Breaking new ground in the East Tennant region – insights on stratigraphy, modelling and IOCG potential

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Introduction

The Barkly Tablelands area east of Tennant Creek, Northern Territory has been the subject of substantial exploration focus over the past few years. This is mainly due to the collaborative efforts of pre-competitive studies undertaken by Geoscience Australia (GA), Northern Territory Geological Survey (NTGS) and the Mineral Exploration Collaboration Program (MinEx CRC) National Drilling Initiative (NDI) – which have encouraged interest from a number of exploration companies in the region.

The deposits of the Tennant Creek district occur as polymetallic (gold–copper–bismuth referred to as Au–Cu–Bi), selective partial-replacements of small metasomatic ironstones (magnetite–hematite), which form within the clastic metasedimentary rocks of the Warramunga Formation (Partington and Williams 1999). Ironstones typically occur as flattened elongate bodies that range in size from a few tonnes to over 15 Mt; all are considered to be hosted by the Warramunga Formation (Donnellan and Johnstone 2004, Donnellan 2013).

The Tennant Creek Au–Cu–Bi deposits have been broadly classified as a type of iron oxide–copper–gold (IOCG) style deposit (Skirrow *et al* 2019). There are several key geological commonalities identified within the deposits of Tennant Creek, most notably the generally close association with the ironstones within the region (Rattenbury 1992). However, it is noted that not all ironstones are mineralised. Alteration patterns are typically similar across the deposits and associated with pipe-like chlorite-rich alteration zones above and below the deposits; alteration is commonly accompanied by carbonate and talc, with local muscovite and variable quartz (Huston *et al* 2020).

Knox Resources Pty Ltd (Knox; a wholly owned subsidiary of Greenvale Mining Ltd) is an early explorer within this region and its exploration is focused on Tennant Creek-style ironstone associated Au–Cu–Bi mineralisation, part of the IOCG group of deposits.

Knox Resources' tenements

Knox was a successful applicant under an open tender for nine Exploration Licences (ELs) over four distinct locations covering some 4475 km^2 between the IOCG provinces of Tennant Creek and Mount Isa (**Figure 1**). Knox's tenements are located near the Barkly Roadhouse and lie within the Warramunga Province.

On 23 September 2020, Knox was granted ELs over seven of the lease areas, with the remaining two being subject to negotiation with the indigenous freehold landowners. Knox has since submitted a further four EL applications in the East Tennant region, all of which remain in the application process.

Geophysics and drilling collaboration program

The Knox tenement package is covered by NTGS airborne magnetic 200–400 m line-spaced survey data from the Tennant Creek, Georgina, Barkly and Bonney Well surveys. NTGS gravity survey coverage is mostly 4 km × 4 km spaced stations in the Tennant Creek, Barkly and South Nicholson surveys, plus some 2 km × 2 km spaced stations as a result of the 2019 infill East Tennant survey.

In 2021, Knox undertook geophysical infill programs across several of its tenements, comprising 27 879 line km of 100 m line-spaced airborne magnetics and 2274 infill gravity station measurements. As part of this program, Knox applied to the NT Government under the Geophysics and Drilling Collaborations program for funding of part of these surveys. The applications included 911 gravity stations at a station spacing of 1 km × 1 km within EL32282 and EL32296, and a 12 618-line km magnetic survey over EL32284 and EL32283. Both NTGS applications were submitted in early May 2021 and were successfully granted in June 2021. The surveys were acquired in July–August 2021 with the subsequent data processed and gridded by Resource Potentials Pty Ltd (Resource Potentials).

These co-funded geophysical infill programs have proved instrumental in the interpretation of the prospective Tennant Creek sequences' structures and exploration targets beneath the extensive Georgina Basin cover within the licence areas; and have provided further geological insights into the new frontier of East Tennant region.

Stripping the cover

Knox commissioned SRK Consulting (Australasia) Pty Ltd to undertake an exploration review and targeting program with the focus on the potential for Au–Cu–Bi IOCG-style mineralisation within Knox's ELs in the East Tennant region.

