



**DEFINING SPECIFIC SUITES OF DIAGNOSTIC  
CHARACTERISTICS OF SOME REDUCED  
INTRUSION-RELATED GOLD SYSTEMS IN  
EASTERN AUSTRALIA**



**September 2015, Michael Leu**





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The information in this presentation that relates to Exploration Information is based on information compiled by Michael Leu a Member of the Australasian Institute of Mining and Metallurgy and the Australian Institute of Geoscientists. Mr. Leu is a qualified geologists and director of Sovereign Gold Company Limited. Mr. Leu has sufficient experience, which is relevant to the style of mineralisation and type of deposit under consideration and to the activity he is undertaking to qualify as Competent Person as defined in the 2012 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves. Mr. Leu consents to the inclusion in this report of the Exploration Information in the form and context in which it appears.

## True Widths

The true-width of most intercepts is not known, mostly downhole lengths reported.



# Specialising in Intrusion-Related Gold Systems

- › Intrusion-Related Gold Systems (IRGS) are a relatively new gold deposit type only defined in 1999.
- › Intrusion-Related Gold Systems (IRGS) include a diverse variety of gold-only deposits with direct spatial and temporal links to intermediate to felsic intrusions and their exsolved fluids. Some can be developed within intrusions (e.g., Hobbs Pipe, Mount Adrah), whilst others can range through proximal to distal from a causative intrusive source.
- › Characterisation of IRGS has developed substantially from research into gold systems in the Tintina Gold Province (TGP) of Alaska and Yukon. Thompson and Newberry (2000) defined Reduced IRGS (RIRGS) to differentiate intrusion-related gold systems associated with magmas of reduced oxidation state from those linked to chalcophile oxidized magmas (Hart 2005).
- › IRGS first identified in the Tintina Gold Province (TGP), Alaska-Yukon
  - “More than 50 million ounces of lode gold resources have been defined in the last 15 years.” (*US Geological Survey*)
  - Almost no lode gold production up to the mid-1990s
- › Similar potential exists in both the New England and Lachlan Orogens in NSW.

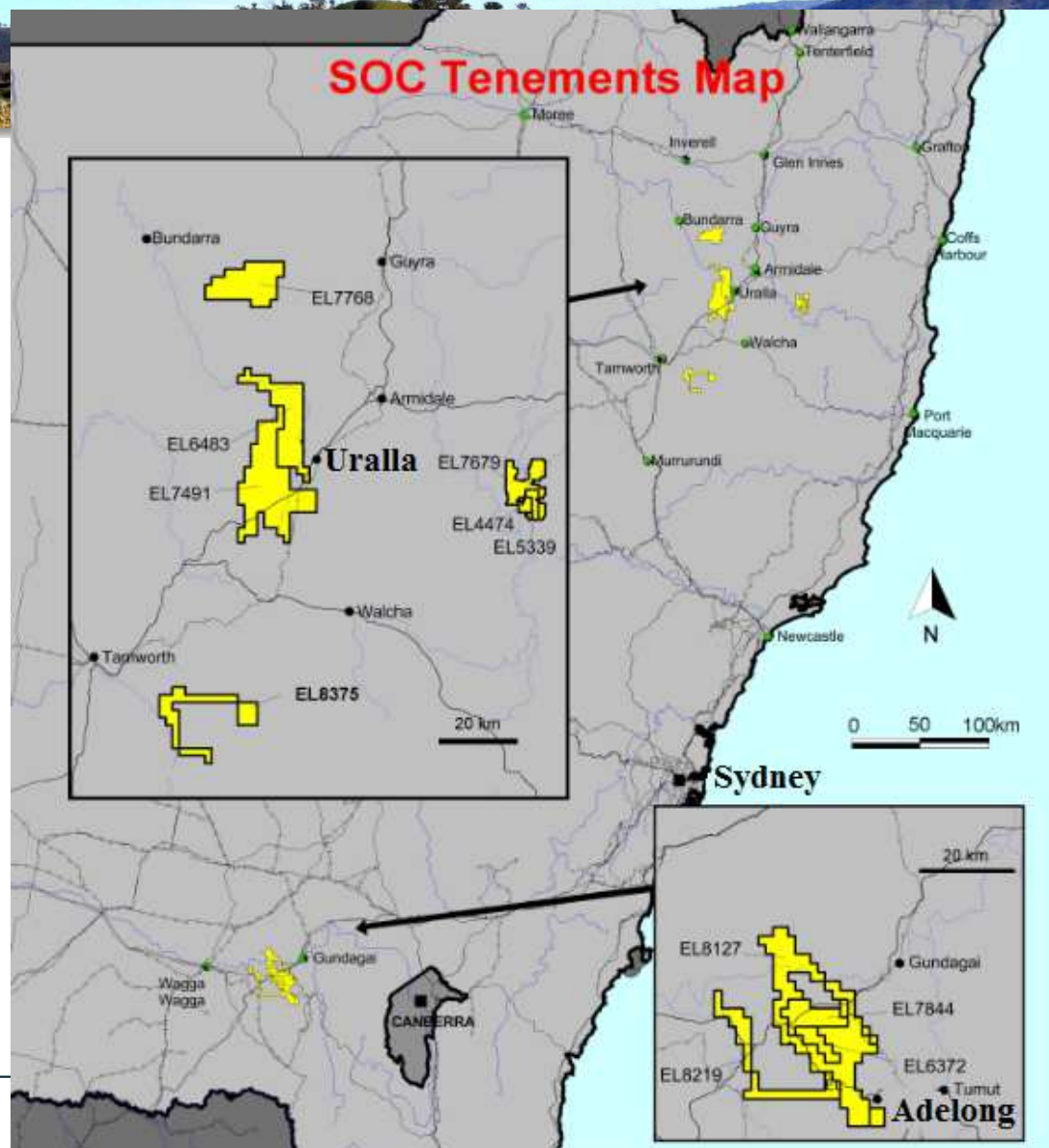


# Sovereign Gold Has Discovered 2 Large RIRGS

- › The Rocky River-Uralla RIRGS in the New England Orogen of Northern NSW.
- › The Hobbs Pipe Mount Adrah in the Lachlan Orogen of Southern NSW.
- › The large mineralised system in Rocky River-Uralla Goldfield has multiple characteristics distinctly diagnostic of well-studied RIRGS.

## Other Assets

- › Halls Peak polymetallic Zn-Pb-Cu-Ag SEDEX deposits.

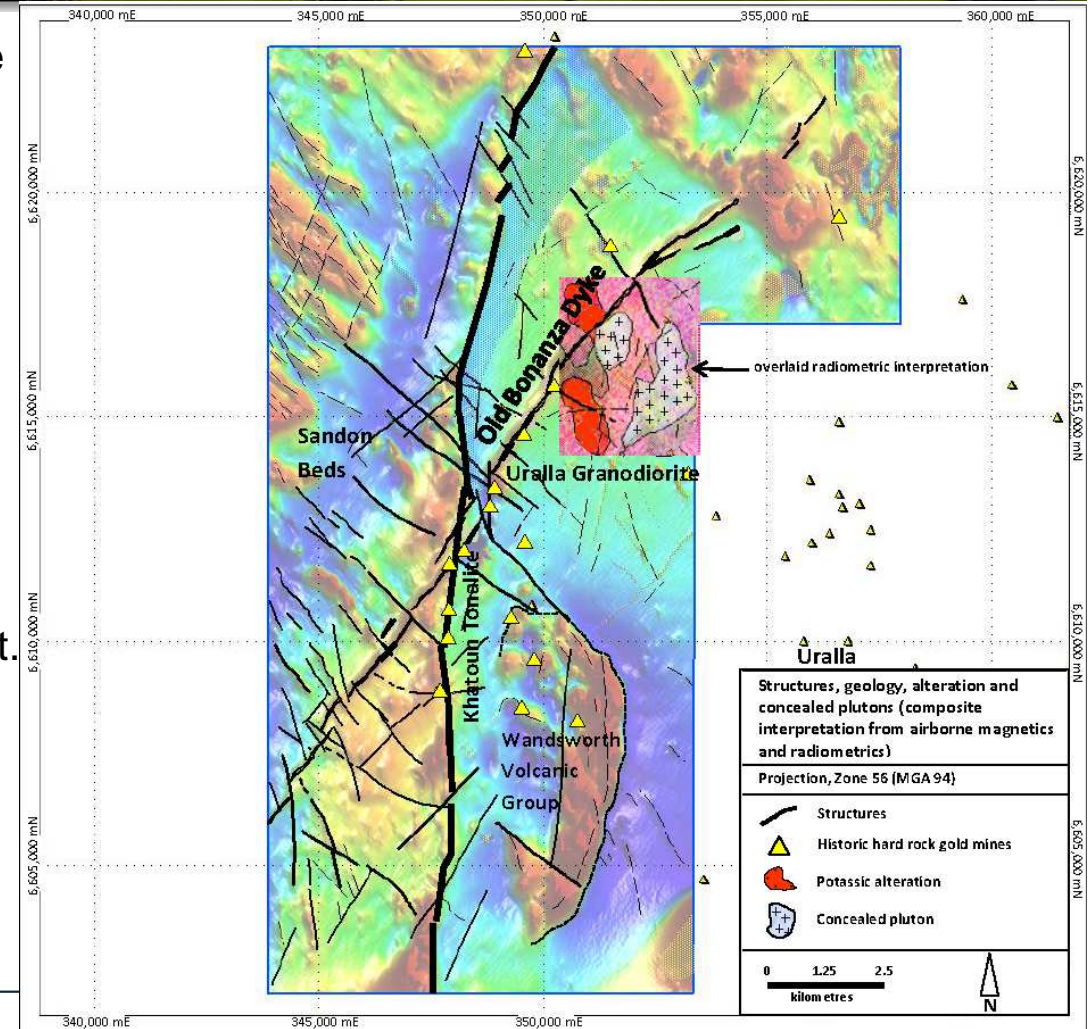






# Airborne Geophysics Identified Large System with Linked Mineralisation

- › The deep lead and recent placer deposits of the Rocky River and Uralla Goldfield yielded 5,200kg of gold during the period 1858-1967.
- › There are 19 historic hard gold mines and prospects that were generally considered disparate, unrelated occurrences.
- › An airborne magnetic and radiometric geophysical survey delineated a linked gold mineralised system that extends at least 11km from north to south and 6.5km from east to west.
- › The yellow triangles depict historic hard rock gold mines and reveal a direct association with strong structural controls, minor plutons and felsic dykes.

