

# Overview

## Overview of mineral exploration in Western Australia for 2009–10

by PB Abeyasinghe and DJ Flint

### Abstract

There were signs of recovery in commodity markets towards the end of 2009–10 following the economic downturn resulting from the global financial crisis of 2008–09. Statistical indicators for the year are mixed; some still show downward trends, whereas others show signs of recovery. In 2009–10, commodity prices generally improved leading to a resurgence in the mining sector, strengthening other related industries, and triggering positive effects in the employment sector. However, economic problems persisted in the United States and parts of Europe.

The Western Australian economy, with its reliance on mineral and petroleum exports, recovered quickly. In 2009–10, the value of mineral production in the State increased by 4% to a new record of A\$52.1 billion (excluding petroleum). Iron ore, gold, and nickel, which form the backbone of the Western Australian mineral sector, accounted for 85% or A\$44 billion of the value of minerals produced in 2009–10. A substantial increase in the gold price led to a significant increase in both production value (25.5%) and production quantity (20%) in 2009–10 compared to the previous year. The recovery of nickel prices also led to a significant increase in value (36%), although production quantity dropped marginally due to the earlier closure of some mines caused by the global financial crisis. In the iron ore sector, although the production increased by 25%, a significant drop in prices triggered by the global financial crisis resulted in a virtually unchanged value (A\$33.7 billion) of production.

Across Australia, mineral exploration expenditure decreased marginally by 1.9% for the year, with drilling (metres drilled) at existing deposits recovering by 1.5% and drilling for new deposits increasing by 12% (comparable WA-specific data for metres drilled are not available).

In Western Australia, the trend was similar — mineral exploration expenditure during 2009–10 decreased by 2.6% (in 2009–10 dollar terms). The area held under granted Exploration Licences in Western Australia increased by 24% by the end of the year, with a moderate (5%) increase in the area under granted Mining Leases. The pro-uranium policy of the State Government continued to have a positive impact in the uranium sector with uranium exploration expenditure in the State increasing to A\$55.4 million in 2009–10 from negligible amounts in the period from 1991 to 2006. A number of companies are planning to start new mines.

Numerous mineral discoveries are being made. This reflects technical success from the sustained, high levels of mineral exploration expenditure over many years and is despite the global financial crisis.

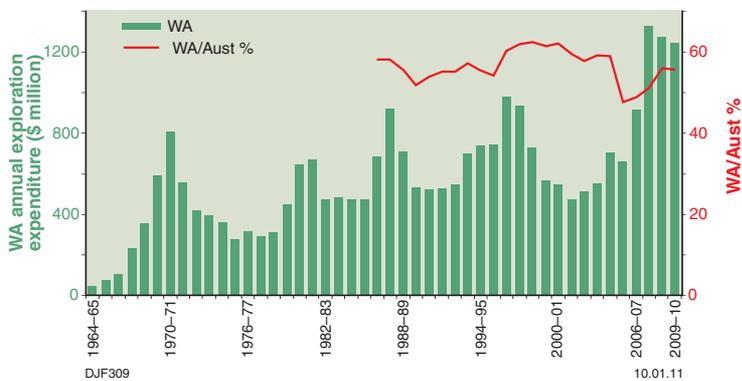
**KEYWORDS:** mineral exploration, exploration potential, exploration licences, exploration expenditure, mineral production, gold, iron, nickel, base metals, copper, lead, zinc, silver, diamond, heavy mineral sands, uranium, molybdenum, rare earth elements, vanadium, lithium, coal, tungsten, manganese, exploration drilling, Western Australia.

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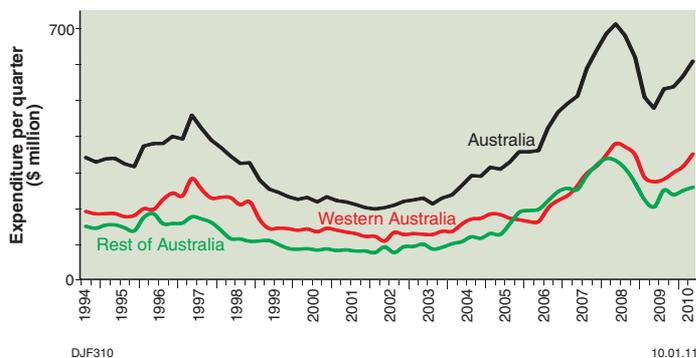
Significant observations for the Western Australian mineral industry during 2009–10 include:

- Mineral exploration expenditure in Western Australia marginally decreased (2.6%) from \$1273 million\* in 2008–09 to \$1244 million in 2009–10 (Fig. 1, in 2009–10 dollar terms).
- Australian mineral exploration expenditure also marginally decreased (2%) from \$2277 million in 2008–09 to \$2233 million in 2009–10 (in 2009–10 dollar terms).
- Western Australia's share of the national exploration expenditure for minerals (excluding petroleum) marginally decreased to 55.7% in 2009–10 compared with the 2008–09 value of 56.1% (Fig. 1).
- Despite the negative effects of the global financial crisis in 2008–09, exploration expenditure for many commodities including gold, iron ore, base metals, and uranium are picking up.

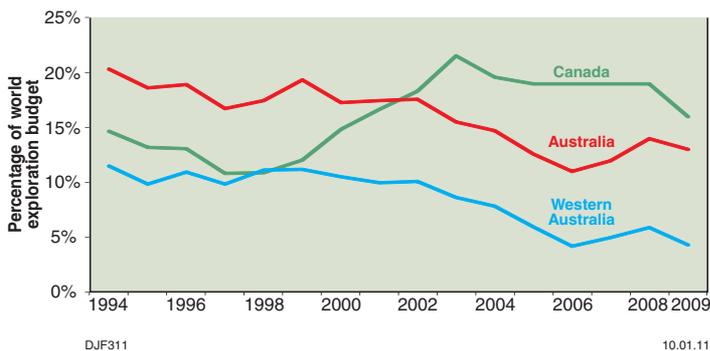
\* All \$ figures in Australian dollars unless otherwise specified. All exploration expenditure figures and drilling statistics are compiled by the Australian Bureau of Statistics unless otherwise specified.



**Figure 1. Mineral exploration expenditure in Western Australia, by year (2009–10 dollars)**



**Figure 2. Mineral exploration expenditure in Australia, Western Australia, and rest of Australia (seasonally adjusted by quarter, June 2010 dollars)**



**Figure 3. Non-ferrous mineral exploration expenditure — comparative market share of Canada and Western Australia since 1994 (source: Metals Economics Group (Canada), Australian Bureau of Statistics, and Department of Mines and Petroleum)**

- Quarterly mineral exploration data indicate that exploration expenditure in Western Australia is still recovering, but at a moderate rate (Fig. 2).
- The main commodities being targeted are iron ore, gold, uranium, base metals, and nickel.
- The average gold price in 2009–10 increased by 25% (in US\$ terms) compared to 2008–09. The gold industry in Western Australia is emerging from the shadow of the iron ore exploration industry and topped \$100 million for the June 2010 quarter, reaching \$109 million. This is the highest level of quarterly expenditure since 1998. This upward trend is likely to continue throughout 2010–11.
- The discovery of Doolgunna has boosted exploration for copper in Western Australia, which reached \$15 million for the June quarter — probably an all-time record.
- Exploration expenditure for nickel in Western Australia is recovering from the disastrous effects triggered by the fall in nickel price in 2008–09. In 2009–10, nickel exploration expenditure was \$195 million, but this is still well below the peak level of \$295 million in 2007–08.
- Uranium exploration expenditure in Western Australia totalled \$55 million in 2009–10 and is the highest since 1980 (in 2009–10 dollar terms).

During the last decade, the proportion of the world's non-ferrous mineral exploration expenditure in Australia has dropped from 19% to 13% (Fig. 3, based on data compiled by the Metals Economics Group of Halifax, Canada, <www.metalseconomics.com>), of which Western Australia's share has dropped from 11% to 4%. This decline for Western Australia is partly attributable to growth in exploration in iron ore in recent years, rather than the move of exploration activity offshore. The sharp decline from 2002 in both Western Australia and Australia appears to show little signs of recovery although there was a slight positive trend in 2008. The Canadian share of world's non-ferrous mineral exploration expenditure appears to have also decreased in 2009 to 16%. These trends suggest that Canada and Australia will continue to lose their dominance of the world's non-ferrous mineral exploration expenditure while the shares of other countries improve. Western Australia is actively working towards improving its competitiveness to attract

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investment, including investment in greenfields exploration, by programs such as the Exploration Incentive Scheme (EIS). For more details on the scheme see Ellis (2010a,b).

## Developments and mineral exploration highlights by commodity

During 2009–10, exploration for iron ore was again dominant (for the third year in succession) with 40% of the total, followed by gold, which increased to 28% of the total. These were followed by nickel and base metals whose share decreased to 21% of the total. Diamond exploration expenditure has dropped to less than 1% of the total (Fig. 4). The exploration expenditure trends for gold, iron ore, nickel, and base metals are shown in Figure 5.

### Gold

Trends in the gold industry in Western Australia during 2009–10 include:

- The international gold price, in Australian dollar terms, rose (6%), from an average of \$1171/oz in 2008–09 to an average of \$1236/oz in 2009–10. In US dollar terms, the increase during the same period was 25% from US\$874/oz to US\$1091. This has been a big boost to gold exploration in Western Australia, but has been partly moderated by the strength of the Australian dollar (which approached parity with the US dollar in 2009–10).
- Gold production in Western Australia increased by 21% to 27 446 kg, and the value increased by 26% to \$1.3 billion. The top eleven gold producing mines during 2009–10 were the Super Pit (Kalgoorlie), Telfer, St Ives, Sunrise Dam, Jundee, Boddington, Kanowna Belle, Higginsville, Agnew, Kundana East, and Paddington.
- Gold exploration expenditure in Western Australia in 2009–10 increased by 30% to \$349 million, reversing the negative trend of the previous year (Fig. 6).

Major developments in the gold industry include:

- In October 2009, Newmont Mining Corporation poured its first gold at the redeveloped Boddington mine and trucked its first shipment of copper concentrate from the mine to Bunbury port. Boddington will join

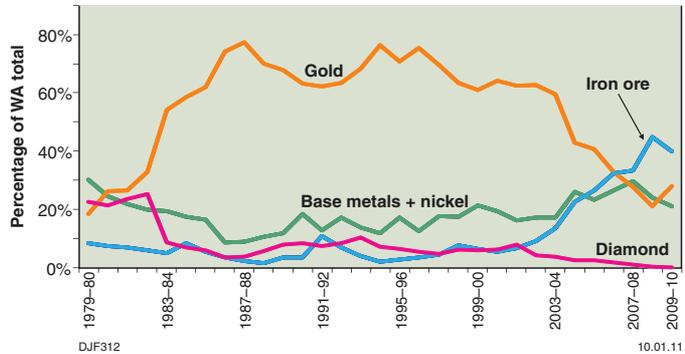


Figure 4. Exploration expenditure in Western Australia since 1979–80 (% of total, by commodity)

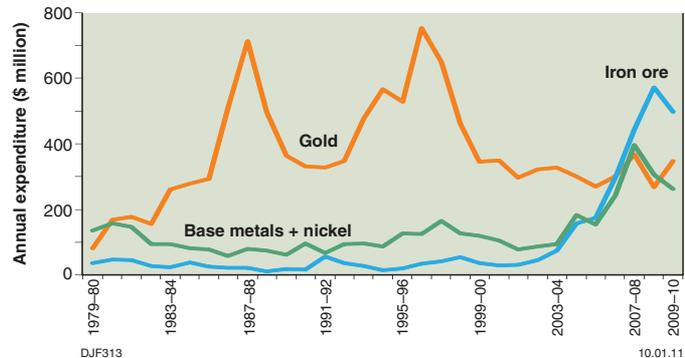


Figure 5. Gold, base metals + nickel, and iron ore exploration expenditure in Western Australia since 1979–80 (2009–10 dollars)

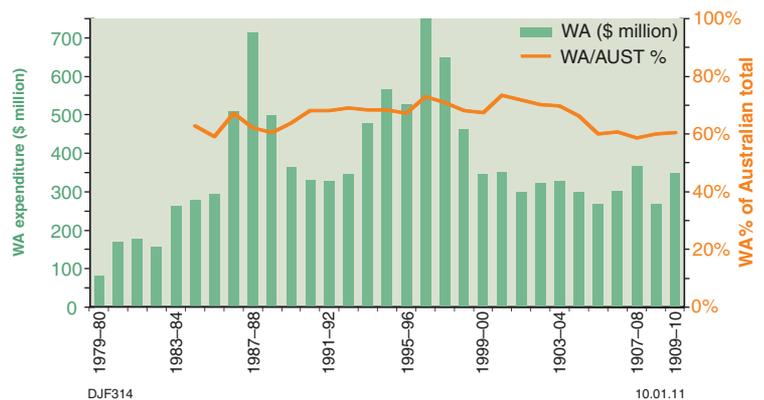


Figure 6. Gold exploration expenditure in Western Australia since 1979–80 (2009–10 dollars)

an exclusive global list of 1 million ounce-plus gold mines and is set to become Australia's largest gold operation. The mine is expected to produce around one million ounces (Moz) of gold annually for the first five years. The mine holds gold reserves of 20.1 Moz and has an expected mine life of more than 24 years (Jacoby, 2009a; Miningnewspremium.Net, 2010a).

