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Genesis of the Changjiang uranium ore field, northern Guangdong, south China

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The Mesozoic of south China is characterized by widespread granitic rocks and economically important granite-related W-Sn-Cu-Ag-U-REE mineralization, including a large-scale uranium ore field in northern Guangdong. This uranium mineralization had provided abundant uranium resources for the development of the nuclear industry during the past decades. But the genesis of the uranium mineralization remains a controversial issue. Changjiang is one of the largest granite-type uranium ore fields in south China It is located in the southeastern part of the Zhuguang granite pluton, an Indosinian and Yanshanian complex massif. Mesozoic mafic dikes are widespread and regularly developed in the interior part of the pluton. Deposits are controlled mainly by NE- and NW-trending faults and the orebodies are hosted predominantly by N-S-trending fracture zones. The main uranium minerals are pitchblende and coffinite.

Samples were collected from drill core of the Changjiang uranium ore field, including separates of quartz, calcite, and fluorite. Microthermometric and Raman spectroscopic analyses of fluid inclusions in quartz, and C, H, and O isotope studies of the minerals were carried out in the Key Laboratory of Nuclear Resource and Environment, East China University of Technology. The inclusions in quartz from early, main, and late ore-forming stages mainly homogenized at temperatures of 285-390℃, 125-270℃, and 86-120℃, with salinities of 6.0-12.4 wt.% NaCl equiv., 4.6-7.9 wt.% NaCl equiv. and 2.0-4.2 wt.% NaCl equiv., respectively. The $\delta^{18}O(H_2O)$ values from the early, main, and late stages are +6.8‰ to +4.8‰, +4.0‰ to +0.8‰, and -4.1‰ to -7.8‰ and $\delta D(H_2O)$ values are -65‰ to -80‰, -75‰ to -116‰ and -47‰ to -83‰, respectively. The $\delta^{13}C$ PDB values of calcite range from -4.3‰ to -12.2‰.

Uraninite grains in the granite have been regarded as the the primary source for the hydrothermal uranium mineralization. It is easy to observe the uraninite, with EMPA and optical microscopy in polished sections, occurring in biotite, quartz, and feldspar, in the Indosinian and Yanshanian granites with high U contents (18 and 23 ppm, respectively) in the Changjiang uranium ore field. The H-O isotope values suggest involvement of meteoric waters with limited magmatic water during the main ore-forming stage. The $\delta^{13}C$ values of calcite fall in the range for mantle carbonate and indicate that the mineralizing $\sum CO_2$ was derived from a mantle magma during Cretaceous crustal extension and lithospheric thinning. Thus, the uranium in the Indosinian and Yanshanian granites was leached from uraninite by CO_2-rich meteoric waters during ore formation in the Changjiang uranium ore field. Uranium combined with CO_3^{2-} to form the uranyl carbonate in the CO_2-rich fluid and migrated to shallower levels during fluid circulation. Then, uranium was probably precipitated to form pitchblende when the fluid physical-chemical parameters, such as Eh, pH, pressure, temperature, and oxygen fugacity, were changed.