

Overview of mineral and petroleum exploration and production in 2018

Ian R Scrimgeour^{1,2}

Exploration statistics

Mineral exploration activity in the Northern Territory (NT) continued to recover during 2018 with increasing expenditure and reported on-ground activity. According to the Australian Bureau of Statistics (ABS), mineral exploration expenditure in the NT in 2017–18 was at \$111.8 million, a 43% increase on a low of \$78.4 million in 2016–17 (**Figure 1**). Exploration in greenfields areas (as defined by the ABS) was up 30% to \$56.5 million (**Figure 2a**). The proportion of exploration expenditure in the NT that is in greenfields areas is 51%, much higher than the national average of 34% (**Figure 2b**). **Figure 1** shows a comparison of annual exploration expenditure in all states since 2000; **Figure 2** shows greenfields versus brownfields expenditure in the Northern Territory

In addition to ABS exploration statistics, which include the costs of mine site exploration, the Northern Territory Geological Survey (NTGS) collects statistics on the admissible exploration expenditure on exploration leases reported by industry to the Department of Primary Industry and Resources (DPIR). This shows that expenditure reports submitted during 2017 (which may relate to activity in 2017 and/or 2018) totalled \$58.7 million, a 21% increase from the previous year. Of expenditure reported to DPIR in 2018, 28% (\$16.3 million) was in the Arunta Region, 23% (\$13.6 million) in the McArthur Basin, and 15% (\$9.0 million) in the Pine Creek Orogen. The bulk of expenditure was for base metals (33%; \$19.6 million), gold (24%; \$14.1 million), rare earths (10%; \$5.9 million) and lithium (9%, \$5.2 million). **Figure 3** shows the breakdown of on-ground expenditure (excluding feasibility and desktop studies) by geological region and primary commodity of interest.

At the end of 2018, there were 838 granted non-extractive mineral exploration licences (compared with 812

at the end of 2017) and 588 outstanding exploration licence applications. During 2018, 179 applications were received (down from 263 in 2017), 122 granted, and 157 licences ceased (down from 340 in 2017). The area of the NT covered by granted exploration tenure sits at about 11%.

During 2018, onshore petroleum exploration activity was largely limited to the Amadeus Basin, with one seismic survey and two appraisal wells. At the end of 2018, in the onshore NT and coastal waters, there were 47 granted exploration permits, three retention licences and five production licences.

Exploration and production highlights

In the following summary of exploration and mining results for the NT during 2018, all mineral resources are assumed to have been reported in accordance with the JORC or NI43-101 codes. Where resource categories are not listed, readers are directed to the original sources for this information. Most material cited here has been sourced from company websites, news releases and stock exchange announcements by companies. As a result, details of exploration by some private and other non-listed companies that do not report publicly could not be included.

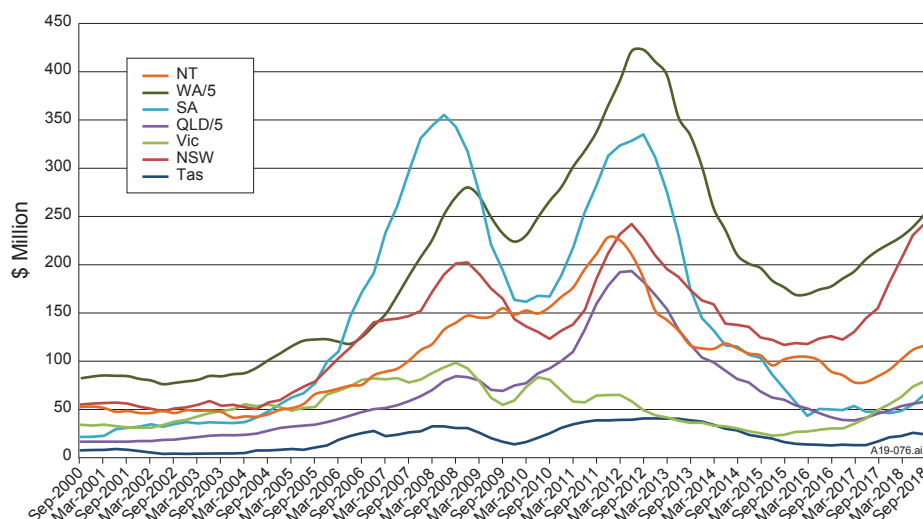
Figure 4 shows selected mineral exploration highlights for 2018. Mineral production statistics for the NT for 2017/18, collected under the NT *Mineral Titles Act*, are given in **Table 1**. This shows mineral production was a record \$4.49 billion in 2017/18.

Gold and copper-gold

Pine Creek Orogen

Kirkland Lake Gold Inc's *Cosmo Deep*s underground mine north of Pine Creek (**Figure 5**) remained in care and maintenance in 2018 following suspension of mining in mid-2017. The company announced that this was to allow them to focus its activities on an aggressive resource definition and exploration program at the mine, including the newly

Figure 1. Annual mineral exploration expenditure for the Northern Territory and all states, calculated quarterly, for the 18 years to the September 2018 quarter.



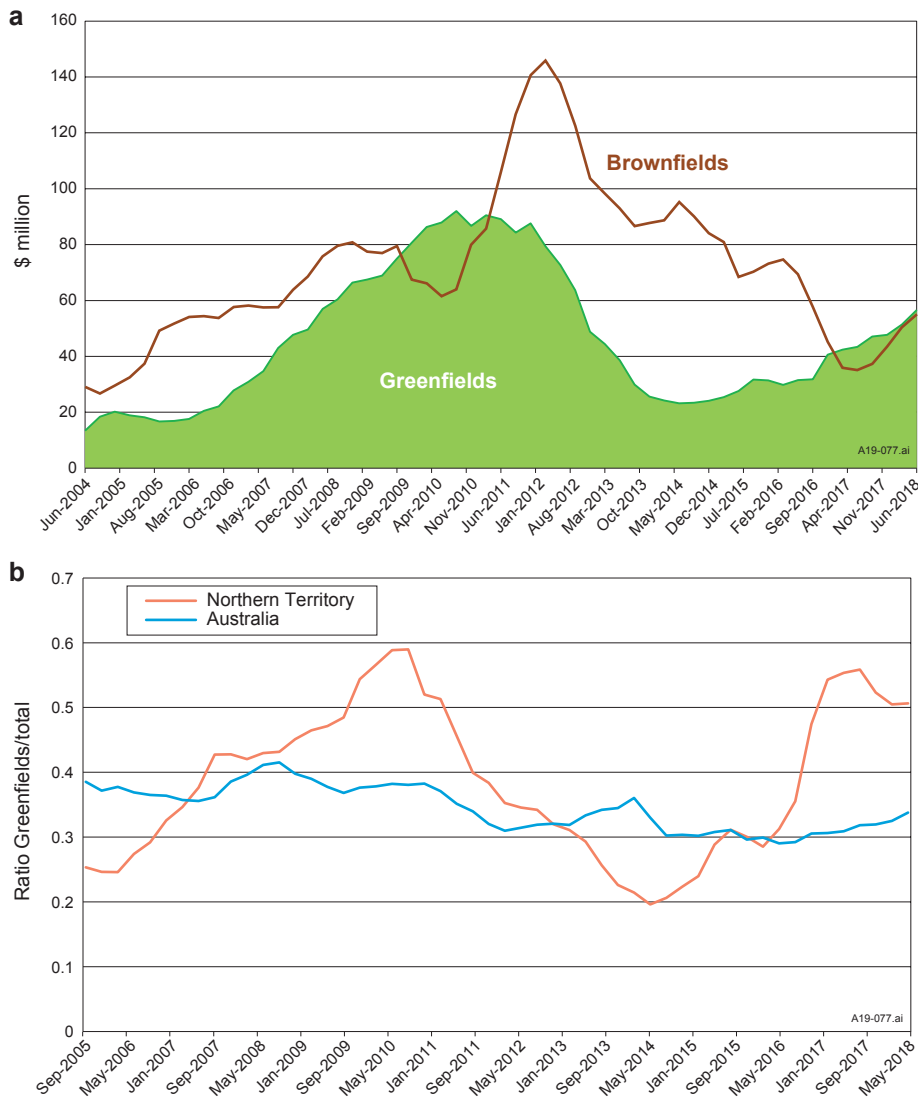


Figure 2. (a) Graph of mineral exploration expenditure (annual expenditure calculated quarterly) in greenfields and brownfields areas, as measured by the ABS, showing a significant rise in greenfields expenditure relative to brownfields since 2014. (b) Graph of the amount of greenfields mineral exploration expenditure as a proportion of total expenditure for the Northern Territory and Australia.