- Ramelius Resources Ltd reached a milestone in June 2010 by achieving 100 000 ounces production at Wattle Dam gold mine, 25 km southwest of Kambalda. The underground high-grade ore has averaged around 30 g/t in the first two years of production, making it the highest grade gold producing underground mine in Australia (Ramelius Resources Ltd, 2010).
- With its feasibility study nearing completion, AngloGold Ashanti Ltd has plans to develop the 5 Moz Tropicana project, 340 km northeast of Kalgoorlie, into production by 2013 (Jacoby, 2010a).

During 2009–10, a number of companies announced the start of new gold operations or their intention to start operations in the near future. These include:

- Catalpa Resources Ltd had its first pouring of gold from its Edna May gold mine at Westonia in April 2010. Total measured, indicated, and inferred resource of the project is estimated at 52.1 Mt at 0.99 g/t Au for 1.656 Moz of contained gold. Of this the proved and probable reserves are estimated at 29.6 Mt at 1.06 g/t Au for 1 Moz of contained gold (Catalpa Resources Ltd, 2010a,b).
- A1 Minerals Ltd had the first gold pour in early March 2010 from its BrightStar project, 35 km southeast of Laverton. The company aims to produce 30 000 oz gold per annum over four years, based on gold resources of 1.7 Moz and reserves of 150 000 oz (A1 Minerals Ltd, 2009, 2010).
- Navigator Resources Ltd acquired the Bronzewing operation from View Resources in late 2009 and then announced pouring of the first gold in April 2010. The company has increased the resource at Bronzewing, and as at June 2010 resources were estimated at 13.65 Mt at 2.1 g/t Au for 946 000 oz of contained gold (Jacoby, 2009b; Navigator Resources Ltd, 2010; Batten, 2010a).

- Saracen Mineral Holdings Ltd poured the first gold bar in late January 2010 from its Carosue Dam operation near Laverton. The company hopes to produce 100 000–120 000 oz per annum (Saracen Mineral Holdings Ltd, 2010a,b).
- La Mancha Resources Inc. has poured the first gold from its White Foil openpit gold mine, 20 km west of Kalgoorlie. The company is on track to produce 13 000–16 000 oz gold for 2010 and is expected to produce 76 000 oz gold over its 27-month phase-1 mine life (Batten, 2010b).
- Focus Minerals Ltd recommissioned the Three Mile Hill gold treatment plant at its Tindals Mining Centre, near Coolgardie. The company aims to produce 80 000 oz gold in 2010 and more than 100 000 oz from 2011 onwards (Focus Minerals Ltd, 2010a).
- Integra Mining Ltd began construction at the Randalls gold project, 55 km east-northeast of Kambalda. The first phase of production at a rate of 90 000 oz per annum gold is due to start in September 2010 and phase 2 will see production rise to 100 000 oz per annum and then to 140 000 oz per annum (Integra Mining Ltd, 2010a,b).
- Avoca Resources Ltd remained confident that its goal of producing a total of 400 000 oz per annum from Higginsville and South Kalgoorlie by the 2013 financial year is achievable. The total measured, indicated, and inferred resources of Higginsville, South Kalgoorlie, and Frog Leg deposits are estimated at 85 Mt at 2.4 g/t Au for 6.7 Moz of contained gold (Avoca Resources Ltd, 2010).

On the resources side, a number of companies announced significant increases in the gold resources of their projects. These include:

- Apex Minerals NL announced a revised indicated and inferred mineral resource of 8.03 Mt at 6.6 g/t Au for 1.6 Moz of gold for its Wiluna mine (Apex Minerals NL, 2009).
- Korab Resources Ltd announced an increase of the global resource of the Melrose project, 95 km northeast of Leinster. The total measured, indicated, and inferred resource of the project consisting of Boundary, Bungarra, and Stirling deposits increased by 11% to 6.57 Mt at 1.61 g/t Au for 339 975 oz (Korab Resources Ltd, 2010).

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- Australian Mines Ltd announced an increase of gold resources at the Mount Martin mine, 30 km southeast of Kalgoorlie, by about 50% to a total indicated and inferred resource of 4.67 Mt at 2.19 g/t Au for 328 000 oz (Australian Mines Ltd, 2010).
- Reed Resources Ltd announced an increase in gold resources at its Sand Queen gold mine, 100 km north of Kalgoorlie, to a total indicated and inferred resource of 534 000 t at 10.8 g/t Au for 186 000 oz of gold (Reed Resources Ltd, 2010a).
- Focus Minerals Ltd announced a maiden total indicated and inferred resource of 182 000 t at 3.7g/t Au for 21 600 oz for the Tindals deposit, and also updated indicated and inferred resources for the Cyanide project near the Tindals Mining Centre to 672 000 t at 5.5 g/t Au for 117 800 contained ounces. In addition, Focus Minerals announced a maiden probable reserve of 68 000 t at 8.6 g/t Au for 19 200 oz for the Mount deposit, about 80 km south of Tindals Mining Centre (Focus Minerals Ltd, 2010a,b,c,d).
- Drilling at the Handpump prospect, 75 km east of Warburton, has confirmed the existence of a new gold mineralized system in the west Musgrave Province. Among the results are 15 m at 2.3 g/t Au from 31 m, (including 5 m at 4.7 g/t Au from 34 m), 7 m at 1.4 g/t from 3 m, and 11 m at 1.1 g/t from 24 m (Beadell Resources Ltd, 2010).
- At the Barlee gold project, about 140 km east of Paynes Find, Beacon Minerals Ltd had impressive gold intersections of 14 m at 45.32 g/t Au from 86 m (including 6 m at 102.66 g/t from 87 m) in one hole with another hole intersecting 10 m at 18.47 g/t Au from 69 m, including 4 m at 41.38 g/t Au from 71 m (Beacon Minerals Ltd, 2009a,b).
- Regis Resources Ltd had impressive intersections of 73 m at 3.61 g/t Au from 51 m and 69 m at 4.26 g/t Au from 42 m at the Garden Well prospect at the Duketon Gold project, 80 km north of Laverton (Regis Resources Ltd, 2009).
- Renaissance Minerals Ltd discovered shallow gold mineralization in its first drillhole at Mount Rankin, 15 km southwest of Southern Cross. The hole intersected multiple zones of gold, including 30 m at 1.08 g/t Au from 71 m (Renaissance Minerals Ltd, 2010).

In the exploration sector, a number of companies reported impressive gold intersections from various projects throughout Western Australia. These include:

- At the Wilber – Andy Well prospect, 45 km north-northeast of Meekatharra, Doray Minerals Ltd reported impressive gold intersections of 12 m at 21.47 g/t from 16 m, 8 m at 62.53 g/t from 60 m (including 4 m at 120.71 g/t from 60 m) — all in the same drillhole. Another drillhole intersected 9 m at 42.97 g/t from 45 m (including 3 m at 114.51 g/t from 48 m). Diamond drilling confirmed these with similar intersections (Doray Minerals Ltd, 2010a,b).
- Southern Gold reported multiple wide gold intersections at the Cannon and Georges Reward prospects at the boundary of the Bulong South project, 30 km southeast of Kalgoorlie. These include 66 m at 2.9 g/t Au (including 21 m at 4.5 g/t Au from 36 m) in hole BNRC057, 43 m at 3.4 g/t Au from 99 m in hole BNRC010. More high-grade intersections at Cannon prospect include 20 m at 4.75 g/t gold from 60 m in hole BSRC095 (including 4 m at 11.24 g/t Au from 63 m) (Southern Gold Ltd, 2009, 2010).
- Drilling by Integra Mining Ltd at the Salt Creek deposit of the Randalls gold project, 55 km east-northeast of Kambalda, returned impressive intersections of 5 m at 129 g/t Au from 16 m (including 1 m at 627 g/t Au from 16 m) and 26 m at 2.13 g/t Au from 1 m. At Maxwell deposit (part of the same project) intersections include 4.6 m at 21.36 g/t Au from 189 m and 2.95 m at 39.29 g/t Au from 221 m (Integra Mining Ltd, 2009a, 2010b).
- Integra Mining Ltd reported 20 m at 1.58 g/t Au from 190 m in a diamond drillhole at KZ5 prospect in the Aldiss project, 90 km east-northeast of Kambalda (Integra Mining Ltd, 2009b).
- Integra Mining also made a gold discovery at their Majestic prospect, 45 km northeast of Kambalda, with intersections of 198 m at 1 g/t Au from 24 m to end of hole, including 20 m at 5.79 g/t Au from 104 m. Another hole, at the same prospect, intersected 64 m at 1.3 g/t Au (Integra Mining Ltd, 2010c).

- Convergent Minerals Ltd reported intersections of 12 m at 5.5 g/t Au from 168 m (including 1 m at 41.4 g/t from 176 m) in one hole and 6 m at 6.02 g/t Au from 182 m in another hole at the Blue Vein deposit, part of the Bounty gold project, 80 km south of Marvel Loch (Convergent Minerals Ltd, 2009).
- At Craiggie more gold project near Laverton, Crescent Gold Ltd had intersections of 26 m at 9.6 g/t Au from 30 m in hole CMRC319, and 17 m at 4.3 g/t Au from 5 m in CMRC313, and 11 m at 5.1 g/t Au from 43 m in hole MMSRC089 (Crescent Gold Ltd, 2010a,b).
- Drilling by Silver Lake Resources Ltd at the Daisy Milano underground mine of the Mount Monger operation, about 35 km northeast of Kambalda, returned an intersection of 1.1 m at 680 g/t Au from 136 m, which includes 0.2 m at 3531 g/t Au (Silver Lake Resources Ltd, 2010; Batten, 2010c).
- Resource drilling at Edna May mine near Westonia returned 41.55 m at 1.5 g/t Au from 231.95 m, 53.4 m at 3.02 g/t Au from 182.9 m, and 70.1 m at 1.4 g/t Au from 210 m (Catalpa Resources Ltd, 2009).
- Anglo Australian Resources NL reported intersections of 6 m at 10.03 g/t Au including 2 m at 25.69 g/t Au at Dalray prospect near Feysville project, 25 km southeast of Kalgoorlie (Anglo Australian Resources NL, 2010a).
- Multiple gold zones were intersected in drillholes outside and adjacent to the current Golden Eagle proposed pit, 10 km south of the township of Nullagine. These include 8 m at 9.32 g/t Au from 45 m, including 1 m at 65 g/t Au, and 6 m at 7.28 g/t Au from 92 m, including 1 m at 16 g/t Au from 93 m (Millennium Minerals Ltd, 2010).
- Diamond drilling at Tregurtha and Hughes prospects of the Mount Jewell project, 60 km north of Kalgoorlie, extended the depth of gold mineralization. At the Tregurtha prospect, intersections include 20.35 m at 1.71 g/t Au from 159.2 m and 22.2 m at 1.95 g/t Au from 80.5 m, and at Hughes intersections include 11 m at 1.23 g/t Au from 159 m (Pioneer Resources Ltd, 2009).
- Drilling by Corvette Resources Ltd at the Stingray prospect of the Plumridge project, 60 km south of the 5 Moz Tropicana project, returned impressive intersections of 3 m at 40.33 g/t Au from 97 m at Camaro prospect and 8 m at 10.0 g/t Au from 119 m at Stingray (Corvette Resources Ltd, 2009).
- Independence Group reported multiple intercepts in single drillholes at the Boston Shaker prospect, 0.5 km northeast of the 5 Moz Tropicana project. Intersections include 12 m at 4.9 g/t Au from 93 m and 16 m at 3.5 g/t Au from 119 m in hole TFRC3294, as well as 5 m at 3.9 g/t Au from 48 m and 17 m at 3.0 g/t Au from 58 m in hole TFRC3293 (Independence Group NL, 2010a).
- At the Boudie Rat pit of the Quinns project, 90 km northwest of Menzies, Wild Acre Metals Ltd had gold intersections of 8 m at 7.36 g/t Au from 113 m and 2 m at 3.81 g/t Au from 68 m (Wild Acre Metals Ltd, 2010).
- Drilling by Pacrim Energy Ltd at the Golden Terrace deposit of the Redcliffe Gold project, 40 km north-northeast of Leonora, returned 69 m at 5.03 g/t Au including 15 m at 10.05 g/t Au and 35 m at 5.48 g/t Au (Pacrim Energy Ltd, 2009).
- Dourado Resources Ltd reported drill intersections of 14 m at 1.83 g/t from 29 m, 6 m at 12.23 g/t from 54 m, and 13 m at 3.17 g/t from 45 m at the Sabbath deposit, 10 km north-northwest of Meekatharra (Dourado Resources Ltd, 2010).
- Drilling by Hannans Reward Ltd at the Sunday deposit, 80 km east of Leonora, returned intersections of 4 m at 16.68 g/t Au including 1 m at 78.97 g/t Au (Hannans Reward Ltd, 2009).
- Eleckra Mines Ltd reported impressive intersections of 3 m at 136 g/t Au from 192 m (including 1 m at 404 g/t Au from 192 m) and 1 m at 105 g/t Au from 104 m at the Central Bore prospect of the Yamarna gold project, 140 km east-northeast of Laverton (Eleckra Mines Ltd, 2010).
- Alchemy Resources Ltd reported intersections of 18 m at 5.25 g/t Au from 5 m, 33 m at 2.78 g/t Au from 91 m, and 22 m at 2.07 g/t Au from 27 m at the Wilgeena deposit, 15 km east-southeast of Peak Hill (Alchemy Resources Ltd, 2010).

