# The prize is in diamonds

Untold wealth in a few square metres of land. But how do we find it? Well, discovers Chris Morrissey, there are these two special bits of kit . . .

The start of it all: an exploding volcano (left) may one day yield a fortune in sparkling stones.
Right, rough champagne diamonds from Rio Tinto's Argyle diamond mine.

**On the temporarily drained bed of a lake in northern Canada, not far below the Arctic Circle, are three tiny centres of wealth generation. They are the small diamond pipes that Rio Tinto is mining at its 60 per cent owned Diavik operation some 300km north east of Yellowknife.**

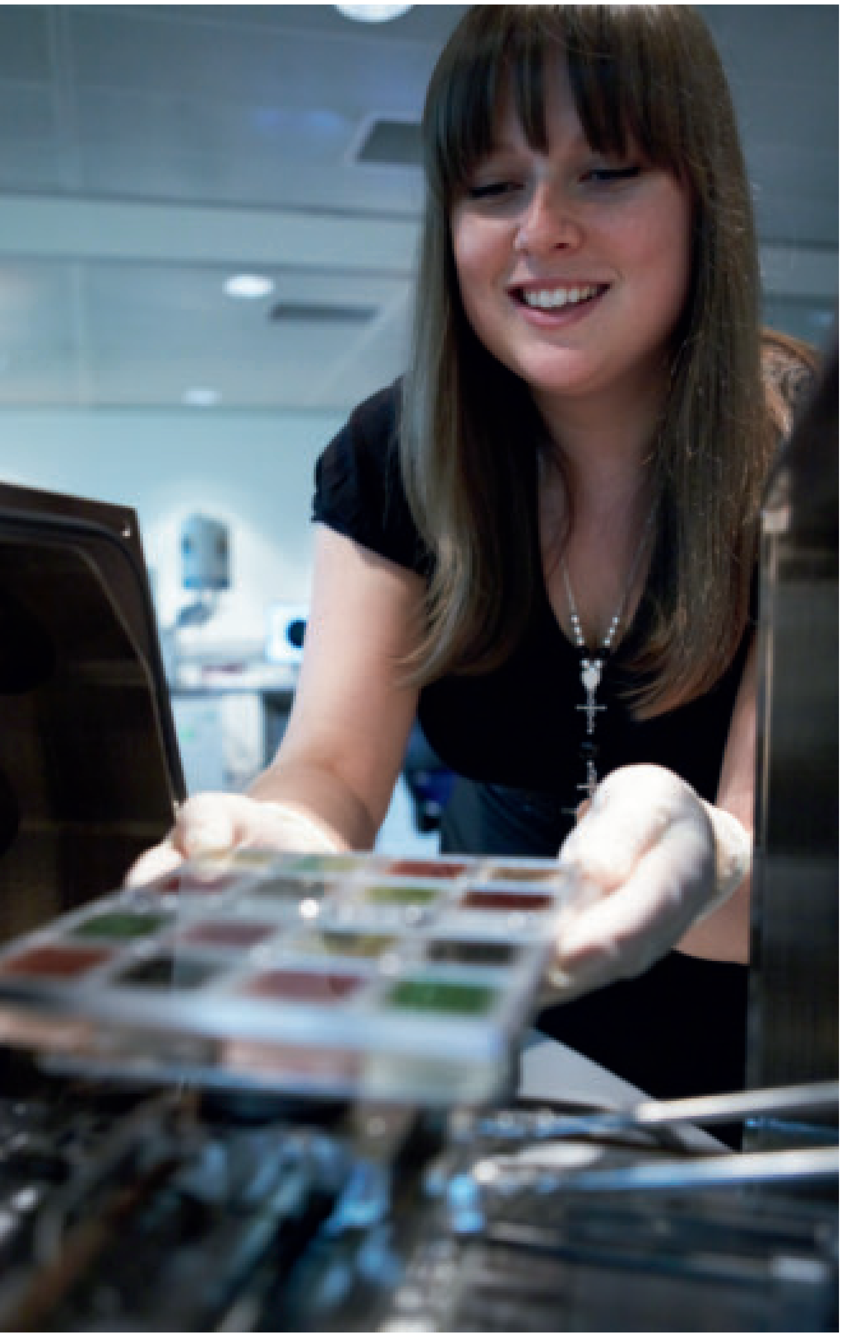
Together they are expected to produce about 100 million carats of diamond during the life of the mine, with a total anticipated revenue yield in the region of US$8 billion. Divide that figure by their total area (3.6 hectares) and you have a demonstration of the extraordinary ability of diamond pipes to concentrate mineral wealth.

