### Highlights of mineral and petroleum exploration and production in 2017

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# **Exploration statistics**

Mineral exploration began to recover in the Northern Territory (NT) during 2017 with an increase in greenfields exploration and in reported on-ground activity. This is despite Australian Bureau of Statistics (ABS) figures showing mineral exploration expenditure in the NT in 2016-17 was at a low of \$78.4 million, down from \$100.8 million in 2015-16 (Figure 1). However, exploration in greenfields areas (as defined by the ABS) has more than doubled from only \$23.4 million in the twelve months to 30 September 2014, to \$47.1 million in the twelve months to 30 September 2017 (Figure 2a). The proportion of greenfields areas' exploration expenditure in the NT has increased over that time from 20% to 56%, much higher than the national average of 31% (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 feasibility studies and mine site exploration, the NT 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 2016 and/or 2017) totalled \$48.6 million in admissible exploration expenditure, although not all reports had been received at the time of writing. Of expenditure reported to DPIR in 2017, 23% (\$11.0 million) was in the McArthur Basin, 20% (\$10.0 million) in the Arunta Region and 20% (\$9.9 million) in the Pine Creek Orogen (Figure 3a). The bulk of expenditure was for base metals (33%; \$16.1 million), gold (22%; \$10.7 million), uranium (10%; \$4.8 million), and lithium (8%, \$3.8 million) (Figure 3b).

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At the end of 2017, there were 812 granted non-extractive mineral exploration licences (compared with 882 at the end of 2016) and 705 outstanding exploration licence applications. During 2017, 263 applications were received (up from 183 in 2016), 146 granted and 340 licences ceased. The area of the NT covered by granted exploration tenure remains at around 12%.

During 2017, onshore petroleum exploration activity was largely limited to the Amadeus Basin, with one seismic survey and airborne survey. At the end of 2017, in the onshore NT and coastal waters, there were 46 active exploration permits, 3 retention licenses and 5 production licenses.

### **Exploration and production highlights**

**Figure 4** shows selected mineral exploration highlights for 2017. In the following summary of exploration and mining results for the Territory during 2017, 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 publicly-listed company websites, news releases and stock exchange announcements. As a result, details of exploration by some private and other non-listed companies that do not report publicly could not be included. Mineral production statistics for the NT for 2016–17, collected under the NT *Mineral Titles Act*, are given in **Table 1**. This shows mineral production was a record \$3.63 billion in 2016–17, largely driven by increased prices for manganese and zinc.

## Gold and copper-gold

#### Pine Creek Orogen

On 30 June 2017, Kirkland Lake Gold Inc (Kirkland Lake) suspended their operations at *Cosmo Deeps* underground mine north of Pine Creek (Figure 5). The company announced that this was to allow them to focus its activities



**Figure 1**. Annual mineral exploration expenditure for the Northern Territory, calculated quarterly, for the 17 years to the September 2017 quarter.

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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 exploration expenditure reported to DPIR during 2017 broken down by (a) geological region and (b) primary commodity of interest. Note that exploration reported during 2017 may have occurred during either 2016 or 2017.

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on an aggressive resource definition and exploration program at the mine, including the newly discovered Lantern deposit, and resume active exploration on advanced regional targets. Gold production from Cosmo Deeps in 2017 prior to the suspension totalled 20 595 oz at an average grade of 2.6 g/t from 259 729 t milled. At the end of 2016, the Mineral Resource for Cosmo mine included 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 Mineral Resource of 0.57 Moz of gold.

In March 2017, Kirkland Lake announced the discovery of high-grade gold mineralisation at the *Lantern* gold deposit at Cosmo Deeps. The initial announcement was based on 25 diamond drillholes totalling 5973 m, which were targeted to test down-plunge extensions of the Cosmo open pit mineralisation. Intersections included 4.5 m at 119 g/t Au, 11.1 m at 15.27 g/t Au and 22.75 m at 4.34 g/t Au. A further 74 holes for 27 737 m were drilled to test the expansion potential of the Lantern deposit. The results substantially increased the deposit footprint, especially to the north, with the highest grade result of 0.31 m at 4750 g/t Au intercepted 250 m north of the existing resource. Other significant intersections included 3 m at 198 g/t Au and 18.7 m at 40.8 g/t Au. Mineralisation has now been defined over a strike extent of more than 30 lodes being identified.



Figure 4. Map of the Northern Territory showing selected mineral exploration highlights for 2017.

Commodity	Unit of quantity	2016–17 <sup>1,5</sup>		
		Quantity produced <sup>2</sup>	Quantity sold <sup>3</sup>	Quantity sold (\$) <sup>4</sup>
Metallic Minerals	1	1		1
Bauxite	Tonnes	9,858,279	9,707,372	\$451,784,022
Gold <sup>6</sup>	Grams	2,580	1,225	\$63,415
Gold Dore <sup>7</sup>	Grams	13,743,533	13,618,732	\$723,568,655
Iron Ore	Tonnes	0	0	\$0
Manganese	Tonnes	5,348,410	5,366,762	\$1,484,958,711
Mineral Sands Concentrate	Tonnes	2,600	0	\$0
Lead Concentrate	Tonnes	15,631	18,286	\$21,160,018
Zinc Concentrate	Tonnes	102,478	97,128	\$139,658,076
Zinc Lead Concentrate	Tonnes	331,263	366,130	\$489,150,006
Metallic Minerals Value	n/a			\$3,310,342,903
Non-Metallic Mine	rals			
Crushed Rock	Tonnes	1,522,268	1,328,430	36,517,091
Dimension Stone	Tonnes	0	0	\$0
Garnet Sands	Tonnes	1,426	0	\$0
Gravel <sup>8</sup>	Tonnes	232,861	217,324	\$3,171,139
Limestone	Tonnes	0	1,749	\$29,771
Mineral Specimen	Tonnes	0.65	0.40	\$74,340
Quicklime <sup>9</sup>	Tonnes	23,877	25,163	\$6,523,822
Sand	Tonnes	267,138	251,585	\$6,603,429
Soil	Tonnes	47,689	45,092	\$643,889
Vermiculite	Tonnes	0	0	\$0
Non-Metallic Minerals Value	n/a			\$53,563,481
Energy Minerals				1
Uranium Oxide	Tonnes	2,315	2,455	\$262,833,908
Total Minerals Value	n/a			\$3,626,740,292
<ul> <li>Explanatory notes</li> <li>1. Fiscal year is 1st July to 30th June.</li> <li>2. Data is from production returns lodged by operators under statutory obligations.</li> <li>3. \$ Amount for Quantity Sold is in AUD and is the gross amount paid to the operator.</li> </ul>				

4. Data has been rounded and autosum applied.

5. Data is correct as at 28 August 2017 and may be subject to revision due to

late lodgements and/or receipt of superior data.

