

***WITWATERSRAND GOLD DEPOSITS - OUTCOMES FROM THE  
INTERNATIONAL GOLD SERIES: APRIL – MAY 2025***

***OVERBERG GEOSCIENTISTS GROUP (OGG)  
& Universities of Melbourne & Stellenbosch***

**Background**

The Overberg Geological Group led an initial series of five lectures on new ideas for known gold deposits in conjunction with the Universities of Melbourne and Stellenbosch.

Original speakers were Dave Crow (Dunedin, New Zealand), Julian Vearncombe (Perth, Australia), Neil Phillips (Melbourne, Australia), John Clemens and Bjorn von der Heyde (Stellenbosch, South Africa).

Interest in the Series was such that three further speakers were added with a focus on southern Africa and especially Witwatersrand gold (Keith Kenyon, Graham Gavine, Terence McCarthy).

All presentations were recorded and are available on the YouTube links below.

Following the Series, interest was such that participants were keen to continue the geology discussions; it was also resolved to capture many of the ideas in this short document on opportunities for South Africa. A further lecture series is planned in late 2025 or 2026 to pursue some of the more challenging ideas.

Participants in post-Series discussions and report contributors:

Neil Phillips (Report compiler); John Bristow (OGG co-chair); Hennie Greef (OGG co-chair), Dave Crow; Grant Cawthorn; Bill McKechnie; Marc Goedhart; Bruce Eglington; Adrian Reynolds; Noleen Pauls; Julian Vearncombe; John Clemens; Bjorn von der Heyden; Alex Kisters; Caitlin Jones; Jonathan Law; David Young; Marshall Palmer; Willem Van Der Westhuizen; Gerhard Meintjies; Terence McCarthy; Andy Clay; Bruce Cairncross; Keith Kenyon; Graham Gavine; Dave Cornell; Tafeeq Dhansay; Rob Lindsay; Phil Bentley.

The work and efforts of Neil Phillips are acknowledged for taking the lead in compiling and editing this report, and diligently collating numerous emails and submissions to construct the comprehensive collection of Annexures.

Gold Presentations *YouTube* link:

**All about Gold:** <https://www.youtube.com/playlist?list=PL-MPMaHidsW2tZEQv06FmiLjubVejMGhh>

All previous **OGG** presentations on *YouTube*:

<https://www.youtube.com/playlist?list=PL-MPMaHidsW1jR8f-KMmPX8ANZGA-OYna>

## Executive Summary

The Witwatersrand goldfields around Johannesburg dominated world gold production throughout the 20th century whilst underpinning prosperity and infrastructure advances in South Africa. Gold mines have been closing, especially after the 1986 centenary of discovery, and production has plummeted. The last discovery of a new goldfield was in 1951.

The amount of gold remaining in the Witwatersrand is not known accurately, but most estimates suggest that it could sustain mining for decades. Industry longevity will be aided by increases in the gold price to allow mining at lower grades; and there is no reason to believe that new goldfields cannot still be discovered, especially by using new thinking and methods.

The 2025 International Gold Series of the Overberg Geological Group and Universities of Melbourne and Stellenbosch brought together international and South African gold experts to discuss the latest ideas on global gold and especially issues pertaining to South Africa and the Witwatersrand.

The 2025 Series was built around recent publications by a core of invited speakers from the Gold24 Conference in Perth WA. An earlier 2022 OGG Gold Series laid some foundations by making modern structural geology, metamorphic petrology and alteration ideas more widely accessible in South Africa.

The existing genetic model to explain the origin of Witwatersrand gold and guide exploration is the placer model: this model draws upon analogy with the world's much younger circum-Pacific gold placer deposits. During the 2025 Gold Series some serious issues with the placer model were exposed, and perhaps the most revealing was that the world's large placers are a poor match for the Witwatersrand gold distribution. This surprise for some will be an opportunity for others.

Confidence in the placer model has already been undermined by the lack of any realistic source for 1700 Moz of detrital gold, and the lack of any special sedimentary sorting environment. The bitumen (graphite) that is closely associated with gold reflects migrated hydrocarbons, and no confirmation was found for original algal mats.

