



Declining greenfields exploration in Western Australia, 1996–2001

by D. J. Flint and R. Rogerson

[Modified extract from: Bowler, J, 2002. Ministerial Inquiry into greenfields exploration in Western Australia: Western Australia Department of Mineral and Petroleum Resources, 146p.]

Abstract

This paper presents results of innovative research undertaken by the Geological Survey of Western Australia. It looks at the significant fall in mineral exploration expenditure in Western Australia since the peak activity in 1996–97, with emphasis on analysing and demonstrating how much of that decline has been specifically related to greenfields exploration. Mineral exploration expenditure in the State is down 47% from 1996–97 to 2001–02, with gold down 55%. Exploration activities in greenfield areas, particularly RAB and RC drilling, have borne the brunt of the decline. Detailed analysis suggests that an average distance of 5 km from mine sites is a reasonable measure of the transition from brownfields to greenfields exploration. Regardless of what distance measure is used as a proxy for greenfields exploration (from 5 km to 40 km), the relative proportion of expenditure incurred from 1997 to 2001 fell in all cases. However, exploration expenditure more than 5 km from mine sites (nominally greenfields) has declined from 40% of the total in 1997 to only 28% of the total in 2001. The gap between brownfields and greenfields exploration is continuing to widen.

These results are not in agreement with the currently available Australian measure of exploration activity compiled by the Australian Bureau of Statistics (ABS) that is widely used as a proxy for greenfields exploration. That measure is exploration expenditure for both production leases and off production leases. The ABS data indicates that exploration expenditure off production leases has remained almost unchanged since 1997 at 75–80% of the total (for Australia as a whole).

Introduction

Mineral exploration expenditure in Western Australia has declined markedly since 1996–97 and is now, in real terms, at levels lower than the recession of the early 1990s (Fig. 1). In 2001–02, mineral exploration in the State was down 47% from the peak reached during 1996–97 (in dollars of the day terms), whereas gold-sector exploration expenditure was down 55.2% for the same period. Unfortunately, quarterly data indicate that the bottom of the downturn had not been reached in mid-2002 (Fig. 2).

The task was to prove the anecdotal belief of recent years that exploration in greenfields areas had suffered the greatest declines and is now at seriously depressed levels. Brownfields exploration may be proving successful in the short term, and win immediate support from shareholders, but it is discoveries in greenfields areas that are required for the long-term sustainability of the mining industry in Western Australia.

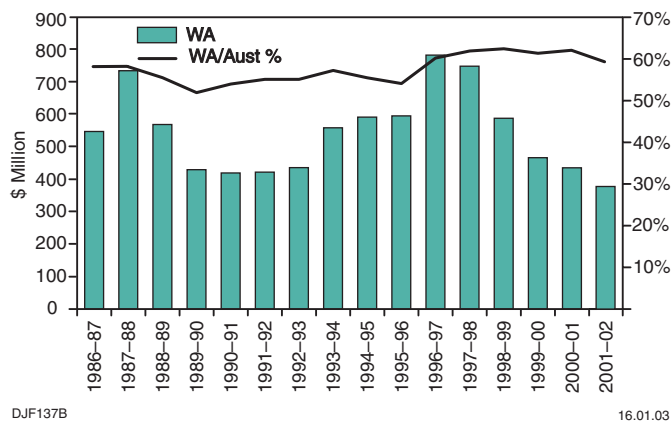


Figure 1. Mineral exploration expenditure in Western Australia, by year (June 2002 dollars)

What is 'greenfields' exploration?

This section examines the meaning of the terms 'greenfields' and 'brownfields' within the context of minerals exploration.

These terms, and their synonyms 'frontier' and 'mature' respectively, are also used for basins within the context of petroleum exploration. An understanding of these terms, and their definitions is critical to the probity of the public policy recommendations arising out of the Ministerial Inquiry (Bowler, 2002).

The importance of clearly defining greenfields exploration is underlined by a statement released by Western Mining Corporation (WMC) on 27 November 2001 to the Australian Stock Exchange (<http://www.wmc.com.au>).

'WMC, Australia's third-largest mining company, plans to halve spending on greenfields exploration and slash staff at its Perth offices as it tries to attract a buyer.'

Expenditure on greenfields exploration will be cut to \$25 million from \$50 million, and 60% of exploration staff at the Melbourne-based miner's Perth offices will lose their jobs. Exploration staff will also be cut in Denver (USA), Chile and Brazil.

Spending on brownfields exploration will remain unchanged, apart from the natural reduction caused by the sale of WMC's gold division.