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## Iron

Highlights in Western Australia during 2009–10 include:

- Iron ore production from Western Australia increased by 25% (79.5 Mt) to 396 Mt, but the value virtually remained unchanged at \$33 billion, reflecting lower unit prices following the global financial crisis.
- Western Australian iron ore exploration expenditure peaked in 2008–09, and dropped by 13% (to \$497 million) in 2009–10, but at that level is still the second highest on record (Fig. 7).
- Iron ore exploration in Western Australia attracts the highest expenditure of any mineral commodity, and since 2007–08 has surpassed gold exploration expenditure (Figs 4, 5), accounting for 40% of the total exploration dollars spent in Western Australia. About 215 companies are currently exploring for iron ore in Western Australia.
- Numerous mines, targeting zones of supergene enrichment, were either being developed or were at an advanced feasibility stage. Mine development work for the State's first two magnetite projects — Cape Preston and Karara — has also commenced.
- Following several years of intense capital investment in project expansion in the Pilbara, Western Australia's iron ore production is likely to increase significantly over the next 5 to 10 years.
- Overseas companies (predominantly Chinese) continued to greatly increase their direct ownership or involvement (e.g. through long-term off-take agreements) in the Western Australian iron ore industry, with all seeking to secure long-term supplies.

Companies exploring for iron ore in Western Australia continue to target numerous mineralization styles, including: channel iron deposits (CID); supergene-enriched hematite over Archean (Marra Mamba) to Paleoproterozoic (Brockman) banded iron-formations (BIF); primary magnetite in BIF (taconite ores) of the Pilbara and Yilgarn Cratons; titanomagnetite in cumulate-layered mafic-ultramafic intrusives (e.g. at Balla Balla in the Pilbara Craton); magnetite in BIF within the Mesoproterozoic gneiss terrane of the Albany–Fraser Orogen

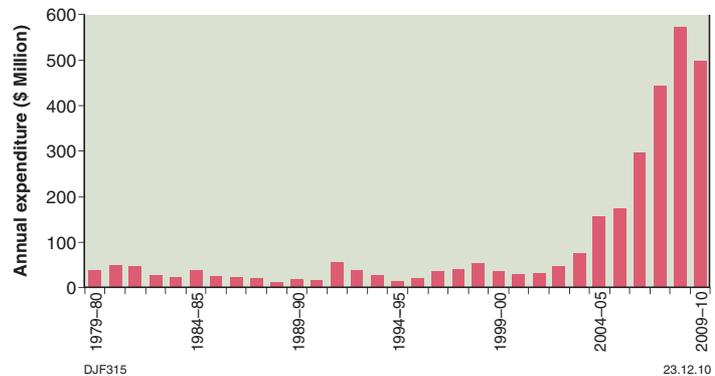


Figure 7. Western Australian iron ore exploration expenditure (2009–10 dollars)

(Southdown and Splinter); clastic hematite in Paleoproterozoic–Mesoproterozoic sedimentary rocks of the Kimberley Basin (Cockatoo Island, Koolan Island, and Irvine Island); hematite iron ore mineralization in the Midwest region; and granular iron-formation deposits in the Paleoproterozoic Earahedy and Yerrida Basins. There was ongoing interest by numerous companies in primary magnetite mineralization within BIF horizons throughout the Yilgarn Craton, with this now even extending into the Eastern Goldfields Superterrane at Norseman and even east of Kalgoorlie at Steeple Hill. In addition, the northern edge of the Yilgarn Craton attracted interest too, with magnetite schists at Beyondie within the Marymia Inlier.

The unprecedented iron ore boom of the past three years continued but at a less frantic pace. The major producers in the Pilbara are still expanding their existing operations and planning new projects, whereas junior companies were still willing to explore in undeveloped and greenfields areas.

Major developments in the iron ore sector include:

- BHP Billiton Ltd's expanded Newman mining hub was officially opened in November 2009 and this will continue to be the centre of its iron ore mining, crushing, and screening activities in the eastern Pilbara region. BHP's Mount Whaleback iron ore operation will now be equipped to mine, crush, and screen the ore onsite, rather than at Port Hedland, before the product is shipped. BHP Billiton has also allocated US\$1.93 billion (A\$2.2 billion) in funding to expand its iron ore operations in the Pilbara. This represents initial expenditure for the Rapid Growth project 6, which is expected to increase capacity at BHP's Western Australian iron ore assets to 240 Mt a year in 2013 (Jacoby, 2009c, 2010b).

- Rio Tinto Ltd will increase the capacity of Cape Lambert port to 180 Mt by 2016 from its current 80 Mtpa rate. This will be achieved through the construction of a new 1.8-km jetty and four-berth wharf that will run parallel to the existing jetty (Winter, 2010; Rio Tinto Ltd, 2010a).
  - Rio Tinto started producing iron ore from the Mesa A/Warrambo mine, near Pannawonica, in February 2010. The mine will have an initial production of 20 Mtpa increasing to 25 Mtpa by 2011 and has reserves totalling 249 Mt of pisolite (CID) ore, giving the project an 11-year mine life (Rio Tinto Ltd, 2010b; Batten, 2010d).
  - Under an agreement with the Western Australian government, BHP Billiton and Rio Tinto will pay higher royalties for all their Pilbara iron ore production from the start of July 2010. This removes some concessionary rates that BHP Billiton and Rio Tinto have enjoyed since the early State Agreement Acts were first negotiated in the 1960s and 1970s, and brings those producers into line with the royalty rates applicable in later State Agreements and the Mining Act 1978. About 40% of the Western Australian production for 2009–10 enjoyed concessionary royalty rates. Royalty rates for these early State Agreement projects will change from 3.75% to 5.625% for fine ore and to 7.5% for lump ore (Jacoby, 2010c).
  - Fortescue Metals Group Ltd's mining operations at Cloudbreak and Christmas Creek, situated about 50 km apart in the Chichester Ranges in the Pilbara region, were progressing satisfactorily. The expansion of the Chichester Hub was in full swing with the commissioning of the Christmas Creek plant scheduled for March quarter 2011 (Fortescue Metals Group Ltd, 2009, 2010a,b).
- Developments in the direct shipping ore (DSO) projects include:
- Atlas Iron Ltd shipped over 1 Mt of iron ore in its maiden year of operations at the Pardoo DSO project, 115 km east of Port Hedland. The ore was shipped through Fortescue Metals Group's Port Hedland port facility (Atlas Iron Ltd, 2009).
  - Atlas Iron has also begun mining at the Wodgina DSO iron ore project, 110 km south of Port Hedland, and is now on target to achieve a combined rate of 6 Mtpa from its Wodgina and Pardoo DSO mines (Atlas Iron Ltd, 2010a,b).
  - Mount Gibson Iron Ltd announced the recommencement of construction and development work at its Extension Hill DSO project, 65 km southwest of Paynes Find. Construction and development is scheduled to be completed by the first half of 2011, incurring \$80 million of capital expenditure. The company has executed life-of-mine sales agreements with each of Shougang Concord International Enterprises Company and APAC Resources for all the production from Extension Hill (Mount Gibson Iron Ltd, 2010).
  - Full-scale mining has begun at the Sinosteel Corporation's Koolanooka – Blue Hills project, 165 km east-southeast of Geraldton, and the first hematite DSO (from Koolanooka) was shipped from Geraldton in mid-2010. Sinosteel plans production of 1 Mt during calendar year 2010, rising to 1.5 Mtpa in 2011, with a seven-year mine life (Miningnews.Net, 2010; Jacoby, 2010d).
  - Gindalbie Metals Ltd finalized a second long-term off-take contract with Ansteel covering the life-of-mine hematite production from the Karara project (95 km south of Yalgoo), which is scheduled to start in mid-2011 at a rate of 3 Mtpa (Gindalbie Metals Ltd, 2010a).
  - At the Spinifex Ridge iron ore project, 50 km northeast of Marble Bar, mining of hematite DSO began with the aim of shipment by December 2010. The deposit is estimated to contain a probable reserve of 4.334 Mt at 59.2% Fe, 1.8% Al<sub>2</sub>O<sub>3</sub>, 8% SiO<sub>2</sub>, 0.13% P, 122 ppm S, with 4.9% LOI, which is derived from an indicated resource of 5.31 Mt at 58.4% Fe, 1.6% Al<sub>2</sub>O<sub>3</sub>, 9.3% SiO<sub>2</sub>, 0.145% P, 122.7 ppm S, with 4.7% LOI. In addition, the deposit has an inferred resource of 2.3 Mt at 57.92% Fe, 0.8% Al<sub>2</sub>O<sub>3</sub>, 13.4% SiO<sub>2</sub>, 0.114% P, 52 ppm S, with 2.8% LOI (Moly Mines Ltd, 2010a).

Developments in the magnetite sector include:

- CITIC Pacific Ltd has begun development activities for production of iron ore from the huge magnetite deposit (greater than 2 billion tonnes (Bt) of resources) of the Sino Iron project at Cape Preston in the Pilbara. The openpit mine is expected to be 5.5 km long,

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3 km wide, and eventually 600 m deep. The project will have the capacity to produce 28 Mtpa of magnetite concentrate for over 25 years. Project construction is estimated to cost about \$5 billion. The infrastructure requirements related to the project are massive and include development of a new port (Cape Preston), power station (450 MW, powered by gas from the Reindeer field), and a desalination plant with a capacity of 51 GL H<sub>2</sub>O per annum. The construction workforce is about 4500 people, whereas the operational workforce will be about 850 people (CITIC Pacific Ltd, 2010a,b).

- Gindalbie Metals announced the finalization of a long-term off-take contract with its joint venture partner, Ansteel, covering the life-of-mine production from the Karara iron ore project, 95 km south of Yalgoo. The contract is valued at more than US\$65 billion, and covers the total magnetite concentrate production from the Karara operations. Stage One production, based on a rate of 8 Mtpa of magnetite concentrate, is scheduled to be commissioned in late 2011. Capital development costs total about \$2 billion (Gindalbie Metals Ltd, 2010b).
- Grange Resources Ltd's Southdown magnetite project near Albany has taken a major step towards construction after the project received conditional environmental approval from the Western Australian Government for the mine and associated infrastructure. The project received another boost after Grange secured a 25% increase in interim pricing for its iron ore pellets and received notification of Commonwealth approval for the Albany port expansion (Jacoby, 2009d; Miningnewspremium.Net, 2010b).
- Crosslands Resources, joint venture owner of Jack Hills project, 140 km west-northwest of Meekatharra, has secured non-binding Letters of Intent from north Asian steel mills to purchase more than 50 Mtpa of magnetite and hematite concentrate products from the Jack Hills Expansion project (Murchison Metals Ltd, 2010a).