The Series was not about picking winners and losers amongst models for Witwatersrand gold genesis, but it did identify the metamorphic hydrothermal model as a viable alternative.

Four action areas are identified to reverse the fortunes of Witwatersrand gold.

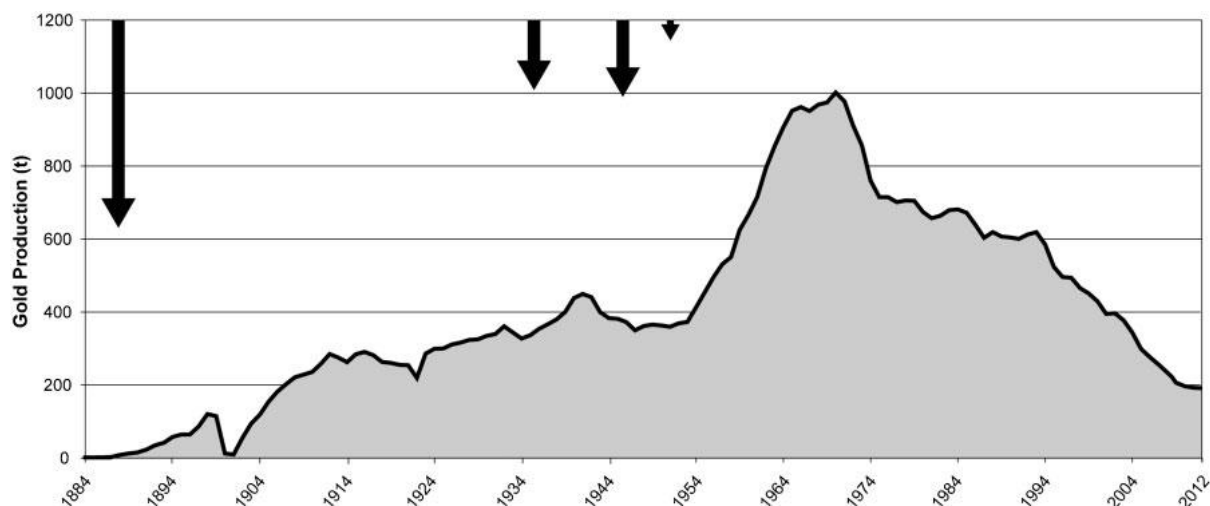
- Education and training targeted at some overlooked but critical areas of geology
- Improved understanding of the placer and metamorphic hydrothermal models for gold
- Scientific environments that encourage new ideas with willingness to part with the old
- Curatorship of the immense irreplaceable intellectual resources from 130 years of gold mining.

Looking to the future, there is optimism that significant gold remains in the Witwatersrand, and new and innovative scientific and technological approaches can aid discoveries.

To achieve success, this regeneration of geological efforts will need to be supported by a political environment and policy regime that is encouraging of investment in South African gold mining, sustaining robust academic and applied training of young geologists, and ensuring preservation and access to the treasure trove of previous data including core material.

## Background: The first 130 years on the Witwatersrand

Shortly after the discovery of gold at Langlaagte in 1886, South Africa rose to become the world's leading gold producer on the back of the Witwatersrand goldfields (Fig. 1). This dominance remained for the whole 20<sup>th</sup> century and provided wages, exports, wealth and infrastructure for the country. So far, 1700 Moz of gold has been produced.