6. Pure gold (100%); does not include gold reported as gold dore.

7. Average metallic content of reported gold dore is 91.9% gold and 8.1% silver.

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. 2016–17 mining production statistics for the Northern Territory.

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The mineralisation at Lantern is hosted within iron-rich, weakly-carbonaceous, siltstones and dolomitic siltstones with common intense carbonate, sericite-pyrite-chlorite and blood-red Fe-oxy-hydroxide hypogene alteration associated with quartz-carbonate veining. Although partly stratabound, gold mineralization occurs in a quartz-sulfidecarbonate vein network of steeply dipping sub-linear shear veins and associated sub-horizontal dipping tensile vein arrays. Kirkland Lake interprets that the high-grade gold mineralisation changes from finer-grained free gold in the Cosmo deposit to coarser-grained free gold in narrow quartz veins in Lantern. Underground exploration development is expected to start in the first quarter of 2018 to access the Lantern mineralisation at two levels, 320 m vertically apart. Ongoing exploration is being conducted to increase Mineral Resources and outline a Mineral Reserve with a defined and sustainable five-year mine plan in order to re-start mining at Cosmo.

The *Mount Porter* gold project, 20 km north of Pine Creek, is owned by Ark Mines Ltd (Ark) and has Indicated



Figure 5. Map of Geological Regions of the NT showing locations of gold and copper-gold deposits and projects mentioned in the text.

and Inferred Resources of 355 000 t at 3.0 g/t Au for 34 200 oz Au (1.7 g/t cut-off). In late 2106, Ark announced plans to develop the project, but due to difficulties in obtaining an agreement to toll treat the Mount Porter ore at the Union Reefs plant, they suspended plans to commence mining in 2017. In March 2017, Ark announced the results of resource definition drilling at Mount Porter South, with a best intersection of 5 m at 4.13 g/t Au. Ark also has gold prospects at Frances Creek, 5 km northeast of Mount Porter and the Glencoe deposit, which has a Mineral Resource of 704 000 t at 1.9 g/t Au, for 42 900 oz Au. In August 2017, Ark secured an option to purchase mining leases at the Union Extended project, north of Union Reefs, for the establishment of a 450 000 t per annum gold plant on the site to process of ore from Mount Porter, Glencoe and Frances Creek.

PNX Metals Ltd undertook a 16 hole, 1609 m drilling program during 2017 at the historic *Moline* goldfield, 38 km east-northeast of Pine Creek; it comprises four key prospects hosted within the Mount Bonnie Formation: Moline, School, Tumbling Dice and Hercules. Drilling intersected 3 m at 7.6 g/t Au from 138 m at the School prospect, downdip from a 2016 intersection of 7 m at 11.89 g/t Au from 115 m. The drilling also intersected 3 m at 2.5 g/t Au and 9 m at 1.55% Au from beneath the Moline open pit.

Primary Gold Ltd's Mount Bundey project, located 90 km southeast of Darwin, includes the Toms Gully, Rustlers Roost and Quest 29 deposits. Following a positive Scoping Study announced in April 2017, Primary Gold undertook a 5600 m drilling program at the Rustlers Roost and Quest 29 deposits in order to assess potential to expand the existing resource base and provide metallurgical samples to support a prefeasibility study. Drilling outside the existing pit design at Rustlers Roost intersected broad zones of mineralisation such as 117 m at 1.5 g/t Au from 78 m, including 8 m at 6.9 g/t Au. At Quest 29, drilling targeted extensions of the gold lodes along strike and downdip. Results showed that mineralised zones extend below and outside of the current scoping pit design, with intersections up to 14 m at 1.0 g/t gold from 45 m, and 5 m at 2.1 g/t gold from 90 m. Following the 2017 drilling program, Primary Gold announced an updated resource at Rustlers Roost, with Indicated and Inferred Resources of 49.6 Mt at 0.84 g/t Au for 1.33 Moz Au, a 72% increase on the previous resource. This forms part of a larger resource in the Mount Bundey project area of 54.1 Mt at 1.03 g/t Au for a contained 1.795 Moz of gold. A prefeasibility study (PFS) for the project is expected to be announced in the first quarter of 2018.

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. In January 2018, Vista received Commonwealth environmental approval and announced an updated PFS that included re-design of elements of the process flow sheet, incorporating automated sorting and grinding circuit design changes in a 50 000 tonnes per day operation.

#### Tanami-Arunta regions

Newmont Mining Corporation (Newmont)'s Tanami Operations, located 550 km northwest of Alice Springs, has produced approximately 8 Moz of gold since start-up and remains the Territory's largest gold operation, producing 459 000 oz of gold during 2016. Mineralisation consists of high-grade Au-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), although recent rapid resource growth has occurred associated with down-plunge extensions of the >3.8 Moz Auron deposit and the 2013 discovery of the >0.5 Moz Federation Limb deposit. As of 31 December 2016, Proven and Probable Ore Reserves were 23.2 Mt at 6.00 g/t Au containing 4.48 Moz of gold. Additional Measured and Indicated Mineral Resources total 2.6 Mt at 5.53 g/t Au for 0.46 Moz Au and Inferred Mineral Resources are 3.2 Mt at 5.85 g/t Au for 0.61 Moz Au. Newmont sees potential to double the current reserve and resource base through continued expansion down-plunge of the Callie and Auron orebodies, as well as through further resource growth from the Federation Limb and 2015 Liberator discoveries. In August 2017, the company announced the completion of a \$120 million expansion project, which included building a second decline and an incremental increase in capacity in the processing plant. The expansion is expected to increase Tanami's annual gold production by 80 000 ounces per year to between 425 000 and 475 000 ounces of gold per year, lower all-in sustaining costs to between \$700 and \$750 per ounce, and extend mine life by three years. It was also designed to be a platform for further growth; studies to develop a second expansion are underway.

During 2017, Northern Star Resources Ltd (Northern Star) continued to explore their 100% owned Tanami Regional project as well as the Central Tanami project as part of a purchase and farm-in agreement with Tanami Gold NL. In January 2013, the total mineral resources for the Central Tanami project stood at 25.50 Mt at 3.2 g/t Au containing 2.63 Moz of gold, including the flagship *Groundrush* deposit with a Mineral Resource of 6.72 Mt at 4.8 g/t Au containing 1.04 Moz of gold. During 2017, Northern Star undertook a 77 946 line km airborne magnetic and radiometric survey over 80% of their tenement package, and completed a 58 hole, 1959 m aircore drilling program over the Cave Hill project area.