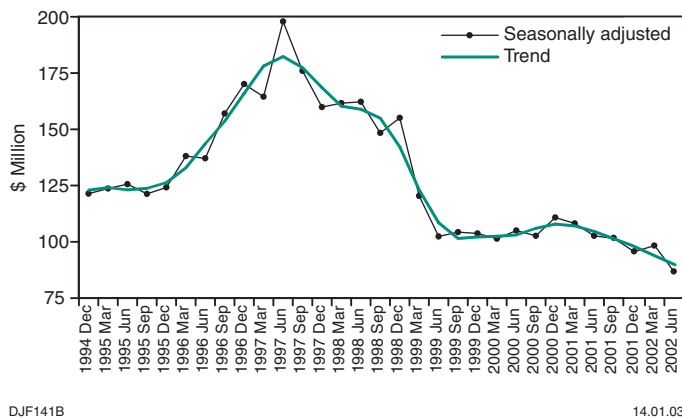


Figure 2. Mineral exploration expenditure in Western Australia, by quarter, on seasonally adjusted and trend terms (dollars of the day)

Exploration now comes under the business strategy and development department headed by Andrew Michelmore, placing it alongside development of technology and other 'value-added' growth areas of the company.

Effectively, it will have to compete with those areas for funds.'

Description of greenfields

A survey of the literature relating to exploration failed to unearth a definition of greenfields and the following statements will serve to establish a number of characteristics of greenfields or brownfields exploration.

- Greenfields exploration is described as work undertaken in search of new orebodies that can be mined economically;
- 'Brownfields' exploration (proving-up known resources on granted leases) rather than 'greenfields' exploration (exploring for new deposits);
- Near-mine or brownfields exploration and away from greenfields exploration;
- The more expensive and time-consuming 'greenfields exploration'... 'greenfields' (grass-roots) and they are not 'brownfields' (next to existing mines);
- Brownfields exploration focusing on the environs of existing mining operations;
- Greenfields exploration to find new deposits;
- Expenditure on greenfields exploration (exploring in new regions).

The prevalence of parentheses in these quotations indicates that the authors have not been sure of how their readers would interpret the terms greenfields and brownfields. Nevertheless, the quotations highlight a number of characteristics of these terms.

Greenfields exploration
Exploring in new regions
Searching for new mineral deposits
Use of 'grassroots'* techniques

Brownfields exploration
Proving-up known deposits on granted leases
Near existing mining operations

An important characteristic of brownfields exploration is that it is more spatially confined than greenfields exploration. Brownfields exploration appears to be carried out near existing mining operations or deposits, and perhaps on a granted mining lease, where work is focused on the discovery close to an existing orebody or discrete mineral deposits containing resources that could be converted easily to ore. Alternatively, brownfields exploration could involve conversion of *mineral resources* in an existing orebody to *ore reserve* status.

In a sense, greenfields seems best defined as those areas that are not tacitly considered to be brownfields.

The greenfields–brownfields continuum

The distribution of existing orebodies within a region would suggest that there should be a continuum between bull's eye-like areas surrounding known mining operations marked by intense brownfields exploration, and areas that gradually pass outwards into those with less intensive exploration where grassroots exploration techniques are employed. Clearly, large areas exist where there is no exploration. A hypothetical case is illustrated in Figure 3.

The shape of the curve in Figure 3 is a reflection of the distribution of perceived prospectivity or mineral potential of the area, which is ultimately a function of geology. Areas with a sharp boundary between prospective rock and non-prospective rock will have steep expenditure–distance curves, perhaps passing from brownfields exploration directly into 'no exploration'.

* Grassroots exploration techniques are usually taken to be those used early in an exploration program, such as wide-spaced sampling and geological mapping.

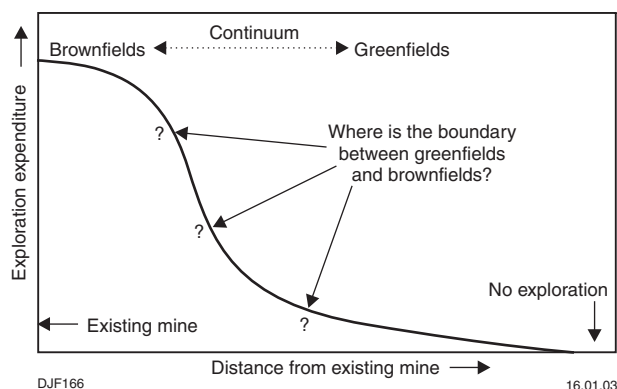


Figure 3. The greenfields–brownfields continuum expressed as exploration expenditure

Approaches used to distinguish greenfields and brownfields exploration

Four broad approaches have been used by different jurisdictions to distinguish between greenfields and brownfields exploration expenditure. The approaches include those based on the following:

- *Tenement type.* Productive mining is usually carried out on mining leases, and exploration on exploration or prospecting licences. Some Australian states use this approach.
- *Exploration technique.* In this case, advanced exploration techniques or studies such as close-spaced diamond or reverse-circulation drilling, metallurgical studies, bulk sampling, and trial mining are taken to indicate an exploration project is at an advanced stage. Papua New Guinea uses this approach.
- *Production.* In this case, brownfields could be limited to the area of a tenement that has existing production. This approach is used by the Australian Bureau of Statistics.
- *Historic production.* In this case, an area would be considered brownfields because it has been defined as a goldfield or mineral field.

