Refining the gold exploration model at the Hyperion Deposit, Tanami: Integrating structural, petrographic, and geochemical analyses

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Introduction

The Tanami Region hosts several multimillion-ounce gold deposits formed during a Palaeoproterozoic shortening event ca 1805–1791 Ma; this event is referred to as the Granites-Tanami Orogeny (GTO) by Bagas *et al* (2008) and the Stafford Event by Crispe *et al* (2007) and Maidment *et al* (2020). Major gold deposits, including Callie and Groundrush, are spatially associated with regional-scale shear zones and complex structural intersections.

The Hyperion Deposit, located within the Central Tanami structural corridor of the Northern Territory, is a structurally-controlled orogenic gold system hosted within mafic and metasedimentary rocks of the Mount Charles Formation **(Figure 1)**. It is situated within the same structural corridor as major known gold deposits and shares key geological attributes characteristic of Tanami orogenic systems. Recent drilling has identified high-grade intercepts at depth, necessitating refinement of earlier structural and lithological models to better constrain shoot

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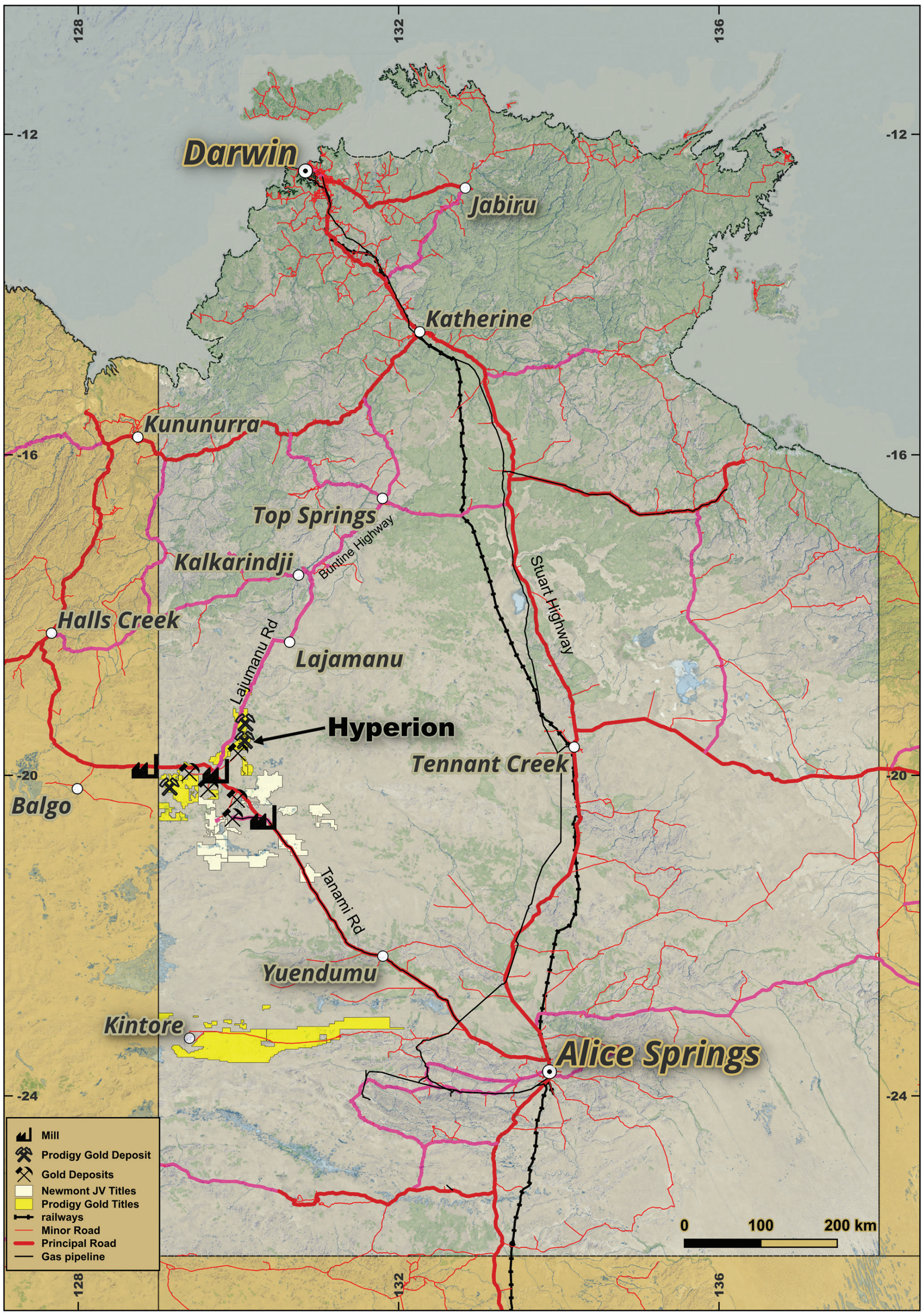


