

Putting the horse in front of the cart: why exploration geoscience needs drilling

by

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Let's start with a pat on the back to 150+ years of effective mineral exploration in Australia. We are good at finding mineral deposits, and our continent is well endowed with them. Global giants of the minerals industry were born and have thrived in Australia. Innovation is a calling card of the Australian minerals industry — and is a significant export industry in its own right. Exploration geoscience is strong (world leading!) in our research institutions and government organizations. Our surveys provide abundant, high-quality pre-competitive data. So why has Australia's share of the global mineral exploration budget halved (from ~1/4 to ~1/8) since the early to mid-1990s (Schodde, 2017), and why has the value:cost ratio of our exploration (Schodde, 2015) more than halved over the same period?

In addressing these questions I am going to play an old tune (you may have heard it before) but try to add a few embellishments that I hope will provide new insights into the problem and how we should address it. To summarize: 'cover' is the perceived problem, but our approach to exploring under cover has been the real problem. The limitations of that approach are psychological (we tend to be overly optimistic in our ability to *predict* the location of ore deposits), statistical (we have insufficient data to *detect* the location of ore deposits) and technical (we do not have the tools to efficiently sample the deep cover search space). My contention is that cost-efficient drilling and sampling (and the sense to know how to use it) provides the key to overcoming these limitations.

Detection vs prediction

The distribution of exposed prospective rocks, drillholes, and known mineral deposits on the Australian continent (Fig. 1) is a graphic illustration of: 1) our exploration success when prospective rocks are exposed; 2) the relationship between drilling and discovery, and 3) the fact that we have barely scratched the surface in the covered search space. These plots underline the importance of *detection* in mineral exploration. The most densely sampled areas have benefited from a virtuous cycle of increasing data, improving understanding and reducing risk, which has led to efficient and effective exploration.

We know these areas well, they are data rich, we can recognize patterns, construct sophisticated models of the mineralizing systems, and make informed decisions about where to invest our exploration efforts and what tools to deploy. Detection in this sense is not restricted to direct detection of ore bodies. It includes measurement of any and all components of the system that influence decisions on where to explore (or indeed where not to explore) and what to do next. Based on this approach we have become confident (I would argue overconfident, perhaps better expressed as overly optimistic) that, if economic mineralization is present, we can find it.

One expression of our overconfidence is the idea that *prediction* is an important component of discovery. It is an attractive idea. It adds an element of scientific mystery and places geoscientists in a position of rare influence in the exploration cycle. But it does not stack up. Prediction in its true form is a misnomer in mineral exploration — there are always some data informing exploration decisions — and, with analogies to seismology, prediction in complex geological systems is practically unfeasible. There may be different levels of data in terms of quantity or quality, and there may be different approaches to assessing and interpreting those data. Some operators have better systems in place to turn data into effective decisions and some of the decisions made may be based on little data and poor decision making, and thus be inherently speculative. They are not, however, predictive.

The mineral exploration community should move away from the language of prediction in the same way that the seismology community has done. Rather than attempting to predict the time, size and location of individual earthquakes, the seismologists focus on probabilistic 'forecasting' of earthquake risk. The latter is specifically designed to inform practical decisions (e.g. building standards, disaster plans) which can mitigate the hazard. The nature of earthquake forecasting (looking for spatial and temporal patterns in highly variable data, albeit backed by a sound understanding of the underlying scientific principles) brings attention to the importance of quantifying variability in complex systems.

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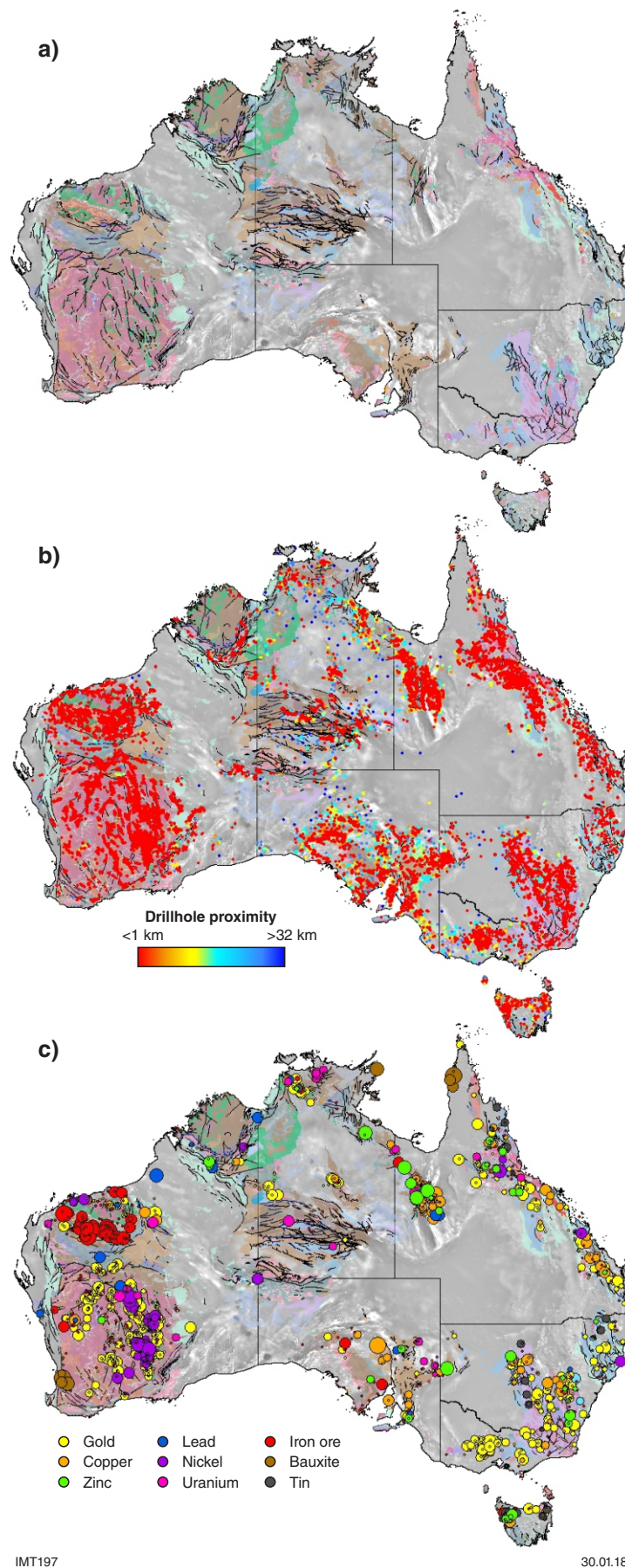