Table 1 outlines the advantages and disadvantages of these approaches in different circumstances.

The Australian Bureau of Statistics has traditionally collected quarterly data from companies relating to exploration expenditure on both 'on' and 'off' production leases — as a quasi measure for brownfields and greenfields exploration respectively. Figure 4 shows that despite a known massive drop in total exploration expenditure and area under tenement in Western Australia, ABS data suggest that expenditure 'off' production leases for Australia remains relatively unchanged at around 75–80% of the total! If any pattern is evident from the ABS data, it tends to suggest the real situation is the reverse of that universally accepted to be the case. That is, the ABS data are indicating the lowest level of exploration expenditure 'off' production leases was during the boom of 1996–97 rather than during 2001–02. This is certainly against the commonly held belief in industry.

Unfortunately, there has been a tendency for many commentators to use the expenditure 'off' production leases as a proxy for greenfields exploration expenditure. This is very misleading, as most industry practitioners would regard brownfields exploration expenditure extending well beyond their immediate production lease. The ABS data also suggest that 70–80% of exploration expenditure is 'off production leases', that is, nominally greenfields, but no one really believes that greenfields exploration in recent years is anywhere near that level.

The reason for the ratio between 'on' and 'off' production lease expenditure remaining approximately constant, despite strong anecdotal evidence that greenfields exploration activity has declined, probably goes to the heart of the definitional problems associated with greenfields exploration.

Table 1. Approaches to defining greenfields and brownfields exploration expenditure

<i>Approach</i>	<i>Advantages</i>	<i>Disadvantages</i>
Tenement type	Clear-cut. Works well where production leases are only granted for production purposes and leases are reasonably small	In WA, most mining leases are only used for exploration purposes. In many cases in WA, greenfields exploration techniques are applied on mining leases
Exploration technique	Theoretically clear-cut if information on exploration techniques being used is easily obtained. Would work well where only a small number of brownfields areas are involved	Where a large number of brownfields areas exist, or where information is not easy to obtain, this approach could be difficult to use
Production	Clear-cut	Brownfields techniques are applied in areas outside leases on which production occurs
Historic production	Clear-cut	Ignores the fact that the mineral field may be greenfields for the particular commodity being explored for. Brownfields techniques may be applied in areas outside mineral fields

One probable explanation is that the outer boundary of greenfields exploration against areas with no exploration has probably moved inwards towards production leases (Fig. 5). While there has been a similar percentage reduction in exploration expenditure 'on' and 'off' production leases, vast areas that were once the object of greenfields exploration now see no exploration.

The brief analysis in Table 1 shows that there is no easy or natural method of distinguishing brownfields and greenfields exploration. A method of calculating brownfields exploration expenditure is therefore required that is easy to understand by industry and policy makers, and that is amenable to rapid database analysis when the number of tenements is high.

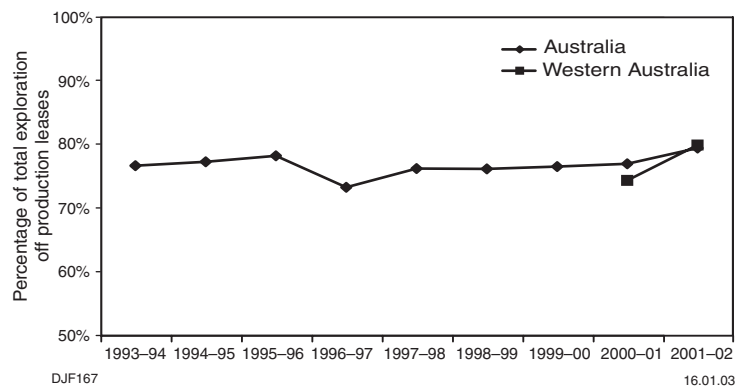


Figure 4. Australian mineral exploration expenditure off production leases (ABS estimates)

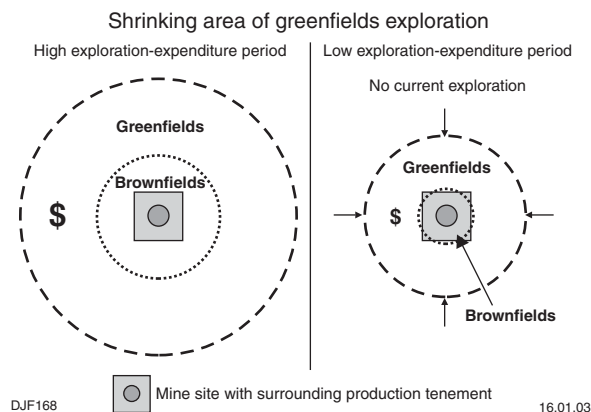


Figure 5. The shrinking area of greenfields exploration may be a major consequence of declines in exploration expenditure generally