A number of companies in Western Australia have either announced maiden resource estimates or upgraded existing resources. Some of these include:

- The resources at Fortescue Metals Group Ltd's Solomon Hub deposits in the Pilbara region increased to 2.8 Bt at 56.3% Fe. This includes

Brockman mineralization at Firetail, CID and colluvial–detrital iron deposits at Kings, and predominately CID deposits at Serenity (Fortescue Metals Group Ltd, 2010b,c).

- The proved and probable ore reserves of the Balla Balla magnetite project, 5 km west of Whim Creek, have grown from 207 Mt to 238 Mt (at 44.7% Fe, 0.62% V<sub>2</sub>O<sub>5</sub>, and 3.7% TiO<sub>2</sub>), with more than 79% being classified in the proved ore reserve category (Aurox Resources Ltd, 2009a).
- The total measured, indicated, and inferred resource at Jack Hills, 140 km west-northwest of Meekatharra, increased to 3 Bt at 31.7% Fe, more than 67% of which is in the measured and indicated categories (Murchison Metals Ltd, 2009).
- The total inferred mineral resource of the Hardstaff Peninsula iron ore deposit on Irvine Island, 135 km north of Derby, has increased to 294 Mt based on updated resource estimates for both the Yampi Member and Wonganin Sandstone. The Yampi Member is estimated to contain an inferred resource of 90 Mt at 46% Fe, 32.4% SiO<sub>2</sub>, 0.68% Al<sub>2</sub>O<sub>3</sub>, 0.12% S, and 0.02% P, whereas the Wonganin Sandstone is estimated to contain an inferred resource of 204 Mt at 23% Fe, 59% SiO<sub>2</sub>, 3.94% Al<sub>2</sub>O<sub>3</sub>, 0.1% S, and 0.03% P (Pluton Resources Ltd, 2010).
- A maiden resource of 143 Mt at 52.6% Fe (55.6% calcined iron) has been estimated for the Winmar iron ore deposit, 35 km west-southwest of Wittenoorn (Cazaly Resources Ltd, 2010).
- Giralia Resources NL announced an upgraded inferred resource of 161.4 Mt at 56.2% Fe, 6.3% SiO<sub>2</sub>, 2.6% Al<sub>2</sub>O<sub>3</sub>, with 9.6% LOI for the McPhee Creek Main Range deposit, 37 km north of Nullagine (Giralia Resources NL, 2009, 2010a).
- A maiden inferred mineral resource of 13.3 Mt at 56% Fe, 7% SiO<sub>2</sub>, 4% Al<sub>2</sub>O<sub>3</sub>, 0.06% P, 0.2% S, 0.13% TiO<sub>2</sub>, with 7% LOI has been estimated for the Jabiru prospect, at the Mount Padbury project, 110 km north-northwest of Meekatharra (Montezuma Mining Company Ltd, 2010a).
- Flinders Mines Ltd has increased its resources at the Pilbara Iron Ore project in the central Pilbara from 550.1 Mt at 55.6% Fe to

658.3 Mt at 55.4% Fe, which consists of an indicated resource of 156.6 Mt at 56.5% Fe and an inferred resource of 501.7 Mt at 55.0% Fe (Flinders Mines Ltd, 2010a).

- A maiden inferred resource of 453 Mt at 23.1% Fe (no cutoff), 37% SiO<sub>2</sub>, 15.8% Al<sub>2</sub>O<sub>3</sub>, 0.04% P, with 8.7% LOI has been estimated for the Spearhole channel iron deposit at Prairie Downs, 50 km west-southwest of Newman (Dynasty Metals Australia Ltd, 2010).
- Midas Resources Ltd reported a maiden indicated resource of 11.5 Mt at 53.1% Fe, 0.042% P, 7.75% SiO<sub>2</sub>, 5.57% Al<sub>2</sub>O<sub>3</sub>, with 9.86% LOI (50% Fe cutoff grade) for its West Pilbara deposit, 110 km west of Tom Price (Midas Resources Ltd, 2010).
- Warwick Resources Ltd estimated a maiden inferred resource of 19.1 Mt at 55.1% Fe, 6.6% SiO<sub>2</sub>, 4.1% Al<sub>2</sub>O<sub>3</sub>, 0.06% P, with 9.3% LOI for the Western Creek iron ore project near Newman. The resource includes a DSO component of 10.8 Mt at 58% Fe (Warwick Resources Ltd, 2009a).
- Golden West Resources Ltd reported an upgraded measured, indicated, and inferred resource of 141.1 Mt 58.77% Fe, 0.06% P, 2.81% Al<sub>2</sub>O<sub>3</sub>, 8.67% SiO<sub>2</sub>, with 3.82% LOI for the Wiluna West hematite project (Golden West Resources Ltd, 2009).
- Atlas Iron Ltd estimated a maiden inferred resource of 20.8 Mt at 57.1% Fe, 6.6% SiO<sub>2</sub>, 2.6% Al<sub>2</sub>O<sub>3</sub>, 0.07% P, 0.03% S, with 8.5% LOI for the Wishbone deposit at the Warrawanda project, 50 km southeast of Newman (Atlas Iron Ltd, 2010c).
- Giralia Resources estimated a maiden inferred resource of 186.8 Mt at 30.9% Fe for the Yerecoin magnetite project, 120 km north-northeast of Perth (Giralia Resources NL, 2010b).
- Iron Ore Holdings Ltd announced a maiden inferred resource of 23.4 Mt at 58.5% Fe for its Fingers deposit at Koodaideri South, 45 km southeast of Wittenoom (Iron Ore Holdings Ltd, 2010).
- Macarthur Minerals Ltd released an initial inferred mineral estimate of 4.4 Mt at 54.2% Fe, 0.067% P, 10.65% SiO<sub>2</sub>, 4.89% Al<sub>2</sub>O<sub>3</sub>, with 7% LOI for its Banjo

and Moonshine North DSO iron ore project located at Lake Giles, about 100 km west-southwest of Menzies (Macarthur Minerals Ltd, 2010).

In addition to the above resource estimates, some of the other iron ore exploration successes include:

- Significant intersections of massive hematite from exploration drilling at the Brindal prospect, 2.5 km south of the main Jack Hills orebody, 140 km west-northwest of Meekatharra. Intersections include 100 m at 67.5% Fe from 62 m in hole MHRC1120, 72 m at 68.5% Fe from 58 m in hole MHRC1043, and 64 m at 68.3% Fe from 50 m in hole MHRC1006 (Murchison Metals Ltd, 2010b).
- Atlas Iron discovered the new DSO prospect, Hercules, at its Wodgina operation, 110 km south of Port Hedland. Drill intersections include 52 m at 59.5% Fe from surface in hole WDRC1446 and 46 m at 59.3% Fe from 2 m in hole WDRC1506. The company has also had significant intersections at Dragon (70 m at 59.7% Fe from surface in hole WDRC1221) and Avro (38 m at 59.9% Fe from 34 m in hole WDRC1451) prospects of the same project (Atlas Iron Ltd, 2010d).
- Warwick Resources Ltd (now part of Atlas Iron) reported significant intersections including 42 m at 60.1% Fe from 44 m depth from step-out drilling at the Wishbone deposit of the Warrawanda project, 50 km southeast of Newman (Warwick Resources Ltd, 2009b).
- Hemisphere Resources Ltd obtained significant intersections including 16 m at 58.2% Fe, 5.08% SiO<sub>2</sub>, 2.96% Al<sub>2</sub>O<sub>3</sub>, 0.06% P, with 7.67% LOI at Yandicoogina South prospect, 6 km south of Rio Tinto's Yandicoogina iron ore mine (Hemisphere Resources Ltd, 2010).
- Hawthorn Resources Ltd reported significant intersections of magnetite mineralization including 70 m at 35.9% Fe from 36 m and 62 m at 38.7% Fe from 28 m at Mount Bevan, 100 km west of Leonora (Hawthorn Resources Ltd, 2010).
- Flinders Mines Ltd announced high-grade intersections outside the current resource boundary at Delta (South Pilbara iron ore project). Intersections include 42 m at 58.8% Fe from 2 m, 24 m at 58.3% Fe from surface, 30 m at 59.2% Fe from 6 m (Flinders Mines Ltd, 2010b).

# Overview

## Nickel

Broad trends for the nickel industry in Western Australia during 2009–10 include:

- The international nickel price in 2009–10 increased (25%) to an average of \$21 984/t from an average of \$17 626/t in 2008–09.
- Recovery of the nickel price led to an increase (by 36%) in the value of nickel production from Western Australia to \$4.1 billion in 2009–10, although the production quantity decreased marginally (<1%) to 177 thousand tonnes (kt) of contained nickel.
- Recovery of the nickel price is leading to the re-opening of a number of nickel sulfide as well as nickel laterite mining operations. However, many of the nickel mines that were put on care and maintenance during the global financial crisis are yet to be re-opened.
- Nickel exploration expenditure in Western Australia decreased by 23% to \$195 million, relative to the previous year (Fig. 8).

Key points in the nickel sulfide sector include:

- Western Areas NL announced the first shipment of nickel concentrate to China from Flying Fox and Spotted Quoll – Tim King Pit mines at Forrestania. Production at Flying Fox began in December 2007 and that from Spotted Quoll – Tim King Pit began in late 2009. During 2009–10, both mines performed beyond expectations (Western Areas NL, 2010a).
- During the 2010 March quarter, the first development ore from the Lounge Lizard nickel deposit was mined. A total of 2295 t at 3.7% Ni was treated through the Cosmic Boy treatment plant and sold to Western Areas (Kagara Ltd, 2010a).
- Mincor Resources NL re-opened the Miitel mine, 40 km south-southwest of Kambalda, and discovered the N10 and N29 orebodies. Mincor has also identified significant new mineralized channels at the South Miitel deposit, the Burnett Zone at the North Miitel deposit, and a new ore shoot ‘Terrace Surface’ at the Mariners mine (about 5 km south of Miitel), immediately south of the newly discovered N10 orebody (Mincor Resources NL, 2009, 2010).
- In July 2009, Independence Group announced a maiden indicated resource of 401 00 t at

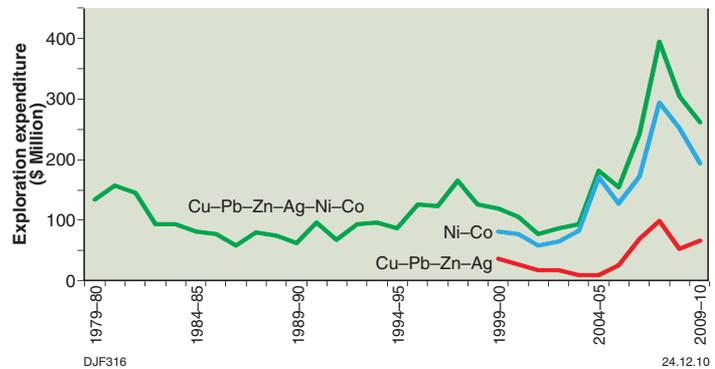


Figure 8. Western Australian nickel, cobalt, and base metal exploration expenditure (2009–10 dollars)

6.9% Ni and an inferred resource of 55 000 t at 8.3% Ni for the Moran deposit. Mine development has begun with first ore mined at a head grade of 4.6% Ni in the June 2010 quarter (Independence Group NL, 2009, 2010b).

- Nickel sulfide, copper, and PGE mineralization has been discovered at Rosie Prospect (2.5 km southwest of the initial Bulge C2 discovery), 120 km north-northwest of Laverton. Intersections include: 41 m at 0.44% Ni, 0.18% Cu, 623 ppb Pt, and 447 ppb Pd from 40 m in hole TBAC126; 60 m at 0.52% Ni, 619 ppm Cu, 102 ppb Pt, and 110 ppb Pd from 36 m in hole TBAC127; and 20 m at 1.32% Ni, 0.23% Cu, 1.54 g/t Pt+Pd from 184 m in hole TBRC070 (South Boulder Mines Ltd, 2009, 2010).
- High nickel, copper, and platinum–palladium values were returned in eight drillholes at the Olympia prospect of the Collurabbie project, about 200 km north of Laverton. Intersections include 2.74 m at 2.03% Ni, 1.06% Cu, 2 g/t Pt+Pd from 218.6 m in hole CLD196; 5.32 m at 1.05% Ni, 0.89% Cu, 1.74g/t Pt+Pd from 226.27 m in hole CLD199; and 3.82 m at 1.74% Ni, 1.05% Cu, 2.37 g/t Pt+Pd from 153.88 m in hole CLD1202 (Falcon Minerals Ltd, 2010).
- The Western Areas and Troy Resources NL joint venture discovered a number of nickel mineralized zones in a greenfields area about 20 km south-southeast of Sandstone. Drilling returned 26.2 m at 0.4% Ni from 60.3 m, including a narrow interval of semi-massive sulfide that analysed 0.2 m at 4.1% Ni from 86.3 m (Western Areas NL, 2010b).
- Western Areas reported an intersection of 88.3 m (true width 20–30 m) 200 m north

and below the New Morning deposit at Forrestania, which consists of several zones of disseminated and localized stringer sulfides separated by bands of granite and footwall sedimentary rocks from 868.4 m. Preliminary Niton (portable XRF analyser) estimates returned spot values up to 2% Ni for the disseminated sulfides and peak values up to 6% Ni and 3% Cu for the stringer sulfides (Western Areas NL, 2010c).