The thickness of the early Palaeozoic Georgina Basin and overlying Cenozoic cover is recognised as a significant exploration risk for this style of IOCG deposit in the underlying Paleoproterozoic sequences in the East Tennant region. To help reduce some of this risk, the review and targeting work included developing a 'solid geology' model to effectively remove the overlying cover sequences from the underlying Paleoproterozoic basement (**Figure 2**). To do so, solid geology interpretations were integrated with available high-resolution and regional seismic data lines, published 1:100 000 geological mapping, published solid geology interpretations of Tennant Creek and Frew River, and open-source drilling data, along with other published literature.

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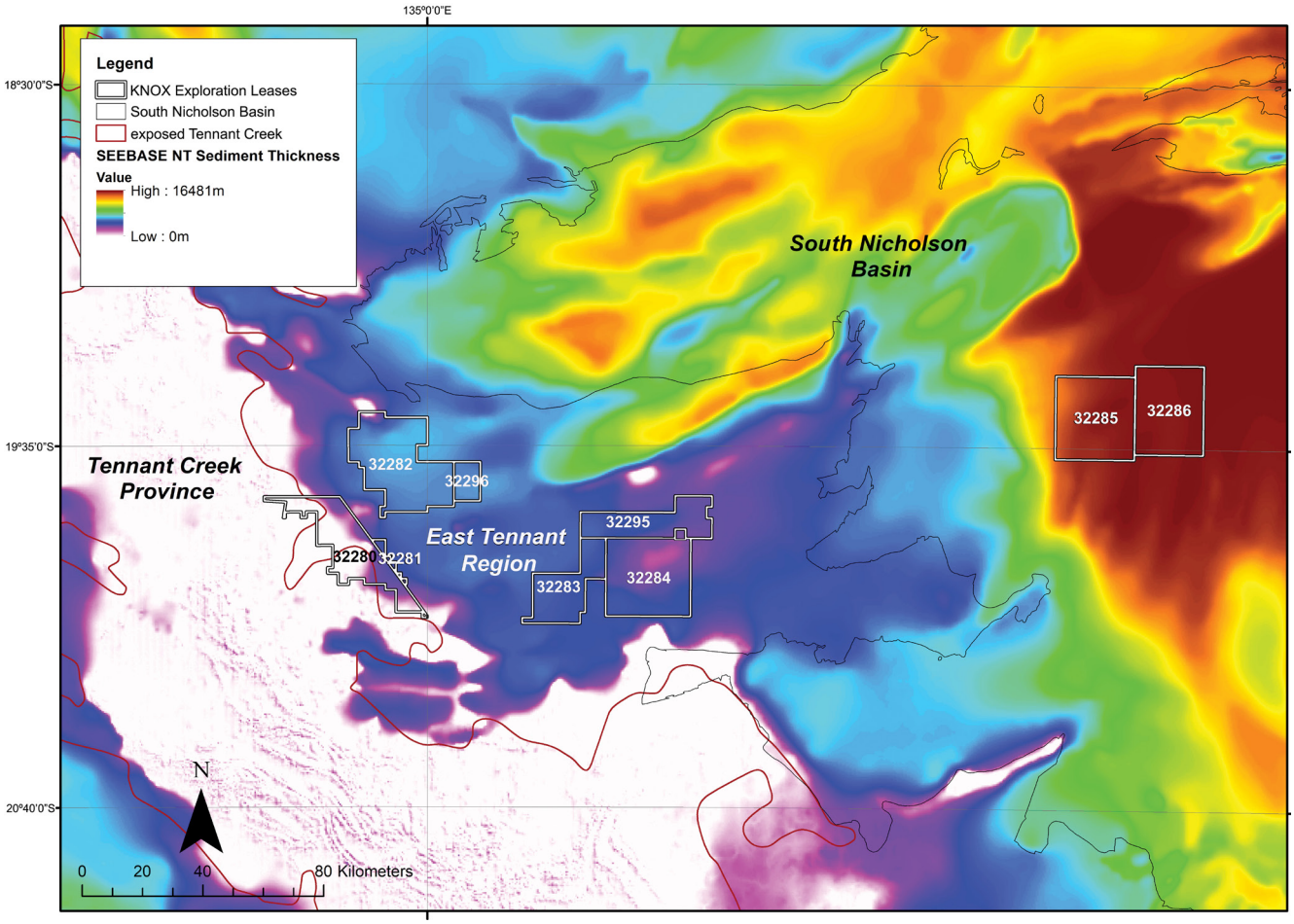


Figure 1. Knox Resources' tenement locations on SEEBASE® imagery.