Given the large number of mineral tenements in Western Australia, and the fact that greenfields exploration techniques are used on mining leases not used for productive mining, any technique used would need to be independent of the underlying tenement type. An effective approach would also need to possess the following characteristics:

- Produce unambiguous, unbiased results meeting the requirements of the Australian Bureau of Statistics;
- Produce results useful for formulating public policy in the mineral sector;
- If possible, be applicable Australia-wide;
- If possible, be simple to apply on a quarterly basis.

The MPR approach

The Department of Mineral and Petroleum Resources (MPR) has three datasets that are amenable to analysis using geographic information system (GIS) software in order to produce exploration expenditure within a user-defined brownfields area surrounding a site that is producing, or has recently produced minerals.

The three datasets are:

- TENGGRAPH — a database of all mineral tenements (includes attributes such as the type of tenement and the geographical coordinates of their boundaries);
- MINEDEX — a database of all mineral deposits and mine sites (includes attributes such as operating status and the geographical coordinates of their location);
- Exploration expenditure — a database containing the statistics of exploration, and production expenditure on mineral tenements submitted by tenement holders (Form 5 of the Western Australian Mining Act, 1978).

Thus MPR has a technique that allows the calculation of the greenfields or brownfields exploration expenditure total for any desired radius from a mine site. Importantly, this calculation can be made independently of the underlying tenement type (Fig. 6).

Notes on the analysis technique

Form 5

Before presenting the results, a comment is required on the use of the Form 5 data as a measure of exploration expenditure. An amended Form 5 was introduced in Western Australia in July 1999, and only since then is there sufficient detail to accurately distinguish exploration expenditure from production expenditure, even when both occur on the same tenement. Data capture for Form 5 submitted to MPR since July 1999 is in progress.

However, a detailed analysis is required for the period from the peak of the boom in 1997 to the current serious recession in exploration activity (2001 and 2002).

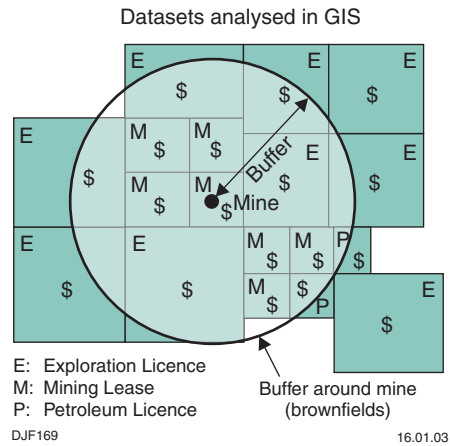


Figure 6. A buffer of flexible radius surrounding a mine location can be used to calculate brownfields exploration expenditure

As detailed Form 5 data are not yet available, the total expenditure for each and every tenement (as sourced from the pre- and post-1999 Form 5) was used. This includes exploration and mining costs as an undistinguished total. As an estimate of the exploration expenditure, an arbitrary \$2 million expenditure was used. That is, any expenditure greater than \$2 million for any one tenement in one year was regarded as production expenditure and excluded from the results.

Such an approach facilitates rapid evaluation of the data, but Table 2 indicates that this is no substitute for full detailed data from the newer Form 5, which is now considered to have high strategic value.

The method using the \$2 million cut-off per tenement produces both overestimates and underestimates of the exploration expenditure, depending on the stage of the boom–bust cycle.

It was found that the method using the \$2 million cut-off produces a reasonable estimate of the ABS estimate of mineral exploration in the recession years of 1999–2001, but significantly underestimated mineral exploration expenditure in the boom times of 1996 and 1997. Further refinement of the technique is required for historical information, but in future the new Form 5 data will be used.

However, for the purposes of this study, the technique using an arbitrary \$2 million cut-off was considered suitable to give indicative trends in mineral exploration.

Table 2. Comparison of estimated exploration expenditure in Western Australia

Year	ABS	Form 5 (\$2 million cut-off)
\$ million		
1996	601.5	499
1997	700.8	552
1998	626.7	495
1999	427.3	417
2000	420.7	425
2001	408.5	442

Mine sites Mine sites were selected from MPR's MINEDEX database, with snapshots taken of the database as it existed in each of the years 1996 to 2001. All mines were included, regardless of whether their stage of operation was operating, under development, care and maintenance, or shut.