Key points in the nickel laterite sector include:

- First Quantum Minerals plans to re-open the Ravensthorpe operation in the first half of 2011, which was put on care and maintenance by BHP Billiton in January 2009. This will be followed by a nine-month ramp-up to the nominal production capacity of 39 000 tpa nickel (Miningnewspremium.Net, 2010c).
- The total combined resource base of the Kalgoorlie Nickel project of Heron Resources Ltd was updated to a total estimated measured, indicated, and inferred resource of 959 Mt at 0.74% Ni and 0.045% Co (7.1 Mt of contained nickel metal, 0.43 Mt of contained cobalt metal). Heron is currently identifying potential partners (Heron Resources Ltd, 2009, 2010).
- Metals X Ltd is reviewing funding options and opportunities for the development of the Wingellina project, which is one of the largest undeveloped nickeliferous limonite accumulations in the world. The deposit is estimated to contain a total measured, indicated, and inferred resource of 183.2 Mt at 0.98% Ni and 0.08% Co (Metals X Ltd, 2008, 2010).
- Norilsk's Cawse nickel laterite operation, 50 km northwest of Kalgoorlie, which was put on care and maintenance during the global financial crisis, is yet to be re-opened.

### Base metals (copper–lead–zinc–silver)

Broad trends in the base metal sector in Western Australia during 2009–10 include:

- Copper–lead–zinc–silver exploration expenditure in the State increased by 25% from \$54 million in 2008–09 to \$67 million in 2009–10 (Fig. 8, 2009–10 dollars).
- There were significant increases in base metal prices in 2009–10 compared to 2008–09,

with copper, lead, and zinc increasing by 18% (to \$7568/t), 23% (to \$2371/t), and 26% (to \$2340/t) respectively.

- Copper production in the State in 2009–10 increased by 17% (from 127 328 t in 2008–09 to 148 553 t in 2009–10). The value increased by 74% to \$1137 million. The increased copper production was due to increased output from the major producers — Nifty and Telfer mines (in the Paterson Orogen) and Golden Grove (Yilgarn Craton). The new Boddington gold–copper mine (Yilgarn Craton) also had significant production, with more than 15 000 t of copper contained in concentrates.
- Lead production in the State marginally increased (3%), from 25 203 t in 2008–09 to 25 918 t in 2009–10. The Magellan lead mine that was put on care and maintenance in April 2007 re-started in early 2010. The only other producing lead mine was Golden Grove. The value of lead production from Western Australia increased by 41% to \$59 million.
- Zinc production in the State decreased by 40% (from 142 062 t in 2008–09 to 85 532 t in 2009–10) and the value of production decreased by 12% to \$202 million. The production decrease was due to the closure of the Pillara mine and to decreased zinc production at Golden Grove.

Sandfire Resources NL continued to have exploration successes at its Paleoproterozoic volcanogenic massive sulfide (VMS-style) Doolgunna copper–gold project, 60 km east of Peak Hill. The discovery of DeGrussa, Conductor 1, and other deposits in the Doolgunna project in mid-2009, is the best base metal discovery in Western Australia in recent times. In early 2010, Sandfire published maiden resources for the DeGrussa and Conductor 1 deposits, which were then updated in July 2010 along with a maiden resource for the Conductor 4 deposit. As at July 2010, the total indicated and inferred resources of all these deposits are estimated at 9.62 Mt at 5.5% Cu, 1.8 g/t Au, and 14 g/t Ag for 533 000 t of contained copper, 559 000 oz of contained gold, and 4.3 Moz of contained silver. The company has also discovered Conductor 5 (Sandfire Resources NL, 2010a,b).

Other key points for base metal projects in Western Australia include:

- Ivernia Inc. re-commenced lead mining at Magellan and expects to produce 60 000 t

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contained lead in concentrate in 2010.

From 2011 onwards, the company plans to process 1.9 Mtpa of ore producing on average approximately 85 000 tpa of contained lead in concentrate (Ivornia Inc., 2010).

- The Boddington gold–copper operation, which began production in December 2009, was performing well. The production of copper and gold until the end of June 2010 amounted to 15 768 t and 464 000 ozs respectively (Newmont Mining Corporation, 2010a,b,c).
- In December 2009, Venturex Resources Ltd announced a maiden resource for the Evelyn deposit of the Liberty–Indee base metals project, 30 km south of Whim Creek. The total indicated and inferred resource was estimated at 708 000 t at 1.9% Cu, 3.6% Zn, 0.35 g/t Ag and 0.8 g/t Au (Venturex Resources Ltd, 2009).
- In late 2009 Fox Resources Ltd announced plans to return to nickel and copper production at Radio Hill, 35 km south of Karratha. The company is currently developing a base metals heap-leaching operation with the aim of establishing an initial five-year mine life, with commissioning expected in early 2011 (Fox Resources Ltd, 2010a).
- Fox Resources also announced a positive preliminary economic evaluation of its Sholl B2 deposit, 6 km north of Radio Hill in the Pilbara. Sholl B2 is a key contributor to Fox's developing heap-leach operation. The new evaluation highlighted a potential mine life of 10 years at Sholl B2 and Radio Hill (Fox Resources Ltd, 2010b).
- A scoping study by CBH Resources Ltd of the Panorama project in the Pilbara shows that it is possible to have an economically viable underground operation producing total contained metals of 185 000 t zinc, 70 000 t copper, and 880 000 oz silver during an initial mine life of around seven years (CBH Resources Ltd, 2009).
- Minerals and Metals Group (MMG) has plans to develop an openpit at its existing underground mining operations at Golden Grove. The openpit is expected to produce around 240 000 t of copper concentrate containing 59 000 t of contained copper metal in concentrate from 2011–14 (Jacoby, 2010e).
- Jabiru Metals Ltd approved the development of the Bentley mine, 48 km north-northwest

of Leonora. The VMS deposit is estimated to contain a total indicated and inferred resource of 1.698 Mt at 1.9% Cu, 12% Zn, 0.8% Pb, 0.8 g/t Au, and 148 g/t Ag. The first ore is expected to be produced in late 2011 (Jabiru Metals Ltd, 2009, 2010).

- Silver Swan Group Ltd reported a maiden total measured, indicated, and inferred resource of 1.484 Mt at 1.02% Cu, 1.39% Zn, 0.24 g/t Au, and 3.51 g/t Ag for the VMS Quinns–Austin deposit, 60 km south-southwest of Meekatharra. Further significant intersections, such as 58 m at 2.0% Cu, 0.42 g/t Au, and 8.6 g/t Ag from 148 m, have been reported since the maiden resource announcement (Silver Swan Group Ltd, 2010a,b).
- Meridian Minerals Ltd has updated the total measured, indicated, and inferred resource of the Lennard Shelf project to 13.2 Mt at 6.3% Zn and 3.8% Pb. The deposits include Kapok, Cadjebut, Palijippa, Kultarta, Fossil Downs, and Napier Range. The viability of recommencing mining at Kapok is being examined (Meridian Minerals Ltd, 2010).
- Kagara Ltd completed a pre-feasibility study for its Admiral Bay project in the Canning Basin and has confirmed that it is a world-class project, with the potential to become one of the largest producers of lead and zinc in the world. The company is now planning a bankable feasibility study estimated to cost \$184.5 million that will include sinking an exploration shaft to 1428 m to drill a 1.2 km section of the deposit to reserve status. The Admiral Bay deposit has an inferred resource of 72 Mt at 3.1% Zn, 2.9% Pb, and 18 g/t Ag (Kagara Ltd, 2008, 2010b).
- Ethan Minerals Ltd has estimated a total indicated and inferred resource of 394 419 t at 6.5% Pb for the Mary Springs deposit (50 km east of Kalbarri) in the Northampton Complex (Ethan Minerals Ltd, 2010).

Other highlights in the base metals exploration sector include:

- The first hole in the infill program at Mons Cupri pit intersected 53 m at 1.7% Cu and 23.2 g/t Ag from 40 m in hole MCR001, and the vertical diamond hole MCD001 intersected 39.4 m at 2.8% Cu and 1.61 g/t Au from 33 m, including an upper zone of 18 m at 5.0% Cu and 3.39 g/t Au. The mineralized

intersection confirms continuity of a high-grade copper–gold zone in the upper part of the Mons Cupri VMS system (Venturex Resources Ltd, 2010a,b).

- At Salt Creek VMS deposit, 17 km northwest of Whim Creek, high-grade lenses of massive sulfide were intersected, including 20 m at 16.8% Zn, 6.9% Pb, and 180 g/t Ag. In the eastern massive sulfide lens, diamond hole SCD005 intersected 3.45 m at 49.2% Zn, 7.1% Pb, 327 g/t Ag, and 4.1 g/t Au from 107.95 m and diamond hole SCD009 intersected 4.75 m at 47.8% Zn, 8.7% Pb, 294 g/t Ag, and 0.9 g/t Au from 72.4 m (Venturex Resources Ltd, 2010c,d).
- Ashburton Minerals Ltd reported encouraging wide copper intersections in a remote greenfields area at Pokali prospect of the Mount Webb project, in the Arunta Orogen. These include 246 m at 0.22% Cu from 4 m (including 12 m at 1.1% Cu from 168 m) and 299 m at 0.10% Cu from surface. The mineralization is thought to be of iron oxide–copper–gold (IOCG) type (Ashburton Minerals Ltd, 2010).
- Drilling by Redstone Resources Ltd at Tollu, in another remote greenfields area in the Musgrave Province, has returned impressive copper intersections. These include 17 m at 2.2% Cu from 145 m and 14 m at 3.5% Cu from 126 m. The mineralization is interpreted to be related to a large nickel–copper sulfide system (Redstone Resources Ltd, 2010a,b).
- Thundelarra Exploration Ltd reported impressive copper intersections at the Red Bore prospect, 2 km east of the DeGrussa deposit, in the Bryah Basin. These include 7 m at 7.25% Cu from 20 m. In addition, analysis of drill cuttings with a hand-held XRF analyser produced significant intercepts including 18 m at 8.37% Cu from 29 m. The VMS mineralization is associated with mafic volcanoclastic rocks of the Narracoota Formation (Thundelarra Exploration Ltd, 2010).
- Drilling by Anglo Australian Resources NL at the VMS Sandiego deposit of the Koongie Park project, 25 km southwest of Halls Creek, continued to produce spectacular copper–zinc–silver–gold intersections including 71 m at 5.04% Cu, 7.69% Zn, 68 g/t Ag, and 0.43 g/t Au and 56 m at 3.7% Cu, 9.26% Zn,

33 g/t Ag, and 0.49 g/t Au (Anglo Australian Resources NL, 2010b).

- RC drilling by Jindalee Resources Ltd at Bow River, 80 km south of Kununurra, yielded encouraging copper intersections including 2 m at 1.4% Cu from 108 m, 5 m at 1.3% Cu from 123 m, and 2 m at 1.9% Cu from 126 m (all in hole BRRC011), as well as 3.8% Cu from 81 m and 1 m at 1.2% Ni from 88 m in hole BRRC012 (Jindalee Resources Ltd, 2010).
- Rock-chip sampling at the Speewah project, about 85 km south-southwest of Wyndham, returned significant assays of copper, gold, silver, and lead. These include 16.5% Cu and 138 g/t Ag at the Eiffler prospect and 8.26% Cu, 4.28 g/t Au, 786 g/t Ag, and 1.25% Pb at the Grey's Vein prospect. The mineralization at Eiffler prospect is associated with malachite-rich, strongly sheared and altered wall rock quartz vein and that of Grey's Vein prospect is associated with quartz veins containing azurite, malachite, galena, and sphalerite (NiPlats Australia Ltd, 2010a).