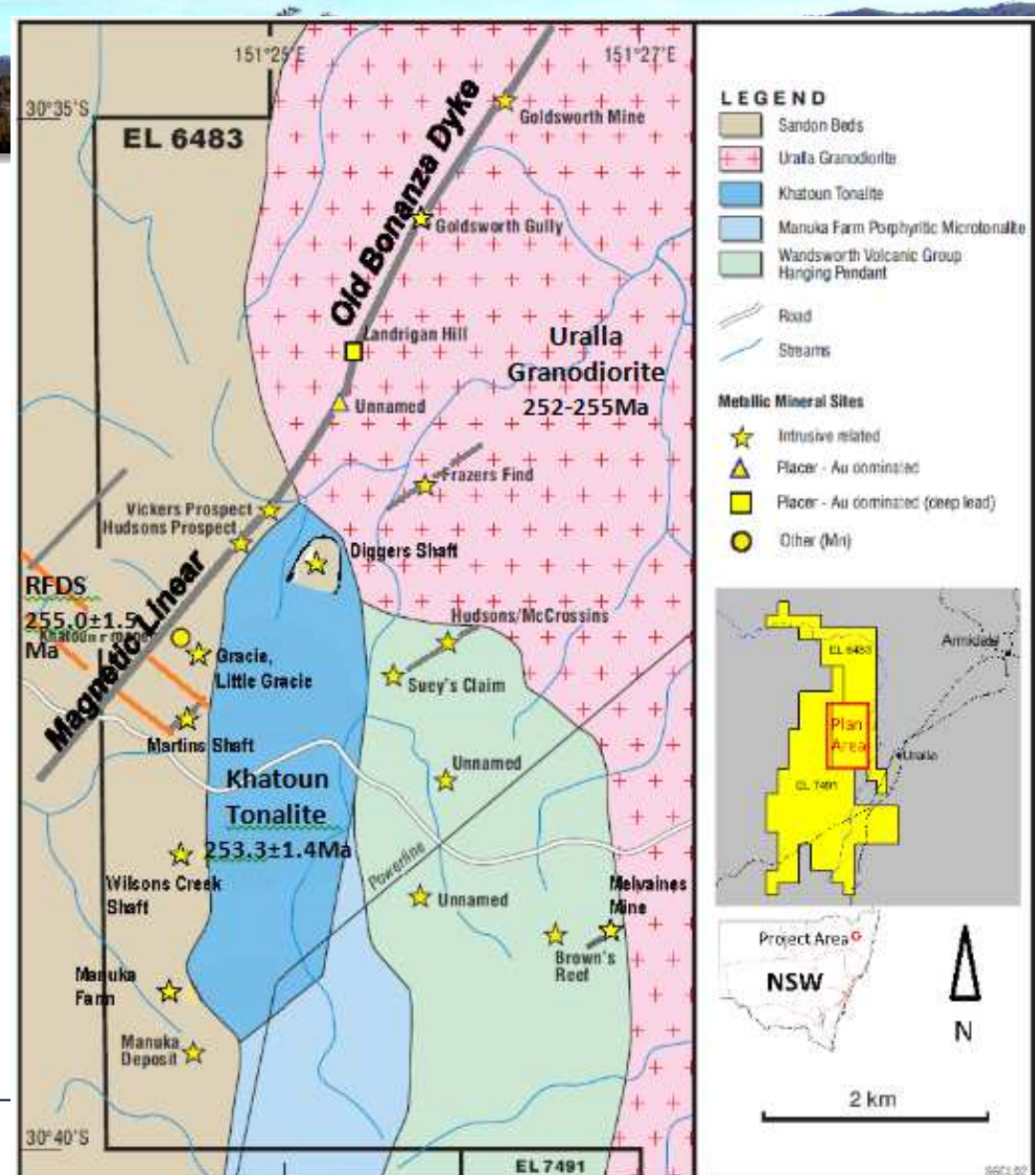




# Gold Mineralisation, Geological and Structural Controls



- › A substantial proportion of the hard rock gold mineralisation is hosted by, and strikes parallel with, northeast trending structures that have been traced over distances of hundreds of metres to several kilometres.
- › These structures and the accompanying gold mineralisation comprise the last tectonic and magmatic events.
- › Many are not controlled by geology and cut through metasediments, the Uralla Granodiorite and the late stage northwest trending RFDS.
- › Gold mineralisation also occurs in roof pendants and along the north-south contact of metasediments with a small elongate pluton (Khatoun Tonalite).

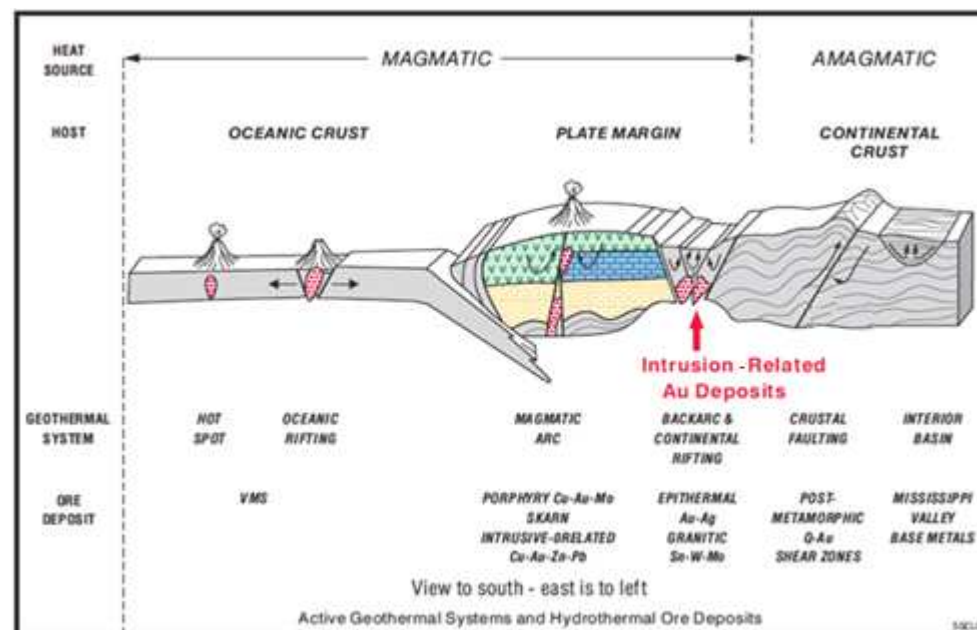






# Regional Scale RIRGS Characteristics

- › A tectonic setting of continental magmatism well-inboard of inferred or recognized convergent plate boundaries.
- › An extensional environment within a thickened-post collisional back-arc setting.
- › Dominated by weakly reduced to moderately oxidised, intermediate to felsic fractionated I-S type magmatism
- › Associated with felsic, ilmenite-series plutons that lack magnetite and have low ferric:ferrous ratios
- › A location in magmatic provinces with historically recorded occurrences in associated granite suites of Sn-W and W-Mo-Bi mineralisation.
- › A regional association with orogenic lode Au deposits.
- › Gold is associated with late stage plutons generated over relatively short intervals of geologic time. They are amongst the final products of much longer time intervals of regional magmatism.
- › Gold mineralisation is coeval with a late stage regional extensional event.





