Defining the stratigraphic framework of the Thunderball Prospect, Central Domain, Pine Creek Orogen, NT

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Introduction

The Thunderball uranium deposit, located in the Central Domain of the Pine Creek Orogen (**Figure 1**), comprises a complex package of structurally controlled, Proterozoic volcaniclastic and sedimentary rocks, which plays host to unconformity-related uranium mineralisation. Increasing our knowledge of the host rock stratigraphy is critical for understanding and interpreting mineralising controls and guiding exploration. In 2025, Patronus Resources (PTN) conducted a ~1600 m diamond drilling campaign (TB25DD001–007) aimed at de-risking known mineralisation, as well as targeting the lesser drilled 'Upper Lode' of the Thunderball deposit. A series of visual observations, combined with multi-element assays from the 2025 drill campaign, were used to delineate two primary stratigraphic horizons, both of which are proven to host replacement-style, unconformity-related, high-grade uranium oxide mineralisation.

Geological context

The Thunderball uranium deposit, located within the broader Patronus Resources Pine Creek Project (PCP), was discovered in 2008 by Thundelarra Resources and a Mineral Resource (JORC 2004) was estimated in 2011 (1.69 m lb U_3O_8 @ 924 ppm; Thundelarra Resources Ltd 2011).

The Pine Creek Orogen (PCO), located on the northern periphery of the North Australian Craton, comprises Neoarchaean granitic and gneissic basement, unconformably overlain by a thick succession of Palaeoproterozoic clastic, carbonate and carbonaceous sedimentary and volcanic rocks that are extensively intruded by syn- to post-tectonic mafic and granitic rocks (Hollis *et al* 2011). The Mesoproterozoic Birrindudu Basin unconformity lies 7 km from Thunderball and can be seen from the top of a nearby hill.

Recent mapping (**Figure 2**) indicates the Thunderball deposit is located on the western limb of a series of north-northeast-trending parasitic folds, displaying minor easterly vergence, on the western limb of a regional anticline (Jones 2025). The deposit is situated adjacent to and immediately north of the regionally significant, northwest-dipping, northeast-trending Hayes Creek fault. The closest anticline lies approximately 3 km to the north of Thunderball,