The interpretation process commenced with the selection of Paleoproterozoic outcrop data and structure from the 1:100 000 geology maps. This initial solid geology dataset, together with limited drillhole data, formed important calibration data during the interpretation of the magnetic and gravity patterns and trends within and under the cover sequence. The magnetic reduced to pole and 1st vertical derivative images proved the most useful for this task.

The interpretation of the solid geology and structure was undertaken at a scale ranging between 1:25 000 and 1:50 000. The location accuracy of the interpretation is estimated to be about ±100 m, reflecting both the 400 m line spacing of some of the magnetic data used and the depth of sedimentary cover.

The structures interpreted included faults, bedding trends, dykes, and fold axes. The faults were subdivided into either major or minor, where major structures could be distinguished by displacements of several kilometres and expressions in the regional gravity data.

Magnetic data were used to interpret areas of either magnetite destruction or enhancement. Areas of magnetite destruction were found to be typically located around fault zones within magnetic host rocks and were interpreted to be associated with hematite alteration. Areas of magnetic enhancement were interpreted to be caused by the addition of magnetite, potentially linked to hydrothermal fluids.

The concentration of magnetite, hematite (in addition to sulfide minerals) with Tennant Creek-style IOCG mineralisation may be expressed in gravity data by a weak high. Several gravity highs over areas of interpreted Warramunga Formation were interpreted across the region.

Depth to basement estimates

To better understand the extent of cover thickness across Knox's East Tennant project area, an interpretation of depth to Paleoproterozoic basement was undertaken using the available geological, drilling and the high-resolution geophysical data. This interpretation involved the following steps:

- calculation of depth to magnetic sources by Euler deconvolution undertaken by Resource Potentials. All sources modelled by this method used surficial, intra-basinal (eg Cambrian volcanics), top basement and deep crustal sources
- separation of top basement sources using magnetic, gravity data and geological interpretation
- interpolation of depth contours using selected modelled source depths, gravity and magnetic imagery calibrated with drillhole and outcrop data
- gridding of interpolated contours (**Figure 3**).

IOCG mineral systems review

To assess the prospectivity of the Knox's East Tennant Project area, a mineral system review of the region was undertaken