# System Scale RIRGS Characteristics

- › A rich alluvial goldfield associated with extensive granitic magmatism and small-scale, enigmatic hard gold rock mining.
- › A magmatic origin for mineralisation.
- › Geophysical Characteristics (also includes some deposit scale data).
  - Felsic ilmenite-series plutons have low magnetic susceptibilities and flat aeromagnetic responses.
  - Highly fractionated granites that have elevated K, U and some Th. These appear white on composite K-Th-U radiometric images.
- › Geochemical Characteristics.
  - Two types of igneous associations are apparent: intermediate (i.e., granodiorite) I-types ( $\text{SiO}_2 = 60$  to  $70\%$ ), and felsic ( $\text{SiO}_2 = 70$  to  $76\%$ ), high-K, I-type and fractionated. The latter are enriched in incompatible elements (Y, REE, Th, U, Nb) and depleted in compatible elements (Ti, P, Sr, Fe, Mg, Ni, Cr).
  - RIRGS: Metaluminous intrusions that lie near the boundary between ilmenite and magnetite series.
- › Evidence of rapid fractionation and fluid exsolution indicative of volatile saturation during crystallisation at mid to high crustal levels.
- › Controls on and styles of mineralisation include late stage, exsolved felsic-aplitic dykes and areas of potential bulk mineable, sheeted veins.
- › Timing: the gold mineralisation is coeval ( $\pm 2$  m.y.) with associated plutons.
- › Some mineralisation associated with structurally controlled emplacement of elongate small plutons (e.g. Khatoun Tonalite).
- › Granites are equigranular to porphyritic and have subequal quartz, plagioclase and alkali feldspar with minor, usually biotite>amphibole, and minor apatite.
- › Monzogranites that have mixed with volatile-rich lamprophyric melts.





# Deposit Scale RIRGS Characteristics



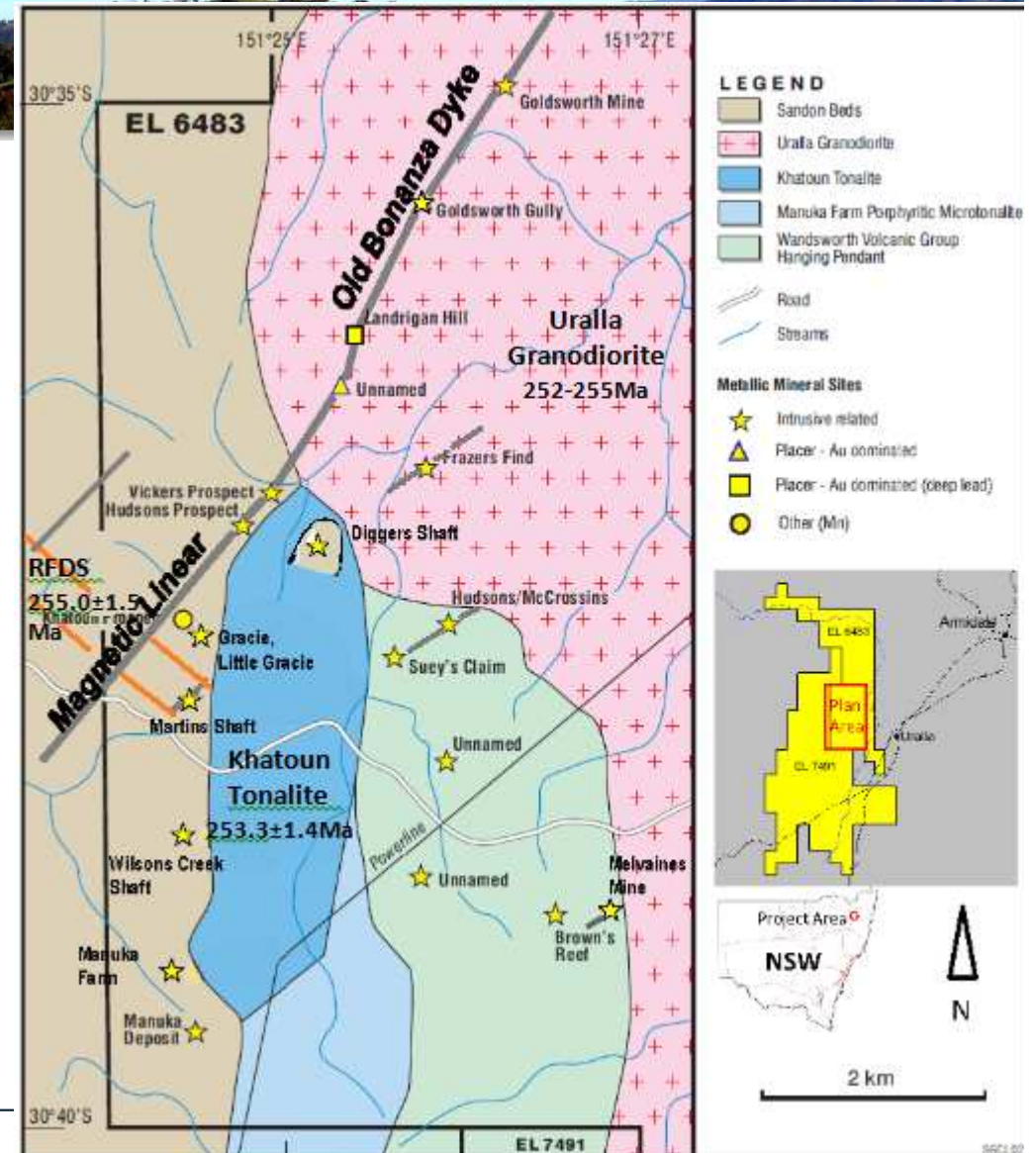
- › Diagnostics geochemical characteristics. Detailed in slides to follow.
- › Pathfinder elements. As, Sb and Bi are the most useful elements to map fluid conduits and mineralisation. Sb and Bi exhibit low mobility and even low values are useful in defining locations of mineralised structures.
- › Metal assemblages are gold-dominant with anomalous As, Sb, Bi ( $\pm$ ) and W ( $\pm$ ), but Te can often be below detection. The occurrence of trace base metal sulphides and arsenopyrite is a favourable indicator for gold mineralisation.
- › A low sulphide mineral content, mostly <5 vol%, with a reduced ore mineral assemblage that typically comprises arsenopyrite, pyrrhotite (minor to absent) and pyrite, and lacks magnetite or hematite.
- › The gold is fine-grained.
- › Alteration styles: Gold mineralisation dominantly associated by phyllic (sericite-quartz-sulphide $\pm$ carbonate) alteration; lesser tourmalinisation.
- › The presence of significant base metal sulphides in some veins, associated with intensely altered host rocks, distinguishes the Uralla mineralisation from typical orogenic gold mineralisation.
- › Deposit style, size, morphology and architecture. Detailed in slides to follow.



# Gold Associated with Melts Generated Over Short Intervals of Geologic Time



- › Gold is associated with late stage plutons generated over relatively short intervals of geologic time. They are amongst the final products of much longer time intervals of regional magmatism.
  - Uralla Granodiorite 252-255Ma
  - Small elongate pluton Khatoun Tonalite  $253.3 \pm 1.4$  Ma
  - A component of the Regional Felsic Dyke Swarm (RFDS) hosting Martins Shaft  $255.0 \pm 1.5$  Ma
- › Indistinguishable in Age, massive late stage melting event.
- › Similarly gold mineralisation of the Tombstone-Tungsten belt of the TGP belongs to the most inboard and youngest of the plutonic suites that were emplaced during a brief (~5 m.y.) period, e.g., Fort Knox (93.5-92.4Ma), Clear Creek (93.6-91.7Ma) and Scheelite Dome (94.6-92.7Ma).



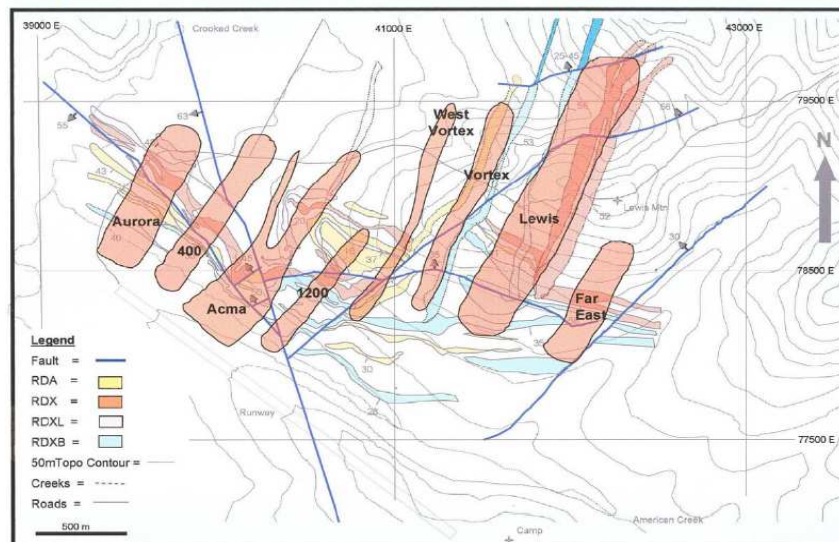




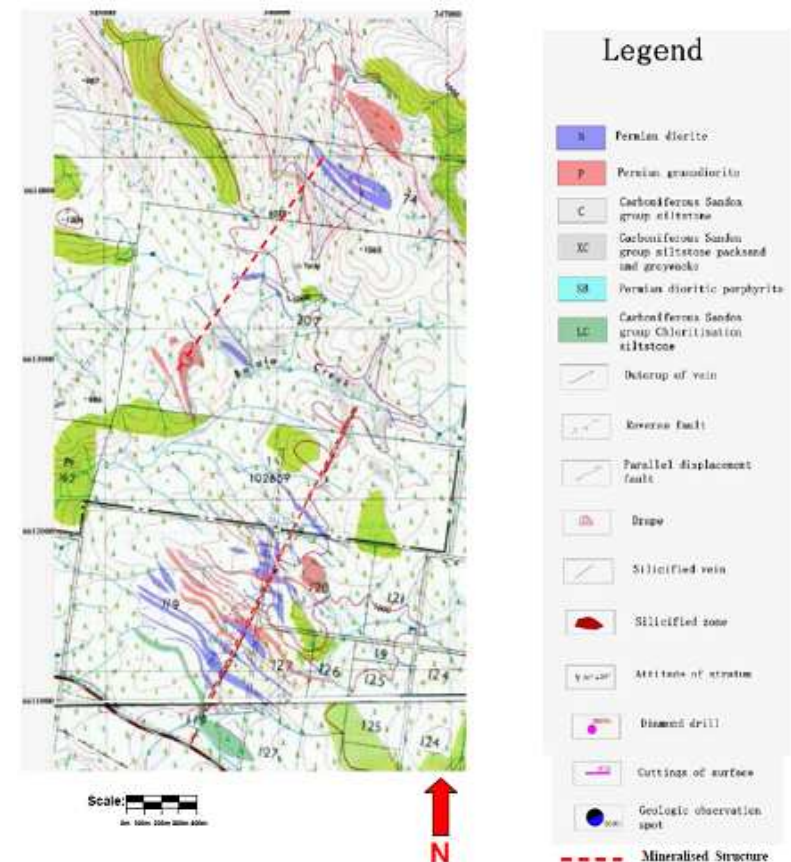
# Gold Mineralisation Coeval with Late Stage Extensional Regional Event