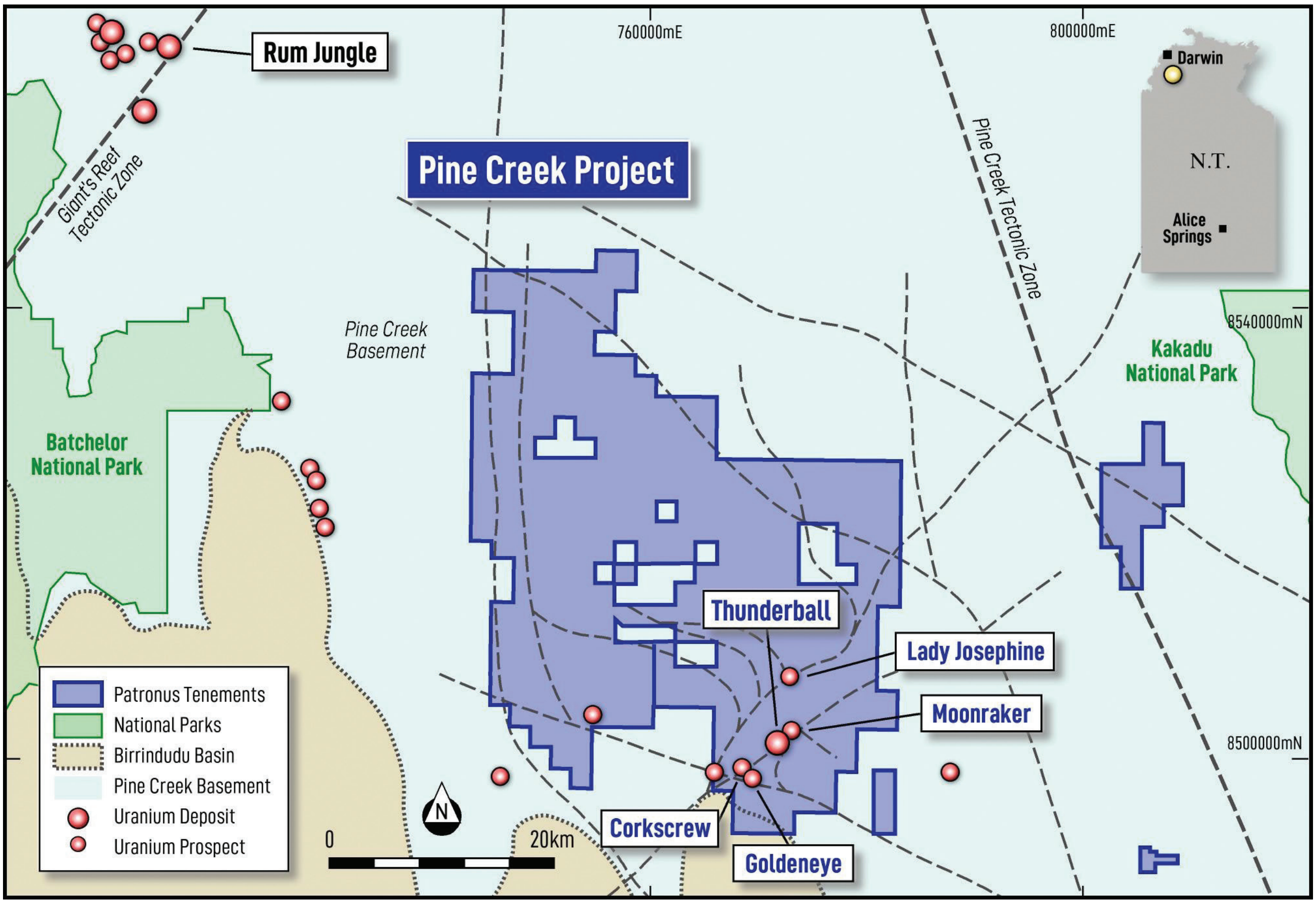

Figure 1. Location map of PTN tenure with Thunderball prospect highlighted.

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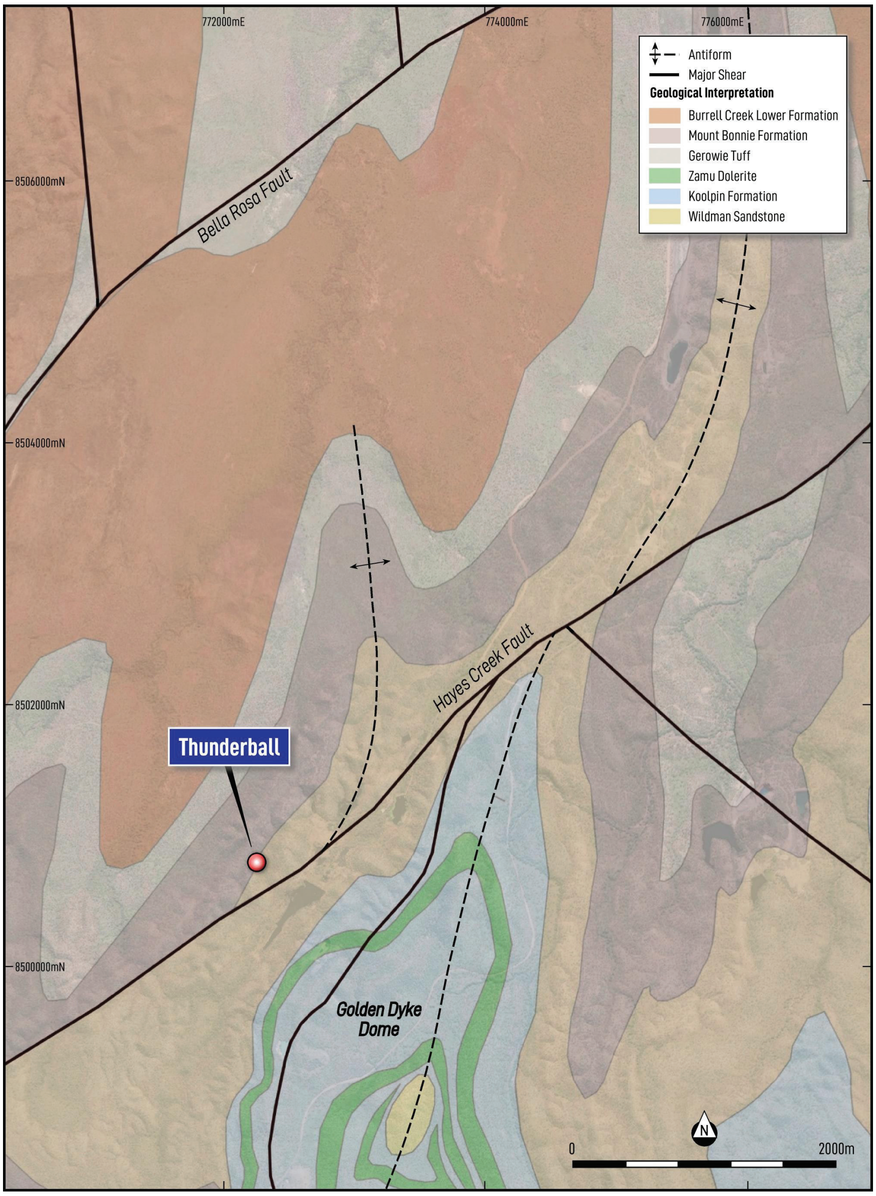