Following a substantial drilling program during 2016, in February 2017 ABM Resources NL (ABM) announced an updated resource for their Suplejack project, which includes the *Hyperion* deposit located 17 km north-northeast of Groundrush. The Indicated and Inferred Resource totals 4.51 Mt at 2.14 g/t Au, containing 309 000 oz Au; this includes a maiden Resources for the *Seuss* prospect of 0.63 Mt at 2.85 g/t Au. A subsequent reverse circulation (RC) drilling program of 3952 m was completed at Seuss in April 2017, with a best intersection of 5 m at 60.9 g/t Au from 54 m. Two mineralised shoots were identified, both of which remain open at depth. This was followed up with a reconnaissance aircore drilling program of 179 holes for 8490 m throughout the Suplejack project area to test for extensions of known structures and to further define rock types and structural intersections interpreted to host mineralised shoots. An additional 1608 m RC drilling program in November resulted in more high-grade intersections, including 4 m at 26.6 g/t Au from 87 m and 13 m at 7.3 g/t Au from 105 m from the Seuss Fault, and 5 m at 8.5 g/t Au from 120 m from the Tethys-Seuss Fault Intersection.

ABM also undertook a reconnaissance aircore drilling program of 159 holes for 8474 m at their **Bluebush** project area, which includes the Capstan, Wild Turkey, Indefatigable and Hornblower projects located 50 km to the northwest of the Callie deposit. This reconnaissance program was aiming to confirm similarities with Callie, to complete an initial bedrock test under large arsenic anomalies, and to commence screening undercover for largescale geochemical anomalies as indicators of concealed deposits. At the Capstan prospect, an 8 km long zone of gold anomalism was identified beneath arsenic anomalism previously defined in soil sampling. Follow-up drilling at Capstan is planned for early 2018.

ABM also announced an updated Indicated and Inferred Mineral Resource for the **Buccaneer** project, totalling 10.0 Mt at 1.82 g/t Au for 585 000 oz Au. This represents a significant reduction in both tonnage and grade of the deposits compared with the 2013 Resource due in part to the finding that the high-grade domains applied in the 2013 model were not predictably based on geological features or structural trends. Gold mineralisation at Buccaneer is disseminated throughout a monzogranite granite intrusion with higher-grade zones typically associated with zones of shallow dipping quartz veins and sulphides (pyrite, arsenopyrite). In October 2017, ABM entered into an Exploration Agreement with Thunderbird Metals on ABM's North Arunta project whereby Thunderbird will sole fund \$6.5M over 4.5 years to earn a 70% interest in the project. The project is located north and northwest of Barrow Creek, and includes the *Kroda* gold prospect.

### Warramunga Province (gold-copper-bismuth)

Emmerson Resources Ltd (Emmerson) continued to explore the Tennant Creek mineral field as part of a major exploration joint venture with Evolution Mining (Evolution) under which Evolution can invest up to \$25 million in exploration to earn up to 75% of the project. In June 2017, Emmerson announced the commencement of small-scale gold production at the high-grade *Edna Beryl* deposit, 40 km north of Tennant Creek, under a tribute mining agreement with the Edna Beryl Mining Company (**Figure 6**). The first 600 t of development ore at Edna Beryl averaged 40 g/t Au; the first gold poured in December 2017.

Following the discovery of high-grade gold mineralisation at Edna Beryl West in 2016 (including 8 m at 157 g/t Au, 34.5 g/t Ag and 0.5% Cu), Emmerson undertook near mine and regional exploration programs and discovered additional ironstones, some highly anomalous in both copper and gold. The deep diamond drill program at Edna Beryl confirmed that ironstones and mineralisation persist at depth, with the best intersection of 0.65 m at 6.53 g/t Au from 305 m. Drilling 200 m to the west of the Edna Beryl mine hit a thick shear zone containing chloritehematite ironstone and quartz veining, with an intersection 7 m at 1.33 g/t gold from 171 m. Drilling also confirmed potential for new mineralisation immediately to the north of Edna Beryl mine with intersections of 12 m at 0.59% Cu and 0.07 g/t gold from 90 m. The company announced they are planning development of an underground exploration drive from the current Edna Beryl mine across to the recently discovered Edna Beryl West mineralisation.



**Figure 6**. Opening of Edna Beryl gold mine in July 2017.

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In late 2017, Emmerson undertook a 2500 m drilling program at the *Gecko-Goanna* following up the discovery of shallow high-grade copper mineralisation (drill intersection of 7 m at 5.98% Cu in 2015). The drilling intersected high-grade copper, including 6 m at 4.0% Cu from 137 m; the company reported that it confirms the potential for non-ironstone hosted copper at the project.

In September 2017, Emmerson withdrew from the Rover farm-in joint venture with Andromeda Metals in the Rover field, 70 km southwest of Tennant Creek. This followed ambiguous results from a 3D induced polarisation (IP) and magnetotellurics (MT) survey covering three blocks over separate prospects at Rover 4, Rover 11 Central and Rover 11 East. This survey had been aimed at assessing the potential of these techniques to generate and define sulphides beneath barren cover sequences; it was co-funded by NTGS under the Geophysics and Drilling Collaborations program.



**Figure 7**. Map of Geological Regions of the NT showing locations of copper, lead-zinc-silver, diamond, manganese, tungsten-molybdenum, and vanadium deposits and projects mentioned in the text.

In June 2017, Chalice Gold Mines Ltd announced the discovery of Tennant Creek-style copper-gold mineralisation at the *Parakeet* prospect, which is part of their Warrego North project, 20 km northwest of the historic Warrego mine. The company's first hole targeted a coincidental magnetic-gravity and IP chargeability anomaly; it intersected interstitial and stringer (vein) style chalcopyrite mineralisation in magnetite ironstone with 8 m at 1.74% Cu and 0.42 g/t Au from 249 m. A follow-up 1575 m drilling program identified two additional ironstone units, with a best intersection of 11 m at 0.24% Cu and 0.21 g/t Au. Chalice can earn up to a 70% interest in the Warrego North project from Meteoric Resources NL by sole funding \$800 000 in expenditure.