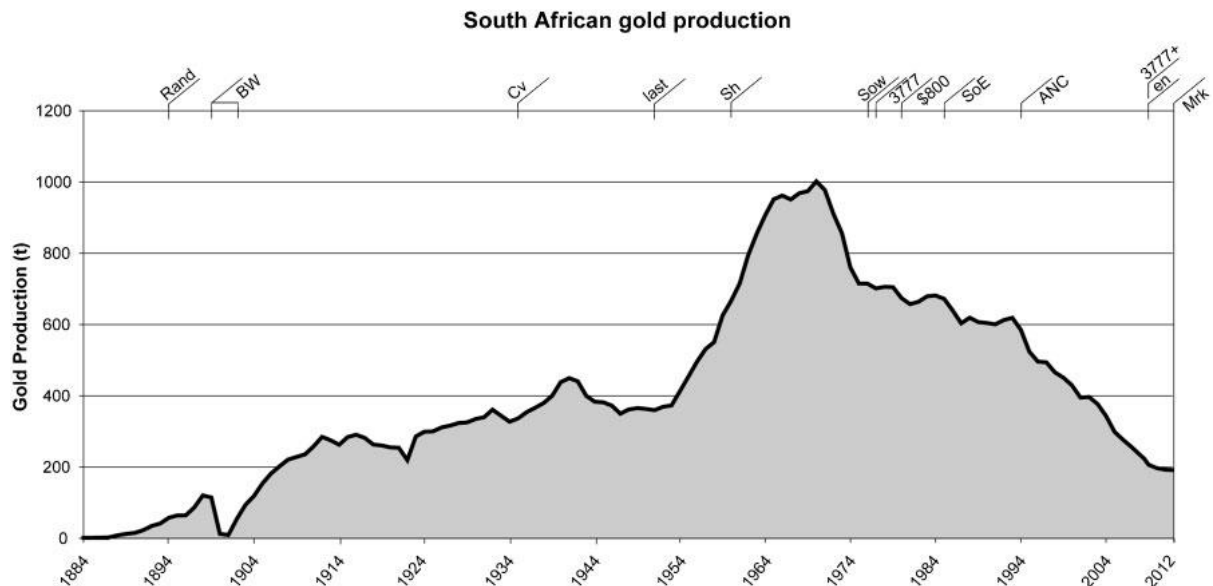
**Fig 1:** Graph showing Witwatersrand gold production and the date of major discovery events. Production increased rapidly after the Rand was discovered in 1886. Production rose strongly again from the 1950s. The length of each discovery arrow is proportional to the gold produced from each goldfield; but some discoveries took place over several years. For example, Klerksdorp and the Rand were both discovered in 1886 and shown thus, but it might be equally valid to show the real Klerksdorp 'discovery' much later when the Vaal Reef was identified in 1942. This graph shows the huge impact of the major discovery events on gold production, with a lag time of one to two decades as reserves are demonstrated and mines built.

### The importance of discovery and relationship to production

The precipitous decline in South African gold production since 1970 has been attributed to many factors, but most of these factors were short-lived and do not explain a consistent 55-year decline.

The 1903 Anglo Boer War shows the effect on Witwatersrand gold production caused by a very serious but relatively short-lived event; upon a ceasefire, resumption of production was instant at this scale. Correlations with mines getting deeper cannot be justified from the facts (Fig. 2).

The lack of exploration success appears to be the best correlation with the decline in production linked to the period after 1951 of no new goldfield discoveries.



**Fig. 2:** Annual production for the Witwatersrand goldfields shown with a timeline of the dates of major events that may have affected Witwatersrand gold production, namely Anglo Boer War (BW), Sharpeville massacre (Sh), Soweto riots (Sow), State of emergency (SoE), end of apartheid and new ANC government (ANC), energy shortages (en), Marikana riots (Mrk), deepest shaft reaches 3777 m (3777), and deepest shaft exceeds 3777 m (3777+). Major discovery events are indicated (Rand; Cv: Carletonville then Welkom; last: last discovery of a goldfield at Evander). For three decades the depth of the deepest shaft did not change but the gold production fell from 700 tpa in 1977 to 205 tpa in 2009.

At the rate of mining in 1970, one major goldfield would need to be discovered every decade to maintain production, however, the last such discovery was 1951. The correlation between discovery and production has already been alluded to by Hartnady (2009) and is a much broader effect than just South Africa. For five leading gold-producing countries with reliable figures there is a strong correlation between exploration success and production since the 1980s (Table 1). Discoveries have been correlated with new science since 1980, and a willingness to drastically revise exploration methods of the past.

