# The Exploration Search Space Concept: Key to a Successful Exploration Strategy

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Several studies over the years have used industry-average base-rates of exploration success in an attempt to model the economics of the mineral exploration business. The results of these studies have typically led the authors to question the economic viability of mineral exploration, despite the fact that the value of the global mining industry in 2006 was of the order of $800 Billion US dollars (Goodyear, 2006) and all of these deposits were at one time discovered by mineral exploration. One very important factor that is often overlooked in studies of mineral exploration is that it is a business where the inputs in terms of time, money and blood, sweat and tears do not correlate closely with the output of discovery success. In fact, industry base-rates are not a particularly relevant guide to designing exploration strategy at the scale of individual organizations.

The reason for the last statement is that the distribution of successful outcomes in mineral exploration is strongly bimodal; comprising a small number of organizations (usually at certain times and in certain regions) that are very successful and a large number that have very little success at all. The aggregate of these two distributions produces our observed industry base-rate of success. This bimodal distribution of success-rates has been recognized since at least the 1975 McKinsey study on mineral exploration success in Australian mining companies (McKinsey, 1975). Clearly this leads to the obvious question: what is it that results in an anomalously successful exploration organization? This question has certainly been addressed by industry leaders in the past and the attempts to answer it have usually focused on the intangible, people-related issues of the business (eg Woodall, 2004). The premise of this paper is that although these human issues are absolutely critical, it is also possible to provide a more analytical perspective on the reason for the widely-differing success rates in our industry. The concept of the **Exploration Search Space** is the key to this analytical perspective and the central concept that relates innovation to commercial success in mineral exploration.

Most economic activity essentially comprises organising input resources of people and/or materials to ***produce*** an output of a product or service that can be sold. However, mineral exploration is quite unusual in that it essentially involves a ***search*** through a defined parameter-space to identify economically-significant outcomes. This parameter space is referred to here as the Exploration Search Space and represents the given set of conditions which constrain economically-effective outcomes of the search process. The parameters which define the search space typically relate to one or more of the following categories: the nature of the target ore-type, cover conditions, available detection technology and the prevailing political/commercial environment (including factors such as tax regimes, metal prices and available infrastructure). The primary feature of mineral exploration that sets it aside from most other businesses is that, for any given exploration search space, the potential for success has already been preordained at the time exploration commences. This is because of the obvious point that all the mineral deposits that will ever be found in a particular search space have already been formed. In addition, once we have found a deposit it means that there is one less deposit to be found in that search space. As the statisticians would describe it, we are “sampling without replacement”. The only other major business that has the same characteristics as mineral (including petroleum) exploration is pharmaceutical research. They explore the parameter space of possible combinations of chemicals but there are not an infinite number of these that are likely to have therapeutic properties.

There are three very important business implications that arise from the Exploration Search Space concept.

The first is that any given search space will progressively become exhausted over time, resulting in smaller and higher cost discoveries. It is common that organizations, when they discover a new district, focus exploration resources there and often deliver a string of discoveries. However, unless they somehow expand the search space (see below) over time it will get harder and harder for them to sustain success. This dynamic is a major part of the explanation for why organizations commonly have “golden periods” of success followed by period of poorer performance.

The second implication of this concept is that the largest deposits in any particular search space are usually found early because they generally have the most obvious signatures. The discovery of Olympic Dam in 1975 is a good illustration of this. It was the first concealed IOCG deposit found on the Gawler Craton and today remains the largest known by a wide margin. This is not surprising – the gravity anomaly that initially focused WMC on this target was large enough to be seen in continental-scale gravity data sets.

In combination, the above two points tell us that the key to exploration success is being the first, or very early, into a new exploration search space. The first movers will get a very disproportionate share of the metal there to be discovered. Figure 1 illustrates the discovery success record for a well –constrained and documented search-space: NiS exploration in the Yilgarn since the discovery of Kambalda and demonstrates clearly both of the above two points.

The third critical business implication arises from the above: the most important discontinuities in our business are those which create a significant new search space! These discontinuities may be linked to new exploration technology (eg the development of airborne EM in Canada in the 1950s), new mining and processing technology (eg the impact of CIP technology on the global gold industry in the 1980s), new geological concepts in old areas (eg the discovery of nickel at Kambalda in 1966), new geographies (usually related to a change in political situation; eg opening up of Central Asia in the 1990s) and new markets (eg development of market for higher-phosphorous iron ores in recent years). In many cases, it is a combination of several of the above developments that drives the opening of a new search space. Interestingly, although it might be assumed that higher metal prices on their own may open up a new search space, history suggests that this rarely happens and some other development also seems to be required for a new wave of discoveries to be made. Figure 2 illustrates how new concepts and technology have expanded the search space for copper exploration in Chile.

The well-established concept of “exploration maturity” relates to the exploration search space idea but there is an important, if subtle distinction. The term “maturity” is typically applied to a particular geographical area (eg mineral province or mining camp). However, even in a mature camp it is possible that innovation can open up a new search space that leads to new discoveries that may be even larger than those previously known in the area. The discoveries of the Resolution Cu-Au deposit in Arizona and the Talnakh Ni-Cu-PGE deposit in Siberia are good examples of the latter outcome.

There is a very important message here for investment in exploration technology development. If a new technology only helps sample existing search spaces more effectively, it will provide very little economic benefit to the industry. If however it assists in opening up new search spaces, the pay-off can be large and will probably be delivered soon after the technology is first deployed. The first application of magnetic surveying to exploration in the Witwatersrand, leading to the discovery of the West Witwatersrand in the 1930s is a great example of this.