#### Copper, lead, zinc, silver

#### Arunta Region

During 2017, KGL Resources Ltd (KGL) continued exploration and assessment of the Jervois copper-silverlead-zinc-gold project northeast of Alice Springs (Figure 7). 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. It has a total resource of 30.5 Mt at 1.07% Cu and 23.0 g/t Ag for 327 000 t contained copper. The existing lead-zinc resource is 3.8 Mt at 3.7% Pb, 1.2% Zn, 0.72% Cu and 67.5 g/t Ag. Exploration in 2017 focussed on newly identified high-grade mineralisation at the Rockface prospect. KGL continued to demonstrate the utility of down-hole electromagnetic (DHEM) surveys in identifying conductors associated with massive, semi-massive and veined chalcopyritepyrite mineralisation within altered magnetite-garnet rich host rock. A nine hole drill program in the first half of 2017 targeted conductors in the eastern zone of Rockface. Intersections included 9.62 m at 3.18% Cu, 26 g/t Ag and 0.40 g/t Au from 679 m, and 5.67 m at 5.2% Cu, 0.2% Zn, 30 g/t Ag and 0.45 g/t Au from 517 m. In September 2017, high-grade mineralisation was also intersected in the western zone at Rockface with 8.24 m at 9.21% Cu, 0.19% Zn, 38.1 g/t Ag and 0.29 g/t Au from 587 m, including 4.57 m at 14.0% Cu, 53.6 g/t Ag and 0.34 g/t Au.

KGL also drilled the first hole in over two years at the Reward prospect, targeting DHEM conductors and discovered high-grade mineralisation with 11.63 m at 4.2% Cu, 0.81% Pb, 1.07% Zn, 86 g/t Ag and 0.65 g/t Au from 636.1 m. The mineralised zone is dominated by a central interval of pervasive, disseminated chalcopyritepyrite in magnetite-garnet-chlorite alteration with carbonate and quartz veining. This has similarities to the style of mineralisation at Rockface. Follow-up drilling intersected more mineralisation (including gold) with results of 9.57 m at 5.11% Cu, 0.4% Pb, 0.31% Zn, 78.5 g/t Ag and 2.44 g/t Au from 561 m, and 8.16 m at 5.03% Cu, 35.9 g/t Ag and 3.35 g/t Au from 691 m. During 2017, KGL also purchased the Unca Creek project area surrounding Jervois, which includes a number of known copper prospects such as Pioneer (along strike from Reward) and Hamburger Hill.

Independence Group NL continued their greenfields exploration in the remote southwestern Aileron Province,

northeast of Kintore, targeting polymetallic mineralisation as part of the Lake Mackay exploration alliance with ABM Resources Ltd. This followed the discovery of polymetallic copper-silver-gold-zinc mineralisation at the Bumblebee prospect in 2015 (7 m at 3.2% Cu 3.3 g/t Au, 37.7 g/t Ag, 0.9% Pb, 1.3% Zn and 0.08% Co from 30 m) and at the Grapple prospect in 2016 (6 m at 8.98 g/t Au, 23.5 g/t Ag, 1.45% Cu, 1.40% Zn, 0.26% Pb and 0.15% Co from 38 m, 9 m at 1.8 g/t Au, 49.1 g/t Ag, 3.26% Cu, 3.63% Zn, 1.09% Pb and 0.26% Co from 85 m). A six hole 2917 m diamond drilling program was completed at the Grapple Prospect during 2017 to further define the extent and grade of mineralisation. Sulfide mineralisation was encountered in all six holes, with the best intersection being 11.4 m at 7.9 g/t Au, 20.7 g/t Ag, 0.8% Cu, 1.1% Zn, 0.5% Pb and 0.1% Co from 284.9 m including 3.5 m at 18.3 g/t Au, 13.8 g/t Ag, 1.1% Cu, 0.3% Ag and 0.2% Pb from 288.8 m. The mineralisation consists of massive to semi-massive pyrrhotite-chalcopyrite-sphalerite-galena-arsenopyrite breccia sulfides and pyrrhotite with chalcopyrite stringers. The drilling confirmed the mineralisation has an extensive plunge component over 800 m and is open to the west. Soil sampling of adjacent areas was undertaken in late 2017. Granted tenure in the project area expanded during the year from 517 km<sup>2</sup> to 7612 km<sup>2</sup>, and an additional 3245 km<sup>2</sup> was applied for covering the extension of prospective geology along the Central Australian Suture.

Following their listing on the ASX in April 2017, Todd River Resources Ltd undertook a 14 hole, 2849 m drilling campaign at the *Mount Hardy* copper-zinc project area, 300 km northwest of Alice Springs. At the Browns prospect, drilling intersected 7 m at 1.77% Cu, 0.43% Zn and 17.7 g/t Ag from 67 m, which when combined with previous drilling, is interpreted to form part of a shallow south-dipping mineralised structure that persists for over 100 m and remains open both up-dip to the north and down-dip to the south. At EM Target 2, three holes were drilled, with a best intersection of 10.5 m at 4.15% Zn, 1.10% Cu and 0.65% Pb from 178 m, including 1 m at 12.75% Zn, 3.30% Cu, and 3.43% Pb from 180 m. The mineralisation at EM Target 2 comprises sphalerite with lesser chalcopyrite and galena; it occurs as semi-massive vein infill and disseminations associated with quartz veining and silica flooded zones with chlorite and sericite alteration. Four holes were drilled at the copper-dominant Mount Hardy prospect returning a best intersection of 3 m at 1.98% Cu. Downhole EM modelling on EM Targets 1 and 2 have identified strong new conductor plates, which will be a focus for future drilling.

### Pine Creek Orogen

PNX Metals Ltd (PNX) continued to progress at their *Hayes Creek* project, which 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. Following a 5242 m, 30 hole RC and diamond drill program completed in early January 2017, PNX announced an upgraded Indicated and Inferred Resources for *Mount Bonnie* (1.55 Mt at 3.8% Zn, 1.34 g/t Au, 127 g/t Ag, 1.1% Pb, and 0.2% Cu) and

Iron Blow (2.53 Mt at 2.1 g/t Au, 122 g/t Ag, 4.71% Zn, 0.78% Pb and 0.26% Cu). The total combined resource is 4.1 Mt at 1.8 g/t Au, 124 g/t Ag, 4.35% Zn, 0.91% Pb and 0.25% Cu. In July 2017, PNX released the results of a PFS on the Hayes Creek project based on 450 000 tpa throughput and a 6.5 year mine life with ore sourced from initial open pit mining at Mt Bonnie and subsequent underground mining at Iron Blow. Following the positive PFS, the company announced that they were proceeding directly to a definitive feasibility study (DFS). As part of the DFS, PNX undertook 4063 m of drilling at Mount Bonnie in late 2017 to provide geotechnical, resource, hydrological, and metallurgical data to inform engineering and environmental studies. Extensional drilling at Mt Bonnie has intersected zinc mineralisation in a number of drillholes outside the existing mineral resource. PNX have also identified a number of polymetallic base metal prospects at their *Moline* project area, with initial drilling planned for December 2017 at the Swan prospect based on soil geochemistry and IP anomalies.