Figure 1. Location of Hyperion Deposit within the Tanami Region of the Northern Territory.

geometry and mineralisation continuity. An integrated program comprising reverse circulation drilling, oriented diamond drilling, borehole televiewer surveys, detailed structural logging, petrography, and geochemical analysis was undertaken to improve predictive targeting.

These new data show that mineralisation is controlled by moderately-to-steeply west-dipping vein systems developed within a structurally focused corridor associated with the Hyperion Fault and related splays. Multi-generation quartz-carbonate veins, episodic brittle reactivation, and rheological contrasts between dolerite and metasedimentary units collectively localised dilation and high-grade shoot development. Most gold-rich intervals (26.9 g/t Au) in drill core HYRCD25002 feature clusters of gold grains associated with brecciated quartz veins and altered mafic rocks.

Historical exploration at Hyperion began in 2001 with geochemical reconnaissance before proceeding to systematic drilling and resource definition beginning in 2011. But the structural framework of the deposit has previously been poorly understood because of inconsistent core orientation and limited structural measurements. The present program aims to integrate structural, petrographical and geochemical datasets to refine the mineralisation model and improve targeting of plunge-controlled high-grade shoots.

Geological setting

Hyperion is hosted within north-south trending mafic volcanic and intrusive rocks interlayered with sedimentary units of the Mount Charles Formation. These units are thrust against younger stratigraphy of the Killi Killi Formation along the regionally significant Suplejack Shear Zone (SSZ) **(Figure 2)**. Deformation during the GTO involved folding, thrust and strike-slip faulting and greenschist facies metamorphism.

Gold mineralisation is spatially associated with west-northwest-striking faults that intersect the dominant stratigraphic orientation and the Hyperion Fault corridor.