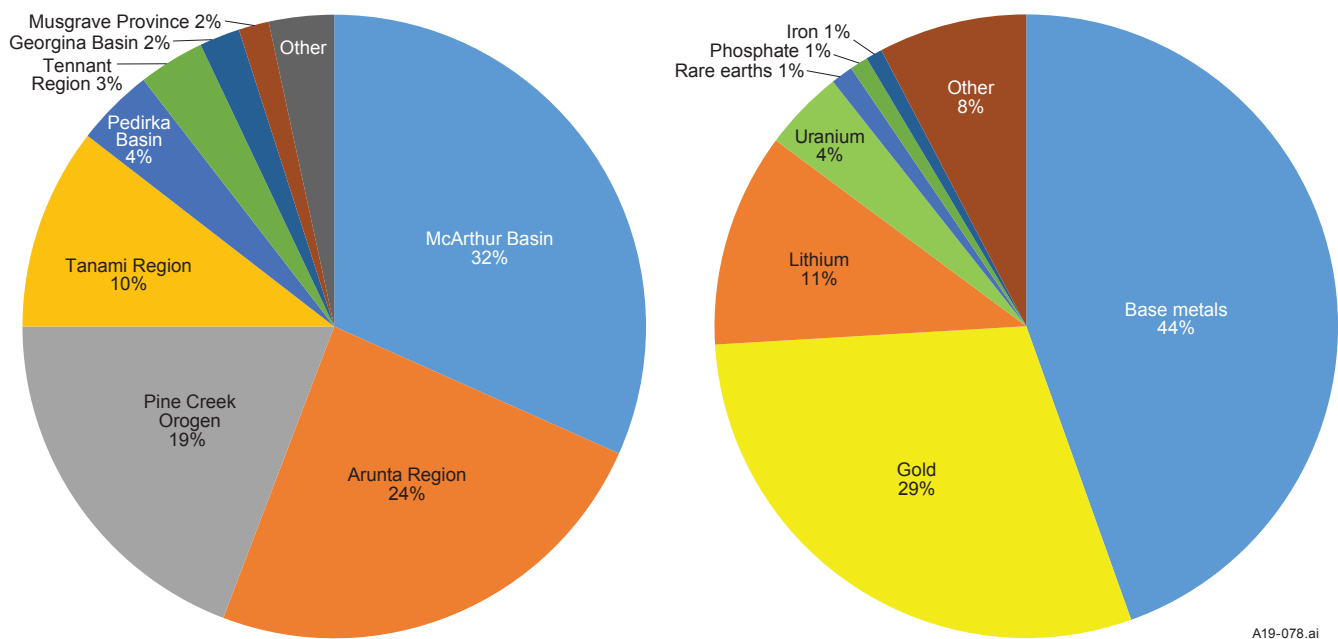


Figure 3. Summary of admissible on-ground exploration expenditure (excluding feasibility studies, desktop studies and overheads) reported to DPIR during 2018, broken down by (a) geological region and (b) primary commodity of interest. Note that exploration reported during 2018 may have occurred during either 2017 or 2018.

discovered Lantern deposit, plus resume active regional exploration on advanced targets. The Mineral Resource at the Cosmo mine includes Measured and Indicated Resources of 4.89 Mt at 3.1 g/t Au and an Inferred Mineral Resource of 2.03 Mt at 2.9 g/t Au, for a total contained 0.57 Moz of gold. At the end of 2017, combined Mineral Resources for all of Kirkland Lake's Northern Territory assets included Measured and Indicated Resources of 26.9 Mt at 2.3 g/t Au and an Inferred Mineral Resource of 16.3 Mt at 2.5 g/t Au, for a total contained 3.22 Moz of gold.

Following the 2017 discovery of high-grade gold mineralisation at the **Lantern** gold deposit at Cosmo Deepes, underground development at Lantern began during April 2018. Drilling commenced from two underground platforms, with up to four underground diamond rigs in operation in the second half of 2018, and further underground development underway. No results of underground drilling were released during 2018.

In April 2018, Kirkland Lake announced drilling results from their **Union Reefs** project, from four deep holes (for

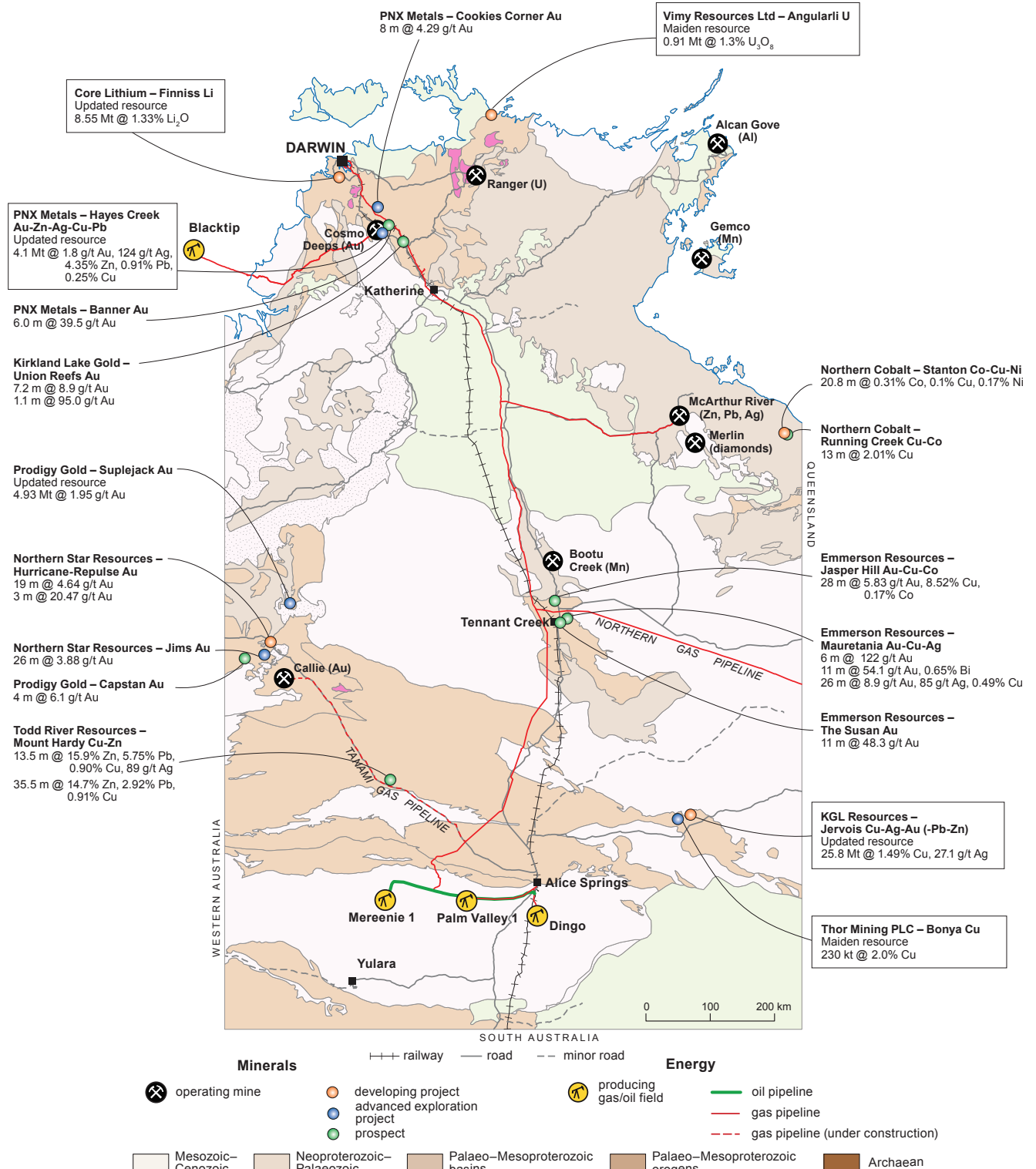


Figure 4. Map of the Northern Territory showing selected mineral exploration highlights for 2018.

Commodity	Unit of quantity	2017–18 ^{1,5}		
		Quantity produced ²	Quantity sold ³	Quantity sold (\$) ⁴
Metallic Minerals				
Bauxite	Tonnes	12 865 457	12 475 080	\$524 922 658
Gold ⁶	Grams	1 275	272	\$12 240
Gold Dore ⁷	Grams	16 988 266	14 489 759	\$780 465 196
Iron Ore	Tonnes	0	0	\$0
Manganese	Tonnes	6 386 814	6 216 596	\$1 974 747 145
Mineral Sands - ilmenite	Tonnes	24 070	24 070	\$6 023 311
Lead Concentrate	Tonnes	6 804	14 544	\$18 057 727
Zinc Concentrate	Tonnes	43 916	41 866	\$68 691 817
Zinc Lead Concentrate	Tonnes	479 348	499 072	\$846 148 318
Metallic Minerals Value				\$4 219 068 412
Non-Metallic Minerals				
Crushed rock	Tonnes	1 623 882	1 360 413	\$35 943 723
Diamonds	Carats	754	4 494	\$656 494
Dimension Stone	Tonnes	0	0	\$0
Garnet Sand	Tonnes	2 158	1 115	\$293 650
Gravel ⁸	Tonnes	142 607	130 707	\$1 630 563
Limestone	Tonnes	8 244	2 611	\$51 520
Mineral Specimens	Tonnes	0.45	0.4	\$72 183
Quicklime ⁹	Tonnes	26 374	24 851	\$6 181 292
Sand	Tonnes	247 578	194 497	\$5 275 600
Soil	Tonnes	32 831	31 204	\$505 551
Vermiculite	Tonnes	0	0	\$0
Non-Metallic Minerals Value	n/a			\$50 610 576
Energy Minerals				
Uranium Oxide	Tonnes	2 090	1 811	\$220 139 144
Total Minerals Value	n/a			\$4 489 818 132
Explanatory notes				
1. Fiscal year is 1st July to 30th June.				
2. Data is from production returns lodged by operators under statutory obligations.				
3. <i>Quantity Sold (\$)</i> is in AUD and is the gross amount paid to the operator.				
4. Data has been rounded and autosum applied.				
5. Data is correct as at 24 September 2018 and may be subject to revision due to late lodgements and/or receipt of superior data.				
6. ‘Gold’ does not include gold reported as gold dore; it is typically gold found as nuggets.				
7. Average metallic content of reported gold dore is approximately 90% gold and 10% silver and other metals.				
8. Average sales values have been applied to some non-metallic minerals if this information was not supplied.				
9. Quicklime is derived from limestone. Processing input and output data is deemed operator commercial-in-confidence.				

Table 1. 2017/18 mining production statistics for the Northern Territory.

4287 m) beneath the *Prospect*, *Crosscourse* and *Lady Alice* deposits. The results included a best intersection of 1.1 m at 95.0 g/t Au from Crosscourse and 3 m at 10.8 g/t Au from Prospect, and indicated the continuation of gold mineralisation at the three deposits below known mineral resources. In November, further results were announced from a 40 hole, 15 192 m drilling program at Union Reefs. The results identified high-grade near-surface mineralisation to the south of Lady Alice pit (best intersection of 7.2 m at 8.9 g/t Au including 0.45 m at 86.0 g/t Au), and confirmed the down-plunge continuity of mineralisation at Crosscourse. Mineralisation was also identified at depth at the southern end of Union Reefs. Kirkland Lake announced that continued exploration success at Union Reefs and in underground drilling at Lantern is increasing the company's confidence that a five-year mine plan can be established that could lead to the resumption of operations in 2019.

