimentary basins.

2 Universality and Division of Coexistence of Oil, Gas, Coals and Uranium in a Basin

Oil, gas, coal and uranium are the world's most important and non-renewable energy minerals. Oil, gas, and coal are almost entirely occurrence in sedimentary basins. It can be thought that oil, gas, coal and uranium are mainly occurred in sedimentary basins. Globally, the coexistence of these four minerals shows a universal and divisional feature (Liu et al., 2005, 2007).

2.1 The universality of coexistence

A total of 639 SUD distributed in 109 sedimentary basins have been found worldwide by June 2015, (IAEA UDEPO database) with an average of 5.9 uranium deposits / basins. Through the investigation, analysis and comparison of many domestic and foreign literatures, in 109 basins of SUD, 570 SUD in 85 basins coexist with identified oil and gas fields or coal fields in a basin, accounting for 78% of the total uranium-producing basins, and 89% of the total SUD (Fig. 1); with an average of 6.7 uranium deposits / basins, which is higher than the global average of uraniferous basins, showing that the majority of SUD occur in oil and gas basins and coal accumulating basins.

The large and super large SUD found in the world are almost entirely among the 85 multi-energy basins. The number of SUD coexisting with identified oil and gas fields or coal fields account for 89% of the number of global identified SUD, but the amount of resources (reserves) accounts for more than 93.4% of the global identified uranium resources (RAR+IR, <\$130/kgU) (at the end of 2013). The above further reveals that large and super large SUD are mainly hosted in energy basins coexisting with oil, gas and coal. Therefore, large

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petroliferous and coal-bearing basins will be the main target site for the future discovering new SUD (Liu et al., 2005).

The above statistical results did not include some non-commercial oil reservoirs, gas reservoirs or coal mines, some of which exist different forms of oil and gas, potential, destructive ancient oil, or poor coal seam. In fact, these organic matter are mostly enough to provide reducing environment for the formation of SUD. The proportion of multi-energy basins will be more if the former basins is involved.

Therefore, the coexistence of oil, gas, coal and uranium in a basin is a worldwide common phenomenon.

2.2 Obvious division of coexistence

Regardless of the quantity of SUD, or the total amount of resources, the northern hemisphere is dominant, with the most concentrated distribution between 25°N~ 50°N, among which the distribution in the central-east Asia and the western United States is the most important. The SUD identified resources in these two metallogenic regions account for about 3/4 (73%) of the global total resources. The coexisting of oil, gas, coal and uranium in a same basin is particularly prevalent and typical.

Across China, Mongolia and some central Asian countries, the giant central-east Asia metallogenetic domain stretches more than 6000 km from Songliao Basin of China in the east to the Caspian Sea in the west. The oil, gas, coal and uranium resources in this area are extremely rich, and the identified sandstone-type uranium resources accounts for 55% of the world.

The western America energy mineralization area is mainly composed of more than 10 basins in the Rocky Mountain Basin. As one of the major oil and gas region in the United States, more than 1000 oil and gas fields were found, including 18 large oil field, and the annual output has reached 3212×10^4 t, natural gas 496×10^8 m³ (LI

Guoyu et al., 2005). It's amount of identified uranium resources accounts for more than 90% of the whole country and 18% of the world; Coal production contributed about a half to US. This area is the important energy production base of United States.

In addition, there are also significant differences on enrichment or not of oil, gas, coal and uranium in different basins of the same mineralization area, or in different areas of the same basin, LIU Chiyang (2013) calls it the "Pareto Principle" on the distribution of mineral resources in nature, which is mainly controlled by factors such as minerogenetic (reservoir forming) conditions, geology environment and the dynamic settings of the basin.

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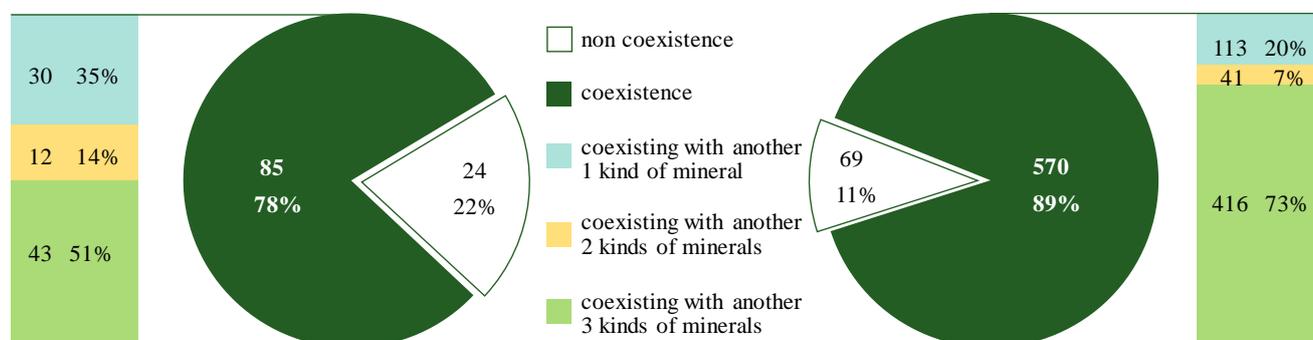


Fig. 1. Statistical graph of global sandstone-type uranium deposits coexisting with oil, gas and coal in basins
Left: the number of uranium-bearing basins and proportion; Right: the number of sandstone-type uranium deposits and proportion