

Mafic basement of the Mesoarchaeon Witwatersrand basin fill: Possible source of the world's largest known accumulation of gold?

**Prof. Dr. Hartwig Frimmel
Marco Depinè**

2006-2012

Supported by the German Research Foundation

Summary

The siliciclastic Mesoarchaeon Witwatersrand Supergroup in the central Kapvaal Craton (South Africa) hosts close to 40% of all known gold. In spite of its enormous economic significance, the genesis of this gold remains unresolved. The currently available data and observations are best explained by a modified palaeoplacer model. The question of the ultimate source of the huge amounts of inferred detrital gold remains, however, unanswered and forms the main focus of this research project. The working hypothesis is that the detrital gold is, contrary to previous ideas, not derived from older, hydrothermal gold-quartz veins in the hinterland, but from finely dispersed magmatic gold in Mesoarchaeon greenstone belts.

Previous work on the immediate basement of the Witwatersrand Basin focused on granitoids, whereas this project is aimed at mafic rocks, their tectonic setting and their potential to transfer large amounts of Au from the mantle into the continental crust. In the first stage of this project, one of very few existing drill core intersections of such mafic rocks underneath basement granite was investigated petrologically and geochemically. The obtained results suggest that both mafic and felsic intrusives are cogenetic and reflect the products of fractional crystallization of an H₂O-rich, calcalkaline, mantle-derived melt in a supra-subduction setting that compares well with some of the most effective modern systems for the transfer and concentration of gold from the mantle into the continental crust.

In the second phase of the project, the encouraging and in certain respects surprising results from the first phase were tested, verified (or otherwise) by independent methods, specifically isotopic ones, and by comparison with other mafic/felsic rock associations in the close hinterland of the Witwatersrand Basin. In addition, the strength of the underlying hypothesis of the Witwatersrand gold being derived from magmatic gold was tested by assessing the role of petroleum in the transport of Au into its crustal position. To that effect, widespread pyrobitumen in the Witwatersrand conglomerates became analyzed, for the first time, for its PGE and Au concentrations. The results obtained revealed considerable high-temperature alteration in one part of the likely hinterland to the Central Rand Basin, whose basin fill represents the world's largest accumulation of gold. Although the type of alteration discovered could be amenable to Au-transport, no specific gold anomaly, that could explain the huge amount of placer gold in the Witwatersrand conglomerates, could be detected in any of the potential source rocks. Thus the question of the ultimate source of the Witwatersrand palaeoplacer gold remains unresolved and will be addressed in a subsequent research project.

Publications

Depinè, M., Frimmel, H.E., v. Seckendorff, V., Harris, C., Mineral-chemical and oxygen isotope study on Mesoarchean pre-Witwatersrand basement rocks, South Africa: Evidence of multi-phase REE mobilization. In prep.

- Frimmel, H.E., Emsbo, P., Koenig, A.E. (2009): The source of Witwatersrand Gold: Evidence from uraninite chemistry. - In: William, P. et al. (eds.), Smart Science for Exploration and Mining, Proc. 10th Biennial SGA Meeting, 17-20. 8. 2009, Townsville, 1, 353-355.
- Frimmel H.E., Zeh, A., Lehrmann, B., Hallbauer, D.K., Frank, W. (2009): Geochemical and geochronological constraints on the nature of the immediate basement beneath the Mesoarchaeon auriferous Witwatersrand Basin, South Africa. - Journal of Petrology, 50, 2187-2220.
- Koglin, N., Frimmel, H.E., Minter, W.E.L., Brätz, H. (2010): Trace-element characteristics of different pyrite types in Mesoarchaeon to Palaeoproterozoic placer deposits. - Mineralium Deposita, 45, 259-280.
- Koglin, N., Frimmel, H.E., Minter, W.E.L., Brätz, H. (2010): Trace-element characteristics of different pyrite types from Mesoarchaeon to Palaeoproterozoic placer deposits.- In: William, P. et al. (eds.), Smart Science for Exploration and Mining, Proc. 10th Biennial SGA Meeting, 17-20. 8. 2009, Townsville, 1, 363-365.
- Koglin, N., Zeh, A., Frimmel, H.E., Gerdes, A. (2010): New constraints on the auriferous Witwatersrand sediment provenance from combined detrital zircon U-Pb and Lu-Hf isotope data for the Eldorado Reef (Central Rand Group, South Africa). Precambrian Research, 183, 817-824.
- Lehrmann, B., Frimmel, H.E. (2007): Mesoarchaeon Basement of the Witwatersrand: A Possible Source of the Gold? - In: Andrew, C. et al. (eds.), Digging Deeper, Proc. 9th Biennial SGA Meeting, 20-23. 8. 2007, Irish Assoc. Econ. Geol., Dublin, 1, 15-18.