<b>Table 1: Discovery and production trends in five countries</b>			
	Exploration success	Production pattern	Higher gold price
South Africa	negligible	long term decline	yes
Brazil	minor	small increase	yes
Canada	modest	increase	yes
USA	MAJOR	LARGE INCREASE	yes
Australia	MAJOR	LARGE INCREASE	yes

## **The origin of Witwatersrand gold and its importance for exploration**

The genesis of gold deposits plays a major role globally in developing exploration programs and interpreting results. Three breakthroughs in the early 1980s in the understanding of how Archean greenstone gold deposits formed were a major contributor to success in Western Australia and Canada. The uptake by industry of new scientific advances was very rapid.

The origin of Witwatersrand gold has been debated for a century between placer (syngenetic) and hydrothermal (epigenetic) ideas. Virtually all teaching, research and exploration in South Africa has been focused on the placer model which postulates detrital gold having been transported and concentrated in river systems. It has consistently required *ad hoc* modifications to explain new findings (e.g. modified, remobilised, HAGS, algal mats, corduroy mats, bi-sulfide-bearing rivers) without success identifying a source for the gold, or any special sedimentary sorting process. The placer model does not explain the structural control on the distribution of gold.

An alternative to the placer model is the metamorphic hydrothermal model. The latter is akin to the genetic model explaining Archean greenstone deposits and owes much to the advances since the 1970s in understanding fluids in the crust led by Bill Fyfe, John Ferry and Roger Powell. Gold-bearing fluids are generated during regional metamorphism and move through the crust on fracture networks. Gold is deposited from the fluids primarily through reaction with carbon and iron in host rocks and utilising favourable chemistry and rheology. Fluids, as they pertain to gold deposit formation, are still poorly understood in South Africa.

## **2025 OGG International Gold Series**

For over half a century, global conferences and major seminar series have tended to focus on either the Witwatersrand or on other Archean gold types. The reasons provided for this separation include a shortage of local experts to speak about both, and audiences with supposed limited interest spanning both types. This separation is unfortunate because geology and people can add so much value across some human-created divisions. After all, we are studying the same element <sup>79</sup>Au.

The 2025 OGG International Gold Series and its precursor, the 2022 OGG Gold series, combined Witwatersrand and non-Witwatersrand experts and topics to demonstrate the value of broader thinking across this artificial separation.

The OGG presentations demonstrated that the lead scientists, the learnings and the multiple geological examples from non-Witwatersrand gold can add great value to understanding the Witwatersrand, and vice versa. Structural geology, metamorphic petrology, igneous petrology and sedimentology are studies we can use to understand today's rocks and those as old as 3000 Ma, i.e. an approach based on uniformitarian principles.

Importantly, breaking-down silos and old approaches of rather parochial work and research, often driven by mining companies and individuals protecting data and information, need to be changed and modern multi-disciplinary approaches pursued.

# Future Activities & Requirements

## 1. Education and training

In some areas of geology South Africa has led the world and in others it has lagged. This imbalance is partly due to the influence of its several world-leading ore deposits (Bushveld, Witwatersrand) that have driven emphasis on training such as in igneous petrology and sedimentology. Another influence can be traced to the apartheid era during which travel to global deposits and conferences was restricted, with virtually no exposure to new ideas such as crustal fluids, structurally controlled ores and metamorphic processes. There was little opportunity to visit and research any of the world's large placer gold deposits.

With respect to Witwatersrand gold geology some gaps stand out. First is the need for an in-depth knowledge and understanding of the world's great placer gold fields; it is risky to speak with any authority on gold placers without understanding those in Otago NZ, Victoria, the Russian Far East, Alaska, California, and Klondike of Canada. Better still would be time spent researching and publishing on these placer deposits. A second gap is the understanding of crustal fluids as they influence structural geology, metamorphic petrology and ore formation.

Training beyond the conventional Witwatersrand skills areas like sedimentology needs to be strengthened so the community is alert to alternatives, can make more balanced observations, and can discuss alternative genetic models from a firm knowledge base. While many geologists have an opinion of the origin of Witwatersrand gold, only a few could give a serious lecture on the placer and hydrothermal ideas and the critical scientific distinctions. Specific suggestions would include studying modern placers and understanding hydrothermal processes.