Figure 2. Local geology of Hayes Creek area overlain on satellite image. Location of the Thunderball prospect, red circle, sitting within the western limb of a local parasitic fold.

which is truncated to the south by the Hayes Creek Fault. Stratigraphically, Thunderball lies adjacent to the contact between felsic–intermediate Gerowie Tuff and overlying Mount Bonnie Formation.

Objectives

Objectives for the 2025 drill program were two-fold: 1) bring the 2004 Resource into current compliance, and 2) characterise and define the lithological, structural, and chemical features of the Thunderball deposit for further exploration. Identification of unique stratigraphic sequences, marker horizons, and/or discrete geochemical fingerprints provide a framework for correlating mineralisation stratigraphy across the project area. Here, we will discuss the findings of objective 2.

Methods

Visual core logging (Sinclair 2025), petrographic observations, and multi-element analysis using 4-acid/ICP–MS were performed across 10 diamond drill holes (TB25DD001–007, TPCDD029, RHCDD005, TPCDD026). Key features documented include lithology, sedimentary and volcanic structures, veining, alteration, evidence of deformation, and textural evidence of mineralising fluid–rock interactions. Sedimentary structures and sequence relationship observations were supported by lithogeochemical interpretations of both main stratigraphic sequences and an observed marker horizon.

Core observations

Sequence 1 comprises interbedded claystone, organic-rich claystone, siltstone, and fine- to medium-grained greywacke with minor volcanic input. Sedimentary structures include parallel lamination, hummocky cross-stratification (**Figure 3a**), rip-up clasts, low-angle cross bedding (**Figure 3b**), and soft-sediment deformation. Pyrite occurs predominantly as bedding-parallel disseminations and blebs, interpreted to be diagenetic in origin, within a fine-grained organic-rich facies. Foliation is weak and discontinuous, resulting in generally low permeability.