Excluded from the dataset were low-impact mines, that is, prospecting sites. Also excluded were mines where the target commodity is construction materials or dimension stone, as there is, in essence, minimal or no exploration for these commodities in surrounding tenements.

Also excluded were the very large number of historic mine sites; basically those worked prior to about 1980. If these were also included, the results would mean that the amount of brownfields exploration would be even higher.

This produces a coherent dataset that consists predominantly of mines worked since about 1980 – a dataset that easily fits most definitions of brownfields exploration.

*The brownfields–greenfields continuum
in a Western Australian context*

Rather than predetermine the distance from a mine site that corresponds to the transition from brownfields to greenfields exploration, the analysis was repeated at a range of distances – 1.75 km (corresponding to the nominal radius of a single mining lease), 5 km, 10 km, 20 km, and 40 km.

The smaller distance of only 1.75 km from mine sites was taken as an unambiguous measure of certain brownfields exploration, thus providing a minimum measure.

The distance of 40 km was chosen as representing the interpreted maximum distance for trucking ore to a nearby plant, and is thus a reasonable measure of the outer limit and maximum amount of brownfields exploration.

The results are equally valid if one of the intermediate values is taken to represent the transition point from brownfields to greenfields exploration.

Although the results are preliminary, clear trends are evident in the data for Western Australia.

*Trends in greenfields
exploration for 1996 to 2001*

These trends are examined in three areas – exploration expenditure and tenement distribution as a function of distance from mine sites, and drilling activity (as another measure of greenfields–brownfields exploration).

Exploration expenditure

Amidst the large falls in exploration expenditure in Western Australia that have occurred since 1997, it is possible to discern the trend towards near-mine exploration. This is best illustrated by using the estimated exploration expenditure data at ± 5 km from mine sites (Figs 7 and 8), which dramatically show the trend towards near-mine exploration in both actual expenditure data and in 'percentage of the total' terms. In addition, the data are revealing that the gap between brownfields and greenfields exploration is widening with time.

Figure 7, dealing with dollars spent, illustrates the trend to brownfields exploration, as well as the widening gap between brownfields and greenfields exploration – the gap widened in 1998 (as exploration expenditure fell generally) and the trend has continued at a more rapid pace since then. Although near-mine (<5 km) exploration expenditure has shown signs of recovering in 2000 and 2001, the greenfields (>5 km) exploration expenditure has continued to deteriorate.

Figure 8, dealing with the same data but expressed as a percentage of the total, illustrates a similar pattern, with the widening gap between brownfields and greenfields exploration. Exploration expenditure more than 5 km from mine sites (nominally greenfields) has declined from 40% of the total in 1997 to only 28% of the total in 2001.

This is not in agreement with ABS data (Fig. 4) that indicate that exploration expenditure off production leases, which is often used as an indicator of

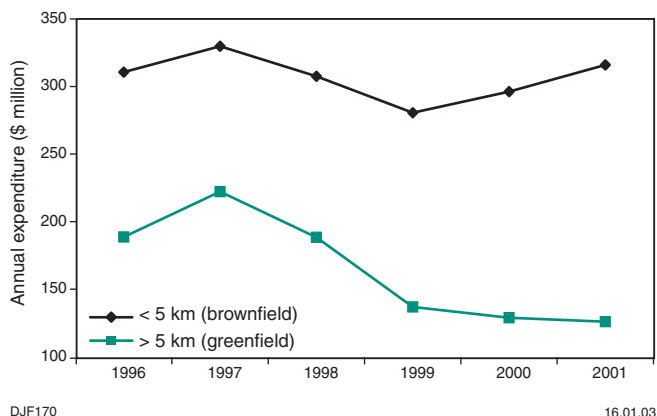


Figure 7. Greenfields–brownfields trends in annual exploration expenditure (actual dollars), Western Australia, 1996–2001 (based on ± 5 km from mine sites)

greenfields exploration, has remained almost unchanged at 75–80% of the total (for Australia as a whole). Comparable, specific ABS data for Western Australia are available only for the last two years (2000–01 and 2001–02), but are similar to the national ABS data.

Results also indicate that it matters little what distance measure is used as a proxy for greenfields exploration, the proportion of exploration expenditure incurred from 1997 to 2001 fell in all of them — at distances more than 40 km from mine sites, at 20–40 km from mine sites, at 10–20 km from mine sites, and even a slight fall at distances of 5–10 km from mine sites (Fig. 9). Expenditure in the distance range of 1.75 – 5 km from mine sites is almost unchanged since 1997, and the proportion of exploration expenditure at mine sites (within 1.75 km) has clearly increased since 1997.