Much more use of the 130 years of Witwatersrand literature will help to identify unfounded *creeping certainties* and overcome the *Evans Effect* where critical but controversial literature is ignored.

Consideration might be given to a Stellenbosch / Johannesburg / Witwatersrand / Otago / Melbourne universities interchange to allow graduates and professors to co-research, visit, discuss in the field, and develop new ideas and encourage a new generation of informed and thoughtful young geologists. A further initiative might be to tailor selected OGG lectures for use in undergraduate and postgraduate classes, on social media platforms and as professionally edited 3-minute videos. Editing full-length OGG presentations might include notes that point to highlights and the main points.

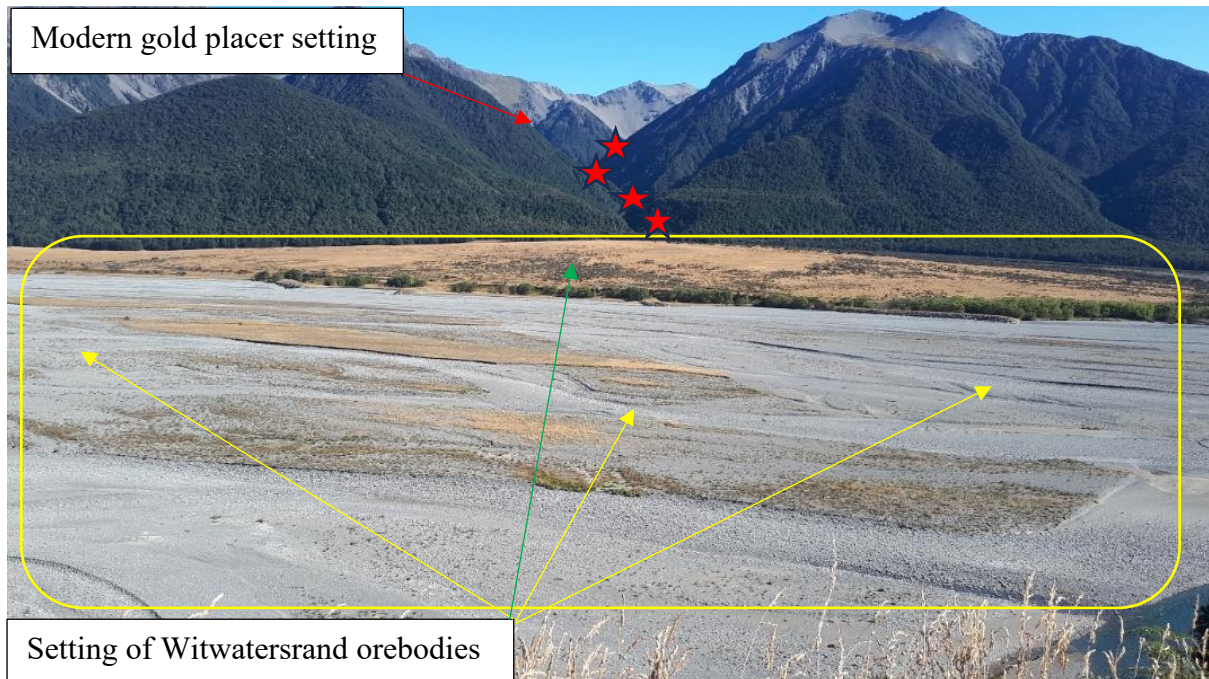
## 2. Placer model

Genetic models explaining how gold deposits form are not factual; they are attempts to explain nature at a certain point in time. The telltale sign that a scientific model needs revision is when anomalies increase and *ad hoc* modifications proliferate, i.e. these are modifications not based on sound science and observations but designed to preserve an existing model.