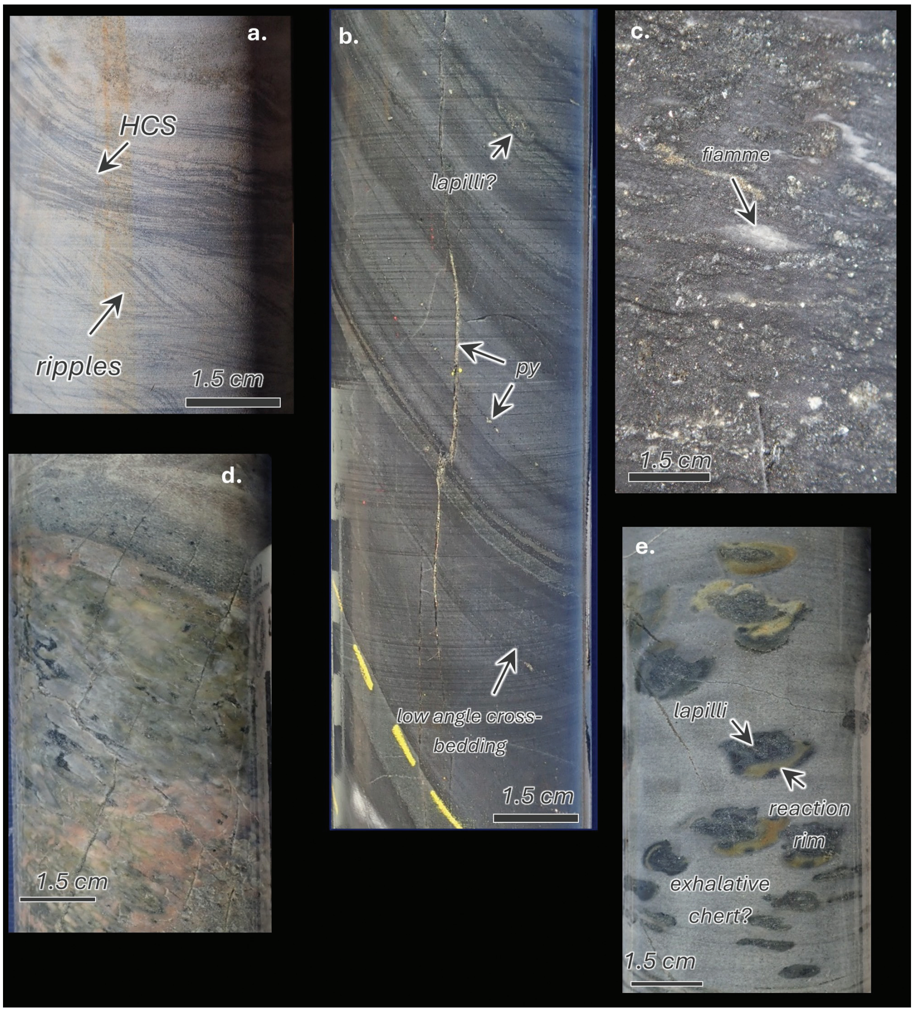

Figure 3. Examples of sedimentary structures for selected samples of core from Thunderball prospect. (**a**) Hummocky cross-stratification and unidirectional climbing ripples. TPCDD029, 98.50 m. (**b**) Interbedded fine sandstone and siltstone, Sequence 1, TB25DD005, 125.60 m. (**c**) Greywacke with fiamme clasts, RHCDD005, 223.80 m. Common diagnostic feature of Sequence 2. (**d**) Welded rhyolitic lapilli tuff overlain by volcaniclastic arenite. RHCDD005, 179 m. Seen across multiple holes. (**e**) Chert bed with lapilli reaction rims.

Sequence 1 is interpreted as a shallow-marine siliciclastic shelf succession, deposited below fair-weather wave base with episodic storm reworking, minor volcanic input, and organic-rich facies, locally forming diagenetic pyrite. The succession was subsequently affected by low-grade contact metamorphism under albite–epidote facies conditions. This is consistent with basal Mount Bonnie Formation.

Sequence 2 is dominated by volcaniclastic lithologies including welded lapilli tuffs, ash (**Figure 3c**) and vitric tuffs (**Figure 3d**), volcaniclastic arenites, fine greywacke, and exhalative bedded cherts. Sedimentary and volcanic structures include hummocky cross-stratification, scours, contraction cracks, soft-sediment deformation, and local overturned stratigraphy. Widespread sericite ± silica ± chlorite alteration is developed within Sequence 2 lithologies, particularly in welded tuffs, with reaction rims around pyroclastic material (**Figure 3e**) and exhalative chert beds. Quartz–pyrite composite veins are abundant but pre-date uranium mineralisation and show no systematic spatial relationship to uranium except where later brittle deformation reactivates pyrite-bearing domains.