During 2018, PNX Metals Ltd (PNX) undertook a 3470 m RC and diamond drilling program on newly acquired leases at *Fountain Head*, aimed at identifying additional mineralisation to complement their nearby Hayes Creek gold-silver-zinc project. The program was designed

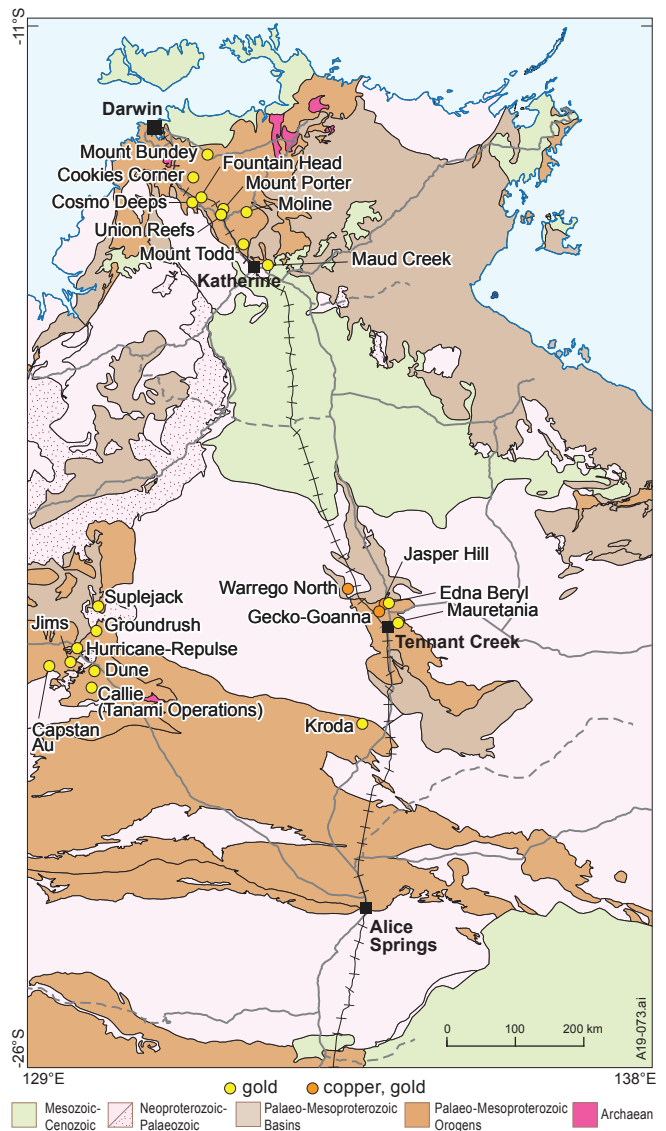


Figure 5. Location of gold and copper-gold deposits and projects mentioned in the text.

to test for gold mineralisation directly under the existing Fountain Head and **Tally Ho** historic mining areas and over a ~1.6 km strike extent to the northwest along the Fountain Head anticline. Highlights of drilling at Fountain Head include 3 m at 11.09 g/t Au from 93 m and 1 m at 28.0 g/t Au from 83 m. At the **Banner** prospect, 1.5 km northwest of Fountain Head, drilling tested a 500 m long, >1 g/t gold-in-soils anomaly and intersected high-grade gold with a best intersection of 6 m at 39.5 g/t Au from 54 m including 1 m at 215 g/t Au. In December, PNX announced drill intersections interpreted as being related to down-plunge extensions of the Tally Ho lode at Fountain Head, including 6.67 m at 11.35 g/t Au from 201 m. PNX have reported that the mineralisation intersected at Fountain Head contains coarse and ‘nuggety’ gold.

In October, PNX announced the results of a 16 hole, 1100 m RC drilling program at the **Cookies Corner** prospect, targeting the source of a consistent >0.1 g/t gold in soils anomaly. All holes intersected mineralisation associated with quartz-sulfide veins over a continuous 500 m strike, with a best intersection of 20 m at 1.93 g/t Au from 12 m, including 8 m at 4.29 g/t Au from 12 m. Cookies Corner is one of a cluster of gold targets in the northwest of PNX’s **Burnside** exploration project located 4 km northeast to the historic **Goodall** mine at the convergence of the Pine Creek Shear Zone and the Howley Anticline.

PNX also commenced a diamond drilling program at the historic **Moline** goldfield, 38 km east-northeast of Pine Creek, to extend three previously drilled RC holes that did not reach target depth and to obtain samples for further metallurgical flotation test work. The company also announced that they plan to release Mineral Resource estimates for the Moline and **Tumbling Dice** prospects.

Privately-owned Bacchus Resources Pty Ltd continued gold exploration in the Pine Creek Orogen in 2018, including at their **Woolwonga** project, but no results have been publicly reported.

In July 2018, Ark Mines Ltd (Ark) announced that they had signed a binding term sheet with Territory Iron Pty Ltd to sell the **Mount Porter** gold project and associated Frances Creek project, 20 km north of Pine Creek. Mount Porter has Indicated and Inferred Resources of 355 000 t at 3.0 g/t Au for 34 200 oz of gold (1.7 g/t cut-off).

Primary Gold Ltd’s **Mount Bunday** project includes the **Toms Gully**, **Rustlers Roost** and **Quest 29** deposits, located 90 km southeast of Darwin. The project has total Indicated and Inferred Resources of 54.1 Mt at 1.03 g/t Au for a contained 1.795 Moz of gold. In May 2018, Hanking Australia Pty Ltd completed an off-market takeover of Primary Gold worth \$37.5 million, and the company was removed from public listing.

Vista Gold Corporation (Vista) continued permitting and project optimisation work at their **Mount Todd** project, northwest of Katherine. Mineralisation at Mount Todd is contained in a stockwork of quartz veins and their margins, hosted within metamorphosed interbedded siltstone, shale and minor tuff of the Burrell Creek Formation. Mineral resources at Mount Todd include Measured and Indicated Mineral Resources of 279.6 Mt at 0.82 g/t Au containing 7.40 Moz of gold, and Inferred Mineral Resources of

72.5 Mt at 0.74 g/t Au containing 1.73 Moz of gold. Proven and Probable Ore Reserves are 222.8 Mt at 0.82 g/t Au containing 5.90 Moz of gold. During 2018, the company undertook high pressure grinding roll crusher and ore sorting tests with associated metallurgical test work. The company announced that the tests demonstrated the value-adding benefit of ore-sorting at Mount Todd; they plan to incorporate these results into a revised preliminary feasibility study in 2019.

Tanami–Arunta regions

Newmont Mining Corporation (Newmont)’s **Tanami Operations**, located 550 km northwest of Alice Springs, has produced approximately 8 Moz of gold. It remains the Territory’s largest gold operation, producing 408 000 oz of gold during 2017. Mineralisation consists of high-grade auriferous quartz veins in folded carbonaceous siltstone in the lower part of the Dead Bullock Formation. The operations include the flagship **Callie** deposit (>7.6 Moz), the 5.83 Moz **Auron** deposit, the >0.5 Moz **Federation South Limb** and the 2016 **Liberator** discovery. As of 31 December 2017, Proven and Probable Ore Reserves were 24.1 Mt at 5.69 g/t Au containing 4.41 Moz of gold. Additional Measured and Indicated Mineral Resources total 4.4 Mt at 5.07 g/t Au for 0.71 Moz of gold; Inferred Mineral Resources are 4.6 Mt at 5.42 g/t Au for 0.79 Moz of gold. The total pre-mining gold endowment at the mine was 14.2 Moz at the end of 2017, with resource additions of 4.21 Moz since 2012.

In August 2018, Nova Minerals Ltd announced that Newmont had earned a 70% interest in their **Officer Hill** project. Follow-up exploration will include diamond drilling, an airborne gravity survey and follow-up geochemistry around the **Paris** prospect, which was identified in 2017 using Newmont’s proprietary Deep Sensing geochemistry technique.

During 2018, Northern Star Resources Ltd (Northern Star) continued to explore the Central Tanami Project (CTP) as part of a purchase and farm-in agreement with Tanami Gold NL, as well as their 100%-owned Tanami tenements. In the CTP area, regional aircore drilling programs were completed at **Jim’s Return**, **Channel 4**, **Terminus** and **Solaris** prospects in the south and at the **Free Fall** area east of the **Groundrush** deposit. RC drilling programs were undertaken at **Jims North**, **Jims West**, and **Carmen** prospects; they returned anomalous results. Diamond drilling beneath the existing Jim’s open pit returned significant gold intersections up to 170 m including 26 m at 3.88 g/t Au from 224 m and 10 m at 5.70 g/t gold from 401 m.

Northern Star also completed a program of RC and diamond drilling beneath the existing CTP treatment plant infrastructure, testing for potential shallow extensions to the main **Hurricane–Repulse** mineralisation. RC drilling intersected significant gold mineralisation at varying depths in all 23 drillholes completed. Significant intersections from the program included 3 m at 20.47 g/t Au from 140 m, 19 m at 4.64 g/t Au from 136 m, and 14 m at 3.19 g/t Au from 150 m. A single diamond drillhole testing the down plunge continuity of the newly discovered zones intersected mineralisation located ~130 m below the base

of the existing Hurricane pit, with 8.5 m at 6.6 g/t Au from 177.9 m. Northern Star reported that this confirms potential for significant depth extensions to the Hurricane–Repulse mineralisation.

At Northern Star’s 100%-owned Tanami Regional Project, an extensive regional aircore drilling program was completed in the **Supernova** area, located approximately 60 km northwest of the CTP camp. Results defined isolated spot anomalies. Regional ground gravity surveys were also completed at Supernova.

