A major gold-bearing crust-forming event at 3.03 Ga

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The Witwatersrand Supergroup (WSG) located in the Kaapvaal craton of South Africa hosts the largest concentration of gold on the planet. Gold and rounded pyrite from the Vaal Reef (VR) of the WSG yield a Re-Os isochron age of 3.03 ± 0.02 Ga and an initial $^{187}Os/^{188}Os$ ratio of 0.1079 ± 0.0001 (Fig. 1).

Osmium concentrations of VR gold are 1-4 orders of magnitude greater than Os concentrations determined for other, younger gold deposits, implying both differences in mineralization processes and resistance to subsequent hydrothermal overprints (Kirk et al., 2001). The 3.03 Ga age is therefore not likely to have been significantly effected by latter hydrothermal fluids, which were likely Os-poor, as reflected by low Os concentrations determined for authigenic Ventersdorp Contact Reef pyrite.

Ages of Vaal Reef gold and rounded pyrite are older than the 2.92-2.71 Ga Central Rand Group conglomerates that host them (Robb and Meyer, 1995), indicating that the gold is detrital and was not deposited epigenetically via later hydrothermal fluids. The initial $^{187}Os/^{188}Os$ ratio of the VR gold and pyrite corresponds closely to the Os isotopic composition of the convecting mantle at ca. 3.0 Ga. As a result, Os and gold were likely sourced from one or more of the relatively contemporaneous mantle-derived rocks that helped to form and stabilize the Kaapvaal craton at ca. 3.0 Ga.

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Precambrian/Cambrian Carbon Cycles and True Polar Wander: A Methane Connection?

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Over a dozen oscillations in the inorganic $\delta^{13}C$ with magnitude up to 4 ‰ punctuate Early Cambrian Time, starting in the Nemakit D'Aldyn zone at the Precambrian-Cambrian boundary and extending into middle Botomian time -- this is the classic interval of the Cambrian explosion. Several oscillations and large excursions are also present in middle and late Cambrian time. No other similar set of carbon cycle perturbations of this magnitude and duration (~ 15 to 20 million years) have been found in any other part of geological time, despite their proven use for stratigraphic correlation. The causes of these oscillations are unknown.

This same interval of time corresponds to large angular displacements in all of the apparent polar wander paths for the major continents; this has been interpreted as an inertial interchange true polar wander (IITPW) event, in which the magnitude of the principal and intermediate eigenvectors of Earth's moment of inertia tensor become equal, and then cross. As a planet must spin about its principal moment of inertia, an IITPW event would cause the solid Earth to undergo a rapid burst of up to 90º of true polar wander, bringing parts of the globe initially located at the polls to the equator in a geologically short interval of time (~5-25 Myr). These large true polar wander events also predict dramatic sea level effects, the magnitude of which will vary greatly with geographic location. IITPW can be used to deduce the absolute paleogeography, including *paleolongitude*.

The IITPW reconstruction for Early Cambrian time implies that large areas of North America and Gondwana moved from the South polar region to the Equator. Methane clathrate deposits which formed in the cold polar regions were moved progressively out of their stability fields into warmer, tropical climates. The epistatic nature of global circulation, coupled with pressure changes induced by sea level variations, suggests that broad regions might be subjected to geologically sudden warming events, leading to fairly rapid bursts of methane emission. Such bursts are capable of producing large fluctuations in the carbon isotope record, such as has been suggested for the single blip at the Paleocene/Eocene boundary. A greenhouse induced transient thermal warming pulse is also expected to occur associated with these Cambrian carbon excursions, and might be detectable if carbonates with unaltered oxygen isotopes could be found. Many of the major negative excursions in the Early Cambrian carbon cycles are followed by a clear evolutionary burst in one or more phyletic groups, as also happened in the Eocene. As biological diversity correlates strongly with temperature, a series of repeated methane-induced warming pulses should have contributed to the biological radiation events during the Cambrian Explosion.