## Diamond

Diamond production (more correctly sales production rather than mine production) in Western Australia in 2009–10 increased to 16.3 Mct (million carats), which is a significant increase of 77% compared to the 2008–09 production (global financial crisis low) of 9.2 Mct. However, the large increase in weight of production only led to a smaller increase in value of diamond sales, which rose by only 16% to \$304 million, as a result of only a slow recovery in unit prices. A considerable portion of these sales were from stock as mine production totalled only about 11.1 Mct, with mine production at both Argyle and Ellendale falling during 2009–10 (see below).

The diamond exploration expenditure for Western Australia in 2009–10 was not released by the Australian Bureau of Statistics (ABS), but is estimated by us at about \$4 million. This represents a fall of about 20% (\$1 million) from the estimated \$5 million spent in 2008–09 (Fig. 9, in 2009–10 dollars). Diamond exploration expenditure is now less than 1% (Fig. 4) of the total Western Australian mineral exploration expenditure. This is the eighth year in a row that diamond expenditure in Western Australia has declined (now at its lowest level in 30 years), reflecting the general lack of exploration success and hence investor interest

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and the now more-cautious spending behaviour of consumers, with the luxury markets hard hit by the global financial crisis.

Rio Tinto owns and operates the Argyle diamond mine in Western Australia. Mine production for 2009–10 decreased to 10.91 Mct from the 14.72 Mct produced in 2008–09. Production at Argyle during 2009–10 has been low due to the global financial crisis in 2009 that severely affected demand for rough diamonds — which is highly reliant on the US economy. This led Rio Tinto to slow down the transition to underground mining at Argyle and also to suspend the surface operations for 12 weeks. First production from the underground operation is now expected in 2012. However, Rio Tinto is of the view that the medium- to long-term fundamentals for the diamond industry are positive with an anticipated material supply shortfall that will drive future price growth (Rio Tinto Ltd, 2010b,c,d,e).

Gem Diamonds Ltd, a global diamond company, acquired the Australian-listed Kimberley Diamonds in December 2007. Kimberley owned the Ellendale mine, 135 km east-southeast of Derby. The mine production of diamond from Ellendale in 2009–10 decreased by 56% to 194 274 carats compared to the 2008–09 production of 442 651 carats. There was a significant reduction in the scale of operations due to the placing of the E4 operation on care and maintenance. In addition, the plant availability and rain hampered plant throughput from March to June 2010. In the latter part of 2009, Kimberley Diamonds formalized an existing supply arrangement with Laurelton Diamonds Inc. (the diamond sourcing and polishing subsidiary of Tiffany & Co.) for the supply and sale of its yellow diamond production from the Ellendale mine. Effective from December 2009, the agreement will run for the economic life of the Ellendale mine (Gem Diamonds Ltd, 2010a,b).

In September 2009, Blina Diamonds NL discontinued mining activities at Ellendale 9 until diamond prices improve (Blina Diamonds NL, 2009).

## Heavy minerals (Ti–Zr and garnet)

The production of heavy mineral sands (garnet, ilmenite, rutile, leucoxene, and zircon) in Western Australia in 2009–10 decreased by 10% to 981 278 t, with the value decreasing by 23% to \$342 million.

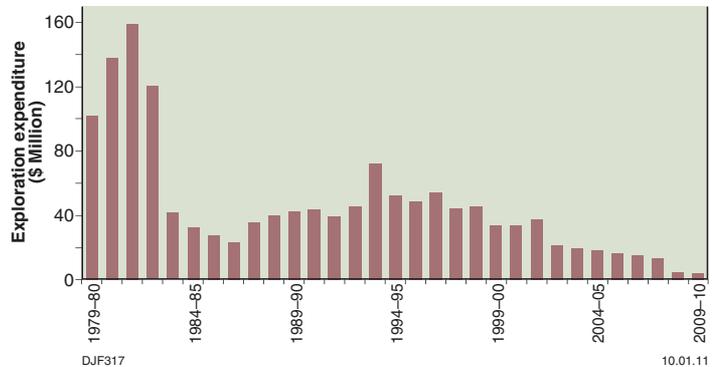


Figure 9. Western Australian diamond exploration expenditure (2009–10 dollars)

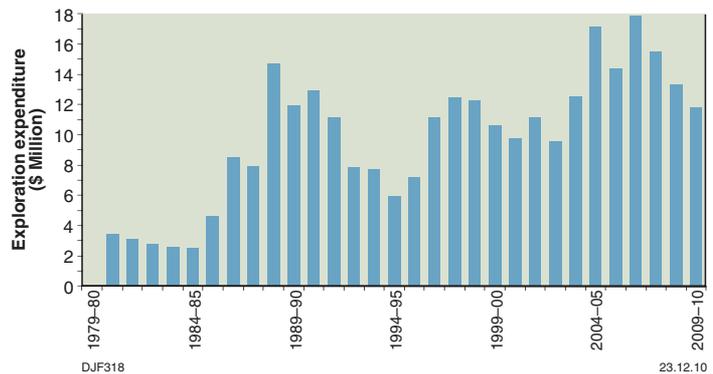


Figure 10. Western Australian heavy mineral sands (Ti–Zr) exploration expenditure (2009–10 dollars)

In 2009–10, exploration expenditure in Western Australia for heavy minerals decreased by 11% to \$12 million (Fig. 10). With the switch in exploration focus to the eastern Eucla Basin and the Murray Basin in Australia’s eastern states in the mid-1990s, Western Australia’s share of Australian exploration expenditure for heavy minerals fell from nearly 69% of the total in the mid-1990s to only 29% in 2002–03. There was a noticeable recovery in Western Australia’s share in 2008–09 to 42.5% with a marginal decrease in 2009–10 to 41.7%.

In early 2010, Iluka Resources Ltd, the market leader of the heavy mineral sands industry in Western Australia, confirmed its decision to shut its remaining Mid West mining operations in June 2010 and replace them with production from the Jacinth–Ambrosia mine in South Australia. The Narngulu mineral separation plant, near Geraldton in Western Australia, is being upgraded to enable it to receive and process heavy mineral concentrate (HMC) from South Australia. In the South West of Western Australia, Iluka’s mining operations ceased at Waroona in late 2009 and the North Capel Separation Mill and Capel Dry Plant are now idle pending the commencement of mining at the

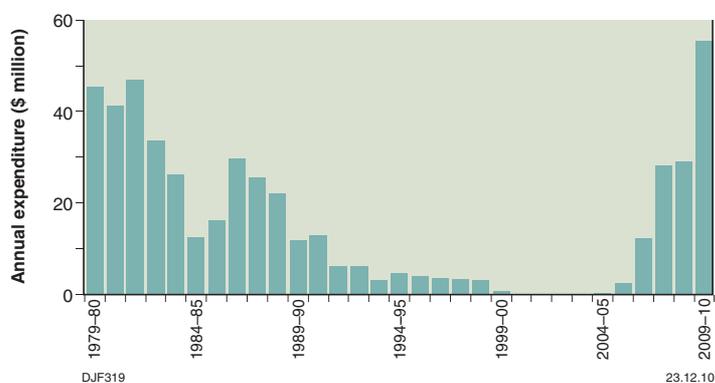


Figure 11. Uranium exploration expenditure in Western Australia since 1979–80 (2009–10 dollars)

Tutunup South project in 2010 (Iluka Resources Ltd, 2009, 2010a,b).

Other highlights in 2009–10 in the heavy minerals sector include:

- Image Resources NL has estimated an initial resource of 148 Mt at 1.5% heavy minerals (HM) (0.75% HM cut-off), containing 445 kt of zircon and 189 kt of rutile and leucosene for the Cyclone Extended deposit of the Serpentine Lake project in the Eucla Basin. The Cyclone and Cyclone Extended deposits have low clay (slimes) contents making them amenable to low-cost conventional mineral sands mining techniques. Combined with the contiguous Cyclone deposit held by Diatreme Resources Ltd, Image estimated a global resource containing 2434 kt of zircon and 990 kt of rutile and leucosene, with a 0.75% HM cutoff (Image Resources NL, 2010a).
- Diatreme Resources has signed a Memorandum of Understanding with BaoTi Group Ltd, based in Shaanxi Province, Central China, for potential development of the Cyclone deposit (Diatreme Resources Ltd, 2010).
- Image Resources is also actively exploring for HM in the North Perth Basin and currently has identified a total inferred resource of 6.4 Mt of HM. The company has also discovered a 16 km-long high-grade HM target zone at Gingin and aircore drilling within this zone has produced significant HM intersections (Image Resources NL, 2009, 2010b).
- Gunson Resources Ltd announced that several parties have expressed interest in a partnership for the Coburn zircon project, 230 km north

of Geraldton. A definitive feasibility study on the project suggested positive economics and a potential mine life of more than 20 years (Gunson Resources Ltd, 2010a,b).

## Uranium

The pro-uranium policy of the State Government continues to have a positive effect on the exploration expenditure for uranium in the State. Expenditure that had been negligible in the period from 2001 to 2006, increased by a further 91% to \$55 million in 2009–10 and there have now been five years of successive increases in uranium exploration expenditure (Fig. 11). The expenditure now is at a level not experienced since at least 1979–80, that is, since the ABS started compiling commodity-specific exploration expenditure statistics.

Highlights in 2009–10 in the uranium sector include:

- BHP Billiton released a Public Environmental Scoping Document in early 2010 on the proposed Yeelirrie uranium mine and a pre-feasibility study is in progress. The scoping document outlined a planned mine life of 30+ years producing 3500 tpa of  $U_3O_8$  concentrate. About 5 Mtpa of ore and waste would be mined by conventional openpit methods, and alkaline tank leaching was preferred over heap leach. Construction may commence in 2013, with construction and operational workforces of about 650 and 300 people, respectively. Vanadium may not be recovered. The work currently underway includes resource definition drilling, test work, process-plant concept design, environmental impact assessment, capital and operating costing, and economic evaluation. The indicated resource estimated for the deposit is old, dating back to at least 2001 when WMC Ltd owned the deposit, and is 35 Mt at 1.5 kg/t  $U_3O_8$  for 52.5 kt of contained  $U_3O_8$ . However, BHP Billiton's proposed production is far in excess of the old resource estimate; a new resource estimate is imminent (WMC Ltd, 2002; BHP Billiton Ltd, 2010).
- A bankable feasibility study for Toro Energy Ltd's Lake Way project near Wiluna is underway and the company plans project commissioning and production of uranium by 2013. The project has estimated measured, indicated, and inferred resources totalling

# Overview

20.21 Mt at 548 ppm  $U_3O_8$  for 11.0 kt of contained  $U_3O_8$  (Toro Energy Ltd, 2010a).

- Cameco Corporation plans to negotiate an agreement with the Martu people (the native land title holders for the Kintyre mine area) for the development of the Kintyre mine, 75 km south-southwest of Telfer. The company also plans to complete drilling and prepare a fresh resource estimate for the Kintyre deposit, conduct metallurgical testing to define the milling process, and begin a prefeasibility study. The historical indicated and inferred resource estimate (CRA brochure in 1990) totalled 23.3 Mt at 1.5 kg/t  $U_3O_8$  for 35 kt of contained  $U_3O_8$  (Cameco Corporation, 2010).
- A scoping study for the recovery of uranium from lignite- and sandstone-hosted material at the Mulga Rock deposits has yielded positive results. The test work demonstrated that reasonably high uranium extraction rates can be achieved using conventional commercially proven processing methods. The Mulga Rock deposits are estimated to contain 55.4 Mt at 0.49 kg/t  $U_3O_8$  for 27.1 kt of contained  $U_3O_8$  (Energy and Minerals Australia Ltd, 2010a,b).
- Mega Uranium Ltd released the Environmental Scoping Document for the Lake Maitland uranium project (95 km north-northeast of Leinster) for public review. The project has an anticipated mine life of 10 years, producing up to 1000 tpa of uranium peroxide concentrate. The deposit is estimated to contain a total indicated and inferred resource of 31.2 Mt at 0.37 kg/t  $U_3O_8$  for 11.4 kt of contained  $U_3O_8$  (Mega Uranium Ltd, 2009, 2010).
- Energia Minerals Ltd announced a maiden inferred resource estimate of 12.2 Mt at 280 ppm  $U_3O_8$  for 3.4 kt (7.46 Mlb) of contained  $U_3O_8$  for the Carley Bore deposit, within the Nyang uranium project, 174 km north of Gascoyne Junction. The mineralization is interpreted to be roll-front type associated with sandstone (Energia Minerals Ltd, 2010).