Figure 1. a) Simplified geology of the Australian continent. Exposed rocks of Paleozoic age and older are superimposed on greyscale total magnetic intensity; b) open-file drillholes extracted from the respective state geological survey online datasets overlain on simplified geology and magnetics. Drillholes are coloured by proximity to their nearest neighbour; red <1 km ranging to dark blue >32 km; c) known mineral deposits scaled roughly by size and coloured by major commodity

Variability and sampling in under-cover exploration

Complex, inherently unpredictable spatial variability is a feature of mineral systems. Variability coupled with sparse sampling is a major source of uncertainty. The only way to decrease the uncertainty is to increase the frequency of sampling. The key question of relevance is: what frequency of sampling is required to reduce the uncertainty so as to adequately inform the next important decision? In under-cover exploration, faced with uncertainty and with inadequate tools (expensive drilling), to reduce uncertainty our tendency has been to fall back on a style of exploration towards the speculative end of the spectrum. For example: 1) build an exploration model based on known occurrences (that may or may not be relevant to the covered exploration space), 2) translate the model into an expression in one or more of the datasets that you have or can cheaply acquire (commonly aeromagnetics or gravity) to identify targets, 3) corroborate and prioritize with an independent dataset if possible, 4) drill with a view to collecting as much high-quality, detailed information from the hole as possible.

It would be unfair to ignore that this approach has led to discoveries — it has. But our declining rates of discovery and the displacement of exploration spending to better-exposed provinces argue that it is a flawed approach. Targets are limited to analogues of existing deposits; thus, we are not exposed to variations on a theme or new styles of mineralization. Targeting is very often based on proxies for mineralization rather than on mineralization itself and thus is beset with false positives, and the financially constrained ‘one-shot-in-the-chamber’ approach to drilling too often does not effectively inform the next level of decision making. The idea of capturing as much detailed information from the drillhole as possible is laudable but misplaced. It is an overinvestment to very precisely collect information that does not influence decision making. The ‘cart’ of targeting (one of the most important decisions in the exploration cycle) is being put before the ‘horse’ of data collection.

It begins with more drilling

This brings us to a conundrum — better drillhole targeting requires reduced uncertainty, reduced uncertainty requires more sampling, more sampling requires drilling. But where do I drill? Three related concepts at the heart of our work in the Deep Exploration Technologies CRC (DET CRC) are that:

1. drilling should be a primary means of data collection in areas of deep cover, whereby the exact location of each drillhole is not as important as the overall drill pattern and spatial density of drilling
2. the density of drilling and the detail of data collected during drilling need only be sufficient to drive the next level of decision making (e.g. where to drill next)
3. the cost and speed of drilling and sampling is the single most important technical barrier to overcome.

The hope of DET CRC is that, having spent eight years developing technology (the RoXplorer[®] CT drilling rig and associated sensing platforms) designed to reduce the cost of drilling and sampling (horse before cart), we can engage with the exploration geoscience community (not least the geological surveys) to determine the required drilling and sampling parameters in various geological scenarios, and thus drive a fundamental change in our approach to under-cover exploration.

Why does exploration geoscience need (cost-efficient) drilling (as a reconnaissance exploration tool)? Without drilling, vast tracts of potentially prospective geology will remain largely unknown and will attract only sporadic and inefficient exploration. With it, we can facilitate the same virtuous cycle of data acquisition, systems understanding, and risk reduction that has underpinned exploration success in our exposed mineral provinces.

References

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