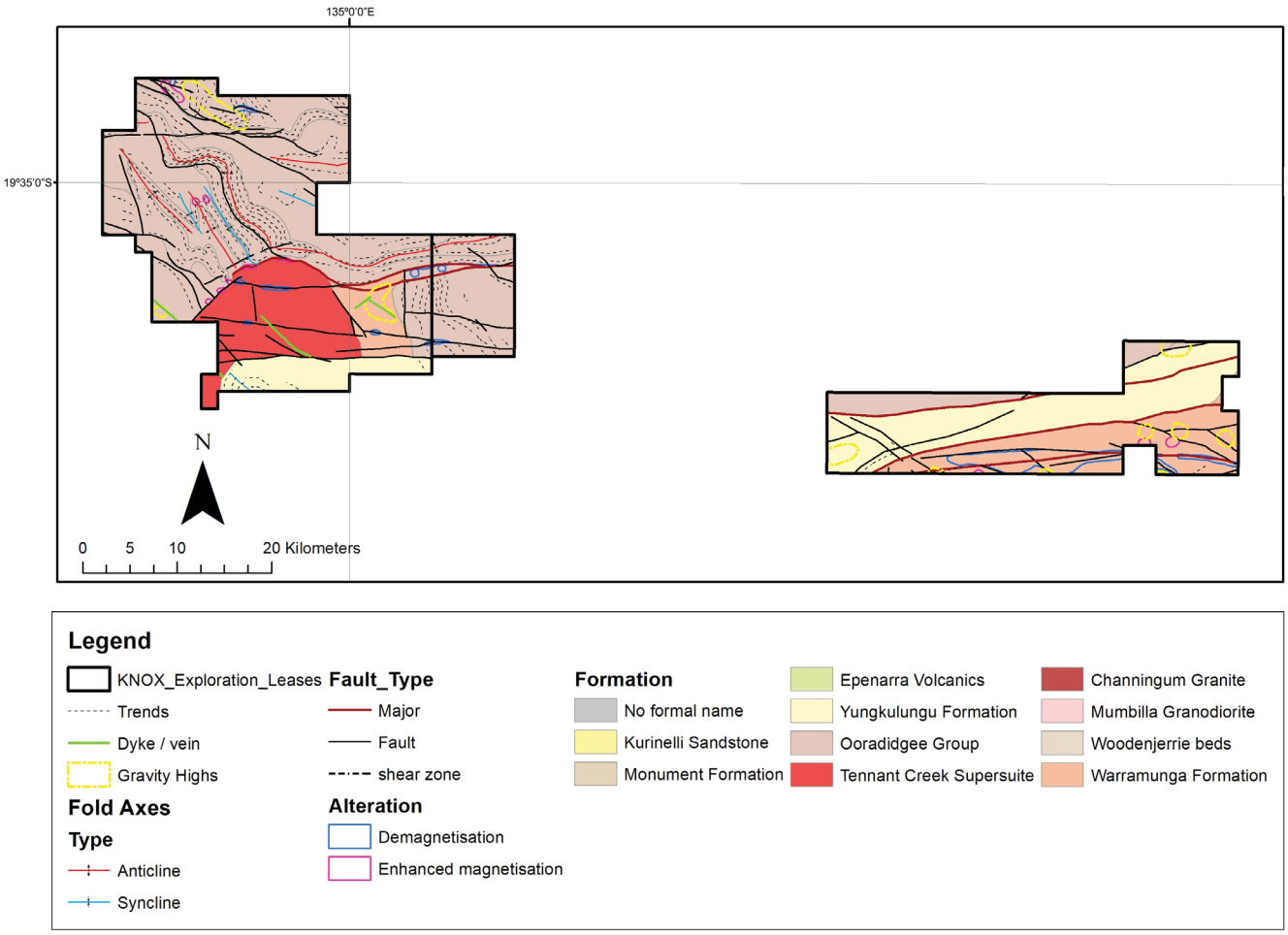


Figure 2. Interpreted solid geology within EL 32282, EL 32296 and EL 32295.