Highlights for greenfields exploration include:

- Scout drilling by Mindax Ltd along paleochannels on the Yilgarn Craton near Mukinbudin, 200 km northeast of Perth, has intersected economic grades of roll-front type uranium mineralization. The significant intercepts in the Jindarra area include 1 m at 1690 ppm U (equivalent to 0.20%  $U_3O_8$ ) from 37 m in hole YAA0184 and 3 m at

1243 ppm U (equivalent to 0.15%  $U_3O_8$ ) from 38 m in hole YAA0188. The Jindarra target area is approximately 2 km long and up to 300 m wide and contains consistent uranium mineralization in two horizons at 35 m and 60 m depths (Mindax Ltd, 2009, 2010).

- Toro Energy Ltd discovered uranium mineralization at the remote Theseus prospect of the Lake Mackay project in the Arunta Orogen. The drilling intersections include 6 m at 216 ppm  $U_3O_8$  and 2 m at 646 ppm  $U_3O_8$  (Toro Energy Ltd, 2010b).
- In the Tanami region (stretching 100 to 250 km southeast of Halls Creek) exploration is increasing at and near some old prospects known from the early 1970s. Prospects include Killi Killi, Gardiner Range, and Birrindudu. These occur at or near the unconformity between the basal Paleoproterozoic Granites–Tanami Complex and overlying flat-lying sandstones of the Mesoproterozoic Birrindudu Basin. Companies exploring these targets include Toro Energy in joint venture with Cameco Corporation, Orion Metals Ltd, Northern Uranium Ltd, Manhattan Corporation Ltd, and Quantum Resources Ltd.
- In the East Kimberley region:
  - U3O8 Ltd explored for uranium and rare earths at Mad Gap, about 70 km northwest of Halls Creek, where the basal Brown Sandstone unit of the O'Donnell Formation unconformably overlies older metamorphic rocks and the Whitewater Volcanics.
  - Kimberley Mining Pty Ltd and Pegasus Metals Ltd are exploring for uranium and gold–tin–tantalite–tungsten–molybdenum mineralization associated with skarn, pegmatite, and radioactive granite of the eastern zone of the Lamboo Complex, about 80 km southwest of Halls Creek.

## Other commodities

Exploration expenditure for other mineral commodities in Western Australia in 2009–10 has decreased by 11% to \$65 million. 'Other commodities' include all industrial minerals, alumina, construction materials, platinum group elements (PGE), molybdenum, tantalum, lithium, manganese, chromium, vanadium, rare earth elements (REE), and coal–lignite. Activities

during 2009–10 were mainly focused on rare earth elements, molybdenum, vanadium, manganese, tungsten, lithium, and coal.

#### Rare earth elements

In the REE sector, construction work on the concentration plant and tailings storage facility at the Mount Weld rare earth project, 18 km southeast of Laverton, recommenced in April 2010 and the first ore feed is expected in late 2010. Phase 1 of the project will produce approximately 11 000 tpa of rare earth oxide (REO), with plans to increase the capacity to approximately 22 000 tpa of REO by 2013. The Central Lanthanide Deposit sector of the Mount Weld project is estimated to contain a total measured, indicated, and inferred resource of 12.24 Mt at 9.7% REO for 1184 kt of REO (Lynas Corporation Ltd, 2010a,b).

#### Molybdenum

Moly Mines Ltd announced a US\$700 million (A\$780 million) debt and equity funding deal with Hanlong Mining Investment, a subsidiary of China-based Sinchuan Hanlong Group Co., for the Spinifex Ridge molybdenum–copper project, 50 km northeast of Marble Bar. Discussions are still continuing and there is a possibility that the project will start soon. The deposit is estimated to contain proven and probable reserves of 450.8 Mt at 0.05% Mo, 0.08% Cu, and 1.3 g/t Ag for contained metal values of 218 000 t of molybdenum, 368 000 t of copper, and 18.6 Moz of Ag (Moly Mines Ltd, 2009, 2010b).

#### Vanadium

In the vanadium sector, a number of companies' plans to develop projects were deeply affected by the global financial crisis in late 2008 and early 2009. The main highlight for the year was the ongoing successful exploration at Speewah in the Kimberley, with its huge increase in estimated resources. The Speewah mineralization is now Western Australia's largest vanadium resource, and within Australia it is second only to the Julia Creek vanadiferous oil shale in Queensland. The main activities in the vanadium sector were:

- NiPlats has estimated a measured, indicated, and inferred resource of 3.16 billion tonnes grading 0.3% V<sub>2</sub>O<sub>5</sub>, 2% Ti, and 14.8% Fe for its Speewah vanadium deposit, about 85 km south-southwest of Wyndham, confirming it

as Australia's largest hard-rock vanadiferous titanomagnetite deposit. The company is carrying out metallurgical and feasibility studies for a potential openpit with downstream processing of the vanadium into vanadium pentoxide and ferrovanadium (NiPlats Australia Ltd, 2010b).

- In April 2010, Atlantic Ltd agreed to acquire the Windimurra vanadium project, 75 km east-southeast of Mount Magnet. Atlantic will procure a full funding package for completion and commissioning of the project and will raise up to \$55.6 million. The Windimurra deposit is estimated to contain measured, indicated, and inferred resources totalling 177 Mt at 0.46% V<sub>2</sub>O<sub>5</sub> (Windimurra Vanadium Ltd, 2009; Atlantic Ltd, 2010).
- In 2009, Reed Resources completed a definitive feasibility study aimed at establishing a vanadium mine at Barrambie, 65 km north of Sandstone. The company is continuing to investigate various project development alternatives and strategies. The deposit is estimated to contain indicated and inferred resources totalling 65.2 Mt at 0.82% V<sub>2</sub>O<sub>5</sub>. Based on the existing resources, the Barrambie vanadium processing plant and associated infrastructure will target a throughput of 3.2 Mtpa of vanadium-bearing magnetite at a grade of 0.82% V<sub>2</sub>O<sub>5</sub> to produce 7700 tpa of ferrovanadium for a minimum period of 12 years (Reed Resources Ltd, 2009, 2010b).
- Investigations by Aurox Resources Ltd show that 7000 t of ferrovanadium could be produced annually from 1.75 Mtpa of titanomagnetite feed at the Balla Balla ferrovanadium project, 10 km northwest of Whim Creek. The ferrovanadium plant could also produce 1 Mtpa of iron concentrate as a byproduct with grades over 61% Fe, which would be suited for blending with the iron concentrate produced from the proposed Balla Balla 10 Mtpa iron concentrate operation. Aurox Resources has now merged with Atlas Iron (Aurox Resources Ltd, 2009b, 2010).

#### Manganese

Manganese production from Western Australia (i.e. mostly from Woodie Woodie) fell sharply during the global financial crisis, but bounced back during 2009–10, increasing by 66% in quantity to 693 392 t of manganese concentrate and by 55% in value to \$350 million.

# Overview

In the manganese sector there have been numerous exploration activities in diverse geological terranes, such as the Archean Pilbara and Yilgarn Cratons, the Proterozoic Manganese Group, and a number of Proterozoic Basins such as Edmund, Earraheedy, Collier, and Bryah. The main developments in the manganese sector were:

- Consolidated Minerals Ltd, the owner of Western Australia's largest manganese mine, plans to spend \$40 million on the Woodie Woodie project in the Pilbara Craton, 105 km west of Telfer, because of increasing demand and higher prices for manganese (Consolidated Minerals Ltd, 2010).
- Mesa Minerals Ltd has received positive feedback from Chinese customers on the trial shipments of 42 009 t of high-grade manganese ore despatched from the Ant Hill mine in the Pilbara Craton, 400 km south of Port Hedland. The ore apparently exhibited excellent handling characteristics and good smelting performance. Mesa Minerals is ready to re-open the mine once final approvals are granted and joint venture issues are resolved. The mine has a total indicated and inferred resource of 4.9 Mt at 20.3% Mn, 25.4% Fe, and 19.8% SiO<sub>2</sub> (Mesa Minerals Ltd, 2010a,b).
- Jupiter Mines Ltd reported encouraging manganese intersections up to 49.6% Mn from its drilling in the Oakover area of the Manganese Group, about 100 km east of Newman (Jupiter Mines Ltd, 2010).
- Also from the Oakover area, 95 km east of Newman, Brumby Resources Ltd reported significant intersections from a number of prospects. At Sixty Six prospect there were intersections up to 27.75% Mn and at JI prospect up to 20.8% Mn. The company also reported nodular manganese intersections within a buried paleochannel at Ethel Creek, 80 km east of Newman (Brumby Resources Ltd, 2010a,b).
- Drilling by Shaw River Resources Ltd at the Baramine project, 80 km northwest of Woodie Woodie, led to identification of more manganese mineralization in Areas 1, 3, 4, and 5. Intersections include 6 m at 14% Mn from 16 m in Area 1, 5 m at 18.2% Mn from 48 m in Area 3, 8 m at 13% Mn from 36 m in Area 4, and 11 m at 10.6% Mn from one metre in Area 5. Mineralization is similar to that at Woodie Woodie, where manganese is hosted in Archean Carawine Dolomite and the Pinjian Chert Breccia (Shaw River Resources Ltd, 2010a).
- At Wandanya, 40 km southwest of Woodie Woodie, rock chips assaying up to 65% Mn have been found in northeast-trending outcrops. The geological sequence present at Wandanya is also considered to be similar to that at Woodie Woodie, with the Pinjian Chert Breccia and Carawine Dolomite present (Shaw River Resources Ltd, 2010b,c).
- Shaw River Resources has confirmed the presence of extensive manganese-rich laterite at 701 Mile project, 80 km south of Newman. The laterite lies alongside outcropping manganese-rich shales, with samples assaying up to 48.6% Mn. The company proposes to outline shallow free-dig manganese gravel suitable for simple beneficiation (Shaw River Resources Ltd, 2010b,c).
- Aurora Minerals Ltd continued to get high-grade manganese from its Capricorn Southeast project in the Edmund Basin. Rock-chip samples collected from various prospects had assays up to 59.1% Mn. The mineralization is associated with paleochannels at the base of the laterite and is also hosted by the Proterozoic Ullawarra Formation (Aurora Minerals Ltd, 2009a,b).
- Zinc Co. Australia Ltd reported assays up to 47% Mn from rock-chip sampling at the Lockeridge manganese prospect, 125 km north-northeast of Wiluna, in the Earraheedy Basin. The mineralization is hosted by the Karri Kari Member, a shale unit stratigraphically overlying the Frere Formation, both part of the Paleoproterozoic Earraheedy Group (Zinc Co. Australia Ltd, 2010a,b).
- General Mining Corporation Ltd reported assays up to 48.4% Mn from rock-chip sampling near the Shoemaker project area, 105 km northeast of Wiluna, also in the Earraheedy Basin. The sampling was in the Proterozoic Frere Formation (General Mining Corporation Ltd, 2010).
- An airborne reconnaissance sampling program by Shaw River Resources over a large area, some 200 to 300 km southeast of Onslow, has identified manganese-bearing horizons within the Proterozoic Ullawarra Formation. A peak assay of 33.8% Mn was returned from manganese-rich shales and siltstones, which were

traced for more than 33 km of strike length (Shaw River Resources Ltd, 2010b).

- Montezuma Mining Company Ltd has identified manganese mineralization in a number of prospects at the Butcherbird project in the Collier Basin, 120 km south of Newman. The company considers Bindi Bindi Hill prospect of this project to be a significant discovery with a potential target of 10 to 20 Mt at between 8 and 12% Mn, where manganese appears to occur as high-grade lump. At the Bilby Hill prospect, rock-chip sampling indicates a new target area with samples assaying up to 45% Mn. Manganese mineralization in these prospects is associated with supergene weathering processes (Montezuma Mining Company Ltd, 2010b).
- A preliminary reconnaissance drill program at Horseshoe in the Bryah Basin had an intersection of 15 m at 32.15% Mn including 7 m at 47% Mn. The drilling has demonstrated the continuity of high-grade manganese and iron outcropping over a 4-km strike, and limited drilling has intersected significant widths of high-grade manganese under cover (Montezuma Mining Company Ltd, 2010c).
- In the Earraheedy Basin, samples from two sites in the Stanley project (170 km east of Wiluna), returned assays ranging from 23% Mn to 48% Mn. The samples are approximately 20 km apart, and in both localities samples are approximately 500 m up-dip from historical drill sites, which had reported intersections up to 4% Mn at shallow depths from 10-m composite samples. Mineralization is in thick carbonate units stratigraphically above the iron formations that occur near the base of the Proterozoic Frere Formation (AusQuest Ltd, 2010).
- Assay results of drill samples from the Wolfe project, 50 km southeast of Halls Creek, had anomalous manganese concentrations in 12 holes, with a best result of 3 m at 18.3% Mn. Average manganese values for the remaining 11 holes varied between 1% and 4% Mn. Mineralization is at the lower contact of the Proterozoic Eliot Range Dolomite and the underlying Proterozoic Mount Kinahan Sandstone (AusQuest Ltd, 2010).

