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U (uranium)-polymetallic mineral systems in the world: Genetic types, metallogenic settings and ore-forming mechanisms, and perspective for exploration

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Examples of uranium (U) exploration and development worldwide show that U can be enriched in U-polymetallic deposits with various genetic types, which include different ore-metal associations such as U and other strategic metals. However, China has historically paid insufficient attention to researching and fully utilizing U-polymetallic deposits. A deeper understanding of the metallogenic processes and enrichment mechanisms of these deposits, including the causes for the presence of U and other metals as symbiotic or concomitant products, is essential for the clean utilization and comprehensive development of U resources. U-polymetallic deposits are classified into nine genetic types based on mineralization, metallogenic settings, and ore-metal associations: hydrothermal iron oxide-copper-gold-U (IOCG) type, quartz-pebble conglomerate type, unconformity-related type, alkaline rock- and carbonatite-type, metamorphite-type, volcanic- and granite-related type, carbonaceous-siliceous-pelitic (CSP) type, phosphate type, and co-basin coexistence type (including U-rich coal- and sandstone types). Among these, the first six are the main types, while the last three are referred to as "Black rock-series" deposits, which are unconventional U resources. The metallogenic processes of these deposits vary. IOCG deposits are commonly found in continental rift or back-arc basins, and are characterized by U, Fe, Cu, Au, Ag, REE, and Co. Quartz-pebble conglomerates occur in intermountain or graben basins, with U, Au, Cu, REE, and Th. Unconformity-related deposits are typically in depression and rift trough basins and contain U, Ni, Co, Cu, Mo, and REE. Alkaline rock and carbonatite deposits are rich in U, Th, REE, Nb, Ta, Zr, and/or Cu. Metamorphite-type deposits form in transitional orogenic settings and contain U, Cu, Mo, Co, Ni, and REE. Volcanic- and granite-related deposits are linked to the subduction of the paleo-Pacific plate, containing a wide range of metals including U, Be, Mo, Cu, Pb, Ag, Au, Th, and REE. The evolution of these deposits is influenced by significant geological and biological events, such as supercontinent cycles, rifting, volcanism, and glaciation, which induced multi-stage tectonomagmatic-hydrothermal processes that shaped the complex nature of U-polymetallic deposits. Further research into their metallogenic conditions and specific tectonic settings will be key to advancing exploration of U-polymetallic resources in China.