During 2018, Prodigy Gold Ltd (Prodigy; formerly ABM Resources NL) focussed significant exploration at their greenfields **Capstan project** within their Bluebush project area, located 50 km to the northwest of the Callie deposit. Following encouraging results in 2017 that identified an 8 km long zone of gold anomalism in interpreted Dead Bullock Formation stratigraphy, a substantial aircore drilling program was undertaken in the first half of 2018 (**Figure 6**). This program defined extensive continuous trends of +50 ppb gold anomalism up to 4.5 km long and 750 m wide, with aircore drill results up to 4 g/t Au. In December 2018, Prodigy announced that follow-up RC drilling had defined a 1.2 km long zone of interest in the **Capstan North** prospect. Results included 4 m at 6.1 g/t Au from 128 m containing 1 m at 23.9 g/t Au. RC drilling was also undertaken at the Hat prospect at Capstan, with a best intersection of 4 m at 1.2 g/t Au from 111 m. Prodigy also drilled two stratigraphic diamond holes for 951.4 m, co-funded by NTGS under the Geophysics and Drilling Collaborations program, to better understand the stratigraphic setting of Capstan. Prodigy also undertook a 95 hole, 6550 m RAB drilling program at the **Galaxy** prospect, 30 km east of Capstan, where they identified an anomalous mineralised trend that extends to 6 km south of Jim’s pit.

In July 2018, Prodigy announced an updated resource for their **Suplejack** project including the **Hyperion–Tethys**, **Seuss** and **Hyperion South** deposits, located 17 km north-northeast of Groundrush. Indicated and Inferred Resources total 4.93 Mt at 1.95 g/t Au, containing 309 000 oz Au. The mineralisation remains open along strike and at depth. In December 2018, Prodigy announced results of a drilling

program 200 m south of the existing resource area; drilling intersected thick quartz breccias in the Suplejack fault with intersections of 89 m at 0.3 g/t Au and 43 m at 0.4 g/t Au, both of which ended in mineralisation.

In July 2018, Prodigy announced the signing of a binding farm-in agreement with Newcrest Mining for Prodigy’s **Euro** project area in the eastern Tanami whereby Newcrest will sole fund up to \$12 million over seven years to ultimately earn up to a 75% interest in the project. An initial 8 hole, 1466 m RC program was completed at the **Dune** prospect in late 2018, targeting a structural repeat of Newmont’s **Oberon** deposit located 1.6 km to the north. Four of the eight holes intersected zones of 3 g/t Au or more, with a best intersection of 2 m at 12 g/t Au from 105 m. The JV also completed IP surveys at Dune, and at **Vivitar** 20 km to the east.

Gladiator Resources Ltd (Gladiator) announced the results of their first drilling program at the North Arunta project, in which Gladiator are sole funding \$6.5 million over 4.5 years to ultimately earn a 70% interest in the project from Prodigy, their joint venture partner. The project is located north and northwest of Barrow Creek, and includes the **Kroda** gold prospect. The program involved 12 RC and diamond holes for 2194 m at the Kroda 4 prospect, testing 350 m strike length of an IP anomaly defined in June–July 2018. The chargeability anomalies were interpreted as being in the plunge extension or duplication of gold mineralisation in historic holes at the prospect. All holes returned elevated gold over broad intervals associated with silicification, quartz veining, sulfides and elevated arsenic; the best intersection was 3 m at 1.4 g/t Au.

Warramunga Province (gold-copper-bismuth)

Emmerson Resources Ltd (Emmerson) continued to explore the Tennant Creek mineral field during 2018, with a major restructure of joint venture arrangements and alliances. In February 2018, Emmerson announced it had agreed with Evolution Mining to restructure the Tennant Creek Mineral Field Joint Venture whereby Evolution would forego its right to a 65% interest in the entire JV area and instead, take a 100% interest in the area of the JV that contains the **Gecko**,



Figure 6. Airborne magnetic survey plane (NTGS Tanami survey) flying over Prodigy aircore rig, Tanami Desert. Photo provided by Prodigy.

Goanna and **Orlando** copper-gold deposits. Emmerson resumed ownership of the remaining 94% of the JV area.

In April 2018, Emmerson announced that it had sampled historic drill core from **Jasper Hills** in the Northern Corridor of the Tennant Creek field. Sample results returned high-grade cobalt, copper and gold intersections including 28 m at 5.83 g/t Au, 0.17% Co and 8.52% Cu from 108 m, and 14 m at 6.72 g/t Au, 0.28% Co and 2.17% Cu from 284 m. In June, Emmerson announced that RC drilling program at the **Mauretania** prospect intersected high-grade gold, silver, and copper with elevated bismuth and cobalt, including 26 m at 8.9 g/t Au, 85 g/t Ag, 0.49% Cu and 0.13% Bi from 53 m; 6 m at 18.9 g/t Au and 0.46% Bi; and 9 m at 2.6 g/t Au, 22.8 g/t Ag, 2.3% Cu and 0.12% Co.

In September 2018, Emmerson announced it had entered a strategic alliance with Territory Resources Limited (Territory Resources) for a mining and exploration joint venture of the Southern Project Area (SPA) at Tennant Creek that includes the historic **Nobles Nob**, **Juno**, **Peko** and **Eldorado** mines. As part of the alliance, Territory Resources will contribute \$5 million over 5 years to earn a 75% equity in the SPA, with Emmerson being the operator and manager during the earn-in period. The alliance also involves the sale of the Warrego mill and associated lease to Territory in exchange for Territory building a 300 000 tpa carbon in pulp processing facility on the site. The alliance aims to fast-track development of Emmerson's small mining projects with processing at the new mill.

Small-scale gold mining at the high-grade **Edna Beryl** deposit, located 40 km north of Tennant Creek, was suspended for most of 2018. It had commenced in 2017 under a tribute mining agreement with the Edna Beryl Mining Company. In December 2018, Emmerson announced that Territory Resources has purchased the Edna Beryl Mining Company, and had immediate plans to develop and recommence mining in the tribute area at Edna Beryl.

In August 2018, Chalice Gold Mines Ltd announced that they had completed four RC drillholes for 1206 m targeting Tennant Creek-style copper-gold mineralisation at their **Warrego North** project, 20 km northwest of the historic Warrego mine. The drilling targeted coincident magnetic and gravity anomalies at the **Emu** prospect, thought to possibly represent ironstone units prospective for copper-gold mineralisation. All holes intersected highly magnetic dolerite intrusions with sporadic, low tenor copper mineralisation and no significant gold.

Copper, lead, zinc, silver

Arunta Region

During 2018, KGL Resources Ltd (KGL) continued infill and extension drilling at the **Jervois** copper-silver project northeast of Alice Springs (**Figure 5**), particularly focussed on the **Rockface** and **Reward** deposits. Mineralisation at Jervois occurs in a series of stratabound, subvertical sulfide-rich deposits along a 12 km strike length in the Bonya Metamorphics in the Aileron Province. Results from drilling announced in the early part of 2018 included 7.55 m at 5.43% Cu, 16.5 g/t Ag and 0.35 g/t Au from

732.72 m at Rockface, and 9.12 m at 3.55% Cu, 30.1 g/t Ag and 0.67 g/t Au from 635.9 m at Reward Deep. In May 2018, KGL announced an updated Mineral Resource for the Jervois project with a higher copper cut-off grade of 1% Cu for resources assumed to be accessible by underground mining. This was subsequently updated in January 2019 with increased Indicated Resources. The January 2019 copper-rich resource is 21.9 Mt at 1.63% Cu and 20.2 g/t Ag, including an Indicated and Inferred Resource for the Rockface underground of 3.58 Mt at 2.58% Cu. If copper and silver contained in the existing (2015) lead-zinc resource (3.8 Mt at 3.7% Pb, 1.2% Zn, 0.72% Cu and 67.5 g/t Ag) is included, the total resource of the project is 25.8 Mt at 1.49% Cu and 27.1 g/t Ag, containing 385 200 t of copper.

Drilling at Jervois during 2018 occurred at Rockface, Reward and **Morely**; the program intersected high-grade mineralisation including 6.16 m at 7.84% Cu, 0.07% Pb, 0.19% Zn, 37.7 g/t Ag and 0.66 g/t Au from 684.6 m at Rockface, and 9.29 m at 4.22% Cu, 0.28% Pb, 0.37% Zn, 67.5 g/t Ag and 0.82 g/t Au from 99.7 m in the oxidised zone at Reward. KGL lodged its Environmental Impact Statement for the project in October 2018.

In June 2018, Todd River Resources Ltd announced the discovery of high-grade polymetallic base metal mineralisation at the EM1 target at the **Mount Hardy** copper-zinc project area, 300 km northwest of Alice Springs. The first drilling program at EM1 tested an electromagnetic (EM) conductor and intersected a broad interval of massive brecciated sulfides, which assayed 25.15 m at 2.4% Cu, 4.0% Zn and 3.1% Pb from 184 m, including 9.15 m at 4.5% Cu, 7.6% Pb and 8.8% Zn from 200 m. In August, further high-grade intersections were announced, including 13.45 m at 15.9% Zn, 0.9% Cu, 5.75% Pb and 83 g/t Ag from 358.55 m, and 55.75 m at 1.0% Cu, 1.5% Pb 3.3% Zn and 43.5 g/t Ag from 131.5 m (not true width), including 7.92 m at 1.4% Cu, 5.0% Pb, 13.8% Zn and 212.3 g/t Ag from 179.38 m. In November, they announced that the deepest and northernmost hole drilled to date at EM1 had intersected a wide high-grade intersection of 35.5 m at 14.7% Zn, 2.92% Pb, 0.91% Cu and 59 g/t Ag from 431.5 m; this included 11.3 m at 22.9% Zn, 3.35% Pb, 1.00% Cu and 58 g/t Ag from 443.6 m. The company has announced that the main EM1 mineralised zone has now been extended to a vertical depth (down-dip) of ~600 m and remains open in all directions; both downhole EM and moving loop EM have generated further conductors for testing.