Sequence 2 represents a submarine volcaniclastic succession deposited in a storm-influenced marine basin adjacent to active felsic volcanism, characterised by rapid accumulation of primary and reworked pyroclastic material, syn-depositional instability, and widespread syn-volcanic hydrothermal alteration. This sequence corresponds to Gerowie Tuff with a transitional increase in volcanic content relative to Sequence 1.

A variably coarse lapilli tuff was identified as a laterally continuous and geologically robust marker horizon separating Mount Bonnie Formation and Gerowie Tuff within Sequence 2. Three-dimensional modelling of this unit highlights folded stratigraphy, with repetition of stratigraphic packages and consistent development of the lower uranium lens beneath this horizon (**Figure 4a**).

Multi-element geochemical analysis supports the above divisions of Sequence 1 and Sequence 2, showing they are geochemically distinguishable across multiple trace-element discrimination plots, including Ti/Zr and V/Sc (**Figure 4b**). Sequence 1 exhibits a comparatively more mafic geochemical signature, showing a higher V/Sc vs Sc ratio and stronger Ti vs Zr, whereas Sequence 2 displays a more evolved felsic signature. Sequence 2 is characterised by extremely low V/Sc ratios, whereas Sequence 1 displays higher and more variable ratios, which maybe a result of higher sediment input.

The following descriptions of uranium mineralisation are based heavily on upper lode observations. Uranium mineralisation occurs within sericite-altered tuffs and interbedded volcaniclastic arenites and represents the thickest and highest-grade mineralised style observed at Thunderball. Bedding-parallel, high-grade mineralisation extends over widths exceeding 3 m and is spatially associated with a deformed, semi-massive pyrite lens.