- › Mineralisation is associated with a series of late stage NE trending structures developed in a regional extensional event . Many are not controlled by geology and cut through metasediments, the Uralla Granodiorite and the late stage northwest trending RFDS. These structures and the accompanying gold mineralisation comprise the last tectonic and magmatic events.
- › The plutons associated with gold mineralization within the Tombstone-Tungsten belt (TGP) were emplaced in brief period of weak extension that followed foreland-directed thrusting and crustal thickening, and were the last magmatic response
- › Multiple NE gold-bearing structures including 1.55km long structure with both high grade - up to 12.35 g/t Au over 0.5m and wide (13.90 metres @ 1.45g/t Au, 11.88g/t Ag from 13.79-27.69m downhole) gold mineralisation.

Figure 9-1: Major Mineralized Corridors – Donlin Creek Resource Area (Piekenbrock and Petsel, 2003)



Geological Map of Area containing Mineralised Structure







# Diagnostic Magnetic and Radiometric Responses



## Magnetic Response

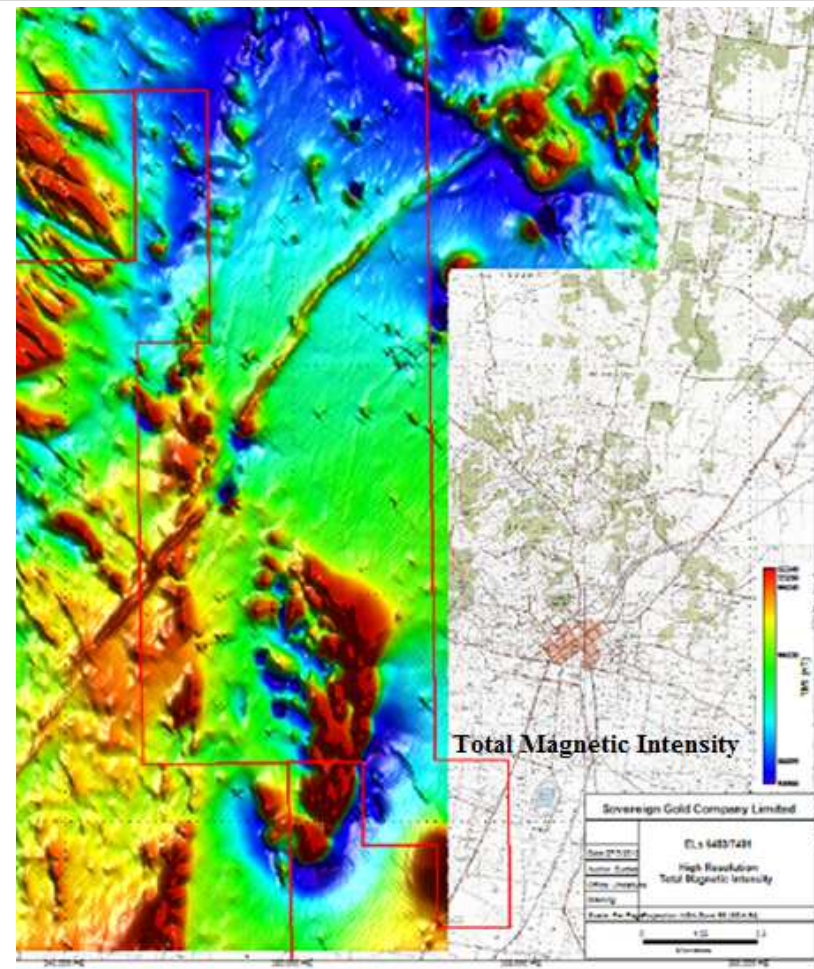
- › The reduced to weakly oxidised plutons have a relatively nonmagnetic response and are of relatively uniform low magnetic relief.

## Radiometric Response

Fractionated granites will have elevated K and U and, in the case of metaluminous I-types, will also have high Th. These will appear white on composite K-Th-U radiometric images (Blevin 2005).

- › Uralla Granodiorite: Has a mottled, whitish appearance indicative of an elevated spectrometric response in all energy bands. The Khatoun Tonalite and the Manuka Farm Microtonalite are characterised by more potassic/felsic response.

Radiometric response (three main radiometric channels K-potassium, U-Uranium and Th-Thorium; KUT-RGB)







# Potential Targets, Effective Exploration Methods



## Potential Targets

- › Shallow bulk mineable sheeted vein systems (1-2g/t Au), auriferous felsic dykes, the preserved carapace of a pluton beneath mineralised hornfelsed metasediments, concealed mineralised small plutons (<500m diameter), hypogene gold within late stage northeast trending structures and along pluton-metasediment contacts. Target model of several satellite mineralised zones (resource blocks) of up to 100,000 ounces.
- › Coinciding anomalies (airborne/ground geophysics supported by soil geochemistry and mapping geology, structure and alteration) effectively define drill targets e.g., airborne magnetics and radiometrics have revealed extensive potassic alteration coupled with potential small plutons emplaced within the Uralla Granodiorite. Jogged, bifurcating and intersecting structures can generate wider zones for mineralisation.

## Diagnostics Geochemical Characteristics

- › The soil and stream sediment geochemical anomalies of RIRGS can be subtle relative to other mineral systems and many explorers have misinterpreted the potential of the magnitude and hence missed out on discoveries.
- › Geochemical Exploration Case Histories - TGP: Hart (2004) studied exploration and discovery histories in the TGP and determined most deposits give surface soil anomalies of 40-100ppb Au, and C-horizon anomalies of 100-250ppb Au. He noted stream sediments with >40ppm As and >10ppb Au ... may best target favourable regions ... for Donlin Creek-Style mineralisation. **Case History:** Dublin Gulch, 4 million ounces of Gold. Gold values were as high as 299ppb, but are typically ~30ppb, with arsenic mostly between 300 and 1,300ppm. Ivanhoe Goldfields Ltd. made the discovery after targeting a region of anomalous soil samples (>50ppb Au) that had been identified but not followed-up by previous exploration programs.
- › Known areas of gold mineralisation within the Rocky River-Uralla RIRGS are expressed Au and As of similar magnitude.



# Alteration, Metallogeny, Mineralisation Styles



- › Drilling has confirmed gold mineralisation in altered felsic dykes (Martins Shaft, continuous from surface to 219m depth), along several northeast trending structures and in sheeted veins systems in the Uralla Granodiorite.
- › Gold is hosted by phyllic alteration (quartz-sericite-sulphides) associated with sheeted quartz-sulphide veins and disseminated mineralisation in dykes (felsic and lesser lamprophyric).
- › Gold-bearing, low sulphide-quartz, epithermally textured, sheeted sub-parallel vein arrays are present in plutons, dykes (e.g. Uralla Granodiorite, Rowbottom's property) and metasediments (e.g. Gracies mine and Hudsons-McCrossins mine). These can be traced over tens to hundreds of metres but near surface gold grades and vein spacing density to date have been insufficient to support economic deposits.
- › Roof pendants within Uralla Granodiorite (Wandsworth Volcanics Group) and Khatoun Tonalite (Sandon Beds) host auriferous sheeted veins. Potential exists for gold mineralisation to be preserved within a pluton's carapace beneath hornfelsed metasediments.
- › Martins Shaft: Disseminated and sheeted vein gold mineralisation within altered predominantly felsic (intrusive phases and host dyke) and lesser lamprophyre dykes. It is hosted in a late stage northeast trending structure cutting a dyke of the RFDS that is in contact with the small, elongated pluton of the Khatoun Tonalite.



Martins Shaft: SGRDD003, sheeted sulphide veins (3mm wide, euhedral pyrite and arsenopyrite) in phyllic altered felsic dyke



Martins Shaft: SGRDD002, sheeted sulphide (arsenopyrite, pyrite) veins (2-4mm wide) in phyllic altered felsic dyke (around 26m)





# Alteration, Metallogeny, Mineralisation Styles



Martins Shaft: SGRDD004, 19.6 g/tg Au, 2.18oz/t Ag, 0.64%/t Sb from 58m (HQ core, diameter 63.5mm). Vein filling composed of abundant carbonate (calcite), plus crudely banded and disseminated medium to coarse grained sulphides, minor, but locally abundant fine-grained sericite and a little quartz.