Independence Group NL (IGO) continued their greenfields exploration in the remote southwestern Aileron Province over a 13 000 km² project area north and northeast of Kintore where IGO is targeting polymetallic mineralisation as part of the Lake Mackay exploration alliance with Prodigy. This followed the discovery of polymetallic copper-silver-gold-zinc mineralisation at the **Bumblebee** prospect in 2015 and at the **Grapple** prospect in 2016 and 2017. During 2018, IGO undertook large-scale regional airborne EM (SPECTREM) surveys, with more than 8000 line km acquired by the end of September. Thirty-nine anomalies from the airborne survey were selected for ground moving loop EM (MLEM) surveys, which commenced in September. IGO also undertook further reconnaissance and selective infill soil sampling across the

project area; results identified a number of new gold-copper, nickel-cobalt and gold-only anomalies. The company have announced that they are planning 9600 m of RC drilling before the end of the 2018/19 financial year.

In November 2018, Thor Mining PLC announced a maiden Inferred Mineral Resource of 230 000 t at 2.0% Cu for the historic **Bonya** copper mine, 20 km west of Jervois, which they hold in joint venture with Arafura Resources.

Pine Creek Orogen

PNX Metals Ltd (PNX)'s **Hayes Creek** project comprises the **Iron Blow** and **Mount Bonnie** polymetallic gold-silver-zinc deposits in the basal Mount Bonnie Formation and Gerowie Tuff of the Pine Creek Orogen. Combined Indicated and Inferred Mineral Resources for the project total 4.1 Mt at 1.8 g/t Au, 124 g/t Ag, 4.35% Zn, 0.91% Pb and 0.25% Cu. In February 2018, PNX announced the results of extensional drilling at Mount Bonnie conducted in late 2017. The drilling intersected zinc, gold and silver mineralisation in 15 drillholes outside of the existing Mineral Resource envelope, extending the known mineralisation by approximately 35 m, with a best intersection of 4 m at 6.14% Zn, 1.14 g/t Au, 176 g/t Ag, 1.29% Pb, 0.11% Cu from 73 m, including 2 m at 10.28% Zn, 1.92 g/t Au, 304 g/t Ag, 2.11% Pb, 0.17% Cu. During the year, PNX submitted a Notice of Intent for development of Hayes Creek and continued to progress a definitive feasibility study.

The **Browns** deposit near Batchelor comprises a large sediment-hosted polymetallic oxide and sulfide resource that was briefly developed by Compass Resources Ltd in 2007–08. Doe Run Australia, a subsidiary of North American lead producer The Doe Run Company, continued exploration and appraisal activities at the project in 2018; no results have been publicly announced.

McArthur Basin

The **McArthur River** mine, situated about 70 km southwest of Borroloola in the McArthur Basin, is operated by McArthur River Mining Pty Ltd (MRM), a subsidiary of Glencore. At 31 December 2018, the McArthur River mine had total Reserves and Resources of 172 Mt at 9.8% Zn, 4.6% Pb and 47 g/t Ag, including Ore Reserves of 108 Mt at 9.0% Zn, 4.3% Pb and 44 g/t Ag. During 2018, MRM produced 254 300 t of zinc, 49 900 t of lead and 1.72 Moz of silver in concentrate, representing a 23% increase in zinc production from 2017. The very fine-grained, thinly bedded sulfide ore is hosted in the HYC Pyritic Shale Member of the Barney Creek Formation. In August 2018, the company received an Assessment Report from the NT Environmental Protection Agency (EPA) that provided conditions for the approval of waste rock management for the remaining 30 years of the project's mine life.

A second major shale-hosted zinc resource occurs at the **Teena** zinc deposit, 10 km west of the McArthur River mine. Teena was discovered in 2013 by a Teck Australia (Teck)–Rox Resources joint venture. The 2016 Inferred Mineral Resource at Teena is 58 Mt at 11.1% Zn and 1.6% Pb for 6.5 Mt of zinc and 0.9 Mt of lead metal (at a 6% Zn+Pb cut-off). No exploration results have been publicly reported from Teena during 2018.

In March 2018, Marindi Metals Ltd announced that it had entered into a binding agreement with Japan Oil Gas and Metals Corporation (JOGMEC) under which JOGMEC can earn up to 70% of their **Carinbirini** zinc project north of McArthur River mine by funding \$4 million in exploration over 3 years. In September 2018, Marindi announced the commencement of a major diamond drilling campaign targeting three coincident gravity and versatile time-domain EM (VTEM) targets, projected to be in the Barney Creek Formation within 500–800 m of the surface. Results of this drilling are pending.

During 2018, Pacifico Minerals undertook a 37 hole, 1100 m aircore drilling program at the **Lorella** project, part of their Borroloola West JV with Sandfire Resources Ltd. The aircore program was designed to test for extensions of the known oxide copper mineralisation along strike from shallow flat-lying mineralisation identified by Sandfire Resources. The drilling encountered low-grade copper mineralisation, with a best intersection of 16 m at 0.32% Cu from 23 m.

In August and September 2018, Todd River Resources Ltd undertook a program of three diamond holes for 1393.1 m at their McArthur project, 75 km south-southwest of McArthur River mine. The holes were designed to test geophysical anomalies within the Mallapunyah and Wologorang formations that were outlined from a 2017 SkyTEM airborne EM survey. The company reported that modest base metal intersections were noted.

MMG Exploration Pty Ltd (MMG) continued to actively explore in the Batten Fault Zone area in the McArthur Basin under their North Batten JV with Sandfire Resources, as well as on their own tenure. Sandfire reported that MMG undertook a significant geophysical and drilling program across the JV tenements in 2019, with no results publicly reported.

Diamonds

Merlin Diamonds Ltd's **Merlin** project (**Figure 7**) in the McArthur Basin comprises 14 kimberlite pipes of which nine were subject to open cut mining between 1998 and 2003, producing 507 000 ct of diamonds. The 2014 combined Probable Ore Reserve for all diamond pipes at Merlin was 2.02 Mt at 0.15 carats per tonne (ct/t) for a total of 0.61 Mct. The Indicated and Inferred Mineral Resource was 27.8 Mt at 0.16 c/t for a total of 4.35 Mct. Small-scale mining continued at Merlin during 2018 with production 3539 ct diamonds reported from the **Ector** deposit and from stockpiles between May and December 2018.

Bauxite and alumina

Rio Tinto Ltd operates the **Gove** bauxite mine in northeastern Arnhem land, which has been in production since 1971. Bauxite at Gove occurs in deeply lateritised, dissected plateau remnants overlying the Cretaceous Yirrkala Formation. At the end of 2017, the Gove operation had Proven and Probable Ore Reserves of 147 Mt at 49.4% Al_2O_3 , with additional Measured, Indicated and Inferred Mineral Resources of 33 Mt at 49.3% Al_2O_3 . During 2018, the Gove operation produced a record 12.54 Mt of bauxite, a 12% increase on 2017.

A new bauxite mine is in operation on the **Dhupuma Plateau**, immediately south of the Gove mineral lease. It is run by the Aboriginal-owned Gulkula Mining Company Pty Ltd. The operation opened in August 2017 and is expected to ramp up to full annual production of 500 000 tpa bauxite within the first four years. It has a projected 15 year mine life at this rate of production. The mine is associated with a Mining Training Centre for local Aboriginal people, established with the support of Rio Tinto. The ore is sold to Rio Tinto's Gove operation.

Iron ore

During 2018, Territory Resources submitted a Notice of Intent for the **Yarram** iron deposit near Batchelor. The company have reported a Mineral Resource estimated at 15.1 Mt at 52.1% Fe and 0.24% P using a cut-off grade of 45% Fe. The deposit includes 4.5 Mt of higher grade ore (61.7% Fe) with lower phosphorus, suitable as either direct shipping ore or for blending with low grade ore to produce

a saleable product. Territory Resources is proposing a small mining operation producing up to 1 Mt per annum.

In February 2018, Britmar (Aust) Pty Ltd (Britmar) received approval for its Mining Management Plan for the **Roper Bar** iron ore mine, 55 km southeast of Ngukurr. No production has been reported for 2018. Northern Territory Iron Ore have a Notice of Intent in place for the development of iron ore from three deposits (Deposits C, W and X) at their **Roper Valley** project, 150 km east of Mataranka. Iron ore would be transported to a purpose-built barge loading facility located near the mouth of the Roper River and then transhipped by barges to ocean going vessels moored offshore in the Gulf of Carpentaria.

Manganese

Oolitic and pisolitic ore in Mesozoic sedimentary rocks on **Groote Eylandt** in the Gulf of Carpentaria forms one of the world's highest-grade manganese deposits. It has remaining resources of 157 Mt at 44.1% Mn. The mineralisation is a stratiform sedimentary deposit in shallow marine Cretaceous sediments, and is commonly oolitic or pisolitic. It was discovered in 1960 and has been continuously mined since 1966 by the Groote Eylandt Mining Company (GEMCO, a majority owned by South32 Ltd). Production from Groote Eylandt in 2017/18 totalled 5.66 Mt of manganese ore.

In January 2019, an exploration licence covering part of **Winchelsea Island**, off the northwest coast of Groote Eylandt, was granted to the Winchelsea Mining Pty Ltd. This is a joint venture between the Anindilyakwa Advancement Aboriginal Corporation (AAAC) and AUS China International Mining. AAAC, the majority partner, consists of the two Traditional Owner clans of Winchelsea Island. They plan to explore for manganese of a similar style to Groote Eylandt.

A second manganese mine in the NT is hosted in Proterozoic rocks at **Bootu Creek**, 110 km north of Tennant Creek. OM Manganese Ltd began mining operations at Bootu Creek in November 2005. At 31 December 2017, the total Reserves and Resources for Bootu Creek were 9.95 Mt at 22.4% Mn, with an Ore Reserve of 7.32 Mt at 20.7% Mn. During 2018, OM mined 1.82 Mt of manganese ore at an average grade of 21.94% Mn, producing lumps and fines totalling 814 040 t at 35.77% Mn. A tailings retreatment plant at Bootu Creek is expected to be commissioned in 2019 and will produce approximately 250 000 t per annum of manganese fines with an average grade of between 36% to 38% Mn for 8 years.

