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Unconventional isotope systems applied to enhancing the petrogenesis of uranium deposits

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Among the new techniques applied to the petrogenesis and evolution of uranium deposits from their formation to later alteration is isotope tracing. The isotope systems being used include Li, C, N, Fe, Mo, Tl, Pb and U, all of which reflect different, but overlapping, processes. Although Pb isotopes have been used to understand the temporal evolution and migration of radiogenic Pb from the deposits, Li, C, N, Mo, Tl and U isotope systems are new ways to analyze deposits and barren areas and to reveal their precise redox mechanisms. Geochemical technologies for exploration include 238U/235U ratios of uranium minerals, which vary as a function of the type of uranium deposit and the efficiency of the redox processes. Lithium isotope ratios in muscovite and chlorite associated with mineralizing events are distinct from background ratios, with the lowest values reflecting the beginning of hydrothermal alteration systems and the highest values indicative of the terminal flow of hydrothermal fluids. Carbon and N reflect the influence of biospheric processes on the deposits and dispersion of elements that can be used for exploration. Iron, Mo and Tl are common elements in many uranium deposits and are among the most redox active elements. Their isotopes separate among phases having different oxidation potentials. They reflect the efficiency of the redox systems associated with fixing the uranium and the subsequent processes involved in mobilizing elements from the deposits. Isotopes add benefits to refining genetic models for uranium deposits, thereby enhancing our exploration models as well. An additional goal of applying isotope geochemistry to uranium deposits is to be able to use them to reflect a definitive process that occurs in the deposit and not in barren systems, and then to relate these to something that is easier to measure, namely elemental concentrations.

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