### Tungsten

Western Australia does not currently have any operating tungsten mines, but Hazelwood Resources Ltd moved a step closer to mining when it completed a pre-feasibility for the Big Hill deposit, 45 km northeast of Nullagine, and started a definitive bankable feasibility study. The deposit has measured, indicated, and inferred resources totalling 47.43 Mt at 0.1% WO<sub>3</sub> for 4.8 million metric tonne units. Of this 25.21 Mt at 0.11% WO<sub>3</sub> (for 2.8 million metric tonne units) are proven and probable reserves, which could support a 12-year operation. The deposit is apparently suited to low-cost openpit mining and gravity separation to recover high-purity tungsten concentrate (Hazelwood Resources Ltd, 2010a,b).

At the O'Callaghans polymetallic skarn deposit, 10 km south-southeast of Telfer, Newcrest Mining Ltd announced a total indicated and inferred resource of 78 Mt at 0.33% WO<sub>3</sub>, 0.29% Cu, 0.50% Zn, and 0.25% Pb for contained metal values of 260 kt of WO<sub>3</sub>, 220 kt of Cu, 390 kt of Zn, and 190 kt of Pb (Newcrest Mining Ltd, 2010).

### Lithium

Galaxy Resources Ltd has commenced extracting ore from the Dowling pit, part of the Mount Cattlin spodumene project at Ravensthorpe. The company signed off-take agreements with Mitsubishi Corporation and thirteen major Chinese lithium-cathode producers for its battery-grade lithium carbonate product. These agreements equate to 100% of Galaxy's planned lithium carbonate production of 17 000 tpa and also includes supply of battery-grade product commencing in 2011. The total measured, indicated, and inferred resource of the Mount Cattlin project is estimated at 15.9 Mt at 1.08% Li<sub>2</sub>O and 161 ppm Ta<sub>2</sub>O<sub>5</sub> (Galaxy Resources Ltd, 2010a,b,c).

Reed Resources, together with Mineral Resources Ltd, is carrying out a pre-feasibility study to produce battery-grade lithium carbonate from lithium concentrates to be produced at the Mount Marion lithium project, 40 km south of Kalgoorlie. The joint venture hopes to produce 200 000 tpa of approximately 6.5% Li<sub>2</sub>O concentrate with first shipment in 2011. The deposit is estimated to contain a total measured, indicated, and inferred resource of 10.5 Mt at 1.4% Li<sub>2</sub>O for 146 500 t of contained Li<sub>2</sub>O (Reed Resources Ltd, 2010c,d).

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## Coal

Major headlines were made when The Griffin Coal Mining Co. Pty Ltd (one of the two operators in the Collie Basin) and some of its related entities, ran into financial difficulties and were placed under External Administration in January 2010. Power supplies to the State's South West region were threatened, but mining at Collie continued.

Production of coal during 2009–10 was 6.7 Mt, which was lower than the 6.9 Mt produced during the previous year. All of this production was by Wesfarmers and Griffin Coal from Collie. About 90% of Collie coal is used as thermal coal, mostly in power stations, and the majority of the remainder is used metallurgically (i.e. as a reducing agent) by the mineral sands industry to transform ilmenite to synthetic rutile. In 2007, Griffin Coal commenced trial export shipments, and up to June 2010 a total of 38 shipments had been made to India and China through the port of Kwinana.

A pre-feasibility study by Rey Resources Ltd on the Duchess–Paradise project, 135 km southeast of Derby, concluded that an initial operation producing 2 Mtpa of saleable thermal coal is the best and most financially robust approach to commercially develop the project. The deposit is estimated to contain measured, indicated, and inferred resources totalling 511 Mt of thermal coal. The company has commenced a definitive feasibility study. The plans are for the coal to be transported by road to Derby port and then shipped to markets in China or India. During the year, an attempted takeover of Rey Resources by Gujrat NRE Coke Ltd (of India) failed (Rey Resources Ltd, 2010a,b).

## Drilling activity

The sharp decline in drilling activity throughout Australia in 2008–09 showed signs of recovery in 2009–10. The details are as follows:

- Metres drilled during 2009–10 in Australia increased by 5% (by 411 million metres) to a total of 8298 million metres (Fig. 12).
- However, the estimated mineral exploration drilling in Western Australia has decreased during 2009–10 by 3% (195 million metres) to a total of 5901 million metres (based on Western Australia's proportion of total Australian exploration expenditure for each year as the ABS does not release WA-specific data).

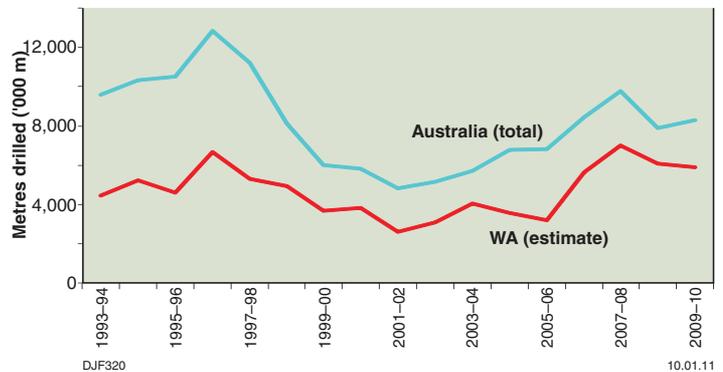


Figure 12. Mineral exploration drilling in Australia and Western Australia

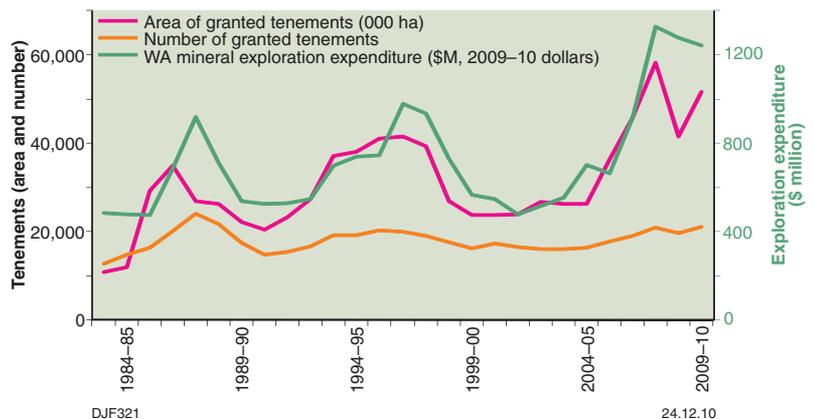
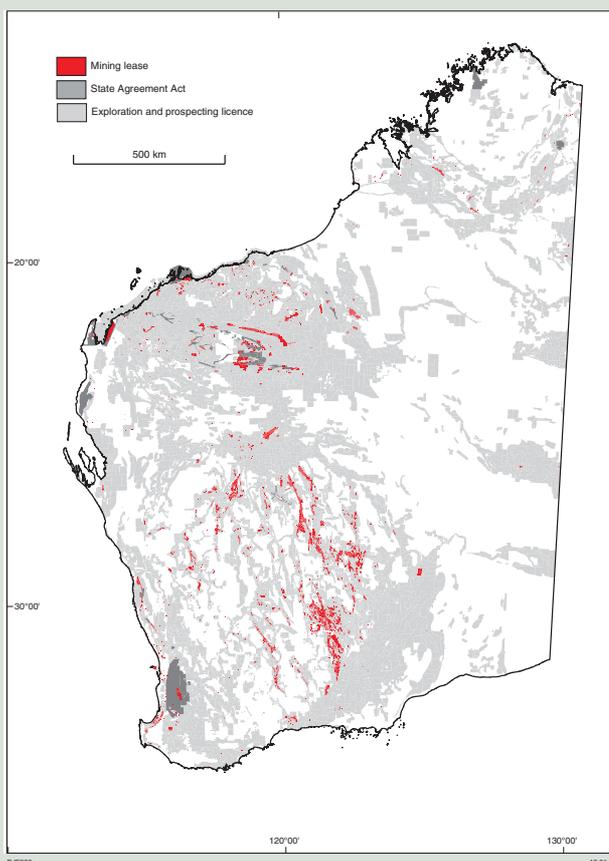
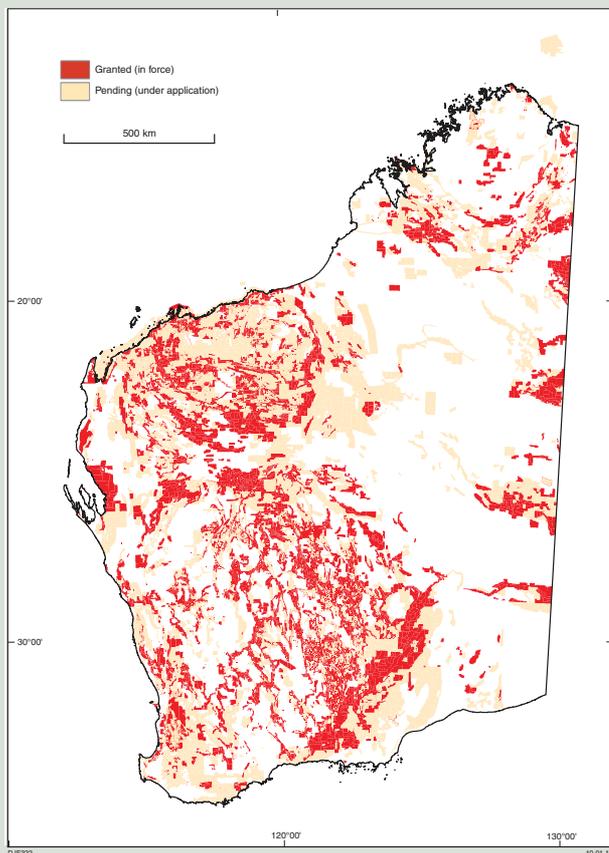


Figure 13. Trends in exploration expenditure and tenement activity (1904 and 1978 Mining Acts) since 1983–84 (source: Department of Mines and Petroleum)

- Mineral exploration drilling for new deposits in Australia increased by 12%, from 2710 million metres in 2008–09 to 3055 million metres in 2009–10.
- Mineral exploration drilling at existing deposits in Australia also marginally increased (2%), from 5167 million metres in 2008–09 to 5245 million metres in 2009–10.

## Mining tenement activity

Tenement statistics demonstrate a recovery from the worst of last year's global financial crisis with a substantial increase in the number of granted Exploration Licences, area covered by granted Exploration Licences, and new (pending) applications for tenements. The number of granted Mining Leases increased only marginally. The details of these are:



- The increase in the number of granted tenements (in force) in Western Australia during 2009–10 was by 8% (1538) from a total of 19 594 in force at 30 June 2009 to 21 132 at 30 June 2010 (Fig. 13).
- The area, in million hectares, under granted tenure increased by 24% (10.2 Mha) from a total of 41.5 Mha at 30 June 2009 to 51.6 Mha at 30 June 2010 (Fig. 13).
- There was a significant increase in the number and the area of granted Exploration Licences — the number of granted ELs in force at 30 June 2010 increased by 29% (1183) and the area under tenure of granted ELs increased by 28% (9.7 Mha). The number and area held under all other tenement types over the year rose only marginally, by 2% and 6% respectively.
- Statistics for Mining Leases show a small increase in granted Mining Leases from 2008–09 to 2009–10, rising in number from 5525 to 5764 and in area under granted tenure from 2.03 Mha to 2.12 Mha.
- The number of applications received by the Department during the year for new tenements increased substantially (30%), from 3883 in 2008–09 to 5043 in 2009–10.

The distribution of tenements, both granted and under application at 30 June 2010, is shown in Figure 14. The distribution of Mining leases, Exploration and Prospecting licences (granted and under applications) and State Agreement Act areas is shown in Figure 15.

*Figure 14. (above) Distribution of mining and exploration tenements, granted and pending, in Western Australia as at 30 June 2010*

*Figure 15. (left) Distribution of Mining leases, Exploration and prospecting licences (granted and pending) and State Agreement Act areas in Western Australia as at 30 June 2010*

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