Tungsten (-molybdenum)

Thor Mining PLC continued to pursue options for development of the **Molyhil** tungsten-molybdenum project located near the Plenty Highway northeast of Alice Springs. Molyhil is a skarn-related scheelite–molybdenite–magnetite deposit within the Aileron Province with a Mineral Resource of 4.71 Mt at 0.28% WO₃, 0.22% MoS₂ and 18.1% Fe, most of which is in the Indicated category, and an open cut Probable Ore Reserve of 3.5 Mt at

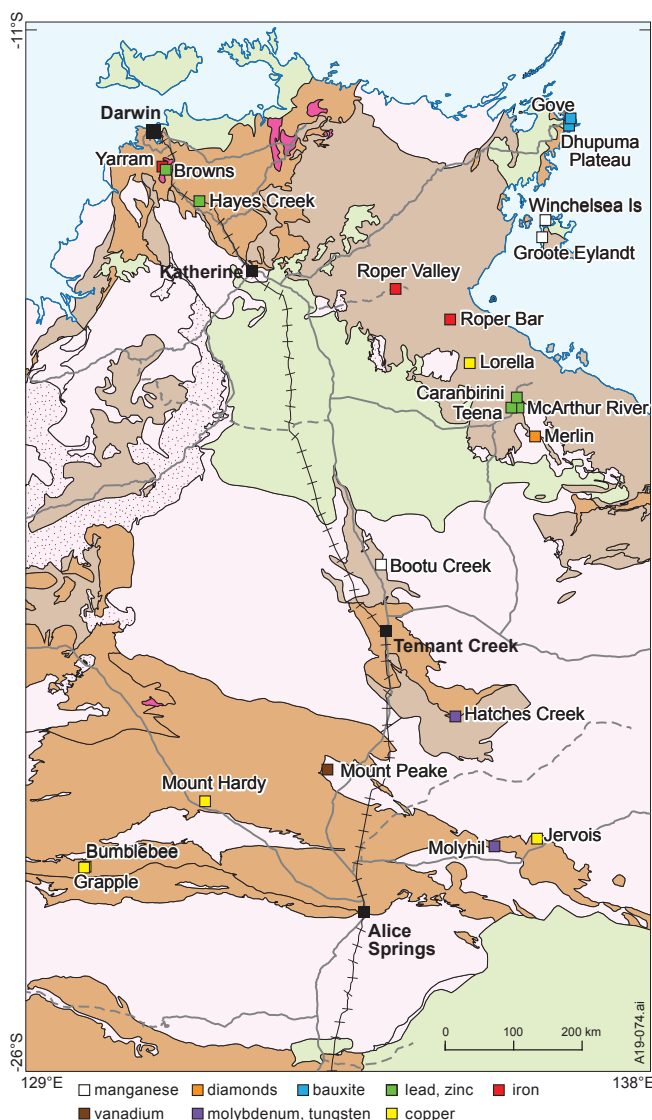


Figure 7. Location of copper, lead-zinc-silver, diamond, manganese, tungsten-molybdenum, vanadium and graphite deposits and projects mentioned in the text.

0.29% WO_3 and 0.12% MoS_2 . During 2018, the company announced an updated definitive feasibility study for a mining operation at Molyhil with a seven-year mine life with potential for subsequent underground mining. The company also finalised acquisition of a 40% interest in the nearby Bonya project area, including a number of outcropping tungsten deposits.

Following drilling programs carried out in 2016 and 2017, GWR Group Ltd announced an Exploration Target of 11.9 to 16.5 Mt at 0.2–0.5% WO_3 for the historic **Hatches Creek** tungsten field in the Davenport Province. The Hatches Creek field contains numerous underground mines that were mined between 1915 and 1957. Mineralisation is hosted in quartz veins containing wolframite with lesser scheelite, bismuth and copper oxides. Surface stockpiles of historically mined ore have an Inferred Resource of 225 066 t at 0.58% WO_3 for 1311 t of tungsten trioxide. In September 2018, GWR Group announced they were selling the project to Tungsten Mining NL; the company later announced that the transaction as originally structured was unable to proceed.

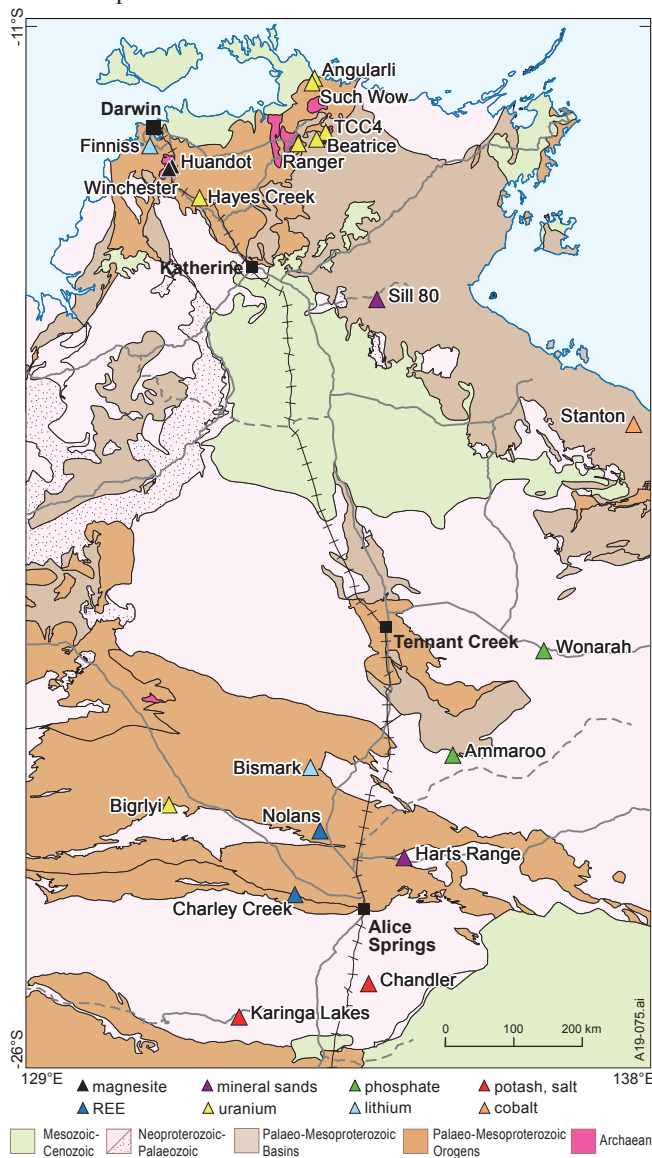


Figure 8. Location of magnesite, mineral sands, rare earths, lithium, phosphate, potash, salt and uranium deposits and projects mentioned in the text.

Vanadium-titanium-iron

TNG Limited's **Mount Peake** project contains a vanadium-titanium-iron deposit hosted in the Mount Peake Gabbro in the northern Aileron Province, 60 km west-southwest of Barrow Creek. It contains Measured, Indicated and Inferred Mineral Resources of 160 Mt at 0.28% V_2O_5 , 5.3% TiO_2 and 23.0% Fe, and a Probable Ore Reserve of 41.1 Mt at 0.42% V_2O_5 , 7.99% TiO_2 and 28.0% Fe at a cut-off grade of 15% Fe. During 2018, TNG Limited received Commonwealth and NT environmental approvals for the project, and subsequently was granted a Mining Lease. The company continued to progress financing and offtake arrangements.

Magnesite

A number of high-grade magnesite (magnesium carbonate) deposits occur near Batchelor in the Pine Creek Orogen (**Figure 8**). They consist of stratabound bodies within the Celia and Coomalie Dolostones. The deposits include **Winchester** (Korab Resources Ltd), with Indicated and Inferred Mineral Resources of 16.6 Mt at 43.2% MgO and **Huandot** (Thessaly Resources Pty Ltd), 7 km northeast of Winchester, with Indicated and Inferred Mineral Resources of 9.1 Mt at 44.3% MgO. Korab announced during 2018 that they were investigating various development options including direct shipping of magnesite rock, export of dead burned magnesia and export of caustic calcined magnesia.

Mineral sands

The **Harts Range** garnet sand deposit, located 170 km northeast of Alice Springs, is operated by Australian Abrasive Minerals Pty Ltd (AAM). After a year in administration, AAM announced in October 2018 that it had obtained finance and was recommissioning the processing plant for a return to production in 2019.

In 2018, Australian Ilmenite Resources Pty Ltd continued commissioning and recommenced production at the **Sill 80** ilmenite project in the Roper region. Ilmenite at Sill 80 occurs in surficial cover overlying sills of Derim Derim Dolerite intruding the Roper Group.

Rare earth elements

Arafura Resources Ltd (Arafura) continued to progress the **Nolans** rare earth-phosphate project located in the Reynolds Range, 135 km northwest of Alice Springs. Measured, Indicated and Inferred Mineral Resources at Nolans total 56 Mt at 2.6% rare earth oxides (REO), 11% P_2O_5 and 0.02% U_3O_8 , containing 1.46 Mt rare earth oxides. The most abundant rare earth-bearing minerals at Nolans are apatite, monazite and allanite, with 26.4% of the mix represented by neodymium and praseodymium (NdPr). In November 2018, Arafura announced that it would build its final rare earths separation plant on site at Nolans rather than offshore. In February 2019, they further announced the results of a definitive feasibility study for the Nolans project. The planned operation will have a 23-year life and produce 4357 tpa of neodymium and praseodymium oxide and 135 808 tpa of phosphoric acid.

The plant will also produce mixed middle-heavy rare earth (SEG–HRE) carbonate and cerium hydroxide.