The *Browns* deposit near Batchelor comprises a large sediment-hosted polymetallic oxide and sulphide resource, which was briefly developed by Compass Resources Ltd in 2007–08. In 2017, Doe Run Australia, a subsidiary of North American lead producer The Doe Run Company, completed a metallurgical, geotechnical, and exploration drilling campaign focussing on the sulphide mineralisation at Browns as part of an agreement with current tenement holder Northern Territories Resources Pty Ltd. The program comprised 21 holes for 4679 m, although no results have been announced.

In October 2017, DevEx Resources Ltd (DevEx; formerly Uranium Equities Ltd) announced that it was commencing a new focus on copper, gold and base metal mineralisation in its tenements in western Arnhem Land, including the U40 prospect where drilling in 2010 intersected 12.3 m at 2.03% Cu, 1.77 g/t Au and 0.74% U<sub>3</sub>O<sub>8</sub>. DevEx undertook an IP survey in late 2017 and identified chargeability anomalies coincident with mineralisation at U40 and U40 South, which will be targets for future drilling.

### McArthur Basin

The *McArthur River* mine, 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 2017, the McArthur River mine had total Mineral Resources of 188 Mt at 9.6% Zn, 4.5% Pb and 46 g/t Ag, including Ore Reserves of 114 Mt at 9.3% Zn, 4.4% Pb and 45 g/t Ag. During 2017, MRM produced 210 000 t of zinc, 44 800 t of lead and 1.62 Moz of silver, representing a 5% increase in zinc production from 2016. The very fine-grained, thinly bedded sulfide ore is hosted in the HYC Pyritic Shale Member of the Barney Creek Formation.

A second major 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, with 14 holes drilled for 14 679 m from 2013–2015 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). The mineralisation is a similar style to McArthur River and occurs as finely laminated sphalerite-galena mineralisation within carbonaceous shales and calcareous siltstones of the Barney Creek Formation. In February 2017, Teck finalised the purchase of Rox Resources' share of the project to assume 100% ownership. No exploration results have been publicly reported from Teena during 2017. Teck is also involved in the *Yalco* joint venture with Marindi Metals Ltd. During 2017, they drilled a single 781 m diamond drillhole into a previously untested sub-basin, which was co-funded by NTGS under the Geophysics and Drilling Collaborations program. The hole intersected pyritic shales in the Carinbirini member of the Lynott Formation and the Barney Creek Formation.

During 2017, Pacifico Minerals undertook a five hole, 1403 m diamond drilling program at their Borroloola West JV with Sandfire Resources, which was co-funded by NTGS under the Geophysics and Drilling Collaborations program. At the Coppermine Creek prospect, 100 km northwest of McArthur River, stratabound copper, cobalt and silver mineralisation occurs associated with an interpreted evaporate horizon in the Amelia Dolostone. Two holes were drilled targeting undercover extensions of the mineralisation; they intersected wide zones of visible copper up to 18 m in width, although at sub-economic grades. At the Mariner prospect, 12 km south of Coppermine Creek, oxidised lead mineralisation occurs at the base of the Roper Group where it is interpreted to have been remobilised from the underlying McArthur Group. Two holes were drilled at Mariner, one of which intersected anomalous copper-bearing pyritic black shales interpreted to be Barney Creek Formation. At the Lorella prospect, Pacifico announced an initial Exploration Target of 5-10 Mt at 0.8-1.1% Cu for flat lying oxide mineralisation related to the base of unconsolidated recent alluvium and gently west-dipping, stratabound horizons within the underlying Amelia Dolostone.

MMG Exploration Pty Ltd (MMG) continued to explore in the Batten Fault Zone area in the McArthur Basin on their own tenure and under their North Batten JV with Sandfire Resources. MMG undertook a significant drilling program in 2017 focussed on the *Rosie Creek* zinc prospect to test the prospective Barney Creek sub-basin at depth.

In December 2017, Red Metal Ltd executed an option and joint venture agreement with MMG whereby MMG can earn up to a 70% interest in their Mallapunyah project located 60 km southwest of McArthur River.

#### Diamonds

Merlin Diamonds Ltd's *Merlin* project in the McArthur Basin comprises 14 kimberlite pipes of which nine were mined by open cut between 1998 and 2003 producing 507 000 ct of diamonds. The 2014 combined Probable Ore Reserve for all diamond pipes at Merlin is 2.02 Mt at 0.15 carats per tonne (ct/t) for a total of 0.61 Mct. The Indicated and Inferred Mineral Resource is 27.8 Mt at 0.16 c/t for a total of 4.35 Mct. In October 2016, Merlin recommenced small-scale operations at the mine with processing of stockpiled material and mining of ore from the Kaye open pit. In July 2017, the company reported that it had processed 86 407 t of material for production of 22 000 diamonds totalling 4605 ct since mining operations recommenced. This included 37 diamonds above 5 ct with the largest diamond being 35.74 ct. In December 2017, a Tomra XRT (x-ray transmission) machine was commissioned at Merlin; this new sorting technology is expected to recover larger diamonds than previously possible and recover low luminescing diamonds that were missed with the previous sorting technology. During 2017, the company undertook a 3500 m RC drilling program on the Merlin mine lease; no new kimberlites were discovered by this work.

## Bauxite and alumina

Rio Tinto Ltd operates the *Gove* bauxite mine and alumina refinery 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 2016, the Gove operation had Proven and Probable Ore Reserves of 147 Mt at 49.2%  $Al_2O_3$ , with additional Measured, Indicated and Inferred Mineral Resources of 44 Mt at 49.5%  $Al_2O_3$ . During 2017, the Gove operation produced a record 11.20 Mt of bauxite.

Gulkula Mining Company Pty Ltd, which is 100% owned by the Gumatj Corporation, was granted a mining lease in January 2017 for a new bauxite mine on the *Dhupuma Plateau*, immediately south of the Gove mineral lease. The operation is expected to ramp up to full annual production of 500 000 tpa bauxite within the first four years, and continue at this production rate for a projected 15 year mine life. The mine is associated with a Mining Training Centre for local Aboriginal people, established with the support of Rio Tinto. The mine and training centre were officially opened in August 2017. The ore will be sold to Rio Tinto's Gove operation.

#### Iron ore

All iron ore operations in the Northern Territory remained in care and maintenance during 2017; no substantial iron ore exploration was reported. However, Northern Territory Iron Ore (NTIO) submitted a Notice of Intent for the development of iron ore from three deposits (Deposits C, W and X) in the Roper region (formerly Sherwin Iron's Roper River iron ore project), 420 km southeast of Darwin and 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.

In early 2018, Britmar (Aust), a subsidiary of the international shipping and mining company British Marine, received an authorisation to recommence activities at the *Roper Bar* iron ore mine, which has been in care and maintenance since Western Desert Resources Ltd went into administration in 2015. The company are hoping to recommence production during 2018.