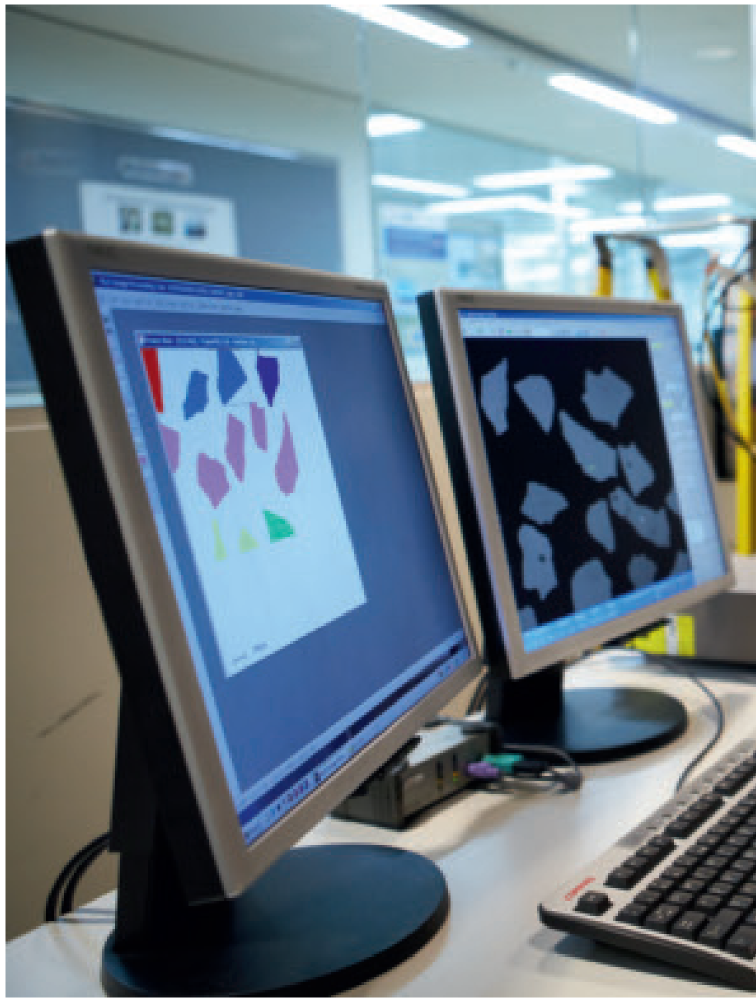
Diamond pipes consist typically of steep, downward-tapering intrusions of a dark green volcanic rock called kimberlite. Their geological footprint is rarely more than a square kilometre and usually less than a fifth of that. Pipes as small as half a hectare may be worth mining if their diamond content is unusually high and the stones are of excellent quality.

Only about 5,000 kimberlite intrusions have ever been found. Fewer than 50 have been worth mining. Rich, lean or barren, they are concentrated in parts of the world where the Earth's crust is old, thick and relatively stable. Geologists call these stable areas cratons and recognise them on every continent. Some are vast, forming the geological backbone of regions as large as southern Africa, Western Australia and central Siberia.

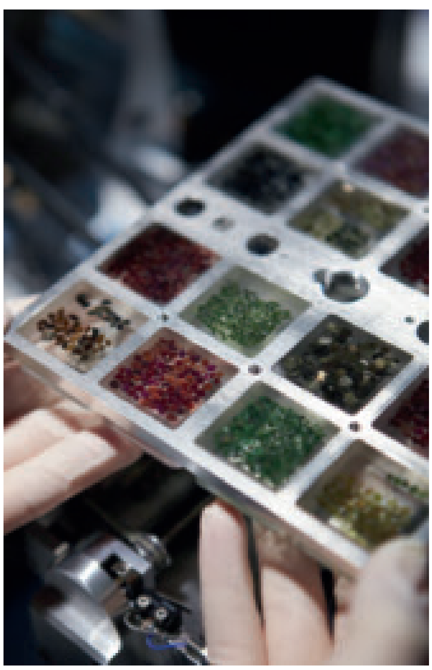
Exploring for diamond pipes may sound as frustrating as looking for a needle in a haystack while knowing that only one needle in a hundred is actually worth finding. But experience and science provide sophisticated explorers with ways to shorten the odds. Some of the most powerful rest on a growing understanding of the natural conditions under which diamonds formed and, upwards of a billion years later, came to be incorporated into the strange mixture of magma, gas and rubble that exploded through the crust as a kimberlite intrusion.