Figure 10 provides a view of the profile of exploration expenditure with distance from a mine site, and how that has changed from 1997 to 2001. Most of the difference between the curves results from lower exploration generally from 1997 to 2001, with the exploration expenditure profile from mine sites usually lower with each successive year (note that the intervening years are not shown on Figure 10). However, the data for 2001 highlight the real trend to brownfields exploration, with the highest recorded near-mine exploration (within 1.75 km) and with low or the lowest recorded exploration expenditure at all other distances.

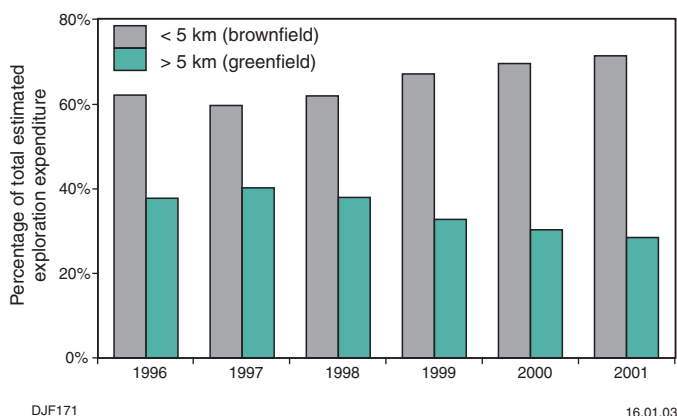


Figure 8. Greenfields–brownfields trends in annual exploration expenditure (percentage of total exploration expenditure), Western Australia, 1996–2001 (based on ± 5 km from mine sites)

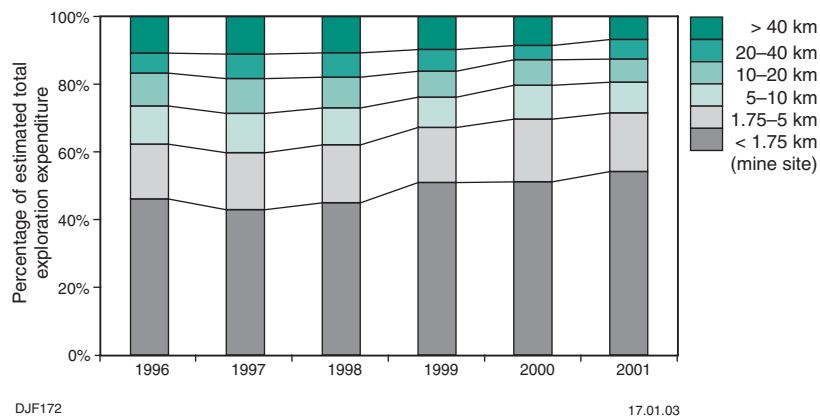


Figure 9. Estimated exploration expenditure by distance from mine sites, percentage of total, Western Australia, 1996–2001

Figure 11 highlights how greenfields exploration (regardless of how it is defined) has borne the brunt of the general decline in mineral exploration from 1997 to 2001. Note that Figure 11 is based on estimated mineral exploration expenditure using Form 5 data and with an arbitrary \$2 million cut-off, but this method does understate the general decline in mineral exploration expenditure since 1997. By this method, the decline in total expenditure to 2001 is only 20%, whereas the ABS data reveal a 47% decline. Despite this, the trend revealed in Figure 11 is considered real.

Furthermore, Figure 11 also depicts the percentage falls in mineral exploration with distance away from mine sites, with the fall generally increasing with distance from the mine sites. The decline in greenfields exploration is greater than the overall decline in expenditure, with mineral exploration at mine sites staying static or even increasing slightly. Brownfields exploration at 1.75 – 5 km from mine sites has declined, but the fall is nowhere near the magnitude of the falls in greenfields exploration. These data are entirely consistent with and strongly support the hypothesis of increasing brownfields exploration (at least relatively speaking, and perhaps even absolutely at mine sites) and that greenfields exploration has borne the brunt of the general decline in exploration expenditure since 1997.

Drilling activity

Drilling data compiled by MPR indicate that cutbacks in drilling are more severe than the general decline in exploration expenditure.

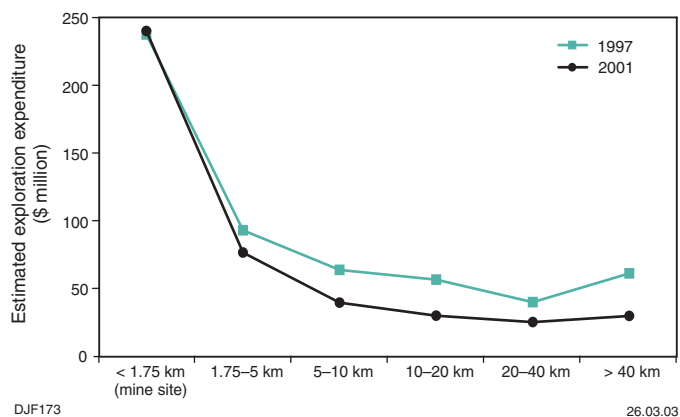


Figure 10. The yearly shift in exploration expenditure profile towards brownfields mineral exploration, 1997 to 2001, Western Australia