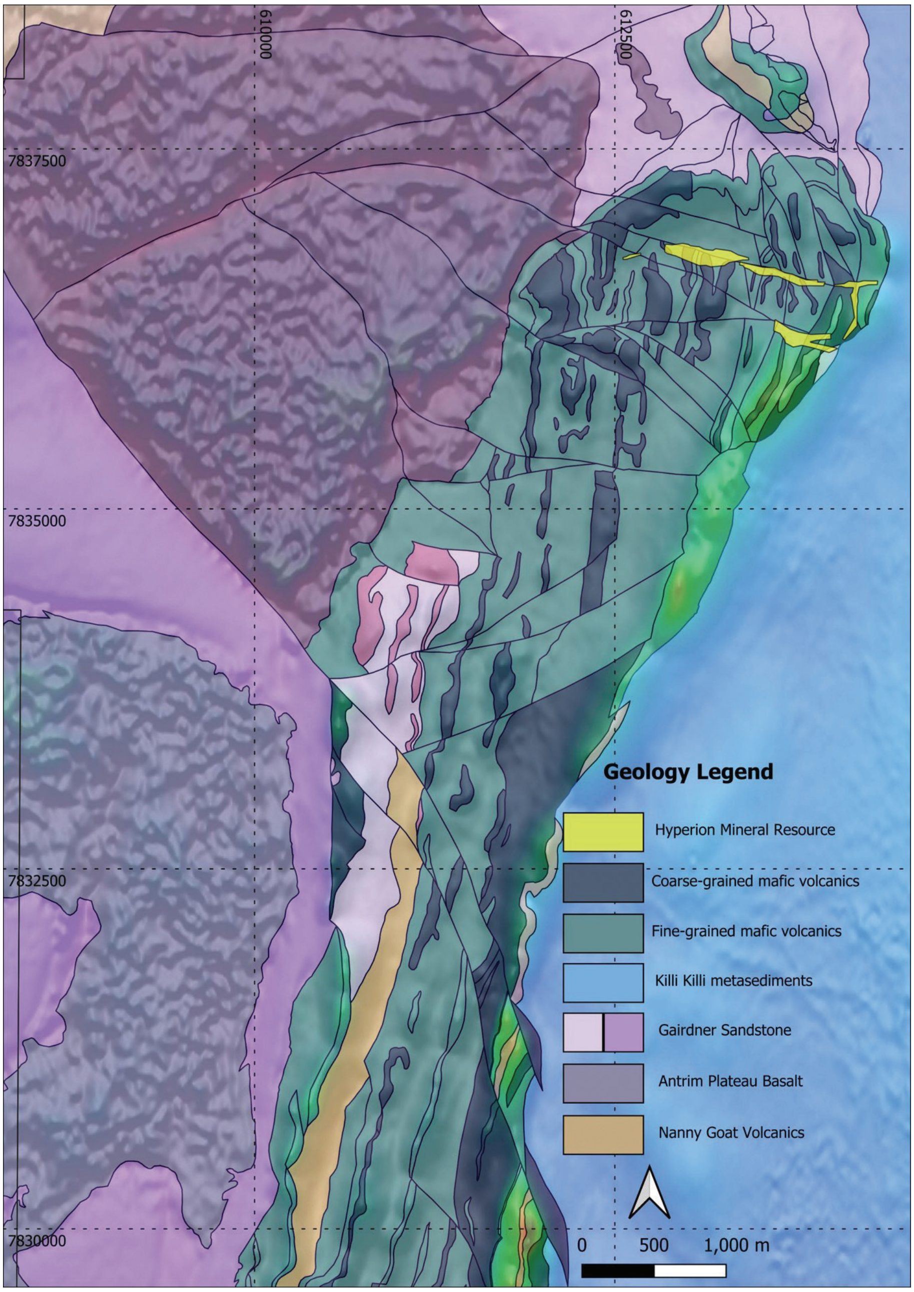


Figure 2. Geological setting Hyperion Gold Deposit.

Structural preparation, rheological contrasts, and repeated brittle-ductile reactivation are interpreted to have played key roles in localising hydrothermal fluid flow.

Drilling and analytical methods

Two HQ diamond drillholes (HYDD25001 and HYDD25002; total 602.8 m) and two NQ diamond tails (HYRCD25001 and HYRCD25002; total 202.9 m) were completed in October 2025 to test down-dip and along-strike extensions of mineralisation and to obtain oriented core for structural analysis. Core was logged in detail for lithology, alteration, veining and structural features. Samples were analysed via 40 g fire assay with ICP–AES finish.

Borehole acoustic televiewer (below water table) and optical televiewer (above water table) surveys were undertaken to capture structural orientation data in zones of broken or poorly-oriented core for one HQ diamond hole (HYDD25001). Petrographic analysis was conducted on selected mineralised and non-mineralised intervals to determine paragenesis and gold deportment.

Vein data were first classified into extensional and shear veins based on observed cross-cutting, offsetting, and abutting relationships in the core. To objectively identify distinct vein sets within both extensional and shear vein populations, clustering techniques were applied to lower-hemisphere stereographic projections. Cluster robustness was evaluated using Pmax (cluster homogeneity), Dmax (cluster separation) and Silhouette coefficient values, which together assess the internal consistency, separation, and goodness of fit of the identified clusters (eg Vollmer 2022). Relative timing relationships between vein sets were subsequently constrained using cross-cutting, offsetting, and abutting relationships, where observable. These observations were compiled into directional matrices, providing a quantitative framework for establishing the relative chronology of vein development.

Selected core from the diamond tails (HYRCD25001 and HYRCD25002), covering a range of gold grades, was scanned with the CSIRO-developed Maia X-ray fluorescence (XRF) mapper to characterise the distribution of native gold grains and major elements. This analysis aimed to elucidate the rock textures and microstructures, as well as to establish relationships among gold mineralisation, hydrothermal alteration and veins.

Structural architecture and vein chronology

Approximately 76% of the veins documented at the Hyperion deposit are extensional. Statistical clustering of the extensional vein orientations indicates the presence of at least four distinct vein sets: (i) a gently dipping (<30°), east-trending vein set; (ii) a moderately dipping (31–60°), north-trending vein set; (iii) a steeply dipping (>61°), east-southeast-trending vein set; and (iv) a steeply dipping (>61°), northeast-trending vein set **(Figure 3)**.