The conditions under which kimberlites form and act as carriers for ancient diamonds produce some distinctive





Above, Mary Harris loads samples (right) into the Mineral Liberation Analyser (MLA). Above right, Mary processes data from the MLA.



minerals and give other minerals distinctive chemistries. An example in the first case is a vivid green mineral called chrome diopside. Examples in the second case include common minerals like garnet, chromite and the iron-titanium oxide ilmenite.

A shared characteristic is that, relative to most rock forming minerals, they are all fairly heavy and hard. When weathering and erosion threaten to destroy them, they have superior powers of survival. Pulverised they may be, and dispersed over enormous distances by water and ice, but until they dissolve they never completely lose the internal evidence of their origin.

Study of these kimberlite indicator minerals – their abundance, their appearance, their composition – has long been important in diamond exploration. Just to find a number of them together in the same soil or gravel sample is a promising sign. But it is when you use state of the art equipment to enquire into the details of their chemistry that the most valuable information comes out. And of course the more mineral particles you can interrogate, at a reasonable cost in money and time, the better.

Rio Tinto is in the forefront of this very advanced form of exploration technology. At its Technology & Innovation (T&I) facility at Bundoora on the outskirts of Melbourne it has developed a way to scan millions of mineral grains, recognise those likely to have come from kimberlites, and probe their chemistry in a way that generates large volumes of potentially useful data.

Resined block samples on a polishing disc being prepared for analysis.

The methodology has involved linking together two instruments – an automated mineral liberation analyser based on scanning electron microscopy, and a laser ablation microprobe capable of analysing trace elements at concentrations of just a few parts per million.

Set among tall eucalyptuses in the bushy grounds of the Latrobe University Research Park, the Bundoora Kimberlitic Indicator Minerals (KIMs) centre is part of a much larger facility which houses an array of Rio Tinto T&I projects and global experts from all spheres of the mining industry, from exploration through to mineral extraction and environmental excellence.

The KIMs facility is based on commercially available hardware but delivers competitive advantage to Rio Tinto because of its unique configuration and specialised software and skills. It is at the heart of Rio Tinto's worldwide diamond search, drawing in samples from all the company's diamond exploration programmes. Its current capacity is in excess of 7,500 heavy mineral populations per year. The annual output is in excess of 850,000 high quality major element analyses and an additional 35,000 trace element analyses of the most interesting grains. Among them may be some that hold the key to an important diamond discovery.

To give an example, one of the main kimberlite indicator minerals is garnet, especially a magnesium bearing variety called pyrope. Normally fiery red (hence the name), there are distinctive sub varieties containing chromium that are beautiful shades of orange and violet. By measuring their chromium content in relation to their calcium content it is possible to recognise garnet that originated at great depths, in materials native to the high pressure hearths where diamond is the stable form of carbon.

Similarly, by comparing their chromium content with that of certain associated minerals it may be possible to work out whether the garnet formed under pressure conditions characteristic of the so called "diamond window". It is leading edge technology, and immensely rewarding when it succeeds.

All the major kimberlite discoveries since the 1940s have relied on the finding and tracking of indicator minerals. (The same is true of rarer diamond finds involving a rock type called lamproite). Which minerals in what proportions tell the clearest story varies from place to place. A common starting point is just one or two grains of one or two minerals. Correctly identified, their presence indicates a kimberlite source, and, expertly analysed, their chemistry indicates the potential for finding diamonds.

Rio Tinto has so far won three operating mines from its expertise in diamond exploration – Argyle in Western Australia (a giant in carat terms), Diavik in Canada's Northwest Territories (small pipes but with high grades) and Murowa in Zimbabwe. They were discovered over an 18 year period (1979-97) before the company had developed the semi automated system it now has at Bundoora. There have already been important new discoveries, including the Bunder project in Madhya Pradesh, India, and others will undoubtedly follow.

**Find out more at**
**www.riotintodiamonds.com**

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