Martins Shaft: Carbonate alteration accompanying Au mineralisation.

Sheeted carbonate-sulphide veins in phyllic altered felsic dyke.



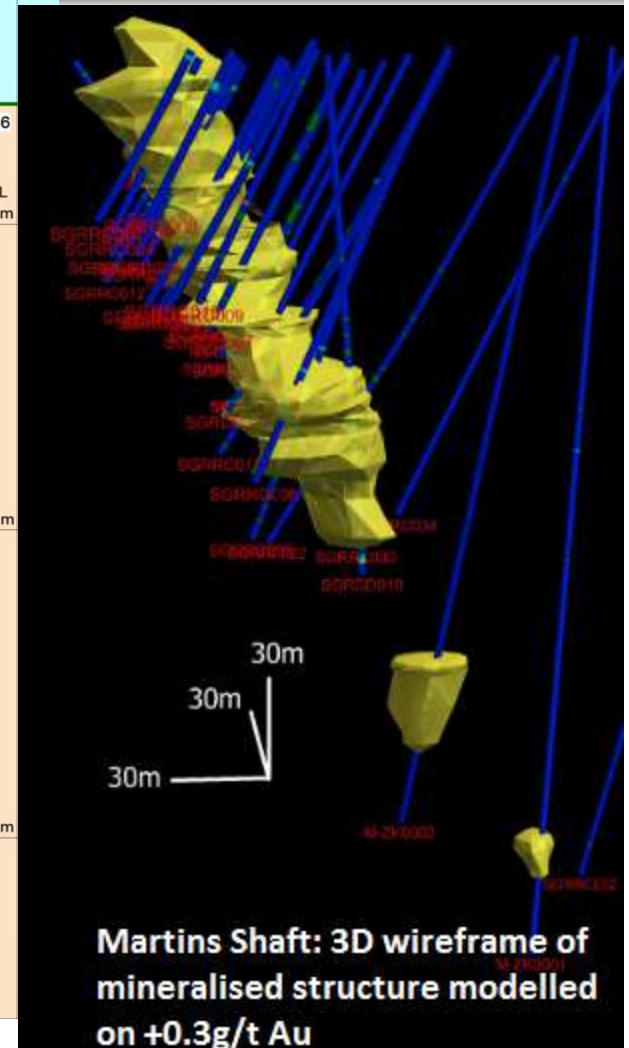
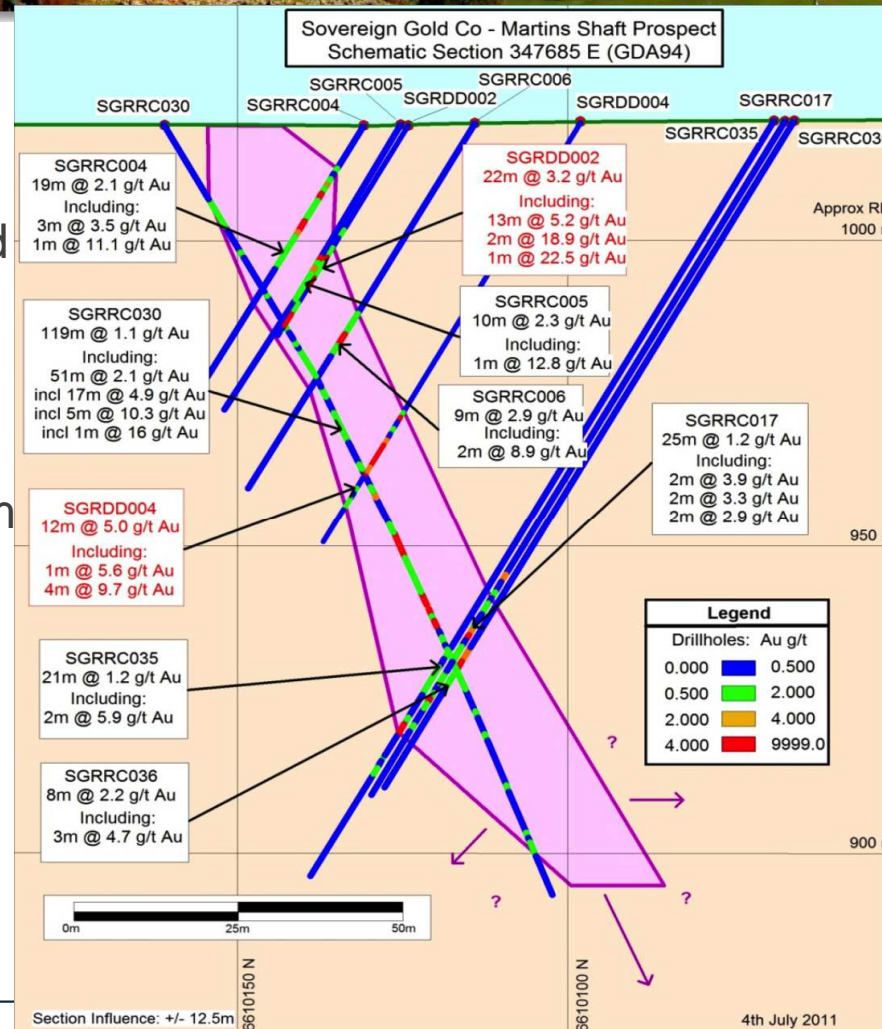
Martins Shaft: SGRDD002, close-spaced sheeted, carbonate-quartz-pyrite-arsenopyrite veins in phyllic altered felsic dyke (around 27m). 27-28m, 10.5 grams/tonne gold, 13.35 grams/tonne silver (HQ core, diameter 63.5mm).



# Martins Shaft

Drill intersections include

- SGRDD002: 22m @ 3.2 g/t Au, including 10m @ 6.1 g/t Au and 2m @ 18.9 g/t Au
- SGRDD004: 18m @ 3.5g/t Au including 7m @ 7.5g/t Au and 1m @ 19.6g/t Au
- Gold mineralisation confirmed to 217.6m downhole. True width 10-27m







# Epizonal Settings



Many of the gold-bearing deposits in the Rocky River-Uralla RIRGS are epizonal (Wilsons Creek mine, Hudsons-McCrossins mine, Bannaweera Structures, Goldsworth mine, Gracies mine, Little Gracies mine, Hudsons prospect, Vickers prospect).

Indicates the bulk of the system still exists at depth and it is highly probable some of these structures will be conduits directly linked at depth to a causative pluton. Mineralisation with Ag-Pb-Zn metal associations indicates a distal position in relation to causative pluton.

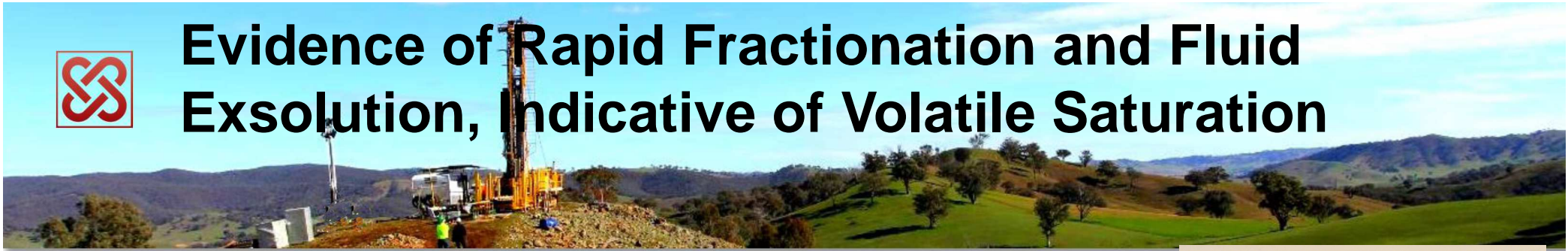
Lattice textures at Hudsons McCrossins Mine; sheeted veins Gracie Mine; sheeted quartz sulphide veins in phyllic altered Uralla Granodiorite, Goldsworth Mine.







# Evidence of Rapid Fractionation and Fluid Exsolution, Indicative of Volatile Saturation



Evidence of rapid fractionation and fluid exsolution indicative of volatile saturation during crystallisation are widespread and include:

Aplitic and pegmatitic dykes, miarolitic cavities, leucocratic dykes, tourmaline and tourmalinisation, zoned dykes containing tourmaline and minor topaz.

Melvaines Mine: miarolitic textures with tourmaline (black mineral), indicative of the late stage volatile portion of the magma becoming trapped within the body of the dyke. 'Boron-streaming' is one of the last stages in the release of magmatic fluids. The last magmatic stages are frequently associated with gold deposition in RIRGS. Plumose euhedral tourmaline within silicified intrusive dyke.

Paul Ashley (2013) noted the mineral proportions in the leucocratic monzogranite indicate that the rock type is strongly fractionated and probably close to granite minimum melt composition.







# Gold Mineralisation Coeval Late Stage Felsic and Lesser Lamprophyre Dykes



Various late stage phases of fractionated mineralised felsic dykes and exsolved fluids have also invaded NE trending structures within metasediments or earlier intrusives.