Lithium

Core Lithium Ltd (Core; formerly Core Exploration Ltd) continued to explore and define additional resources at their **Finniss** lithium project, which forms part of the Bynoe pegmatite field, 20–50 km south-southwest of Darwin. Lithium mineralisation in the Bynoe field occurs as spodumene (**Figure 8**) hosted in north-trending pegmatites up to 40 m in width, which occur along a 30 km north-trending corridor. Following the announcement of a maiden lithium Mineral Resource of 1.8 Mt at 1.5% Li₂O at the **Grants** prospect in May 2017, the company undertook further infill and extensional drilling, which returned high-grade intersections outside the existing resource, such as 45 m at 1.72% Li₂O from 188 m including 22 m at 2.09% Li₂O. In October 2018, the Mineral Resource at Grants was increased to 2.89 Mt at 1.5% Li₂O, with over one third in the Measured category. In May 2018, Core announced a maiden Mineral Resource for the **BP33** deposit, 6 km south of Grants; in November, they announced a subsequent upgrade to the size and confidence of the BP33 resource, reporting an Indicated and Inferred Resource of 2.15 Mt at 1.5% Li₂O. In late 2018 and January 2019, the company announced maiden Inferred Resources for the **Sandras** (1.3 Mt at 1.0% Li₂O), **Carlton** (0.79 Mt at 1.3% Li₂O) and **Hang Gong** (1.4 Mt at 1.2% Li₂O) deposits, bringing the total combined Mineral Resource for the Finniss project area to 8.55 Mt at 1.33% Li₂O for 115 700 t contained Li₂O. Core also announced promising exploration results from other prospects including **Lees-Booths Link** (13 m at 1.46% Li₂O from 193 m), and **Turners** and **Talina 3** prospects in the southern part of the project area. Drilling results at Hang Gong and Lees-Booths Link suggest that pegmatites in these areas are shallowly-dipping and stacked, unlike the sub-vertical pegmatites at Grants and BP33.

PNX Metals Ltd announced in July 2018 that surface rock chip samples from their newly acquired **Kilfoyle** project, near Daly River, 130 km south-southwest of Darwin, returned high grades of lithium. This included rock chip sample assays up to 7.16% Li₂O at the **White Rocks** prospect, and up to 6.24% Li₂O at the northern end of the **Goosewing** trend. This trend also hosts evidence of historic small-scale tin-tantalum workings and indicates a strike of at least 10 km in length.

In July 2018, Kingston Resources Ltd announced the sale of its Bynoe and Arunta lithium tenements to private company Lithium Plus Pty Ltd for \$1.8 million.

In the northern Aileron Province, Todd River Resources Ltd announced the results of petrography on pegmatites from the **Bismark** prospect near Barrow Creek that returned rock chip values of up to 4.63% Li₂O. The petrography confirmed that the pegmatites contain 33–52% spodumene.

Cobalt

In April 2018, Northern Cobalt Ltd (N27) announced an updated resources for the **Stanton** cobalt-copper-

nickel deposit, part of their Wollongorang project in the McArthur Basin near the Queensland border. Following a major drilling program in late 2017, N27 announced an updated Indicated and Inferred Mineral Resource totalling 942 000 t at 0.13% Co, 0.06% Ni and 0.12% Cu. The mineralisation as flat lying, stratabound, occurs from surface and is non-refractory (predominantly comprising the cobalt sulfide mineral siegenite). In the first half of 2018, N27 undertook a 973 hole aircore (AC) drilling program, testing for near-surface cobalt over magnetic lows. Of the 75 magnetic features tested, 21 had significant cobalt anomalism (>100 ppm Co) in the equivalent horizon to that exposed at the surface at Stanton. These 21 targets were prioritised for a follow-up drill program that commenced in August 2018. At the first priority target at the **GregJo** prospect, drilling intersected broad intervals of shallow copper mineralisation of 9–20 m at 0.2%–0.5% Cu, including higher grade intervals of 1–4 m at between 1 and 5% Cu. The mineralisation is spatially associated with two structures within the GregJo fault. At the **Running Creek** prospect, 1.8 km east of Stanton, drilling intersected significant copper with cobalt mineralisation, with 55 m at 0.78% Cu from surface, including 13 m at 2.01% Cu and 12 m at 380 ppm Co. This followed re-interpretation of historic drilling that suggested the mineralisation is controlled by a northeast-trending structure. An IP survey over the prospect has identified a large chargeable feature at depth beneath the existing mineralisation that remains to be tested.

In the Tennant Creek mineral field, Emmerson announced that it had sampled historic drillcore from **Jasper Hills**, within the Northern Corridor of the field. Sampling returned the following high-grade cobalt, copper and gold intersections: 28 m at 0.17% Co, 5.83 g/t Au and 8.52% Cu from 108 m including 19 m at 0.47% Co, 11.4% Cu and 0.56 g/t Au; 14 m at 0.28% Co and 6.72 g/t Au; and 2.17% Cu from 284 m including 2 m at 1.32% Co and 2% Cu. Emmerson reported that the high-grade cobalt zone transgresses the copper and consists mainly of cobaltite in association with chalcopyrite and digenite.

As part of the Lake Mackay joint venture managed by IGO, Prodigy announced assay results from rock-chip samples of up to 2.5% Co, 1.1% Ni and 46.4% Mn from pyrolusite-bearing duricrust overlying a gabbro-norite intrusion at their **Grimlock** prospect northeast of Kintore.

Phosphate

Verdant Minerals Ltd's (Verdant) **Ammaroo** phosphate project is located in the southern Georgina Basin, ~80 km east of Barrow Creek. The project has Indicated Mineral Resources of 165 Mt at 15.5% P₂O₅, and total Measured, Indicated and Inferred Mineral Resources of 1.141 Bt at 14% P₂O₅ at 10% P₂O₅ cut-off. In May 2018, Verdant released a bankable feasibility study for the project for a proposed mining operation with an initial stage producing 1 Mtpa of rock phosphate concentrate (33% P₂O₅), then increasing to 2 Mtpa. The project received Federal Government environmental approval in June 2018 and NT EPA approval in October 2018.

In August 2018, Avenira Ltd announced that a demonstration plant, run by their technology partners JDC Phosphate Inc, had successfully produced high-quality super-phosphoric acid from low-quality (14%) phosphate rock tailings; they reported that this technology is potentially applicable to their large **Wonarah** phosphate project in the Georgina Basin.

In November 2018, Phosphate Australia Limited announced it had granted an Option to sell its wholly owned **Highland Plains** phosphate project to a private Canadian company, P2O5 Resources Inc.

Potash

The NT's only advanced potash project is Verdant's **Karinga Lakes** project, located between Erldunda and Curtin Springs, 200–300 km southwest of Alice Springs. The project area contains hundreds of salt lakes representing the eastern extension of the Lake Amadeus system. Measured, Indicated and Inferred Mineral Resources at Karinga Lakes are 8.4 Mt K_2SO_4 at an average resource thickness of 17 m and contained beneath 25 lakes with a total area of 132 km². The average potassium grade in the resource is 4760 mg/l (at 3000 mg/l cut-off). Consolidated Potash Corporation (formerly Aqua Guardian Group Ltd) have entered into a \$3 million earn-in agreement to earn up to 40% of the project through staged evaluation of their mineral processing technology in producing sulfate of potash at Karinga Lakes. In the first half of 2018, they completed evaporation trials of an 8000 litre brine sample, which provided mixed potash salts for pilot testing. They continued to test the performance of the aMES™ technology on brine and salt samples from the project. A new evaporation trial with 11 400 litres of brine commenced in September 2018.

Salt

Tellus Holdings Ltd (Tellus) continued plans to develop an underground rock salt mine at their **Chandler** project near Titjikala located 120 km south of Alice Springs in the Amadeus Basin. The project consists of a proposed underground salt mine with a waste storage and isolation facility in the voids (rooms) created by underground mining. The project is focussed on a halite resource within a flat-lying, extensive evaporite unit (in excess of 200 m thick) within the Cambrian Chandler Formation. Chandler contains a Measured Mineral Resource of 309 Mt NaCl, and Indicated and Inferred Mineral Resources of 1.128 Bt NaCl and 3.103 Bt NaCl respectively, with an average halite grade of 88.6%. The total thickness of the deposit varies between 220–261 m. In 2018, Tellus continued to progress regulatory approvals for the Chandler project and have received NT and Commonwealth environmental assessment reports.

Uranium

The Territory's only operating uranium mine is at **Ranger**, which is hosted in the lower Cahill Formation in the Pine Creek Orogen, and which has been in production since 1981. During 2017, Energy Resources of Australia Ltd

(ERA) produced 1999 t of uranium oxide from the Ranger mine, a 15% decrease from 2017. All production was from stockpiles from the Ranger 3 open pit, which is now backfilled and being used as tailings facility. At the end of 2018, Ore Reserves at Ranger (entirely within stockpiles from Ranger 3 pit) are 4.90 Mt at 0.076% U_3O_8 for 3735 t of uranium oxide, (at 0.06% U_3O_8 cut-off); additional Mineral Resources (in stockpiles and in Ranger 3 Deeps) are 46.74 Mt at 0.12% U_3O_8 for 54 701 t of uranium oxide. No exploration was undertaken in 2018, and the exploration decline for the Ranger 3 Deeps deposit remains in care and maintenance.

In March 2018, Vimy Resources Ltd (Vimy) announced that it has acquired the Alligator River Project in western Arnhem Land from Cameco Australia Pty Ltd. This includes the King River–Wellington Range project JV with Rio Tinto (who own 25% of the JV). The JV includes the **Angularli** deposit, which was discovered by Cameco. In late March, Vimy announced a maiden Inferred Mineral Resource for the Angularli deposit of 0.91 Mt at 1.3% U_3O_8 for 25.89 Mlb (11 558 t) of uranium oxide. The resource was calculated on the basis of diamond drilling undertaken by Cameco, which included high-grade intersections of 22.9 m at 4.63% U_3O_8 from 244.6 m and 25.4 m at 1.62% U_3O_8 from 235.4 m. In late 2018, Vimy undertook a wide-spaced 10 hole, 2868 m RC drilling program at Angularli, focusing on broad alteration haloes along strike and within parallel structures to the Angularli deposit. Five of these holes located southwest of the deposit intersected significant Angularli-style hydrothermal alteration with anomalous uranium mineralisation. In December 2018, Vimy announced the results of a scoping study for a mining operation at Angularli in which underground mining would be undertaken over approximately 36 months after a pre-production mine development period of approximately 12 months. The study assumed that mining at Angularli would be undertaken using conventional long-hole open stope methods. This would allow for the underground mine workings to be used for disposal of all the process tailings as paste fill and eliminates the need for a surface tailings storage facility.

