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Radon, Pb-isotopes and gold mineralisation in the Witwatersrand Basin

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Anomalously high levels of radiogenic Pb isotopes, far outside the normal variation, have been recorded in bulk rock [1] and galena [2] from the Witwatersrand gold deposits. An investigation of the Pb-isotope composition of gold grains from the Witwatersrand Basin has identified an unusual mineralization process which was active at the beginning of the gold remobilization in the Witwatersrand Basin.

LA-ICP-MS analysis of gold grains from the Vaal Reef and the Carbon Leader Reef show systematic deviations from expected bulk earth ratios, and variable amounts of trace elements. Based on these data, we distinguish three fundamentally different groups of gold compositions, which imply distinct conditions and processes of formation.

The first and presumably oldest type of gold is characterized by elevated chlorine concentrations, attributed to halide inclusions which formed in a boiling system, such as implied for gold from orogenic vein systems as in Barberton [3]. This is inherited as there is no evidence that this mineralization process was active within the Witwatersrand Basin.

The second type of gold occurs in two distinct parageneses. The first is associated with the hydrocarbon layers, such as the Carbon leader Reef, and is interpreted as originating from primary precipitation as colloidal gold, and the second is interpreted to have formed within the Wits Basin through a process of remobilization and re-deposition, associated with various hydrothermal events affecting the Basin. This gold has a few minor components, mainly Ag, Cu and Hg, with only trace levels of other elements. Both parageneses imply a relatively cool aqueous environment, and can at present not be chemically differentiated.

The third type of gold is characterized by the presence of anomalously high levels of U, Th, Pb, Bi and Fe, which are not normally observed in Wits gold. In some of these grains from the Vaal Reef, the Pb isotope composition is radically skewed towards ^{206}Pb (up to 85%). This is attributed to the preferential retention of ^{222}Rn (which decays to ^{206}Pb) by carbon, from the highly U-enriched carbon reefs. Other radiogenic Pb isotopes are mobile in the aqueous environment.

In the initial stages of diagenesis of the gold-bearing Wits sediments, the carbon-rich layers formed hydrocarbon fluids [4], which concentrated and redeposited dissolved metal species under highly unusual reducing conditions, which allowed the incorporation of elements such as U, Th, Pb, Bi and Fe into the Au precipitate [5]. Gold deposited subsequently under more aqueous and oxidising conditions shows lower Pb contents and a more “normal” Witwatersrand Pb isotope signature.

As Pliny paraphrased Aristotle: *semper aliquid novi Africam adferre*.

References:

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