Bannaweera NE Trending Structure SGRDD043, 32-33m. Brecciated metasediments exhibiting quartz-sulphide-felsic dyke flooding. The light brown material (centre of core) is a finger of felsic dyke with disseminated sulphides that has forced its way through the metasediments.

SGRDD043, 32-33m. Detail of light brown felsic dyke and quartz veins, with disseminated sulphides, extruding through brecciated metasediments (field of view L-R 25mm).





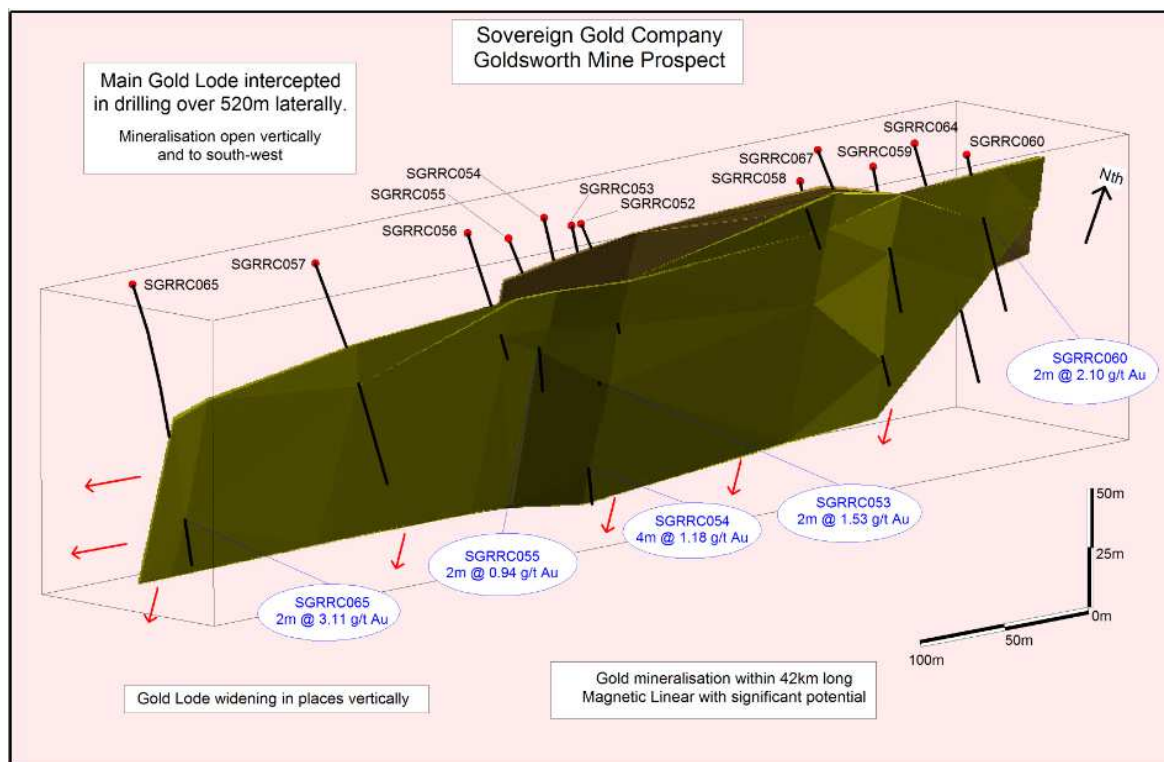
# Some NE Trending Gold-Bearing Structures Several Kilometres Long



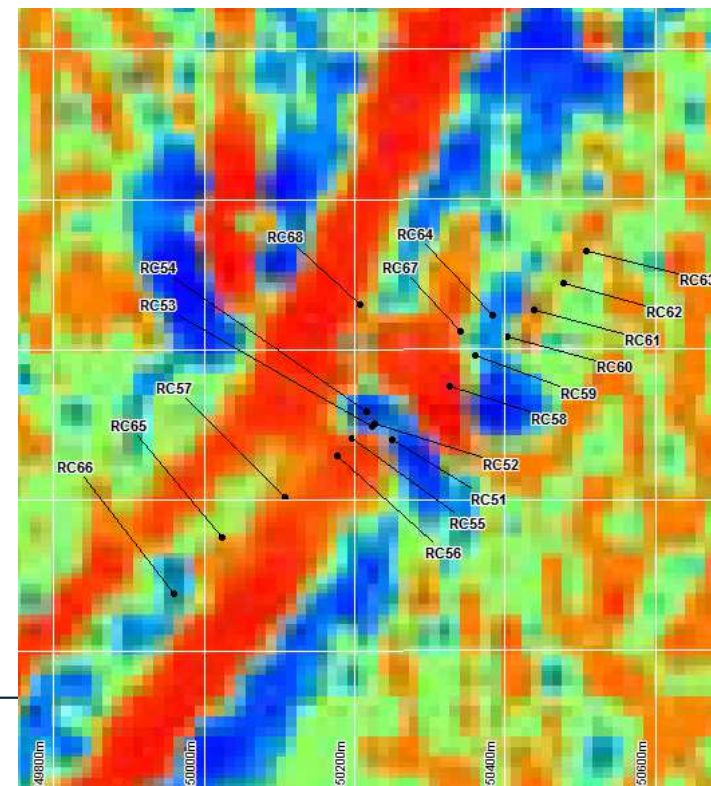
The Goldsworth mine area: Mineralisation is present for 570m along the strike of the magnetic linear and to a depth of 108m downhole (open in all directions).

Drilling encountered narrow zones of gold mineralisation ranging from 1-4m wide (down-hole width). The widest intercept was 4m at 1.17g/t Au, including 1m at 2.7g/t Au from 101-105m downhole. The highest grade was 1m at 5.14g/t Au from 103-104m from an interval of 3m @ 2.14g/t Au from 102-105m downhole.

The Goldsworth mine area, 3D wireframe of mineralised structure and drill hole plots.



Jagged magnetic linear, Goldsworth mine area.

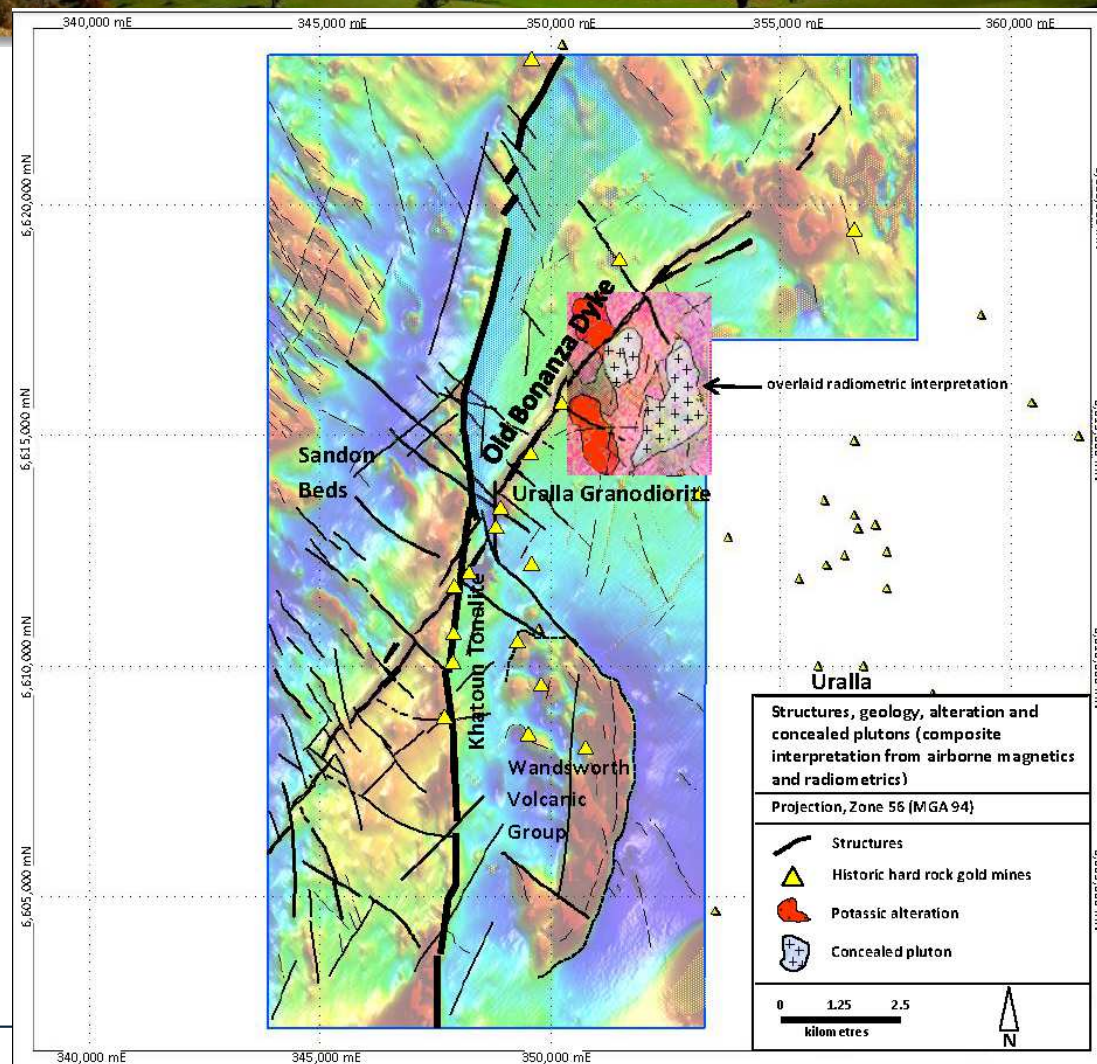






# Airborne Geophysics has Identified Several Potential Small Blind Plutons

- › The magnetic linear has defined a significant structure that has channelled mineralising fluids. It hosts several historic gold mines and some recently discovered soil and rock chip anomalies. There are untested targets over many kilometres that are either on/or immediately adjacent to this structure.
- › The airborne geophysical survey has identified potential small, concealed plutons linked with large areas of potassic alteration (radiometric overlay) that are associated with the gold mineralisation of the Goldsworth mine and jogging of the magnetic linear.