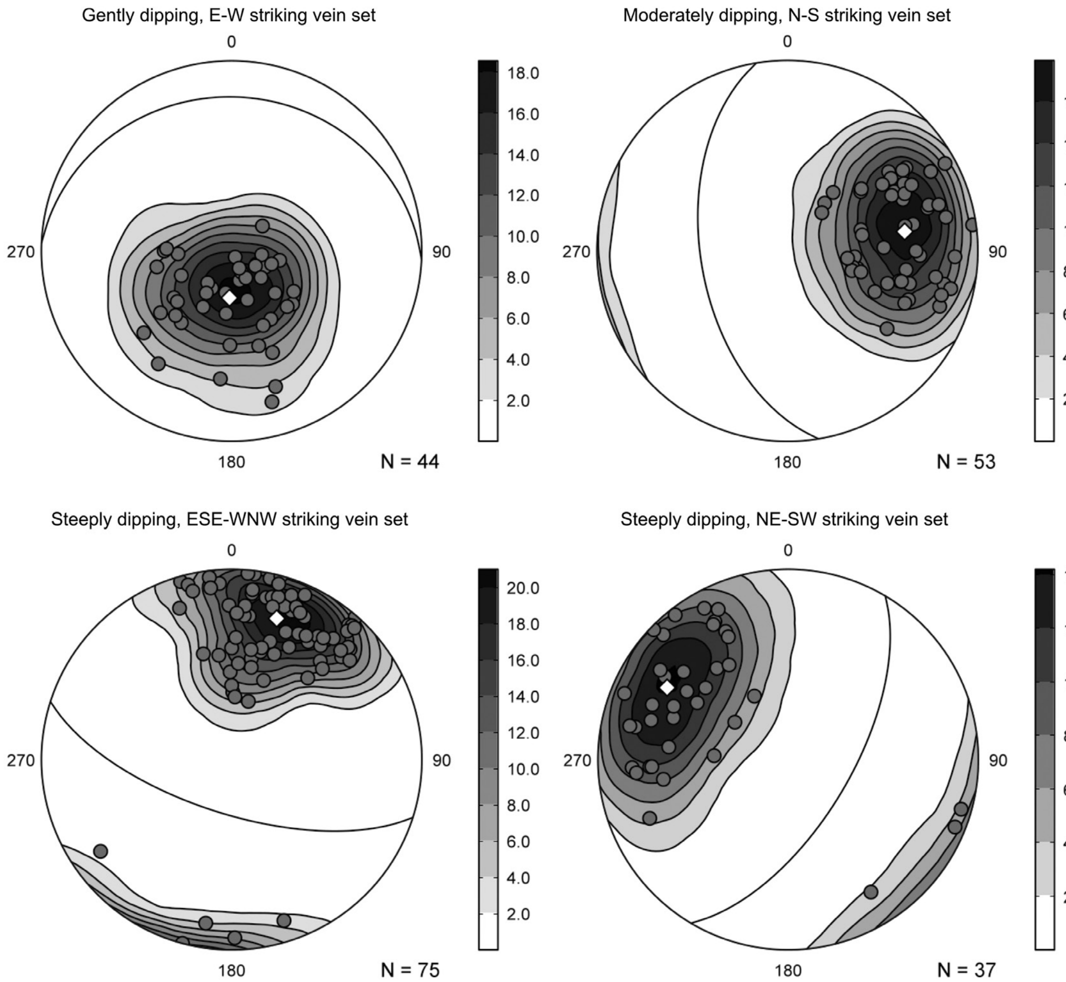


Figure 3. Equal-area, lower-hemisphere stereographic projection of poles to extensional veins showing four distinct vein sets.

Temporal relationships between these extensional vein sets are dominated by cross-cutting rather than rather than abutting relationships. Although the observed cross-cutting and abutting relationships define a complex and non-linear temporal evolution, a relative chronology can nevertheless be established. The steeply dipping, east-southeast-trending vein set is interpreted to be the oldest, whereas the steeply dipping, northeast-trending vein set represents the youngest phase of extensional veining. Sulphide mineralisation (pyrite + arsenopyrite ± gold ± chalcopyrite) is observed across all four extensional vein sets, indicating repeated episodes of ore-bearing fluid flow during the structural evolution of the Tanami Region. However, sulphide mineralisation is most prominently developed within the east-southeast-trending vein set.

Statistical clustering of shear vein orientations suggests at least three distinct vein sets: (i) a moderately dipping, south-southeast-trending vein set; (ii) a subvertical west-northwest-trending vein set; and (iii) a subvertical, northeast-trending vein set. Two of these shear vein sets form a conjugate pair. Sulphide mineralisation is observed within the south-southeast-trending and the northeast-trending vein sets, indicating that shear-related structures also played a significant role in focusing mineralising fluids.