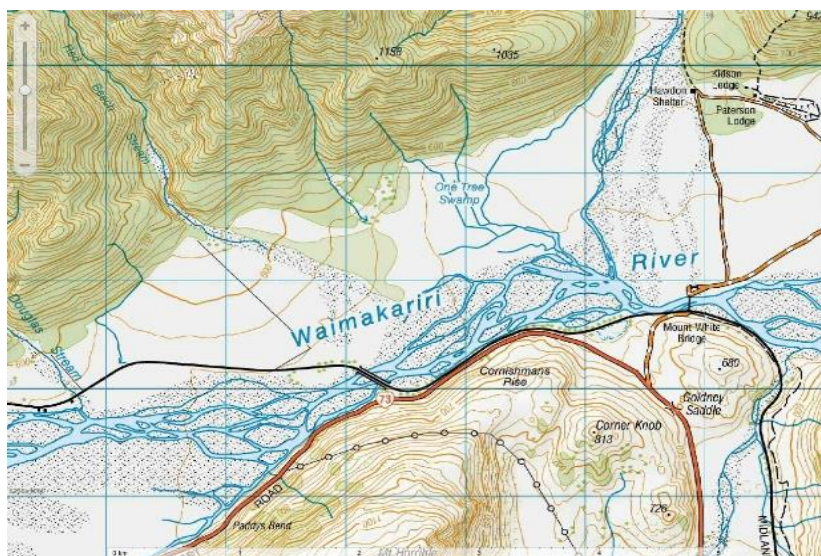
Having nearly all Witwatersrand exploration and mining based around the placer model is an inherent risk; and change becomes more difficult over time as investments in the model have grown.

One anomaly with the placer model relates to the contrasting distribution of gold in modern gold placers and in the Witwatersrand orebodies – specifically, the base of Phanerozoic

erosion channels is the location of rich alluvial gold whereas modern braid plains and their channels are sites of gold and black sands dilution rather than concentration (as exemplified in Otago NZ; Figs 1 and 2). These features do not match the Witwatersrand where the base of erosion channels is not the setting for the gold; instead, the unconformity planes are the sites for Witwatersrand mining of the planar sheets that include braid plain settings.