# 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. The oolitic or pisolitic mineralisation is a stratiform sedimentary deposit in shallow marine Cretaceous sediments. It was discovered in 1960 and has been continuously mined by the Groote Eylandt Mining Company (GEMCO) since 1966. GEMCO is majority owned by South32 Ltd. Production from Groote Eylandt in 2016–17 totalled 4.99 Mt of manganese ore. There are remaining resources of 157 Mt at 44.1% Mn.

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 2014, the Total Resources for Bootu Creek were 20.5 Mt at 22.24% Mn. After suspension of mining in December 2015 due to a low manganese prices, mining recommenced at Bootu Creek in February 2017. In 2017, OM mined 1.59 Mt of manganese ore at an average grade of 21.17% Mn, with production of lumps and fines totalling 656 149 t at 35.87% Mn.

## Tungsten (-molybdenum)

Thor Mining PLC (Thor) 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 Arunta Region. It has a Mineral Resource of 4.71 Mt at 0.28% WO<sub>3</sub>, 0.22% MoS<sub>2</sub> and 18.1% Fe, most of which is in the Indicated category. During 2017, based on improved ore sorting results and operating cost estimates, the company announced an upgraded open cut Probable Ore Reserve of 3.5 Mt at 0.29% WO<sub>3</sub> and 0.12% MoS<sub>2</sub>; this upgrade increases the open pit life by one year to seven years and increases metal content by 10% for tungsten and 19% of molybdenum.

GWR Group Ltd continued exploration in the historic Hatches Creek tungsten field in the Davenport Province, which contains numerous underground mines that were mined between 1915 and 1957. Mineralisation is hosted in quartz veins as 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<sub>3</sub> for 1311 t WO<sub>3</sub>. In March 2017, GWR announced the results of their maiden RC drilling program at Hatches Creek, which intersected wide zones of mineralisation including 53 m at 0.26% WO<sub>3</sub> and 0.13% Cu from 63 m from the Treasure, and narrow high-grade intersections including 2 m at 3.05% WO<sub>3</sub> from 3 m the *Hit and Miss* prospect. A follow-up 33 hole RC program during 2017 confirmed the widespread and polymetallic nature of the mineralisation with further high-grade intersections from Hit and Miss: 9 m at 2.03% WO<sub>3</sub>, 0.18% Cu and 0.05% Mo from 93 m including 1 m at 17.52% WO<sub>3</sub>, plus broad intersections such as 69 m at 0.23% WO<sub>3</sub> and 0.34% Cu from 41 m. Results from Treasure included 8 m at 0.73% WO3 and 0.41% Cu from 55 m. A total of four holes were completed at Pioneer, which also contained significant gold, with a best intersection of 7 m at 1.16% WO<sub>3</sub> and 0.81 g/t Au, including 1 m at 3.36% WO<sub>3</sub> and 5.32 g/t Au. High-grade mineralisation was also intersected at *Black Diamond* (10 m at 0.46% WO<sub>3</sub>), *Green Diamond* (1 m at 3.90% WO<sub>3</sub>) and *Bonanza* (14 m at 0.39% WO<sub>3</sub>). The company have announced that a maiden Mineral Resource estimates for Pioneer, Treasure and Hit or Miss are in progress and will be completed in early 2018; they also plan a Scoping Study to review potential for near term production.

# Vanadium-titanium-iron

TNG's *Mount Peake* project is a vanadium-titanium-iron prospect hosted in the Mount Peake Gabbro in the northern Arunta Region, 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. TNG released an updated FS in November 2017 and continued progressing environmental approvals for the project.

## Magnesite

A number of high-grade magnesite (magnesium carbonate) deposits occur as stratabound bodies within the Celia and Coomalie Dolostones near Batchelor in the Pine Creek Orogen (**Figure 8**). The most notable of these is *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, which has Indicated and Inferred Mineral Resources of 9.1 Mt at 44.3% MgO. Both companies are investigating potential development options for these deposits. Korab announced in November 2017 that they were commencing an update of the PFS for Winchester.

## Mineral sands

During the first half of 2017, Australian Abrasive Minerals Pty Ltd (AAM) continued to move towards full production at the *Harts Range* garnet sand deposit (formerly known as Spinifex Bore) located near Harts Range community, 170 km northeast of Alice Springs. However, in August 2017 AAM were placed into administration, putting the short-term future of the mine in doubt.

In 2017, Australian Ilmenite Resources Pty Ltd undertook refurbishment and upgrading of the processing plant at the *Sill 80* ilmenite project in the Roper region in the hope of moving into full production in 2018. 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 feasibility and project optimisation studies on 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 Bore total 56 Mt at 2.6% rare earth oxides (REO), 11%  $P_2O_5$  and 0.02%  $U_3O_8$  containing 1.46 Mt REO. The most abundant rare earth-bearing minerals at Nolans Bore are apatite, monazite and allanite, with 26.4% of the mix represented by neodymium and praseodymium (NdPr). During 2017, Arafura undertook a detailed resource assessment, which established that two-thirds of Measured and Indicated Resources inventory are NdPr-bearing phosphate-rich material types, supporting a mine plan that extends the life of the proposed operation to 37 years. In late 2017, Arafura received a positive Assessment Report from the Northern Territory Environment Protection Authority (NTEPA) for the Environmental Impact Statement (EIS) for the Nolans project.

Crossland Strategic Metals Ltd announced that they were undertaking a resource re-evaluation and an update of their 2013 Scoping Study at its *Charley Creek* alluvial rare earths project, located 120 km west of Alice Springs.



**Figure 8**. Map of Geological Regions of the NT showing locations of magnesite, mineral sands, rare earths (REE), lithium, phosphate, potash, salt and uranium deposits and projects mentioned in the text.

The resource is contained within unconsolidated alluvial outwash and is hosted in xenotime and monazite. It has an Indicated Mineral Resource of 387 Mt at 295 ppm TREO and an Inferred Mineral Resource of 418 Mt at 289 ppm TREO.