Our structural results were compared with detailed structural analyses from vein-hosted gold mineralisation of the Callie deposit at the Dead Bullock Soak mining camp (documented by Petrella *et al* 2020). At Callie, the main vein-hosted gold mineralisation is associated with east-southeast-trending and northeast-trending vein sets (Petrella *et al* 2020). Comparable vein orientations are also recognised at the Hyperion deposit, where these vein sets similarly contain sulphide mineralisation, indicating a shared structural control on mineralising fluid flow. The U–Pb xenotime geochronology from the Callie deposit constrains the timing of vein-hosted mineralisation to ca 1805 Ma (Petrella *et al* 2020). Based on the geometric relationships between vein orientation, axial planar cleavage and fold hinge line orientations, the east-southeast-trending vein set is interpreted to have formed during northwest-southeast-directed shortening. In addition to these dominant vein sets, Petrella *et al* (2020) also documented minor gold mineralisation hosted in gently dipping, east-trending veins at Callie. A similarly oriented vein set is also observed at the Hyperion deposit. This vein set is interpreted to have formed during the east–west-directed shortening event (Petrella *et al* 2020). Based on U–Pb monazite and xenotime dating, the age of this shortening event is constrained at ca 1791 Ma (Petrella *et al*l 2019).

Diamond drilling confirms a complex, multi-phase vein system. Vein styles include:

- Early, narrow, fracture-controlled quartz veinlets that cross-cut the foliation.
- Thicker (centimetre-scale) quartz + carbonate veins that exploited and dilated earlier fractures.
- Anastomosing stockwork networks that developed in zones of structural dilation.
- Late, narrow quartz stringers that reflect waning hydrothermal activity.

Crack-seal textures, brecciation and repeated cementation indicate episodic brittle reactivation and multiple pulses of hydrothermal activity rather than a single mineralising event. Vein density increases within structurally disturbed intervals and at lithological contacts, particularly between competent dolerite and more ductile metasedimentary rocks.

Mineralisation at the Hyperion Deposit occurs within the regional Suplejack Shear Zone (SSZ), a long-lived structural corridor that also hosts the nearby Groundrush Gold Deposit. At Groundrush, gold is hosted predominantly in stacked quartz ± carbonate extensional and shear veins developed within competent mafic intrusive rocks (quartz dolerite/dolerite) that intrude Killi Killi Formation sediments, with mineralisation associated with minor sulphides (pyrite ± arsenopyrite ± pyrrhotite). The Hyperion deposit is similarly characterised by shear-hosted quartz veins with pyrite developed within mafic volcanic and intrusive lithologies interbedded with sedimentary rocks; mineralisation is localised by higher-angle fault sets operating within the broader SSZ structural framework. In both settings, rheological contrasts between mafic units and surrounding sediments, coupled with episodic brittle deformation and dilation along oblique fault intersections, are together interpreted to have focused hydrothermal fluid flow and vein development. Although the deposits differ in scale and development maturity, the shared structural position, host lithology associations and vein-dominated mineralisation style indicate a comparable Tanami-style orogenic gold system operating along the same regional corridor.

Mineralisation at Groundrush is structurally controlled and developed within a major northwest-trending deformation corridor. Gold is associated with steeply dipping (typically 60–80°) quartz ± carbonate ± sulphide veins emplaced within brittle–ductile shear zones and locally enhanced in dilation sites and structural flexures. Vein arrays are broadly parallel to the regional structural grain of the Tanami belt and reflect transpressional deformation and episodic fluid flow during orogenic gold mineralisation. This structural architecture is consistent with published descriptions of the Tanami Mine Corridor and Central Tanami Project deposits (eg Wyborn *et al* 1998, Bagas *et al* 2008, Tanami Gold NL Half Year Report 2021).

Extensive zones of lensoidal extensional veining are developed within the principal shear-hosted mineralisation at Groundrush. The irregular geometry of these veins, particularly where they form complex contacts with the host dolerite and quartz dolerite, locally complicates reliable orientation measurements. Consequently, structural data have predominantly been collected from narrower, more planar veins. Measured veins are generally moderately-to-steeply west-dipping, with a subordinate population of shallowly west-dipping veins also recognized (Annison 2017). No systematic distinction is evident between the orientations of mineralised and barren veins at Groundrush (Annison 2017).