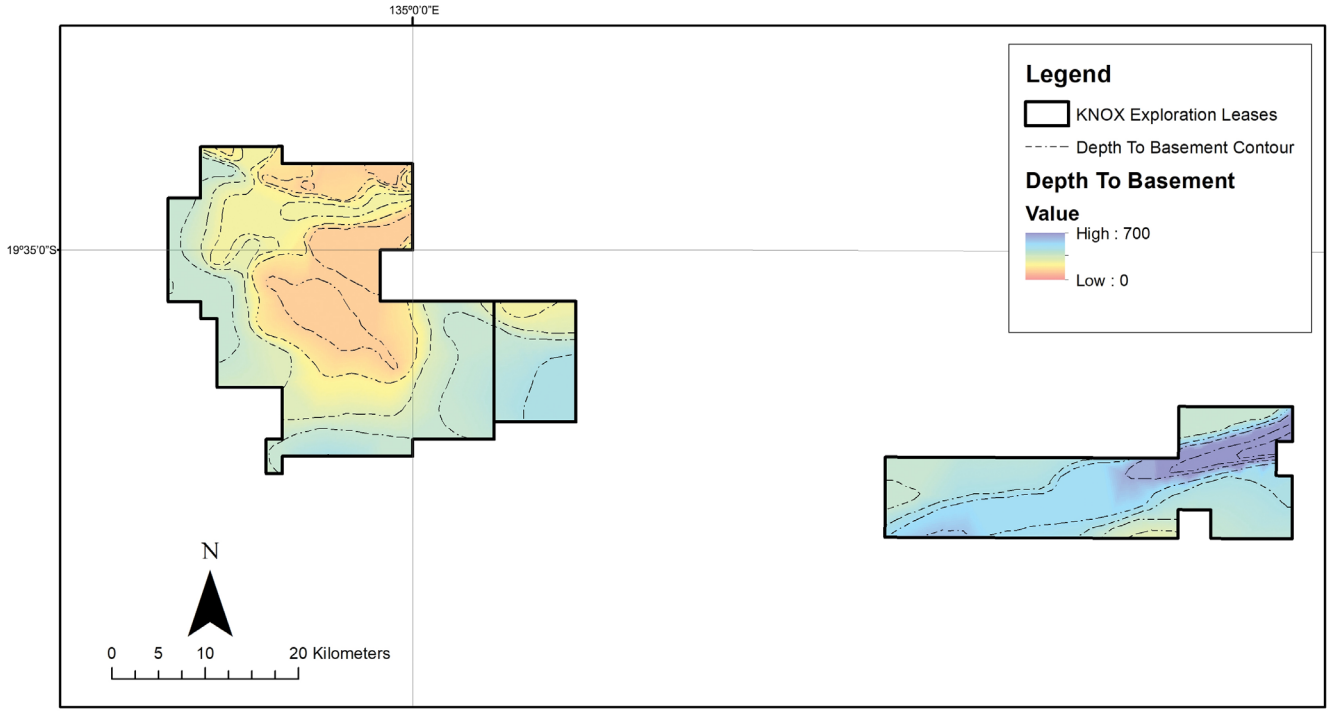


Figure 3. Interpreted depth to basement within EL 32282, EL 32296 and EL 32295.

for the Tennant Creek- or Au–Cu–Bi IOCG-style systems. This work encompassed a review of the available literature and data to identify the underlying components (fluid source, fluid driver, fluid pathway and fluid trap) of the IOCG system and define these as discrete mappable elements. Due to the extensive cover in Knox's project area, geophysical data such as magnetics and gravity were critical tools to interrogate the key mineral systems elements for target vectoring. Each

of the mineral system elements and mappable features are briefly summarised as follows:

Fluid source and driver.

- There is a spatial and temporal relationship between mineralisation and intrusives within Tennant Creek. While there is some uncertainty in the source of the metals in the system, there is consensus that there is a magmatic component to the fluids, as well as connate brine fluids. In addition to providing a source of fluids, the granites acted as a potential local thermal driver, circulating fluids through favourable pathways (eg faults or fold structures). Therefore, proximity to granites was identified as an important targeting element for the Tennant Creek IOCG mineral system.

Pathway.

- There are a diverse range of structural controls associated with the Tennant Creek IOCG deposits as these deposits are typically associated with structurally complex areas. A relationship to local-scale folding is evident in Tennant Creek where many of the host ironstones can occur in parasitic fold hinges of thrust structures or fold axial planes. They are considered to have formed by fluid migration along the dominant S1 (typically east–west) cleavage. Crustal-scale structures are additionally important fluid flow corridors acting to focus migrating fluids from intrusive sources at depth. Faults have been interpreted based on both the magnetic and gravity datasets throughout the project area and defined as major or minor structures.

Trap.

- The trap (or focus area) mechanisms for mineralisation within the region are relatively well understood with ironstones within the Warramunga Formation acting as a chemical trap for the mineralising fluids. Deposits therefore generally show a strong magnetic and/or gravity response reflecting these ironstones.

Each of the exploration criteria was spatially assessed using GIS against known mineral deposits within Tennant Creek to evaluate their relative importance to mineralisation, with each feature then ranked accordingly. Exploration targeting across the East Tennant project area was conducted applying a 'fuzzy logic' overlay methodology within ArcGIS™ using each mapped and ranked exploration criteria. From this, a mineral potential map was derived as the product of the combined ranked exploration criteria (**Figure 4**). Several scenarios were evaluated to test the model sensitivity, as well as to cross-validate against input datasets**.**

Exploration targeting summary

The fuzzy logic targeting process resulted in several conceptual targets being reviewed, ranked and prioritised for follow-up exploration. Over 20 high priority targets were defined in EL32282, EL32296 and EL32295. Two of the high priority targets are the 'Twin Peaks' targets, which were characterised by spatially related 'bulls-eye' magnetic and gravity anomalies within a zone of interpreted magnetite-destructive alteration bound between east–west regional faults. Unconstrained inversion of gravity and magnetic data was conducted by Resource Potentials using high resolution gravity and magnetic datasets in order to assist with drill planning for these targets. The top of the west and east target features were estimated to be 300 m and 450 m deep respectively.