#### Lithium

#### Pine Creek Orogen

Lithium exploration continued to progress strongly during 2017 following the 2016 discovery of significant pegmatitehosted lithium mineralisation in the Bynoe pegmatite field, 20-50 km south-southwest of Darwin. Lithium mineralisation in the Bynoe pegmatite field occurs as spodumene in northtrending pegmatites up to 40 m in width along a 30 km north-trending corridor. On the basis of drilling undertaken since August 2016, in May 2017 Core Exploration Ltd (Core) reported a maiden lithium resource at the Grants prospect of Indicated and Inferred Resources totalling 1.8 Mt at 1.5% Li<sub>2</sub>O (Figure 9). They subsequently commenced a PFS study at Grants; in November 2017, Core submitted a Notice of Intent for development of the resource. Also during 2017, Core purchased a number of tenements owned by Liontown Resources Ltd to consolidate their tenement holding in the Bynoe pegmatite field. Following the purchase, the company undertook a drilling campaign at the BP33 prospect and intersected broad zones of mineralisation, including 62 m at 1.24% Li<sub>2</sub>O from 66 m and 54 m at 1.42% Li<sub>2</sub>O from 101 m. A resource drilling program at BP33 was in progress during the 2017–18 wet season, in addition to further resource drilling at Grants. The company also reported intersections from the Sandras prospect, including 27 m at 1.45% Li<sub>2</sub>O from 195 m, with 7 m at 2.13% Li<sub>2</sub>O.

In December 2017, an RC drilling campaign in former Liontown Resources tenements intersected significant mineralisation in all four prospects targeted, including 10 m at 1.6% Li<sub>2</sub>O from 83 m at the *Carlton* prospect, 5.5 m at 2.2% Li<sub>2</sub>O from 70 m at *Hang Gong*, 4 m at 1.4% Li<sub>2</sub>O at *Lees*, and 3 m at 1.6% Li<sub>2</sub>O from *Booths*. The company reported that these four pegmatite prospects share characteristics including 5 m–15 m true width, consistent geometry, shallow dip (<45 degrees), stacked sets, high grades (~ 1.5% Li<sub>2</sub>O), and proximity to current roads and the proposed Grants mine.

Kingston Resources undertook a maiden drilling program of 45 holes for 4507 m in their tenements in the Bynoe pegmatite field at the *Lei*, *Cai*, *Bao* and *Liana* prospects, with a best intersection at Lei of 12 m at 1.43%  $Li_2O$  from 121 m, including 9 m at 1.69%  $Li_2O$ . The company also tested the use of deep ground penetrating radar (DGPR) technology, which they consider has potential to be an effective targeting tool for pegmatites.

### Arunta Region

In March 2017, Kingston Resources Ltd announced the identification of Cs, Ta and Li geochemical anomalies in soils from their *Spotted Wonder* project area 160 km northeast of Alice Springs. They also located an amblygonite (lithium phosphate)-bearing pegmatite that returned a rock chip assay of 9.63% Li<sub>2</sub>O at the newly identified Delmore prospect.

Todd River Resources Ltd announced in August that mapping and sampling the Anningie Tin Field near Barrow Creek had identified rock samples with exceptionally highgrade lithium results including values of up to 4.42% Li<sub>2</sub>O and anomalous soil results over a 12-hectare area around the **Bismark** prospect. Follow-up infill sampling returned values of up to 4.63% Li<sub>2</sub>O, along with highly anomalous Cs, Sn, Ta and Nb. Core also reported positive rock chip and soil sampling results from a number of prospects in the Anningie and Barrow Creek fields.

## **Cobalt**

A new NT-focussed cobalt explorer, Northern Cobalt Ltd (N27), listed on the ASX in September 2017. N27's flagship project is the Wollogorang project in the McArthur Basin near the Queensland border, which includes the existing Stanton cobalt-copper-nickel resource. Prior to listing, N27 announced a maiden JORC-compliant resource for Stanton from historic drilling, reporting an Inferred Resource of 500 000 t at 0.17% Co, 0.09% Ni and 0.11% Cu. In late 2017, the company drilled 70 RC holes for 6259 m and 10 diamond holes for 773 m on the Stanton resource, with best intersections including 37 m at 0.28% Co, 0.12% Cu and 0.16% Ni from 25 m, 18 m at 0.33% Co from 32 m (including 1 m at 2.13% Co), and 20 m at 0.31% Co, 0.10% Cu and 0.16% Ni from 27 m. The company describe the mineralisation as outcropping flat-lying sediment-hosted mineralisation; it is non-refractory and predominantly comprising the cobalt sulphide mineral siegenite. Drilling has shown that the deposit remains open to the southeast and northwest. As well as resource definition and extension drilling at Stanton, the company also undertook exploration drilling at the Stanton SW, Stanton NT, Stanton SE, Running Creek and East Felix prospects, with 57 RC holes for 4554 m on a broad spacing, although no high-grade results were reported. A further 15 targets were not tested due to the onset of the wet season.

## **Phosphate**

Verdant Minerals Ltd continued to progress their bankable feasibility study (BFS) and environmental approvals for their *Ammaroo* phosphate project located in the southern Georgina Basin, approximately 80 km east of Barrow Creek. In March 2017, Verdant announced an upgraded resource with the Indicated Mineral Resources more than doubling to 165 Mt at 15.5%  $P_2O_5$ , while total Measured, Indicated and Inferred Mineral Resources remained largely unchanged 1.141 Bt at 14%  $P_2O_5$  at 10%  $P_2O_5$  cut-off. The BFS is focussing on the development of a surface mining operation, a flotation beneficiation facility and associated infrastructure with a maximum annual capacity of 2 Mt of export quality phosphate rock concentrate (30%  $P_2O_5$ ). They submitted their draft EIS to the NTEPA in October 2017.

In May and June 2017, Verdant undertook a 62 hole, 1457 m RC drilling program at the **Rockhole** prospect, 50 km northeast of Ammaroo. This was the first testing of the greenfields potential of their eastern tenement package, which comprises a number of palaeo-embayments along the western margin of the Georgina Basin. The best intersection from the drilling was 6 m at 35.6%  $P_2O_5$  from 27 m, as part of a broader intersection of 11 m at 29.2%  $P_2O_5$ . Based on the drilling, Verdant announced an Exploration target for the Rockhole prospect of 40–70 Mt at 17–24%  $P_2O_5$  at a cutoff grade of 10%, or 30–50 Mt at 20–27%  $P_2O_5$  at a 15% cut-off grade.

### Potash

The Territory's only advanced potash project is Verdant Minerals' *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



**Figure 9**. Diamond drill rig at the Grants lithium prospect, Bynoe pegmatite field.

Mineral Resources at Karinga Lakes are 8.4 Mt  $K_2SO_4$  at an average resource thickness of 17 m beneath 25 lakes with a total area of 132 km<sup>2</sup>. The average potassium grade in the resource is 4760 mg/l (at 3000 mg/l cut-off). Two distinct aquifers are present: one contained in unconsolidated near-surface lake sediments; the second hosted in siltstone and sandy interbeds of the Devonian Horseshoe Bend Shale of the Finke Group (Amadeus Basin). In August 2017, Verdant announced that an Australian water technology company, Aqua Guardian Group Ltd, had entered into a \$3 million earn-in agreement to earn up to 40% of the project through staged evaluation of their mineral processing technology for producing sulfate of potash at Karinga Lakes.