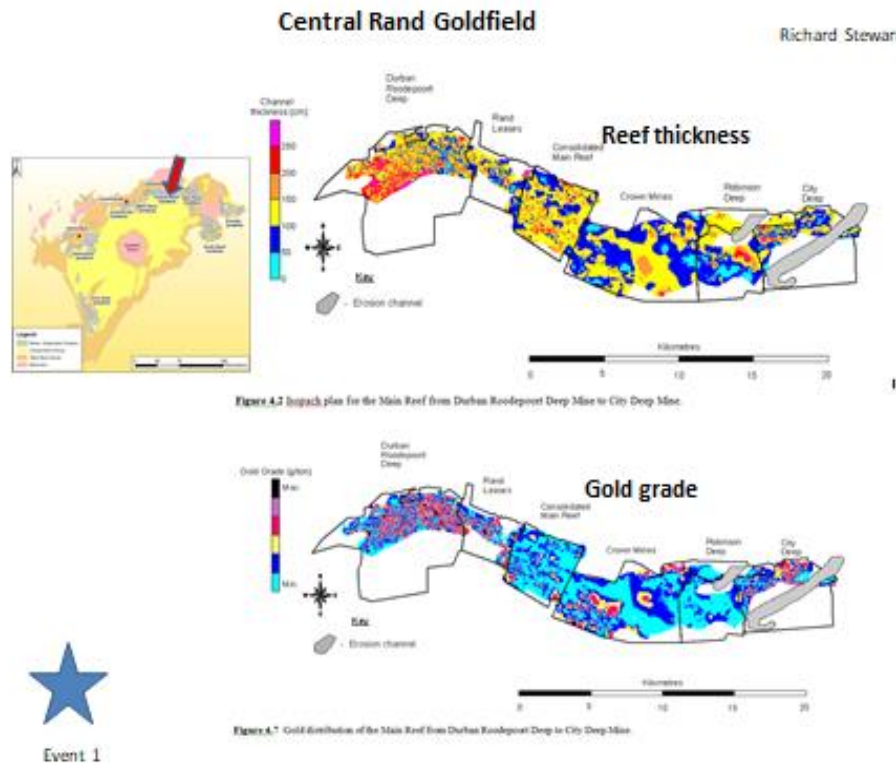


**Fig. 3:** Modern fluvial system (Waimakariri River in New Zealand) with steep-sided erosion gullies incised into basement (red), alluvial fan (green) and braid-plain with channels (yellow). The world’s large Phanerozoic gold placers are at the base (thalweg) of the steep-sided erosion gullies (red) – obviously there needs to be gold mineralisation in the source. The fan and braid-plain are dilutionary and do not concentrate gold or black sands. The sedimentary setting of the Witwatersrand orebodies matches the braid plain and maybe the fans, so it is not the setting for sedimentary sorting to enrich gold. Based on OGG lecture by Dave Craw (U Otago).



**Fig. 4:** Contour map for part of the Waimakariri River, NZ.

The photo in Fig. 3 was taken from Cornishman’s rise and towards the NW and the Red Beech Stream area. The braid plain, alluvial fan and erosion gullies are reflected by contrasting contour patterns.



**Fig. 5:** Gold distribution on the Central Rand showing erosion channels on Robinson Deep and City Deep mines. The base of these channels would be prime targets for placer gold targets; however, in the Witwatersrand they are barren and avoided. Compilation by Richard Steward, slide from OGG Gold lecture by Spike McCarthy 2025.

Two further anomalies that remain unresolved (by placerists) are the absence of any viable source for 1700 Moz of detrital gold and absence of any special sedimentary sorting process to account for the 10,000 times enrichment of gold above crustal background.

Of some concern should be the long history of making *ad hoc* changes to maintain the placer model in the face of contrary observations. The idea of hydrothermally altered granites (HAGS) was an *ad hoc* modification to explain the source of the Witwatersrand gold prior to any confirmation that the alteration of the granite pre-dated Witwatersrand sedimentation (it was later). No examples were provided of HAGS being the source for major Phanerozoic gold placers globally.

Algal mats are another *ad hoc* modification to explain the role of carbon within a placer model. There is no definitive evidence for algal mats in the Witwatersrand, and it would not be expected anyhow after the multiple deformation events and greenschist facies metamorphism. Much of the carbon has been shown to be secondary. There is no evidence that the bitumen (graphite) was present at the time of burial, and the whole sequence has exceeded anthracite grade. Algal mats are not associated with post-Archean gold deposits, whereas secondary carbon is a common association with gold. These *ad hoc* changes do not help science nor industry, and a more scientifically rigorous and informed approach to discussing Witwatersrand gold genesis would be useful.

Student classes have been known to vote on placer versus hydrothermal before their first Witwatersrand gold lecture. This is fun and shows they have some knowledge of scientific differences. However, they need to understand that scientific differences are not decided on numbers despite the widespread use of this approach by senior scientists in publications. They learn that science is not a democracy. Importantly it is valuable that they understand alternative ideas.

There is a viable alternative to the placer model for Witwatersrand gold, and it does have global analogues. The metamorphic hydrothermal model to explain the origin of Witwatersrand gold has analogues in Archean greenstone belts and younger metasedimentary gold provinces and explains many of the features of the Witwatersrand such as the Fe and C association and structural control. The model is based upon auriferous fluids generated through metamorphic devolatilisation processes such as the greenschist to amphibolite facies transition. These fluids are channeled and focused by shear zones, vein networks and fractures and then deposited in favorable structural and chemical sites.

The important message from the OGG Series was the need to welcome challenges to placer thinking and to understand alternative science (metamorphic, structural, igneous and other areas). Informed discussions might also be enhanced where scientists could attain a deeper understanding of modern gold placers such as those in Otago NZ and Victoria.

### **3. Scientific environment that encourages new ideas with freedom to challenge dogma**

A scientific environment that encourages new ideas is also likely to be an environment that encourages the best young geologists. Groupthink is a well-known and studied phenomenon of research groups when personalities and dogma dominate to the detriment of advancement. Groupthink works against a positive research environment.

Suggestions to avoid the ill effects of groupthink include:

- Do not ignore data that does not fit
- Pay attention to anomalies, and be alert to *ad hoc* modifications
- Do not assume that someone else has already proved some assumption
- Understand that because a theory explains some observations does not mean it is correct
- Do not be afraid to ask awkward questions and expect considered answers
- Respect any well-thought-out alternatives.