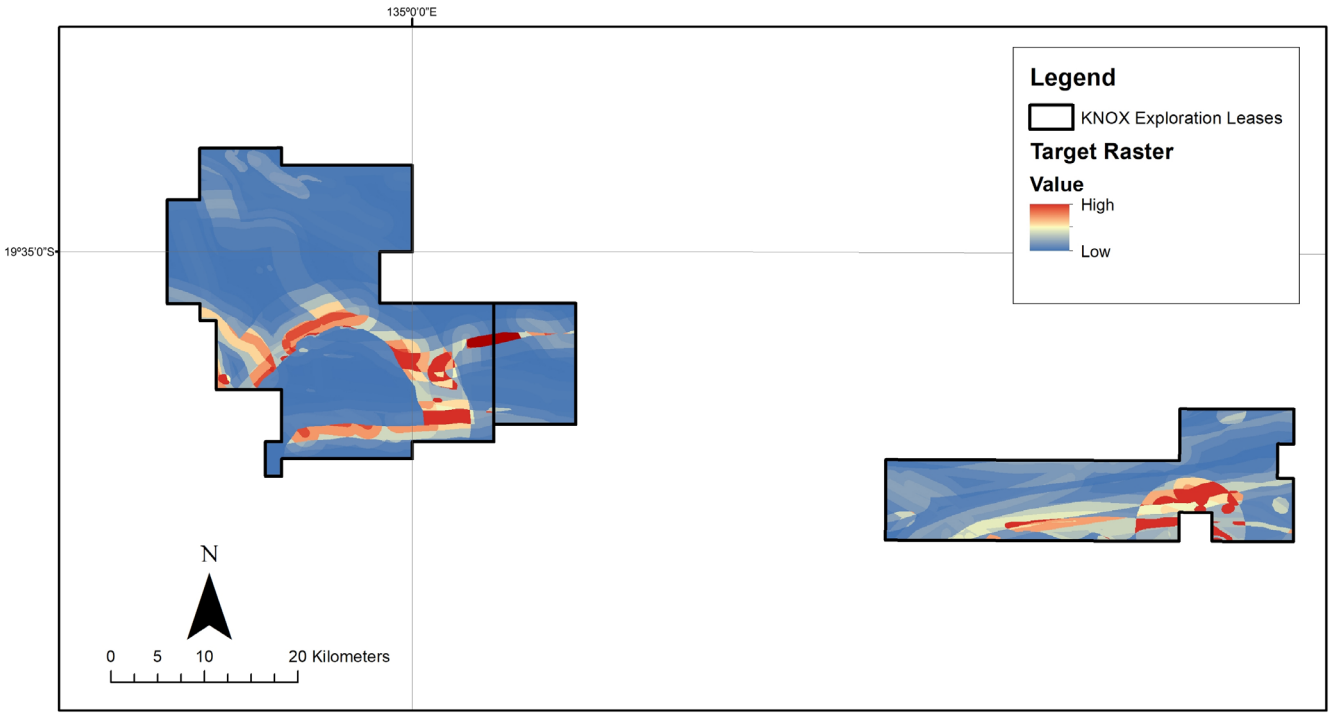


Figure 4. Mineral potential map illustrating areas of higher prospectivity in warmer colours.

Drilling planning and results

Four drillholes were planned to test both the Twin Peaks targets and to gain a better understanding of the underlying Paleoproterozoic stratigraphy in the EL area. Based on inversion modelling, both targets presented as similar features consisting of magnetic anomalies slightly offset from moderate density bodies (**Figure 5**). To date, the drill program has completed a single hole in each of the Twin Peaks targets, with KNRDD002 drilled into the western target for a total depth of 796.6 m, and KNRDD004 into the eastern target for a total depth of 900.9 m.

Drilling intercepted Proterozoic basement underlying approximately 350 m of Georgina Basin cover rocks. Preliminary logging of interpreted Proterozoic sequences has identified variably sheared, faulted and brecciated metasediments with chlorite, haematite and silica alteration present.

The drill core was despatched to ALS Laboratories in Townsville for core cutting, sample preparation and assay. Further test-work to be completed includes gas pycnometer density, magnetic susceptibility measurements, petrographic section preparation, microscopy and sample descriptions. A downhole geophysical survey has also been planned for the Twin Peaks targets using a triaxial magnetometer.

Conclusions

Knox is continuing to explore its East Tennant leases with further drilling of several target areas. The acquisition of the detailed aeromagnetic and gravity data over the granted ELs through the Geophysics and Drilling Collaborations program is believed to have greatly helped to further the understanding of the prospectivity and geology of the East Tennant region. This data has allowed a better interpretation of important structural corridors, distribution and architecture of prospective geological horizons, and potential fluid sources; thus providing greater confidence for drill targeting across Knox's East Tennant project area. Several target areas identified from this data will be followed up in upcoming exploration work, including additional drill testing.