## Salt

Tellus Holdings Ltd (Tellus) continued to progress plans to develop an underground rock salt mine at their Chandler project near Titjikala, located in the Amadeus Basin 120 km south of Alice Springs. The business model is based on the usage of the voids from salt mining for the storage, recovery and permanent isolation of waste, as well as equipment and archive storage. 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. It 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. Tellus have continued to progress regulatory approvals for the Chandler project and in December 2017, Tellus received the Assessment Report from the NTEPA on their EIS.

## Uranium

Activity for uranium in the Northern Territory remained subdued in 2017 due to ongoing low uranium price. The Territory's only operating uranium mine is Ranger, in production since 1981, which is hosted in the lower Cahill Formation in the Pine Creek Orogen. During 2017, Energy Resources of Australia Ltd (ERA) produced 2294 t of uranium oxide, a 2% decrease from 2016. 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 2017, Ore Reserves at Ranger (entirely within stockpiles from Ranger 3 pit) are 7.43 Mt at 0.078% U<sub>3</sub>O<sub>8</sub> for 5783 t U<sub>3</sub>O<sub>8</sub>, (at 0.06% U<sub>3</sub>O<sub>8</sub> cut-off); additional Mineral Resources (in stockpiles and in Ranger 3 Deeps) are 47.74 Mt at 0.12%  $U_3O_8$  for 55 135 t  $U_3O_8$ . No exploration was undertaken in 2017, and the exploration decline for the Ranger 3 Deeps deposit, which has a Mineral Resource of 19.58 Mt at 0.224% U<sub>3</sub>O<sub>8</sub> for 43 858 t contained U<sub>3</sub>O<sub>8</sub>, remains in care and maintenance.

Alligator Energy Ltd (Alligator) continued exploration at their *Beatrice* project area in western Arnhem Land, with a helicopter-supported field program; 262 samples were collected and two separate pathfinder anomalies identified at target BT7. Cameco Australia Pty Ltd (Cameco) also undertook exploration program in their *Wellington Range*  project area, located near the north coast of western Arnhem Land, although no results have been publicly reported.

Energy Metals Ltd (Energy Metals) have uranium projects in the Ngalia Basin northwest of Alice Springs, including Bigrlyi uranium deposit, which has total Indicated and Inferred Mineral Resources of 7.5 Mt at 0.13% U<sub>2</sub>O<sub>2</sub> and 0.12% V<sub>2</sub>O<sub>5</sub> at a 500 ppm U cut-off, for a contained 9600 t of U<sub>3</sub>O<sub>8</sub> and 8900 t of V<sub>2</sub>O<sub>5</sub>. Following drilling at the *Malawiri* project area in the eastern Ngalia basin in 2016, Energy Metals announced a maiden Inferred Resource for the deposit of 421 000 t at 0.129% U<sub>3</sub>O<sub>9</sub>, for 542 t of contained U<sub>3</sub>O<sub>8</sub>. The company reported that although Malawiri is a small deposit, it is relatively high grade and has similarities in style to Bigrlyi. Mineralisation is sandstone-hosted and occurs within a number of sub-vertically oriented, stacked, tabular lenses bounded by conglomerate marker beds. The width of the mineralised intervals varies from 0.3 m to 12.6 m, averaging 3.2 m in thickness. The host Mt Eclipse Sandstone is unconformably overlain by 80 to 100 m of younger, unconsolidated sediments of Cenozoic age. The 2017 exploration program in Energy Metals' Ngalia Regional project area focused on geophysical exploration using aerial electromagnetic (AEM) and induced polarization (IP) survey methods to target undercover uranium mineralisation in reduced pyrite-bearing beds, with a number of chargeable anomalies identified.

#### **Onshore petroleum**

Petroleum exploration activity in the onshore basins of the Northern Territory in 2017 was largely limited to the Amadeus Basin, with no substantial exploration in the greater McArthur Basin (including the Beetaloo Sub-basin) pending the outcome of the Scientific Inquiry into Hydraulic Fracturing. **Figure 10** 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 near Dunmarra and Daly Waters. It is the Territory's most advanced shale gas play. In February 2017, following the completion of extended production testing during 2016 at the Amungee NW-1H exploration well in the Beetaloo Sub-basin, Origin Energy Ltd (Origin) announced it has submitted the Velkerri B Shale Pool Discovery Evaluation Report to the Northern Territory Government. Origin reported that drilling and seismic results across more the 10 000 km<sup>2</sup> indicate the continuity of the Velkerri Formation shale play over a large area, and that the 'B-shale' member of the Velkerri Formation is interpreted to be the most continuous of three individual targets in the play. Origin also reported that production test data from the Amungee NW-1H well with 11 fracture stimulation stages across approximately 600 m of the lateral section, confirmed the ability of the Velkerri Formation 'B-shale' to flow gas following hydraulic fracture stimulation. Origin announced a 2C Contingent Gas Resource Estimate for the Velkerri B



Figure 10. Map of Geological Regions of the Northern Territory showing granted exploration permits as of January 2018, along with wells and prospects mentioned in the text.

shale pool of 6.6 trillion cubic feet (TCF) over 1968 km<sup>2</sup>, with original gas in place (OGIP) of 6.0 TCF. No field exploration was reported in 2017 by the main tenement-holders in the sub-basin, which also include Santos and Pangaea Resources.

### Amadeus Basin

The Territory's onshore gas production is sourced from the *Mereenie*, *Dingo* and *Palm Valley* fields in the Amadeus Basin south and west of Alice Springs, operated by Central Petroleum Ltd. Since Central Petroleum took over the Mereenie field in 2015, they have been transitioning the field towards an increase in gas production relative to oil. With the increase in gas production at Mereenie, the Palm Valley gas field has been placed on standby, with no production in 2017, although it can be brought back online at short notice to satisfy any increase in gas was produced in the

onshore NT, comprising 4.184 bscf from Mereenie (a 30% increase on 2016) and 0.795 bscf from Dingo. Onshore oil production in the NT in 2017 was sourced entirely from the Mereenie field, with 0.216 million barrels (mmbbls) of oil, a 7% decrease on 2016.

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 intrasalt plays of the Neoproterozoic lower Gillen-Heavitree Quartzite System in the southeastern part of the basin, which have potential for large gas and helium accumulations hosted in the Heavitree Quartzite. In November 2016, Santos commenced a 1300 km 2D seismic program, targeting the Dukas, Mahler and Rossini leads. They completed Stage 1 of the program in early 2017, with a total of 932 km of seismic line data acquired to mature the Dukas lead and to gather data for the Rossini lead. Seismic acquisition is scheduled to continue in 2018.