Alteration and gold deportment

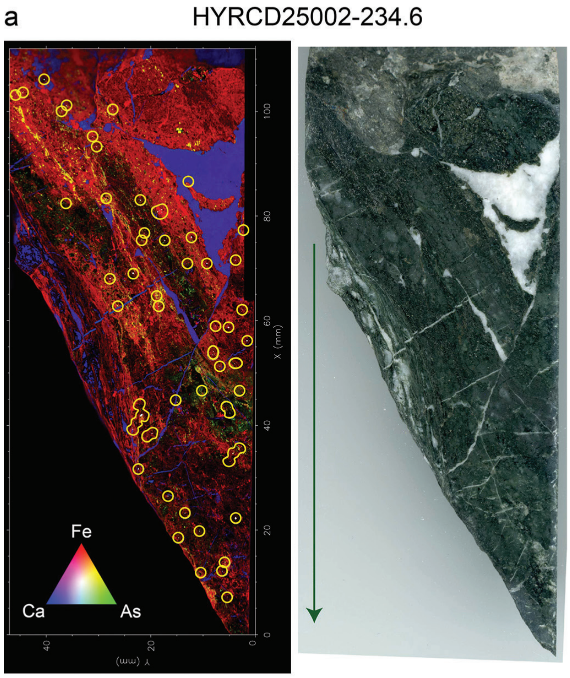
The least mineralised rocks record lower greenschist facies assemblages, characterised by euhedral albite, actinolite, quartz, chlorite and pyrite, with minor epidote and carbonate veinlets. The mineralised zone is bordered by K-alteration, including a sericitisation zone and shear zones characterised by biotite + chlorite assemblages. Sulphides (pyrite and arsenopyrite) and gold are concentrated within the central brecciated zone. Visible gold (~0.3 cm) has been observed at 235.4 m in drillhole HYRCD25002, occurring along the margins of brecciated quartz and enclosed within chlorite and carbonate (**Figure 4**). Sulphide mineralisation is structurally controlled and spatially associated with increased vein density and stronger alteration intensity.

Selected drill cores without visible gold were scanned using the CSIRO-developed Maia XRF scanner to detect gold grains too small to be identified visually or which may be enclosed within quartz and silicate minerals. A high-grade interval (8.7 g/t Au) in drillhole HYRCD25002 was revealed to contain clusters of native gold grains (up to several hundred mm) and fine-grained arsenopyrite within altered mafic matrix, both within and adjacent to brecciated quartz veins. Associated sericitised rocks locally contain native gold and are cross-cut by late-stage dolomite veins. Back-scattered electron (BSE) imaging shows that gold clusters comprise multiple fine-grained native gold particles ranging from <10 µm to ~100 µm. In contrast, low-grade intervals (<1 g/t Au) contain euhedral arsenopyrite disseminated in chlorite + muscovite + biotite + quartz altered and sheared rocks.

Drillhole HYRCD25001 contains lower gold grades (<4 g/t Au) but more abundant arsenopyrite. Mineralisation occurs in two styles. Outside the main brecciated zone, veins of arsenopyrite + pyrite with discrete gold grains are associated with chloritisation and sericitisation. Within the main brecciated zone, abundant arsenopyrite with minor pyrite occurs in sericitised and quartz breccia, hosting fine-grained native gold. Fine-grained euhedral arsenopyrite and dolomite locally overprint earlier pyrite and quartz mineralisation **(Figure 5)**.

Lithogeochemistry

Lithogeochemical studies at the Groundrush gold deposit demonstrate that integrated whole-rock geochemistry