This co-funding initiative has proven an invaluable contribution to Knox's exploration program targeting a successful discovery.

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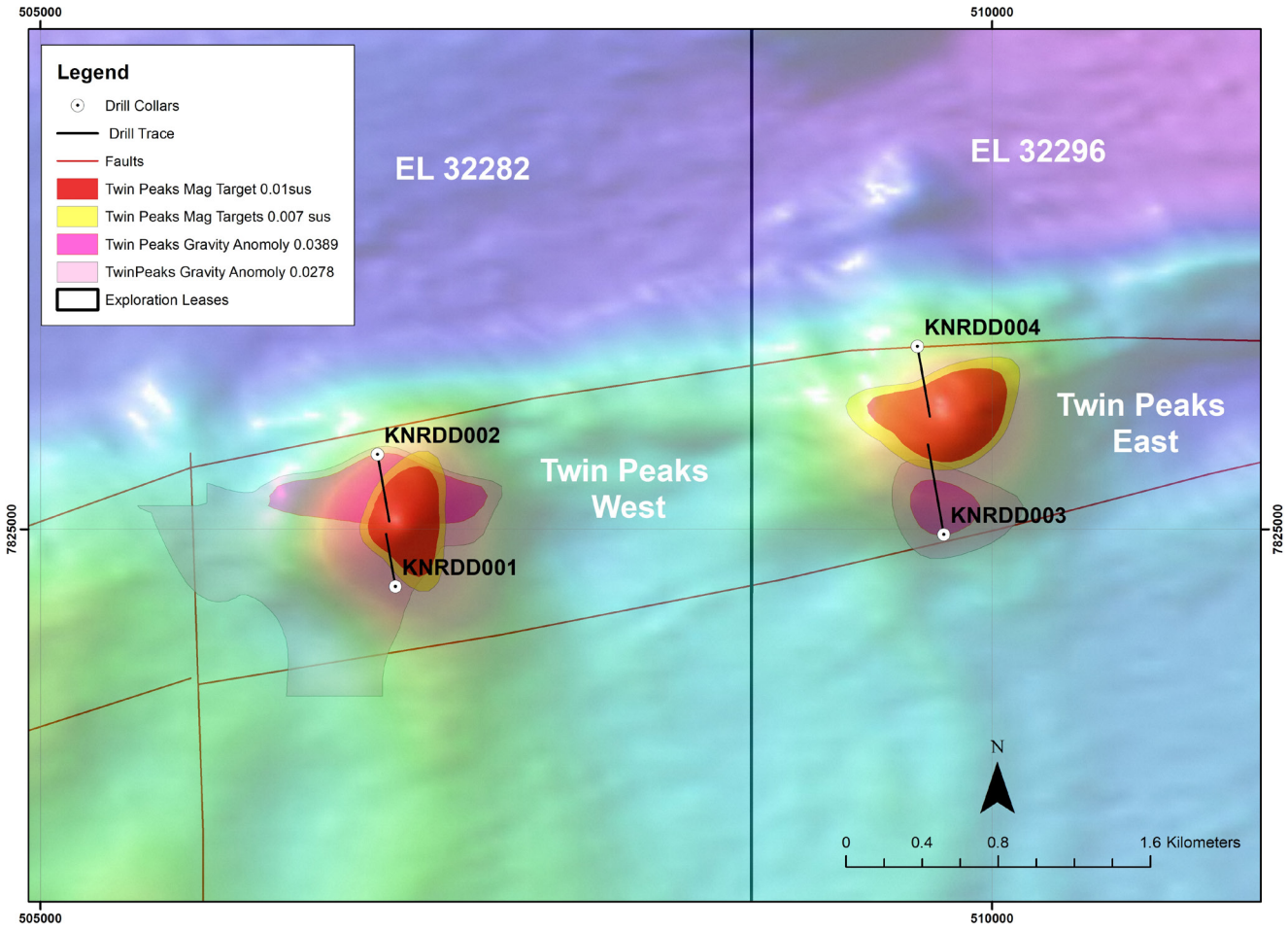


Figure 5. Map of proposed preliminary drill plan for Twin Peaks targets (KNRDD001 and KNRDD004).

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