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Relative timing of alterations in the Witwatersrand Basin

Wulff, K., Hein, K.A.A., and Kinnaird, J.A.

School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa, Private Bag 3, 2050 Wits; email: katharina.wulff@wits.ac.za

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The Witwatersrand basin is host to the largest gold resource on Earth. Despite a long history of mining and research the genesis of the Witwatersrand gold deposits is not yet fully understood and is subject to a lively scientific debate. Relatively little work has been done to date on the basins post-depositional history. The knowledge on the actual number of deformation phases, their characteristics and possible causes of deformation as well as on related fluid/alteration events is accordingly poor. In this study it is intended to characterise different alteration events in the Witwatersrand basin by their mineralogy, textural/structural context and relative age. From previous studies on the structural development of the Witwatersrand Basin it is known that several syn-depositional compressional and extensional events occur in the Witwatersrand Supergroup (e.g. [1]). Seismic data [2] show that most of the faults in the Witwatersrand basin do not crosscut the Transvaal Supergroup. The most intense deformation occurred in pre-Transvaal times.

In our study the following alterations were identified: (1) Muscovite porphyroblasts are interpreted as one of the oldest alteration or metamorphic events since they may be partly replaced by pyrophyllite, hydrocarbons or chlorite associated with subsequent events. (2) A pyrophyllite alteration is commonly related to faults and high strain zones. In conglomerates affected by this alteration the quartz clasts often show signs of corrosion indicating the acid nature of this alteration. The pyrophyllite alteration is often accompanied by hydrocarbons which may occur on veinlets or disseminated in the fine-grained pyrophyllite matrix. Locally a diversification of the sulphide mineralogy is related to the pyrophyllite alteration. (3) Chloritoid occurs throughout the Central Rand Group metasediments. The chloritoid overgrows the pyrophyllite alteration. It also occurs pervasively in altered shales and in shale clasts in the Central Rand Group. Chloritoid alteration is absent from mineralogically similar conglomerates of the Black Reef Fm. indicating that this alteration occurred in pre-Transvaal Supergroup times. (4) In quartzites and conglomerates located in the vicinity of crosscutting (Ventersdorp) dykes a reduction in the phyllosilicate content is often observed. It is interpreted to be caused by thermal dehydration. Pyllosilicates associated with the contact zones are generally muscovite and chlorite, the latter occurring particularly in vicinity to Fe-bearing minerals (e.g. pyrite). A foliation may be developed. The occurrence of euhedral pyrite and a macroscopic impression of bleaching of the rocks are further characteristics of the alteration zones around the dykes. (5) A nodular carbonate alteration locally affected the Booysens Shale in the Carletonville area as well as shale clasts in the Klerksdorp area. Extensive carbonate-chlorite alteration (non-nodular) was also observed in basalts of the Ventersdorp Supergroup. (6) There is further indication of several syn- to post-Transvaal Supergroup alteration and tectonic events characterised by the development of pressure shadows around pyrite clasts in the Black Reef and around euhedral pyrite porphyroblasts in the Central Rand Group, the replacement of chloritoid porphyroblasts by quartz and pyrite and by sulphide remobilisation. The above described textural record seems to correspond well with the basins sedimento-chemical development. The early (muscovite, pyrophyllite, chloritoid) alterations occurred in pre- to syn? Ventresdorp Supergroup times when the sediment composition comprised mainly quartz, white mica and pyrite (as well as Fe-oxides in the West

Rand Group). Due to the lack of Ca and Mg, these sediments have poor buffer qualities and related fluids are likely to have a low pH. This is consistent with the observed alteration mineralogy and textures. Alterations interpreted to have occurred in syn- to post Ventersdorp Supergroup times (i.e. after a thick pile of Ca- and Mg-bearing basalts was added to the lithological record) are characterised by minerals (chlorite, carbonate) indicative of neutral to alkaline conditions.

References:

[1] Dankert BT and Hein KAA (2010) Prec Res 177: 1-22

[2] Manzi MSR et al. (2013) Tectonophys 590: 94-105