In summary, exploration strategy should be focussed around the development and exploitation of new exploration search spaces. This analytical perspective in no way diminishes the importance of the focus on creativity and the human dimension advocated by former industry leaders such as Woodall (2004) because it is exactly that creativity that is required to recognize a new search space.

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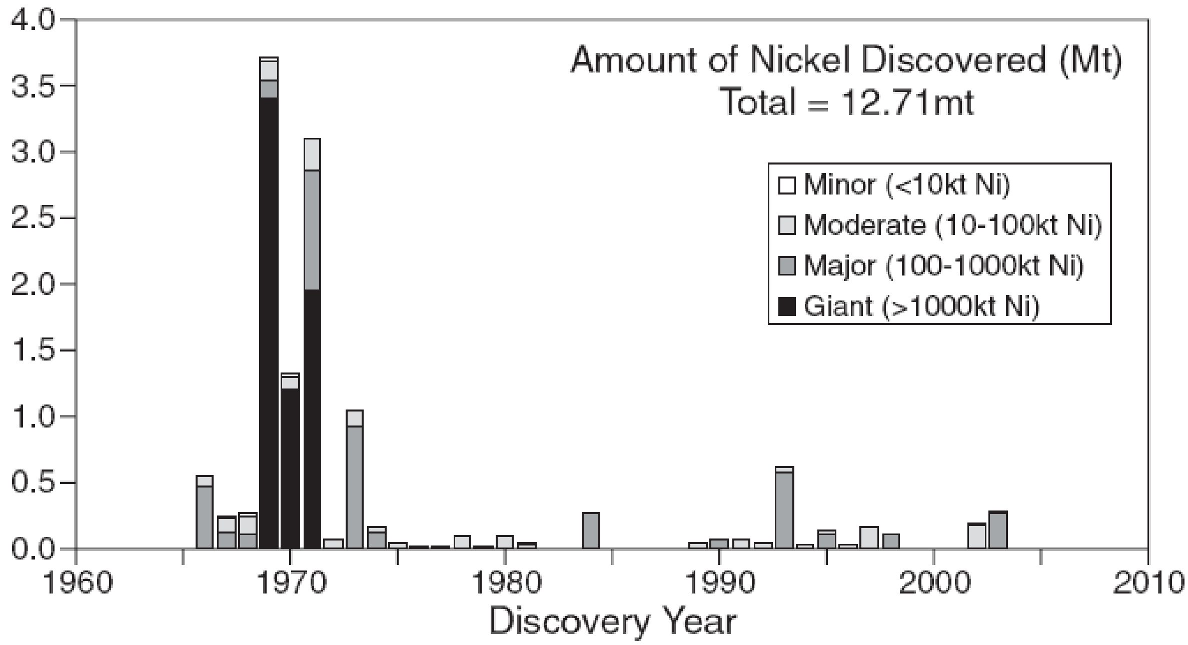


**Figure 1: Discovery history within the exploration search space for NiS deposits in Western Australia. All deposit extensional resource growth assigned to the original time of discovery. Note the classic pattern of the major discoveries and most of the metal being found early, with successive smaller discoveries over time. From Hronsky and Schodde (2006)**

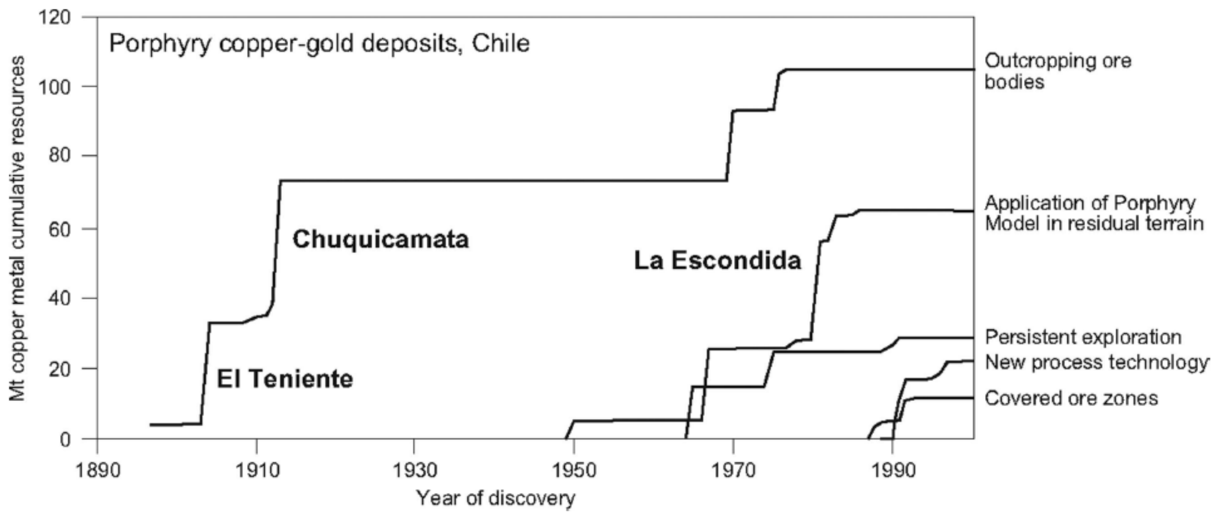


**Figure 2: Porphyry exploration in Chile: An example of the role of technical innovation in expanding the exploration search space and leading to new waves of discovery. From Hronsky and Groves (2008), based on original WMC data compiled by John Black.**