Unconformity-related uranium mineralization in the Athabasca Basin, Canada: deep burial diagenetic-hydrothermal or epithermal?

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The unconformity-related uranium deposits associated with the Proterozoic Athabasca Basin in northern Saskatchewan (Canada) are known for their high grades and large tonnages, accounting for 17% of current uranium production in the world. These deposits have been generally considered to have formed from basinal brines derived from the Athabasca Basin, which circulated through the basin and into the upper part of the basement, and extracted uranium from the sediments in the basin or metamorphic and igneous rocks in the basement. The uraniferous fluids thus formed, inferred to be oxidixing, reacted with reducing agents (either graphitic and Fe^{2+}-rich lithologies or basement-derived fluids rich in hydrocarbons, H_2S and Fe^{2+}) and precipitated uraninite near the unconformity. Because the mineralizing fluids were initially of diagnetic origin and the mineralization may have been taking place while the basin sediments were experiencing diagenesis, this mineralization model is generally referred to as diagenetic-hydrothermal model.

The conventional diagenetic-hydrothermal model inferred that the mineralization took place at deep burial (>5 km). This inferrence has been mainly based on esitmation of high fluid pressures (> 1 kbar) and temperatures (~200ºC) from fluid inclusions recorded in diagenetic quartz as well as hydrothermal quartz in the uranium deposits. However, recent studies suggest that the high fluid pressures may be erroneous and the high fluid temperatures may be explained by fluid convection within the basin rather than deep burial. A deep burial model is also not supported by the preserved basin stratigraphy as well as the ages of mineralization, which indicates that the basin was likely not under deep burial at the time of mineralization. Furthermore, the presence of low-density vapour-dominated fluid inclusions in hydrothermal quartz in the uranium deposits suggests fluid immiscibility and low fluid pressures (perhaps episodic), which appears to be difficult to explain if the mineralization environment was >5 km deep. Instead, the current geologic, geochonological and fluid inclusion data appear to be compatible with an epithermal mineralization model, which derserves to be further examined.