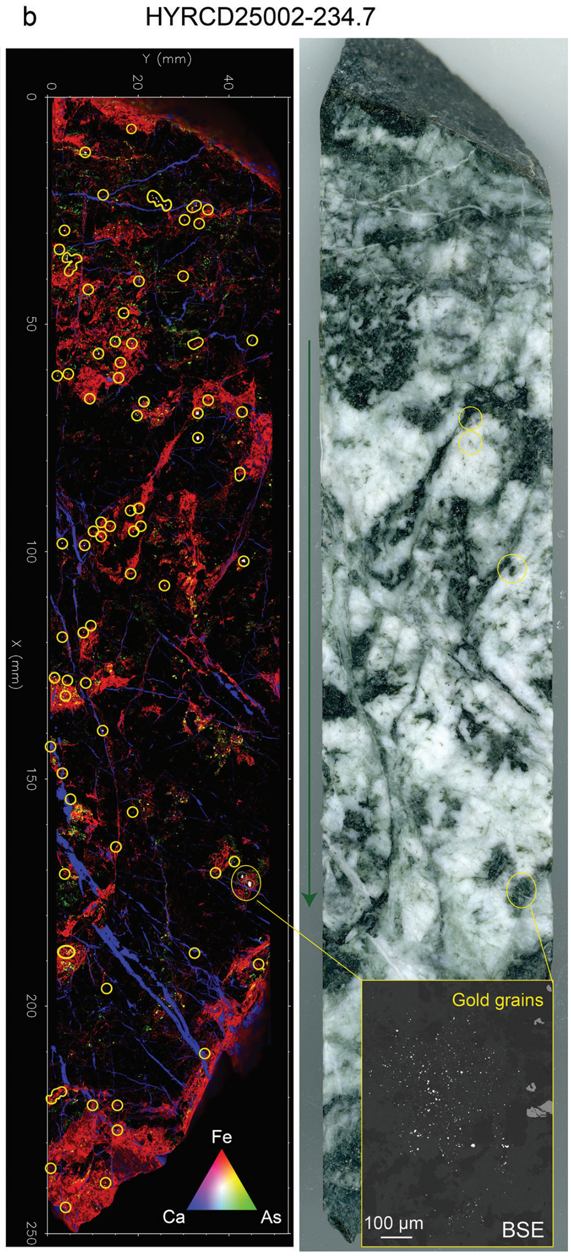


Figure 4. Gold distribution in the high-grade gold interval of HYRCD25002, shown by comparison between optical photographs and three-element false-color (red-green-blue) XRF maps, where gold is highlighted by white spots and circles. Gold grains are also observed in the back-scattered electron image insert.

provides an effective framework for resolving host stratigraphy and hydrothermal alteration within the Tanami Mine Corridor. Immobile element systematics enable discrimination of sedimentary protoliths through to strongly deformed sequences, and mass-balance approaches define potassium enrichment and carbonate-sulphide addition associated with gold mineralisation. Gold is spatially associated with arsenopyrite-bearing quartz ± carbonate veins emplaced within structurally prepared, chemically reactive units (Murphy and Stanley 2007).

Building on this framework, Prodigy Gold NL has initiated the first integrated 3D structural, mineralogical and lithogeochemical investigation of the Hyperion deposit in collaboration with CSIRO. The program is designed to test the hypothesis that gold mineralisation within the Hyperion–Tethys system is spatially controlled by structurally-focused fluid flow along discrete, multi-phase vein corridors developed within a broader transpressional deformation framework. By integrating quantitative vein orientation analysis, gold deportment studies and alteration geochemistry, the study aims to resolve the controls on gold distribution at multiple scales and establish predictive criteria for resource growth and regional targeting within the Tanami belt.

Refined exploration model

Integration of structural orientation data, lithological controls, vein chronology and geochemistry supports a refined model for the Hyperion deposit that is characterised by:

- Steeply dipping west-trending vein systems.
- High-grade shoots developed at structural intersections.
- Multi-phase hydrothermal activity during progressive deformation.
- Rheological contrasts promoting localised dilation.

The mineralised system extends over at least 1.3 km along the Hyperion–Tethys corridor and remains open at depth and along strike.

Implications for Tanami Exploration

The refined Hyperion deposit model is consistent with regional Tanami orogenic gold systems, where mineralisation is localised at structural intersections within large-scale shear corridors. Recognition of multi-generational veins and plunge-controlled shoots provides an exploration framework applicable to adjacent targets within the SSZ structural trend.

