IMPACT-RELATED HYDROTHERMAL ALTERATION OF WITWATERSRAND GOLD REEFS IN THE VREDEFORT DOME AND WITWATERSRAND GOLDFIELDS, SOUTH AFRICA. S.N. Foya, R.L. Gibson and W.U. Reimold, Department of Geology, University of the Witwatersrand, Private Bag 3, WITS, Johannesburg, 2050, South Africa (065foya@cosmos.wits.ac.za).

Recent petrographic studies of the gold-bearing conglomerate reefs of the 2.9-2.7 Ga Witwatersrand Supergroup have shown that they have experienced a polyphase metamorphic-hydrothermal history since deposition. Some workers, such as [1] have suggested that these metamorphic-hydrothermal events may have been responsible for introducing gold into the permeable conglomerate horizons from an extrabasinal source (epigenetic model). Other workers (e.g., [2]), however, prefer a modified-placer model whereby hydrothermal fluids derived from the rocks of the basin during metamorphism circulated through the reefs, leading to dissolution and reprecipitation of detrital gold particles. Despite the conflicting views on the source of the gold, both schools have suggested that gold mineralisation achieved its current form close to the peak of lower greenschist facies (350 ± 50 °C, 0.2-0.3 GPa) metamorphism. However, no consensus has yet been reached concerning the timing of this event, with ages of ~2.5 Ga, ~2.3 Ga and ~2.0 Ga having been proposed on the basis of available geochronological data. Recent improvement in the regional geochronological data-base has established that at ~2.0 Ga the Kaapvaal craton experienced two exceptional events: at 2.061 Ga, voluminous magmatism marked the Bushveld event, whereas at 2.023 ± 0.004 Ga a large meteorite impact occurred centered some 120 km SW of Johannesburg. The structural effects of this impact include: the formation of a 70 km wide central uplift, the Vredefort dome; shatter cones, high-pressure quartz polymorphs, PDFs in quartz and zircon, and impact breccia dykes in the Vredefort dome; and voluminous pseudotachylitic breccias in both the Vredefort dome and the goldfields along the periphery of the Witwatersrand basin. However, comparatively little is known of the thermal effects caused by the impact event and how these relate to the metamorphic evolution of the gold-bearing reefs.

Recently, [3] established that a strong radial post-impact thermal gradient existed across the Vredefort dome, ranging from ≥700 °C in the center of the dome to ~500 °C and ~400 °C, respectively 20 km and 25 km from the center. They attributed this to shock heating and differential uplift effects in the impact crater basement. In order to evaluate the post-impact thermal effects on the gold reefs in the basin we have examined samples from the Kimberley Reefs from the Vredefort dome and the West and East Rand goldfields, located respectively 30, 90 and 170 km from the center of the dome. All 3 sets of samples contain a peak metamorphic silicate mineralogy comprising pyrophyllite-chloritoid-muscovite-chlorite-quartz, similar to that described from all the other goldfields [4], although chlorite-chloritoid thermometry indicates that slightly higher temperatures existed in the Vredefort samples. In the Vredefort samples, this peak metamorphic paragenesis is cut by pseudotachylitic breccias and related brittle fractures, and quartz contains decorated PDFs. This places the metamorphic peak as pre-impact; however, the breccias are themselves recrystallized to a chlorite-muscovite paragenesis which also partially replaces the peak paragenesis. A similar feature is observed in the West and East Rand samples. Chlorite thermometry indicates T = 300 ± 10 °C in all 3 areas, suggesting relatively uniform post-impact thermal conditions across the basin. These data concur with the results obtained from chlorite in the Venterdorp Contact Reef in other goldfields [5].

The ore mineralogy of the reefs indicates that, while significant authigenic pyrite growth accompanied the peak metamorphic event, the only evidence of concurrent gold deposition is as invisible gold in arsenic-rich pyrite. Conversely, the samples show a pyrrhotite-chalcopyrite-sphalerite-galena-gold post-impact paragenesis, with visible gold occurring in fractures and voids in, and interstices between, existing pyrite and quartz grains. This indicates that the Vredefort impact had a profound effect on the gold mineralization in the Witwatersrand basin.