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The continent of Ur and the beginning of the crustal gold cycle

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The crustal gold cycle can trace its roots back to the "original" continent, Ur, which at about 3.00 Ga was comprised of the Kaapvaal craton (southern Africa), Dharwar, Singhbhum and Bjanadara cratons (Indian subcontinent) and Pilbara craton (Australia) [1]. Ur grew to a size somewhat smaller than modern Australia through accretion of the Yilgarn, Kimberley and Gawler cratons (Australia), Aravalli craton (Indian subcontinent), Zimbabwe craton (southern Africa) by about 2.60 Ga.

The southern African, Australian and Indian remnants of Ur have contributed approximately 1.85, 0.35 and 0.1 billion oz gold production, respectively, or 39% of historic global gold production estimated at about 5.9 billion oz [2]. Considering less than 3% of Earth's presently exposed continental crust once belonged to Ur, this large gold endowment is quite profound. The next youngest supercontinent, Arctica, comprised of cratons of the Canada Shield, Greenland and Siberia that assembled around 2.50 Ga [1], has only contributed around 10% of historic global gold production, a quarter that of Ur. When considering the entirety of Earth's continental crust, rocks of Ur have produced about 20 times the amount of gold per unit area as their younger counterparts.

By about 3.00 Ga, the Ur continental platform was sufficiently stable to support deposition of thick sequences of sedimentary and volcanic rocks in shallow marine and terrestrial basins. One of these, the Witwatersrand Basin, has yielded about 29% of historic global gold production or three quarters of Ur's total gold production. Millimetric to centimetric gold-rich carbon seams occurring near the base of the 2.894-2.714 Ga Central Rand Group [3] are some of the oldest and most prolific gold sources in the Witwatersrand Basin. The presence of kerogen and bitumen along with copious observations on the spatial distribution of these carbon seams confirm that this carbon originated *in situ* from living organisms in microbial mat cover that grew contemporaneously with sediment deposition [4]. Early O_2-producing life forms, probably cyanobacteria, that evolved in shallow marine environments were an important component of these microbial mats and were responsible for oxidative precipitation of gold thus fixing huge amounts of gold over large areas [5,6]. This depositional event marks the earliest significant event in the crustal gold cycle.

It has been postulated that emission of sulphurous gases from large volcanic eruptions formed acid rain that resulted in chemical weathering and transport of gold as sulphur complexes in anoxic surface waters that flowed into basins where gold precipitated onto microbial mats [7]. While this idea is intriguing, it requires extensive chemical weathering of huge tracts of ancient terrestrial terrane in order to source sufficient gold to form the vast gold deposits of the Witwatersrand Basin. Alternatively, seawater, under similar atmospheric conditions, would have proved highly effective at leaching gold from oceanic crust underlying Earth's ancient ocean basins thus making it a more probable source of gold. Tidal inflows of seawater repeatedly washed across microbial mats living in broad estuaries thus delivering a near endless supply of gold for cyanobacteria to precipitate. New work indicates this process was not restricted to the Witwatersrand Basin. Economic gold mineralization and associated carbon have recently been discovered in transgressive lag horizons in the Fortesque Basin, Australia, here presented for the first time.

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