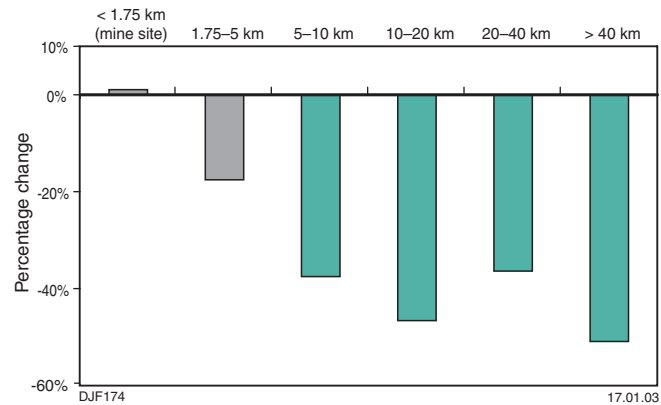


Figure 11. The percentage change in greenfields and brownfields exploration expenditure from 1997 to 2001, by distance from mine sites

Drilling activity* since the peak of exploration in 1996–97 clearly shows that cutbacks in exploration budgets have had a severe impact on all types of drilling (Fig. 12). Rotary air blast (RAB), reverse-circulation (RC), and diamond drilling have now declined by about 80%, 65%, and 65% respectively since their peaks in 1996–97 or 1997–98. RAB drilling was the first to be adversely affected as companies reduced expenditure and moved away from grassroots greenfields exploration, and this was followed one year later by declining RC drilling, as expenditure cuts deepened. RAB and RC drilling continued their decline during 2001–02, and have now been joined by falling diamond drilling during 2001–02.

The falls in 'metres drilled' from their earlier peak levels are more severe than the general fall in overall exploration expenditure. The decline of about 80% in RAB, 65% in RC, and 65% in diamond drilling since the peak of the boom should be compared with the corresponding drop of 'only' 47% in total exploration expenditure.

Recent quarterly data from the Australian Bureau of Statistics show that the downward trend is still firmly in place and has not shown any sign of levelling off. That data, which includes all mineral exploration drilling of all

* Drilling statistics extracted from MPR's Western Australian mineral exploration (WAMEX) database, as supplied by the mining industry and best regarded as a trailing indicator.

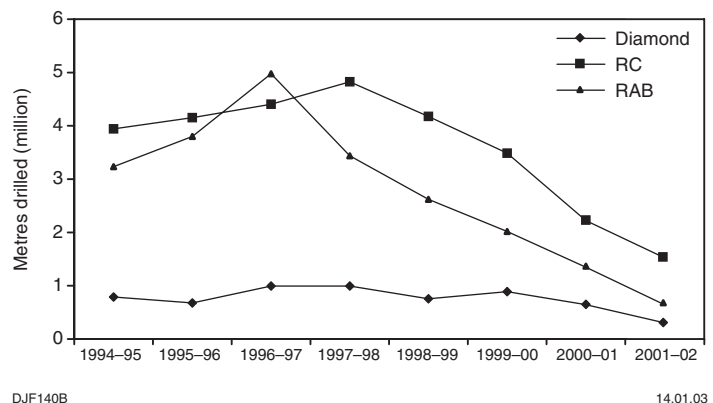


Figure 12. Mineral exploration drilling in Western Australia, by drilling type and year

types, both on and off production leases, shows that mineral exploration drilling in Australia has declined by 75% (2.79 million metres) since mid-1997.

Such declines in drilling activity greatly diminish the opportunity for significant discoveries that are so necessary to change perceptions and boost exploration.

Tenement distribution

Tenement activity can also be used as a measure of exploration activity; hence, the analytical method was also used to examine the number of granted tenements as a function of the distance from mine sites, and how this has changed with time since 1997 (Fig. 13). Figure 13 shows that the number of granted tenements in Western Australia within 5 km of mine sites has increased since 1999, whereas the number of granted tenements in all zones more than 5 km from mine sites has been declining since 1997.

Other points to note from the analysis include the following:

- The number of granted tenements greater than 40 km from mine sites (i.e. unquestionably greenfields tenements) has dropped from 1407 in 1997 to 802 in 2001, a decline of 43% over four years. Such greenfields tenements represent only 7% of the granted tenements. This supports the concept (see Fig. 5) of the shrinking area of greenfields exploration.
- The exploration expenditure on those tenements has dropped from \$76 million (1997) to \$45 million (2001), a decline of 41% over the four years.
- That exploration expenditure in undisputed greenfields areas (>40 km from mine sites) has dropped from 2.0% (1997) to 1.2% (2001) of reported expenditure on granted tenements (i.e. including mining and all other costs). This highlights how little of industry's total costs are directed to undisputed high-risk greenfields exploration (i.e. more than 40 km from mine sites).

