

Gold and Uraninite Formation by Immiscible Fluid Intermixing in the Witwatersrand, South Africa

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The Witwatersrand basin in South Africa hosts the largest known gold and uranium resource in the world. The formation of the native gold and uraninite has been a matter of debate for several decades. Opinion has been divided over whether the gold represents detrital mineralization that has been partly remobilized by hydrothermal fluids or if it is entirely hydrothermal in origin. Uraninite is generally regarded to be of detrital origin. Oil inclusions preserved in different generations of quartz grains show that there was contemporaneous migration of hydrothermal and petroleum phases. The highest gold and uranium concentrations occur in reefs that are enriched in solidified hydrocarbons (bitumen) and point to an important role for hydrocarbons in gold and uranium concentration. SEM imaging of bitumen in the Carbon Leader Reef has revealed that much of this gold is concentrated around the bitumen, and Laser-Ablation ICP-MS analyses that there is also a large enrichment of Au in uraninite enclosed within the bitumen. High-Resolution TEM analyses have been performed on these uraninite grains to investigate the genetic association among gold, uranium and hydrocarbons. Bright-field TEM images show that the uraninite is not present as single crystals, but consists of numerous nanocrystals that form complex aggregates. Pore spaces in the aggregates are filled with solid hydrocarbons and gold mono-crystals. The gold crystals contain numerous spherical or elliptical inclusions of solidified hydrocarbons. The hydrocarbons within the gold crystals and those surrounding them contain pervasively distributed uraninite nanocrystals. The textural relationship between uraninite and gold nano/microcrystals and the bitumen show that uraninite and gold crystallization occurred (at different stages) during liquid oil and water intermixing. Preferential gold crystallization around the bitumen and the uraninite nanocrystal growth within the bitumen strongly suggests that gold crystallized from aqueous solution due to reduction and uraninite crystallized directly from the hydrocarbons.