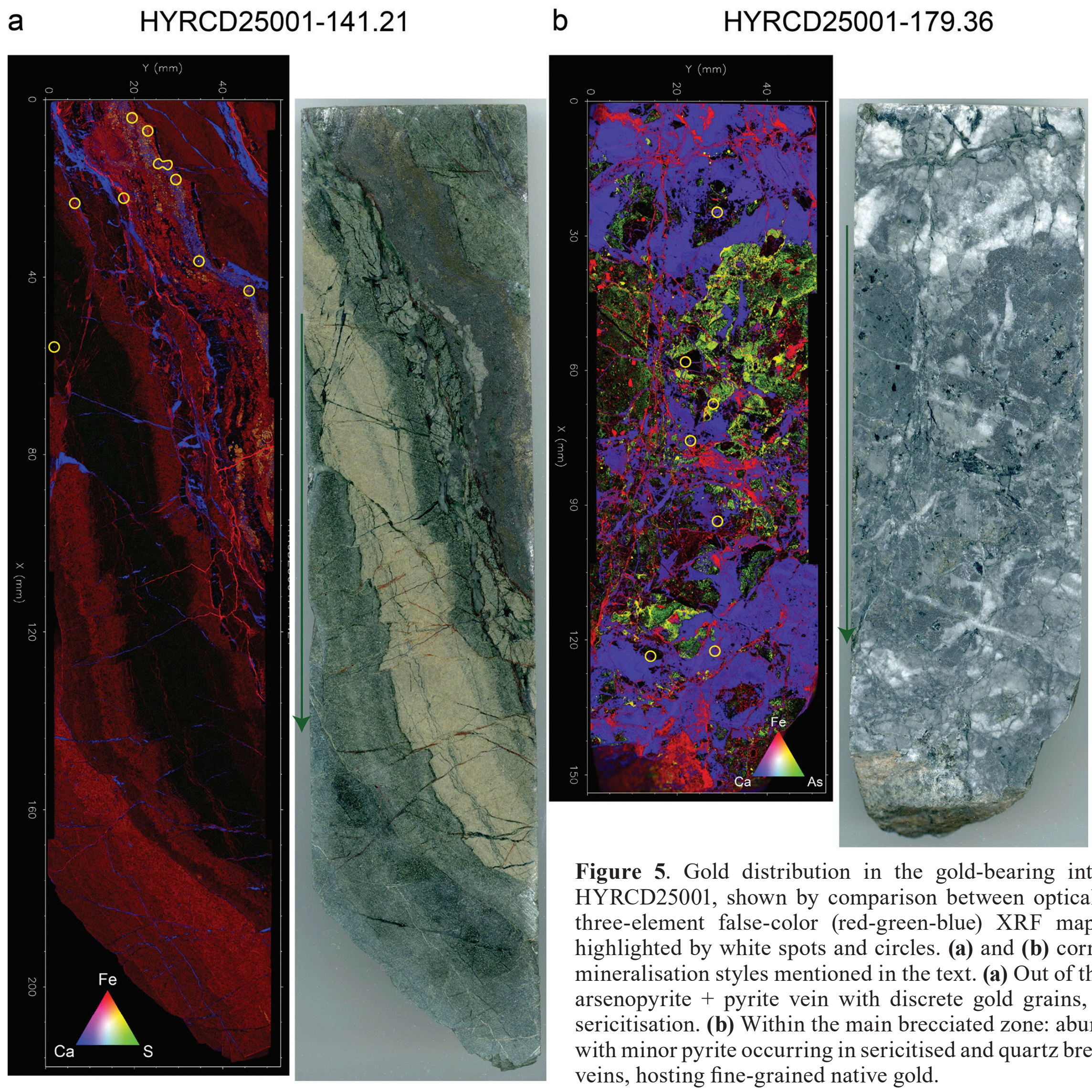


Figure 5. Gold distribution in the gold-bearing interval of drillhole HYRCD25001, shown by comparison between optical photographs and three-element false-color (red-green-blue) XRF maps, where gold is highlighted by white spots and circles. **(a)** and **(b)** correspond to the two mineralisation styles mentioned in the text. **(a)** Out of the brecciated zone: arsenopyrite + pyrite vein with discrete gold grains, chloritisation and sericitisation. **(b)** Within the main brecciated zone: abundant arsenopyrite with minor pyrite occurring in sericitised and quartz breccia and carbonate veins, hosting fine-grained native gold.

Future work will involve expansion of structural datasets, continued petrographic analysis, and integration with geophysical and geochemical vectoring to further constrain shoot geometry and mineralising processes.

Conclusions

Although this study is ongoing, work to date demonstrates that gold mineralisation at the Hyperion deposit is controlled by a complex, multi-phase structural system developed within the Central Tanami structural corridor. Integration of oriented diamond drilling (supported by televiewer data, quantitative vein clustering, petrography and geochemistry) has significantly refined the geological and structural model, revealing that mineralisation is preferentially localised within moderately- to steeply-west-dipping extensional and shear-related vein systems associated with the Hyperion Fault and its splays. The recognition of multiple extensional and shear vein sets, their relative timing relationships, and evidence for episodic brittle reactivation highlight a prolonged history of structurally focused hydrothermal fluid flow during Palaeoproterozoic deformation. High-grade gold is concentrated within brecciated quartz + carbonate veins and altered mafic rocks, particularly where rheological contrasts and structural intersections promoted dilation and fluid accumulation. Integration of structural data has significantly improved 3D modelling and provides a transferable framework for exploration within the broader Suplejack structural trend.

Comparison with well-studied Tanami deposits, including Callie and Groundrush, indicates that Hyperion shares key structural and temporal characteristics typical of orogenic gold systems in the region, reinforcing the broader applicability of the refined model. The identification of plunge-controlled high-grade shoots and regionally consistent vein geometries provides a robust framework for ongoing resource definition and regional exploration along the Hyperion–Tethys corridor and the wider SSZ structural trend. Continued integration of structural, mineralogical and lithogeochemical datasets will further constrain shoot geometry and mineralising processes, supporting predictive targeting and resource growth within the Tanami Province.

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