Trends in greenfields exploration in the backlog of pending tenements

A total of 11 768 tenements were at the application stage in June 2002. The expenditure commitment associated with these tenements (and assuming no overlap) would total \$458 million. This compares with a total of only \$408 million of exploration expenditure spent on all the granted tenements in Western Australia during 2001, and only \$376 million spent in 2001–02.

The potential exploration expenditure as a function from existing mine sites is shown in Figure 14. This indicates that most of the potential exploration commitment is near mines (within 10 km) and that there is much less interest in areas more distant from mine sites.

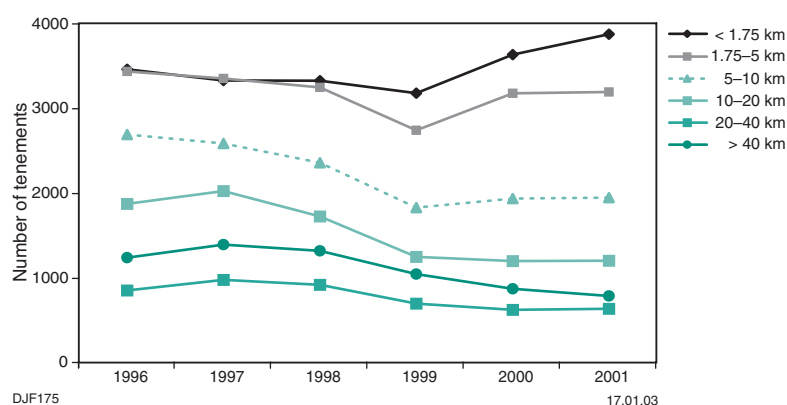


Figure 13. Granted tenements in Western Australia, by distance from mine site and year

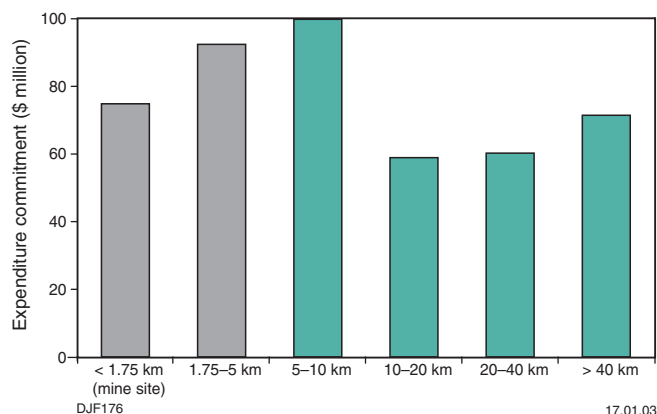


Figure 14. Expenditure commitment if pending tenements granted, by distance from mine sites

Summary

- In 2001–02, mineral exploration in the State was down 47% from the peak reached during 1996–97 (in dollars of the day), and with gold down 55% for the same period;
- Discoveries in greenfields areas are required for the long-term sustainability of the mining industry in Western Australia, but the decline in greenfields exploration since 1996–97 has been more severe than the general decline;
- These developments coincide with a long-term decline in the rate of discovery of new major mineral deposits;
- Detailed analysis by MPR suggests that an average distance of 5 km from mine sites is a reasonable measure of the transition from brownfields to greenfields exploration;
- Results also indicate that it matters little what distance measure is used as a proxy for greenfields exploration (that is, from 5 km to 40 km) — the proportion of exploration expenditure incurred from 1997 to 2001 fell in all of them;
- Exploration expenditure more than 5 km from mine sites (nominally greenfields) has declined from 40% of the total in 1997 to 28% of the total in 2001;
- The gap between brownfields and greenfields exploration is continuing to widen;
- These results are in stark contrast to the ABS data that indicate that exploration expenditure off production leases has remained almost unchanged since 1997 at 75–80% of the total (for Australia as a whole);
- The number of granted tenements in Western Australia within 5 km of mine sites has increased since 1999, whereas the number of granted tenements in all zones more than 5 km from mine sites has been declining since 1997;
- Despite a total of 11 768 tenements at the application stage in June 2002, with a corresponding potential exploration-expenditure commitment of \$458 million, it is unlikely that the total potential expenditure commitment associated with these would be realized if granted immediately. Reasons for this include the depressed state of the minerals sector (low metal prices and returns on investment) and the difficulty of raising investment capital for minerals exploration;
- The location of applications for tenements reinforces the notion that there is still greater interest near mines, rather than in remote greenfields areas.