# Hobbs Pipe Mount Adrah



- The Hobbs Pipe at Mt Adrah is on the Gilmore Fault Zone – the same large-scale tectono-structural system that hosts several World-class gold and base metal deposits and mines, including the Northparkes Mine, Cadia-Ridgeway and Cowal gold mines.
- Hobbs Pipe Mineral Resource estimate: 770,000 oz of gold (440,000 oz Indicated; 330,000 oz Inferred), within a total Mineral Resource estimate of 20.5Mt at 1.1 g/t gold, at various cut-off grades.



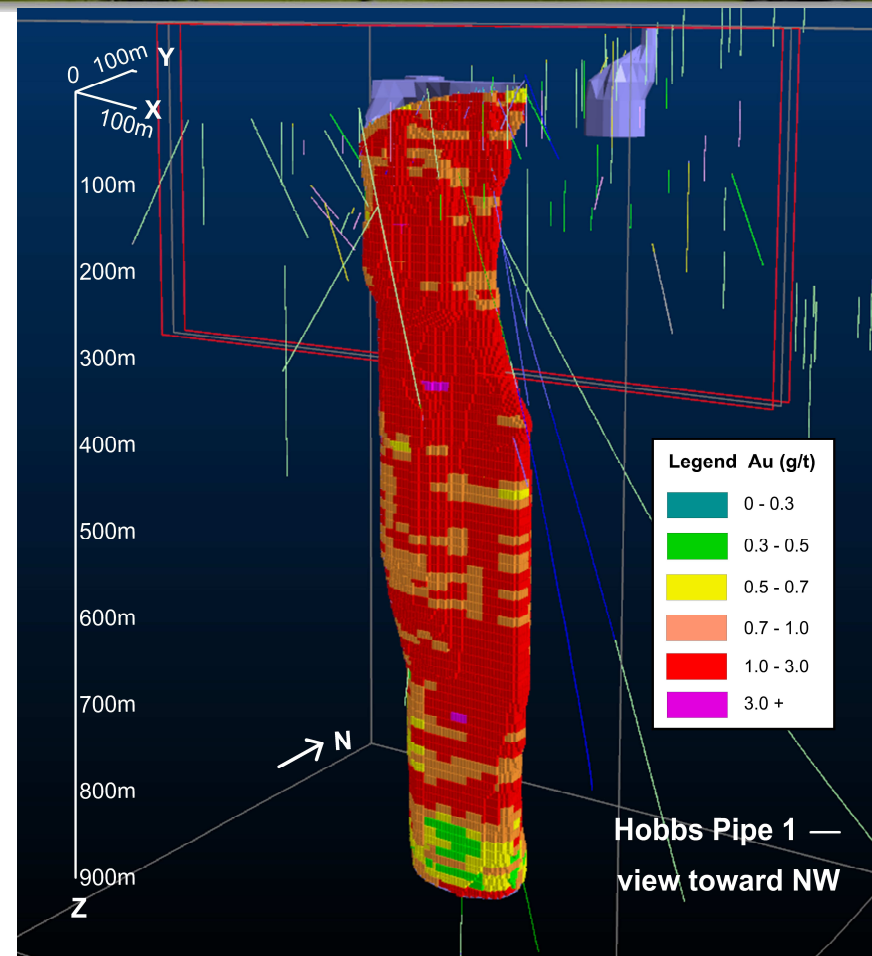




# Hobbs Pipe Remarkable Homogenous Mineralisation



- The Hobbs Pipe is a transversely sub-elliptical, vertical stock composed of weakly oxidised altered monzodiorite that is 180m x 160m in diameter at 500m vertically below surface.
- Remarkably homogenous gold mineralisation from surface to a vertical depth of at least 886m (limit of drilling).
- Drill Hole GHD001: 1.17g/t Au from 0.0-886m, including 1.3g/t Au from 0.0-720m; 1.4g/t Au from 0.0-400m; 104m @ 1.6g/t Au from 292-396m; 50m @ 1.9g/t Au from 300-350m; 96m @ 1.6g/t Au from 622-718m.
- The Hobbs Pipe has undergone pervasive phyllic alteration with the dominant sulphide phases being arsenopyrite and pyrite (total <5%) associated with <10% free gold.
- It exhibits the enigmatic RIRGS characteristics of negligible quantities of the typically ubiquitous felsic magmatic fluid components of Bi and Mo.
- Sodium content 2.86% (GHD001).
- Petrochemical work by Wormald and Price indicated that mineralisation is directly linked to relatively deep level passive crystallization of the magma.
- The Hobbs Pipe provides the opportunity to study an RIRGS that crystallised under deep confining pressure.



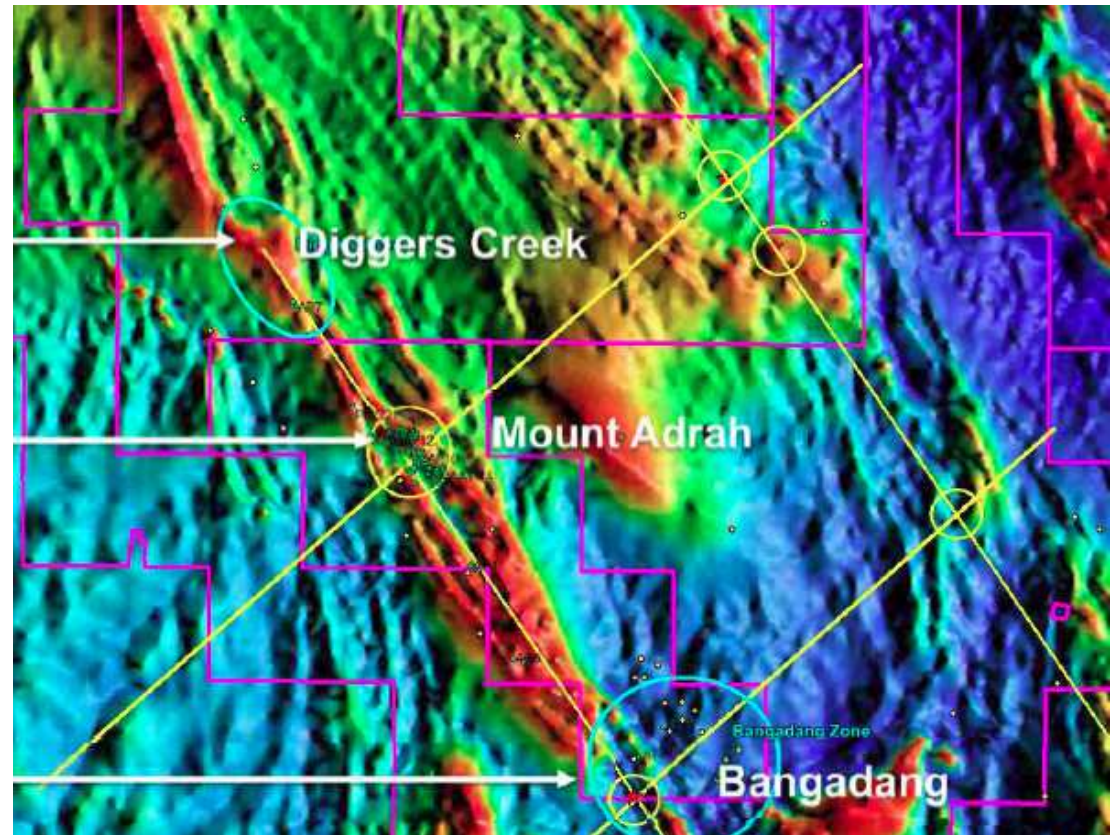






# Quality Targets in Close Proximity to Mt Adrah

- Multiple historical gold mines extend from Diggers Creek to Bangadang (10km south of Mt Adrah).
- Geophysical (magnetics, radiometrics, IP), geochemical and ground mapping (alteration, mineralisation styles) surveys have identified potential targets for repetitions of Hobbs Pipe-style mineralisation.





# Conclusion



- Sovereign Gold Company Limited is currently researching two RIRGS in New South Wales.
- The Hobbs Pipe RIRGS in the Lachlan Orogen and the Rocky River-Uralla RIRGS in the New England Orogen.
- The large mineralised system in Rocky River-Uralla Goldfield (RRUG) has multiple characteristics diagnostic of well-studied RIRGS. They provide a template for explorationists to identify similar auriferous systems within the granite belts of the New England Orogen.



