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Re-Os Isotope and PGE Constraints on the Timing and Origin of Gold Mineralisation in the Witwatersrand Basin: A Hybrid Model

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The Archean Witwatersrand basin is the largest single gold producing occurrence in the world and hence understanding the processes that lead to gold concentration are highly important for ore-genesis models. Since the initiation of geological studies on the Witwatersrand basin an enduring controversy has surrounded the origin of the gold contained within it. The two basic end-member models are the detrital or placer model (e.g., Minter, 1978) and the hydrothermal model which invokes post-depositional introduction of the gold into the basin (Phillips and Meyers, 1989; Barnicoat et al., 1997). Intermediate between these two end-members is the "modified placer" model (Frimmel et al., 1993) which advocates post-depositional remobilisation of existing gold of detrital origin. Recent detailed petrographic studies of mineralised samples from the Witwatersrand basin have shown little evidence for detrital origins, but that gold was precipitated late in the paragenesis in association with bituminous hydrocarbons and sulphides during fracturing (Barnicoat et al., 1997). Gold occurs within a few centimetres of hydrocarbon seams and is considered to have formed in association with it. There is also a ubiquitous Au-Fe-S association in all mined Witwatersrand reefs, however it is important to recognise the numerous generations of sulphides occur within a given reef. Our approach has been to utilise the siderophilic/organiphilic character of gold and of the platinum group elements (PGEs) together with the intimate association of gold with hydrocarbons and pyrite in the selected samples, to date gold mineralisation using Re-Os isotopes. We selected six samples from the study of Barnicoat et al., (1997), and analysed whole rock, sulphide and organic fractions for Re-Os isotopes and PGE.

The complete Re-Os isotope dataset defines a broadly isochronous array at 2.34 ±0.26 (2σ) Ga. More significantly, the organic and sulphide fractions of the samples analysed give 2.26 ±0.19 Ga and 2.47 ±0.67 Ga respectively. These ages post-date the minimum depositional age of the Witwatersrand basin (2699 ±32 (2σ) Ma), defined by a U-Pb zircon age for the immediately overlying Ventersdorp metavolcanic sequence (Phillips and Meyers, 1989). PGE patterns from all fractions analysed are similar, indicating that no significant post-mineralisation mobilisation of the noble metals (and hence Au) has taken place since formation of the sulphide-organic textural association. Such a correlation would not be expected of noble metal derivation from a heterogeneous detrital source.

The chronological information is compelling, given the following caveats: 1) mineralogical indicators suggest that the maximum temperature experienced by the Witwatersrand sediments is <400ºC (Phillips and Meyers, 1989), i.e., below the likely Re-Os "blocking temperature" of sulphide systems, making it unlikely that complete isotopic equilibrium was achieved during mineralisation, and 2) the samples are texturally unequilibrated, and the likelihood of multiple generations of sulphide and various tectono-thermal events experienced by the Witwatersrand basin, are not conducive to achieving highly precise isochronous relationships between samples.

In addition, three samples contained a phase with high Os concentrations and nonradiogenic isotope ratios which dominated their noble metal budget. These samples have exceedingly low Re/Os ratios and their T_{RD} ages of ~2.6 to 3.1 Ga are characteristic of their provenance. The latter age corresponds to both the peak age of detrital zircons in the Witwatersrand basin (Robb et al., 1990) and the provenance ages for osmiridiums and erlichmanites from the Witwatersrand basin (Hart and Kinloch, 1989). These data point strongly towards derivation from a terrain of similar age to the TTG source of detrital zircons as suggested by Robb et al (1990), but significantly younger than the ~3.4 - 3.5 Ga Barberton Belt.

In summary, the new data indicate a detrital source for the noble metals from a granite-greenstone terrain formed ~3.1 Ga. The noble metals underwent hydrothermal remobilisation and deposition at ~2.2-2.5 Ga to form the textural association hosting the gold mineralisation. Due to the heterogeneity of the noble metal source region, and multiple generations of sulphide growth, a precise age for this mineralisation event is difficult to ascertain, but is clearly of the order of 200 to 300 Ma after sedimentation.

Barnicoat AC, & 11 others, *Nature*, **386**, 820-823, (1997).
Frimmel HE, Le Roux AP, Knight J & Minter WEL, *Econ. Geol.*, **88**, 249-265, (1993).
Hart SR & Kinloch ED, *Econ. Geol.*, **84**, 1651-1655, (1989).
Minter WEL, *Mem. Can. Soc. Petr. Geol.*, **5**, 801-829, (1978).
Phillips GN & Meyers RE, *Econ. Geol. Mon.*, **6**, 598-608, (1989).
Robb LJ, Davis DW & Kamo SL, *Jl. Geol*, **98**, 311-328, (1990).