**6.4.12**

# Re-Os evidence for juvenile 3.0 Ga gold at Witwatersrand and implications for the giant goldfields

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The Archean conglomerates of the Witwatersrand basin in South Africa\s Kaapvaal craton host the largest concentration of gold on Earth. The Witwatersrand has been a focal point for studies devoted to both gold mineralization and the evolution of the atmosphere because of the magnitude of gold mineralization and the presence of rounded uraninite and sulfides. Over 100 years of scientific debate has centered on whether the gold, uraninite and sulfides found in the conglomerates are a detrital or hydrothermal assemblage. Uraninite and sulfides are rapidly dissolved in surficial waters in the presence of \ oxygen, so if detrital, these minerals tells us that the Witwatersrand sediments were deposited under a reducing atmosphere. Detrital gold mineralization requires exploration models based on sedimentology, while hydrothermal gold mineralization focuses on structural controls and patterns of alteration. In order to constrain these models, we have dated gold and sulfides from the Witwatersrand basin using Re-Os isotopes, dated zircons by laser ablation ICPMS and have examined the elemental patterns within gold and possible greenstone belt sources.

The gold of the Witwatersrand basin contains much higher concentrations of Re and Os (ppb to ppm), than gold from hydrothermal systems examined. The very high Os concentrations are though to have preserved the Re-Os systematics within the gold from influxes of later hydrothermal fluids. Gold and rounded pyrite from the Vaal Reef conglomerate of the Witwatersrand basin yield a Re-Os isochron with an age of 3.03 ± 0.02 Ga and an initial $^{187}Os/^{188}Os$ ratio of 0.1079 ± 0.0001. The ages of the gold and rounded pyrite are older than the 2.89-2.71 Ga conglomerate host and indicate that the gold is detrital. Zircons from the basin also yield data that suggest a large zircon population at ~ 3 Ga with lead loss at around 2 Ga, coincident with the emplacement of the Bushveld complex. The ages of gold, rounded pyrite and detrital zircons, the mantle-like initial Os isotopic composition of the gold, as well as trace element concentrations in gold suggest that the source of these minerals are similarly aged shear-zone hosted gold deposits of the Murchison and/or Kraiipan greenstone belts.

The Re-Os data indicate that the Witwatersrand gold was extracted from the mantle at ~ 3.0 Ga and was likely related to formation and stabilization of the Kaapvaal craton. The extreme magnitude of gold mineralization may be related to the processes of cratonization with large gold fluxes from the mantle that have not been repeated.

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# Ru-Os-Ir-Pt alloys from the Evander Goldfield (Witwatersrand Basin, South Africa): Osmium isotope evidence for the oldest PGE-mineralization on Earth

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The compositionally diverse platinum-group minerals (PGM) from the Evander Goldfield, in the eastern part of the Witwatersrand Basin, South Africa, have been studied for the first time by a number of modern techniques including SEM, EMPA, N-TIMS and LA MC-ICP-MS [1]. The characteristic feature of PGM from Evander is an extensive presence of Ru-rich alloys (i.e., Ru-Os-Ir, Ru-Os-Ir-Pt, Ru-Ir-Pt, Ru-Pt), which prevail over osmium, iridium, rutheniridosmine, Pt-Fe, Pt-Ru-Fe and Pt-Ir-Os alloys.

The $^{187}Os/^{188}Os$ value measured by N-TIMS in PGM, which contain Os in the range 18-53 wt. % (i.e., Pt-Ir-Os alloy, ruthenium, rutheniridosmine and osmium), varies from 0.0987 to 0.1068, revealing the lowest three $^{187}Os/^{188}Os$ values (0.0987-0.1024) reported so far in terrestrial PGM. The $^{187}Os/^{188}Os$ value measured by LA MC-ICP-MS in PGM with Os contents between 2 and 10 wt.% (Pt-Fe, Ru-Ir-Pt and Ru-Pt alloys) was found to range from 0.1053 to 0.1095. For the major set of PGM, independently of their chemical composition, two groups of isotopic values were distinguished. The mean $^{187}Os/^{188}Os$ value for the first group amounts to 0.1053 ± 0.0002, while that of the second group is 0.1064 ± 0.0004. Accordingly, estimates of age based on the mean osmium-isotopic composition of PGE alloys yielded model $^{187}Os/^{188}Os$ ages of 3222 ± 78 and 3074 ± 60 Ma. Three PGM, however, appear to imply ages of 4100 ± 130, 3930 ± 130 and 3610 ± 85 Ma, respectively, representing the oldest terrestrial PGM known so far.

Unradiogenic $^{187}Os/^{188}Os$ values are clearly indicative of a chondritic to subchondritic mantle source of the platinum-group elements. We further propose that the PGM formed under mantle conditions. The model $^{187}Os/^{188}Os$ ages obtained for the main set of PGM (4104-3020 Ma, n=12) imply that the PGM are detrital and were thus not deposited by later hydrothermal fluids. Our results support a scenario in which the majority of PGM were incorporated into the Witwatersrand basin by their release during weathering of Archean ultramafic or mafic source-rocks.

**References**

[1] Malitch K.N. and Merkle R.K.W. (2004) *Can. Mineral.* **42** (in press).