Also during 2018, Vimy undertook a six hole, 1416 m RC drilling program at the **Such Wow** prospect, 15 km south of Angularli, targeting broad alteration haloes coincident with northwest to north-northwest-striking fault zones. All drillholes intersected significant hydrothermal alteration with anomalous uranium mineralisation, including a broad 30 m-wide zone in one hole.

In September–October 2018, Alligator Energy Ltd undertook a seven hole, 2138 m drilling program at the **TCC4** prospect, part of their Alligator Rivers uranium project in west Arnhem Land. The drilling targeted the northeastern end of a 4 km long zone of coincident SAM geophysical and radiogenic pathfinder surface anomalies. Five holes intersected key target features including graphitic schists of the Cahill Formation, and chlorite and hematite alteration in both basement and overlying sandstone cover.

Energy Metals Ltd (Energy Metals) have uranium projects in the Ngalia Basin northwest of Alice Springs, including the **Bigryli** uranium deposit, which has total

Indicated and Inferred Mineral Resources of 7.5 Mt at 0.13% U_3O_8 and 0.12% V_2O_5 at a 500 ppm U cut-off for a contained 9600 t of uranium oxide and 8900 t of vanadium oxide. During 2018, Energy Metals undertook airborne electromagnetic and deep-sensing ground penetrating radar surveys, as well as a soil geochemical survey at the Crystal Creek prospect.

Onshore petroleum

Petroleum exploration activity in the onshore basins of the Northern Territory in 2018 was largely limited to the Amadeus Basin. There was no substantial exploration in the greater McArthur Basin (including the Beetaloo Sub-basin) pending the implementation of recommendations of the Scientific Inquiry into Hydraulic Fracturing (the Inquiry). **Figure 9** shows granted petroleum tenure and basins in the NT, and the location of wells and fields mentioned in the text.

McArthur Basin

The **Beetaloo Sub-basin** is a significant depocentre of Mesoproterozoic Roper Group sedimentary rocks that underlies the Mesozoic Carpentaria Basin in the vicinity of Dunmarra and Daly Waters; it is NT's most advanced shale gas play. The most prospective shale units in the Roper Group occur within the Velkerri and Kyalla formations. Drilling of the middle Velkerri Formation has demonstrated the consistent presence of gas saturated, quartz-rich shale source rocks that are mature for gas over extensive areas, and which appear to meet all of the physical and chemical parameters for a successful shale gas play. Following the successful hydraulic fracturing and production testing from the Amungee NW-1H exploration well by Origin Energy Limited (Origin) in 2016, Origin announced a 2C Contingent Gas Resource Estimate for the Velkerri B-shale pool of 6.6 trillion cubic feet (Tcf) over 1968 km², with Original Gas In Place of 61.0 Tcf. Wells drilled to date by Santos Limited, Origin and Pangaea Resources, and as reported in associated confidential discovery reports, indicate a P50 Gas-In-Place Resource for the Velkerri B-shale alone of at least 500 Tcf, with the additional potential for liquids across the basin.

Exploration in the central part of the Beetaloo Sub-basin is operated by Origin in joint venture with Falcon Oil and Gas Ltd. Origin has announced that, subject to relevant approvals and implementation of the exploration recommendations of the Inquiry, they plan to evaluate the potential of the liquids-rich gas fairways in both the Kyalla and Velkerri plays in 2019, including the drilling and hydraulic fracture stimulation of two horizontal wells. Together with the Velkerri B-shale dry gas play discovered in 2016, this allows for the assessment of three plays and

enables the most commercially prospective play to be targeted for Stage 3 drilling during 2020. Elsewhere in the Beetaloo Sub-basin, Santos have installed two water monitoring bores in late 2018 to support applications for multi-well exploration activity in 2019.

Amadeus Basin

The Territory's current onshore gas production is entirely sourced from fields in the Amadeus Basin operated by Central Petroleum Ltd (Central Petroleum). In 2018, 6.151 billion standard cubic feet (bscf) of gas was produced, comprising 4.919 bscf from **Mereenie**, 0.429 bscf from **Palm Valley** and 0.803 bscf from **Dingo**. This was a 23% increase on 2017, with gas production ramping up to meet increased demand following the completion of the Northern Gas Pipeline. Onshore oil production in the NT in 2018 was sourced entirely from the Mereenie field, with 0.194 million barrels (mmbbls) of oil produced.

In November 2018, Central Petroleum announced increased net reserves and contingent resources, with Proven and Probable (2P) gas reserves of 88.55 PJ at Mereenie, 42.00 PJ at Palm Valley and 38.18 PJ at Dingo. 2P oil reserves at Mereenie increased by 154% to 0.97 MMBbl oil.

Central Petroleum drilled two appraisal wells in 2018. The **West Mereenie 26** well was spudded in May 2018 and drilled to a total depth 2388 m measured depth, including a horizontal lateral length of 893 m through the Lower Stairway 2 formation. The company described the results from the well as disappointing, with mineralisation of natural fractures leading to reduction in permeability and resulting in only minor gas shows. Central Petroleum also drilled the **Palm Valley 13** appraisal well to a total depth 2242 m. The company reported very encouraging initial gas flows from Palm Valley 13, with further production testing to commence once connected to the Palm Valley facilities. The well intersected natural fractures as predicted within the Pacoota Sandstone.

Central Petroleum also have a farm-in agreement worth up to \$150 million with Santos for a large area in the Amadeus Basin. Santos are targeting sub-salt and intra-salt plays of the Neoproterozoic lower Gillen–Heavitree Quartzite System in the southeastern part of the basin that have potential for large gas and helium accumulations. In April 2018, Santos completed acquisition of 403 km of seismic data, infilling the previous 932 km of seismic acquired in 2016 and bringing the total to 1335 km. The additional seismic lines reduce dip line spacing over the **Dukas** prospect to ~5 km over the central prospect area and ~10 km towards the flanks. Santos have announced they are progressing final approvals and agreements to support the drilling of the planned 2019 Dukas 1 wildcat well.

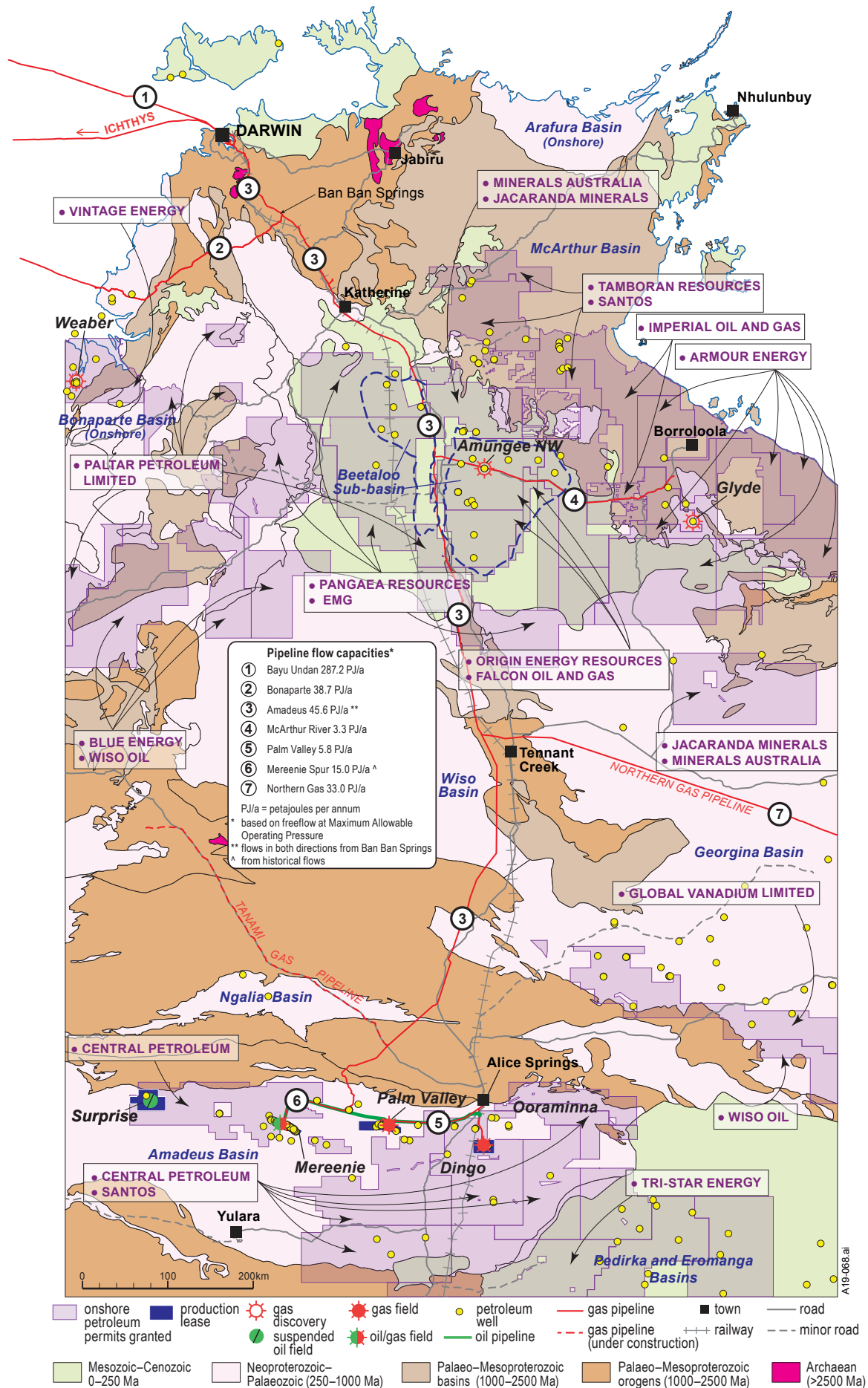


Figure 9. Map of Geological Regions of the Northern Territory showing granted exploration permits as of January 2019, along with wells and prospects mentioned in the text.