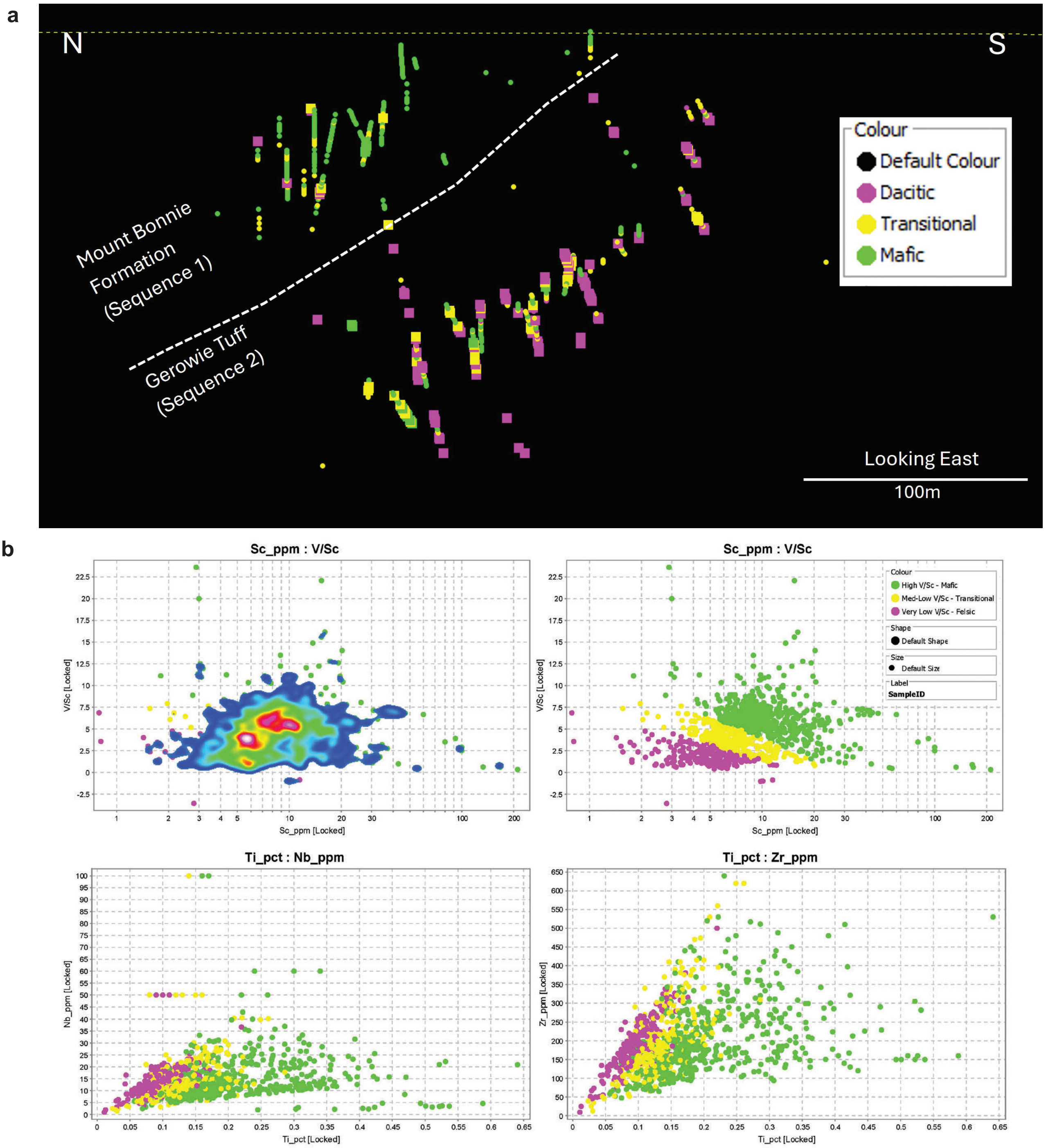

Figure 4. (**a**) 3D chemostratigraphic modelling of the Thunderball deposit displays a clear spatial separation between Sequence 1 and Sequence 2 horizons. (**b**) Sequence 2 shows a distinctly more dacitic to rhyolitic compositional trend compared to Sequence 1, best demonstrated using Sc vs V/Sc plots. This chemical distinction is observed across multiple discrimination plots including Ti vs Zr and Ti vs Nb.

Uranium minerals, predominantly pitchblende, occur as pervasive replacement of semi-massive to blebby pyrite, with irregular to scalloped contacts between pyrite-rich domains and uranium–illite domains. Remnant pyrite clasts are locally preserved within uranium-rich zones, and both gradational and sharp replacement fronts are observed.

The mineralised interval is characterised by abundant illite ± kaolinite alteration, including 'worm-textured' illite and hematitic illite (**Figure 5**) developed marginal to uranium-rich zones. Silica occurs as fine-grained quartz or silicified domains associated with deformed pyrite clasts. The replaced pyrite exhibits massive, brecciated, and localised ductily deformed textures that are inconsistent with simple diagenetic sulfide formation observed elsewhere in the stratigraphy. Minor secondary uranium vanadates occur along late fractures.

Based on these observations, uranium mineralisation is interpreted to have formed as a result of the interaction of an oxidised brine, generated in the overlying Mesoproterozoic Birrindudu Basin and circulated through post-basinal fault systems, with intraformational syn-sedimentary and diagenetic reductants (pyrite and organic matter) hosted within the underlying Palaeoproterozoic volcaniclastic sequences.

Uranium mineralisation within Sequence 1 is strongly decoupled from rare earth elements (REE), showing negative