# Appendices







# Alteration, Metallogeny, Mineralisation Styles



Martins Shaft: Euhedral pyrite and arsenopyrite in sericite-quartz (phyllic) altered felsic dyke.

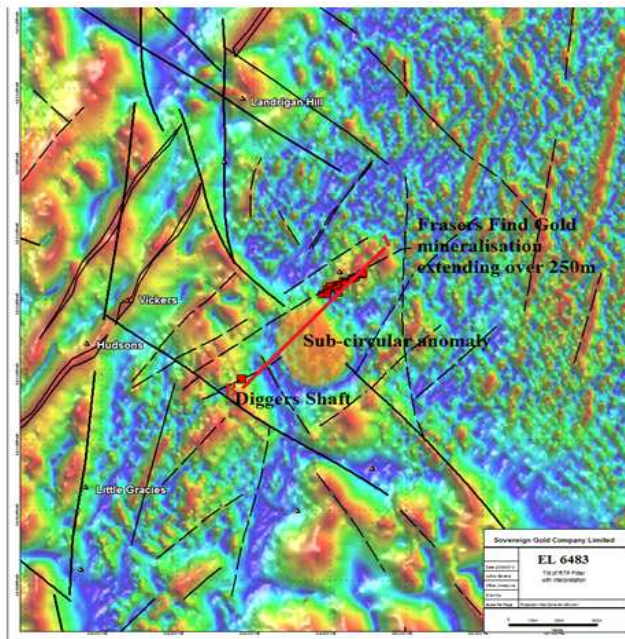




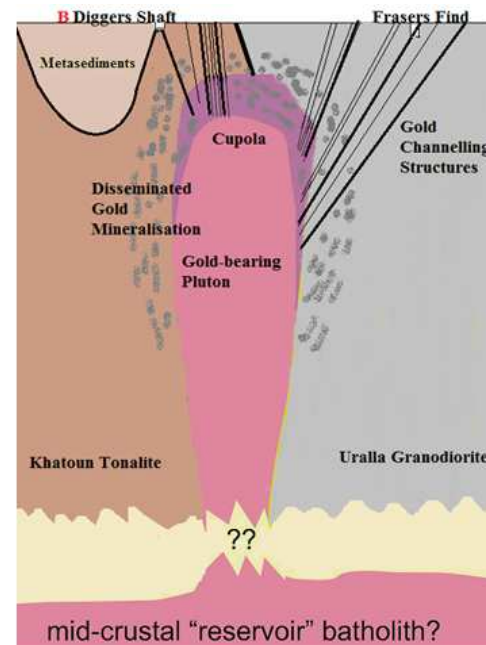


# Fraser's Find, Narrow Vein High Grade Gold Mineralisation in High Level Feeder Structure

Fraser's Find: Narrow vein high grade structures several hundred metres long: 19.1/t Au and 141g/t Ag over 0.6m from 11.1-11.7m downhole; 25.1g/t Au and 5.6g/t Ag over 0.11m from 23.84-23.95m downhole; 10.0g/t Au and 316g/t Ag over 0.13m from 27.0-27.13m downhole.



Sub-circular Magnetic Anomaly with Radial Structures Hosting the Gold Mineralisation of Fraser's Find and Diggers Shaft.



Fraser's Find Feeder Structure Above Potential Gold-Bearing Pipe Pluton.



SGRDD033: closest to the potential causative blind pluton; encountered a wide mineralised zone in altered granodiorite over 27.35m downhole (from 11.75 - 39.1m) comprising narrow sulphide bearing alteration veins with anomalous gold, the highest grade vein 19.2 g/t Au over 0.16m (top core row).



# Classic IRGS Diagnostic Characteristics

Key characteristics of IRGS	Donlin Creek, Alaska	Sovereign (Martins Shaft)
History	Region with alluvial gold production 1909-1956 (30,000 ounces) but minimal hard rock mining.	✓
Mineralisation Lithological Control	Mineralisation is best developed in the competent felsic intrusive dykes and metasediments	✓
Gold Mineralisation	Gold mineralisation is associated with quartz±carbonate and sulphide vein and veinlet networks (dominant) as well as disseminated in favourable host rocks.	✓
Mineralisation Structural Control	Mineralisation is structurally controlled along NNE-trending extensional fault/fracture zones	✓
Multiple Gold Deposits	Gold mineralisation in numerous deposits that are part of a Gold-Arsenic-Antimony hydrothermal system	✓
Tectonic Setting	A post accretionary basin-fill flysch sequence that has been intruded and locally overlain intrusions, dykes, sills and subaerial volcanic rocks.	✓
Magnetic Signature	Mineralisation is related to a low magnetic signature in the intrusive rocks	✓
Plutonic rocks	Plutonic rocks comprise monzonite, quartz monzonite, syenite, granodiorite and granite, and both intrude and are overlain by coeval volcanic rocks.	✓
Gold Hosts	Disseminated gold-bearing sulphides	✓
Geochemical Signature	Gold-arsenic-antimony geochemical signature	✓
Alteration	Vein zones occur within larger, continuous zones, or mineralised “corridors”, with phyllic alteration.	✓





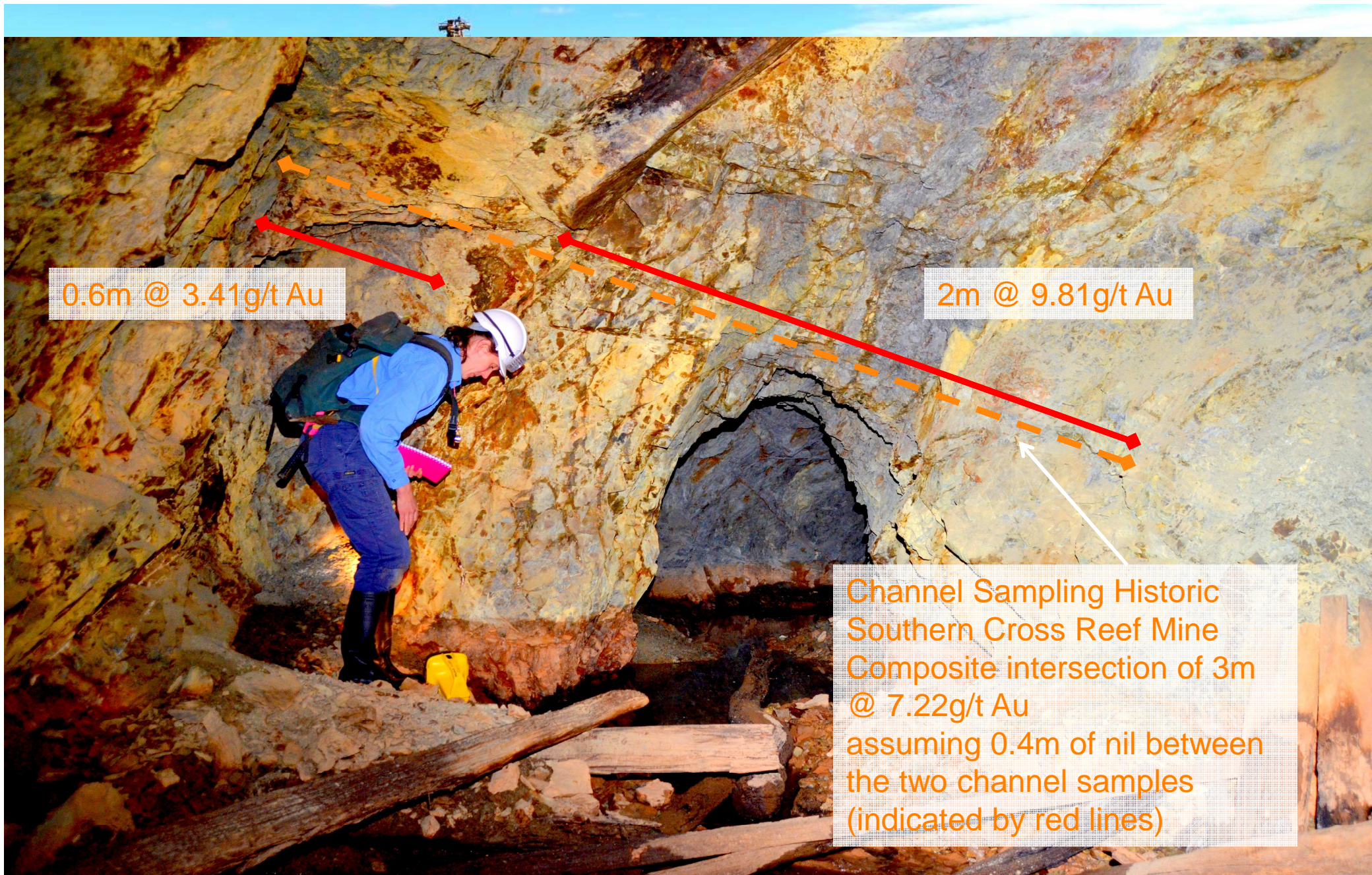
# White Deer Reef



Further high grade gold was discovered in the **White Deer Reef**, a parallel structure ~50m to the NE of the Castor Reef.

1.2m @ 61g/t Au





0.6m @ 3.41g/t Au

2m @ 9.81g/t Au

Channel Sampling Historic  
Southern Cross Reef Mine  
Composite intersection of 3m  
@ 7.22g/t Au  
assuming 0.4m of nil between  
the two channel samples  
(indicated by red lines)