Given that the placer model is assumed and used in virtually all Witwatersrand mining and exploration, it is essential for all to understand it thoroughly, including its strengths and weaknesses, and modern analogues. The same might be said about the alternative metamorphic hydrothermal model as a deep understanding should precede any migration towards one model or the other. An environment in which a model is passed down without question is an unhealthy environment especially for exploration.

Clemens (OGG lecture 2025) highlighted the existence of dogma surrounding the mode of formation of one type of gold deposit (Cu-Au porphyry deposits). In this case there is a *creeping certainty* that someone else has already sorted out the perfect model. Some *unexpected* anomalies from outside economic geology (e.g. structural timing, igneous petrology) had not been anticipated and properly addressed, and he could demonstrate the value of drawing upon geological fields outside economic geology e.g. igneous petrology and experimental petrology.

There needs to be encouragement for the best young geologists in South Africa and beyond to research the Witwatersrand, and they should not be hampered by the existing (unsuccessful) dogma and prejudices against any alternatives.

Instead, the best young researchers need backing, and what they find is what they find! Asking them to re-enforce old models will not create a new future for the country. More likely it will force the best people to move elsewhere. However, there will need to be consideration and respect for previous ideas, and no championing and promulgation of premature and poorly tested ideas just because they are different.

#### **4. Importance of legacy Witwatersrand data**

A worrying pattern was reported during the 2025 Series about the whereabouts, curatorship and accessibility of the century-plus of geological data from the Witwatersrand. It became clear that storage of this valuable national resource had been erratic with whole mines discarding years of data. The Series identified the problem and was determined to help address this but had no instant fixes. Importantly preservation is in the interest of the nation and community, not just the mines. Most of all there needs to be a robust process of ensuring the millions of dollars of previously collected drill-core and data, and current information, is collated and made accessible for future generations of geoscientists to further unlock scientific and economic data from this invaluable data resource. It was pointed out that new ideas—and entirely new deposits—will emerge from the intelligent use of legacy data. This means that everything must be preserved (chips, core, pulps, logs, paper records, and digital files).

A major textbook on the Witwatersrand could be a further way to retain the information gleaned by many geologists and others through their lifetimes of work in industry and academia. Some work is published already in journals but much work is just as important but not written up or less suitable for international journals, e.g. exploration drilling including drilling techniques for resource estimation, core logging, underground geological and sampling maps, types of exploration projects, downhole and surface geophysics applications, mine-scale and regional structural geology, applied mineralogy, and in-house and until-now confidential projects.

The ~140 history of Wits Gold mining and its role, positive and negative, in shaping South African society, geology, research and analytical institutions, mining and economic development, offers Geoheritage and Geotourism opportunities that should be more robustly documented, marketed and unlocked.

### **Summary**

- The 2025 OGG Gold series was one of the most productive and diverse discussions on Witwatersrand gold geology for many years
- The amount of gold remaining in the Witwatersrand is not known accurately, but most estimates suggest that it could sustain mining for decades
- The scientific content of the presentation series was more about providing foundations and information from which to evaluate ideas, rather than simple arguments in favor or against a genetic model

- The need for new and much broader education to understand Witwatersrand geology has become clear.
- Current gaps include understanding of placer gold deposits, structural geology, fluids, metamorphism and alteration
- Groupthink is a phenomenon of research groups that needs to be avoided if new ideas and discoveries are to be given any chance of success.
- The data that remains from 130 years of mining is incredibly valuable when the cost of past drilling, seismic surveys and geological mapping is considered. If lost, much information would be irreplaceable.

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## Notes

**Annexures that support and supplement this Report are being compiled and will be available for distribution shortly.**

**For further information, or if interested parties’ have information to contribute to this initiative, please contact:** Dr John Bristow, [jwbdia@gmail.com](mailto:jwbdia@gmail.com) OR Professor Neil Phillips [neil@phillipsgold.com.au](mailto:neil@phillipsgold.com.au).