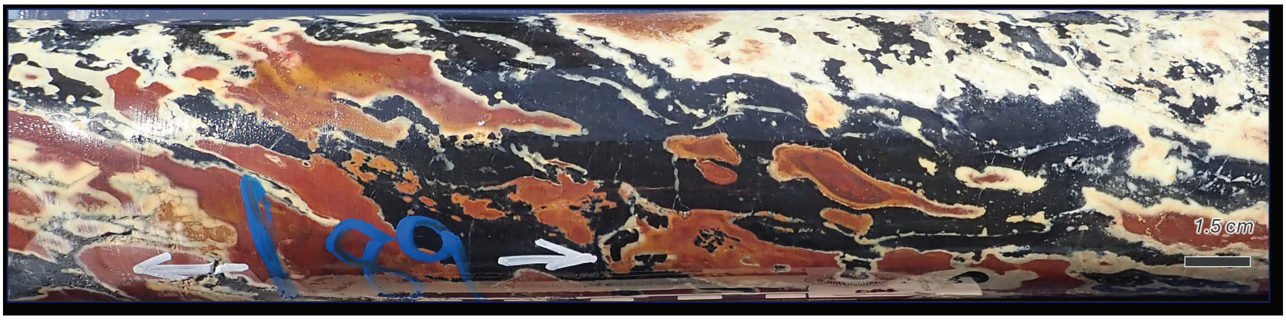

Figure 5: High grade mineralised zone, TB25DD004, 89 m. Worm textured illite/haematitic illite with dark uraniferous mineral (likely pitchblende) mineralisation.

correlations and a stronger association with As–Sb–Mo. In contrast, mineralisation in Sequence 2 shows strong positive correlations with REE and a higher affinity for base metals including Cu, Pb, Zn, and Bi.

The presence of a semi-massive sulfide lens within a felsic-dominated, submarine volcaniclastic sequence, together with associated base metal enrichment and exhalative chert horizons elsewhere in Sequence 2, suggests that the pyrite body may have an exhalative origin, analogous to volcanogenic massive sulfide (VMS)-style mineralisation. In this context, uranium mineralisation represents a later redox-driven replacement of a pre-existing sulfide lens, with the volume of semi-massive pyrite providing a substantial and localised reductant.

Conclusions / Implications

The stratigraphic framework at Thunderball is defined by a siliclastic sequence (Sequence 1) underlain by a volcaniclastic-dominated package (Sequence 2), with transitional contacts and distinctive marker horizons. Understanding the defining features of these sequences enables more accurate targeting of uranium mineralisation and supports exploration along strike and in structurally favourable positions.

The combined lithological, structural, and geochemical datasets indicate that Sequence 1 and Sequence 2 represent a transitional sedimentary-to-volcaniclastic stratigraphic package, with Sequence 1 interpreted as the basal Mount Bonnie Formation and Sequence 2 corresponding to the Gerowie Tuff. The apparent mafic geochemical signature of Sequence 1 is interpreted to be influenced, at least in part, by organic-rich sedimentary input within black shales, rather than reflecting a true volcanic provenance. In contrast, Sequence 2 exhibits a cleaner felsic volcaniclastic geochemical signature, with very low V/Sc ratios suggesting a mid-crustal melt source and a rift-related felsic magmatic environment that is permissive for volcanogenic massive sulfide systems.

The identification and modelling of the coarse lapilli tuff as a marker horizon provides a critical stratigraphic reference for correlating mineralised intervals and recognising folded and repeated stratigraphy. This horizon consistently separates upper and lower parts of Sequence 2 and constrains the stratigraphic position of the lower uranium lens, highlighting the importance of stratigraphic control in understanding mineralisation distribution.

Differences in uranium metal associations between the two sequences reflect contrasting mineralogical and redox environments. In Sequence 1, uranium precipitation is associated with As–Sb–Mo-rich assemblages and depleted REE, consistent with interaction between organic-rich sediments and diagenetic pyrite under restricted permeability conditions. In Sequence 2, uranium mineralisation is spatially associated with REE-enriched and base metal-bearing assemblages, reflecting precipitation within permeable, brittle volcaniclastic units where uranium-bearing fluids interacted with pyrite-rich domains during deformation.

These results demonstrate that multi-element geochemistry, when integrated with detailed stratigraphic logging and 3D modelling, provides a robust tool for distinguishing stratigraphic position where lithological contrasts are subtle or transitional. The systematic differences between Sequence 1 and Sequence 2 support the use of sequence-specific pathfinder assemblages for exploration, in which U–REE–base metal associations are characteristic of Sequence 2 and U–As–Sb–Mo associations with depleted REE signatures are indicative of Sequence 1.

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