"EXPLORATION - THERE ARE NO NEW MINES WITHOUT IT"

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AN ARRAY OF SELF-EVIDENT TRUTHS

The title of my talk "Exploration - there are no new mines without it" is a self-evident truth. My talk will contain what I believe are many self-evident truths many of which have been handed on to me by people older and wiser than I but who, 30 to 40 years ago, sat as undergraduate students wondering where their career paths lay. Self-evident truths are just that - self-evident but frequently formless until articulated; the light goes on and you say "but I knew that". If, at the end of this talk you have that response, but realise that some of the points raised weren't ones you had considered before then my trip over here will have been worthwhile.

EXPLORATION - INTUITIVE OR LEARNT?

How much of exploration is intuitive, how much can be learnt? By 'intuitive' I do not mean that some people are genetically disposed specifically to explore for minerals, but that some people do have the capacity to recognise, absorb and filter information from the physical environment better than others and use it to explore. It is worth reflecting on mankind's early involvement with metals and considering that, once our species had gone up-market from stone to metal, the first pre-historic equivalent to the yuppie with the mobile

phone was an individual with a useful piece of native copper, gold or silver. Other individuals, envious of the enhanced social status accruing to the possessor of these metals, also desired them and a need and a market was created. Early humans would have found those native metals as nuggets or exposed in outcrop. Their value as weapons' parts, utensils, shields and ornaments would soon have been established. It wouldn't have taken long for them to work out that excavating downwards would yield more and that additional occurrences could be found in the same area, in the same rocks and so forth. Subsequent developments, yielding metals from oxide and carbonate ores and the giant leap forwards arising from the invention, accidental or otherwise, of alloys, simply increased demand. Exploration was empirically based but with time, and the increasing difficulty of new discovery, there would have been an increase in 'learning' and 'teaching'. It would appear that, given that no 'secret society' or religion based on metals exists, information was freely given and shared - a feature of our industry that generally prevails today.

Basically, humans have always had a requirement for materials from the ground, from stone implements to titanium alloy castings for jet turbine blades. Having established the need, someone has to look for it. Many of you have decided to join that group and to become explorationists - is it, I hear you cry, intuitive or can you learn it? My belief is that both are required but you may find that in your career you will come across those people who have a 'nose for ore'. Many of them will have had no formal eduction but have built up an empirical data base that leads them to mineralisation. Others may

lack that practical nature but can, by following the academic approach (but still getting their hands dirty from time to time) develop new models for emplacement of ore - predictive geology. The rest of us sit somewhere in between the two extremes: the art form or geological poetry and pure geological science.

PROSPECTOR OR GEOLOGIST?

What was to stop any of you, on leaving high school, from throwing a pack on the back of a trail-bike and heading off to look for a mine? Where would you go? How would you start looking? What techniques would you use? Who was going to pay for it? A decision was made presumably to indulge in a little education. (As the years go by and you look back on your time at University you will realise the thing you will have (or should have) best learnt is **how** to learn because in geology, more so than in the more predictable sciences the empirical data gathering, storage and understanding process is critical).

When you emerge from these hallowed halls, if you enter the corporate exploration industry, you will not be expected single-handedly to find a mine but you will be part of a team working towards that objective. Let's look at the processes involved and later consider some case histories.

WHICH, WHERE AND WHEN

My role, as an Exploration Manager for Delta Gold, is to create the environment for my team to make discoveries. I have to consider the following aspects - **which** commodities will we look for and

where will we look. When we will look for them is determined by elements of which and where.

Which commodities to explore for is a function of perceived demand, market price, risks and potential for discovery. Recent history indicates that at various times, (roughly cyclically) metal prices increased; then the exploration rate increased, the discovery rate increased, the production increased and, predictably, metal prices fell. Ideally one should be a counter-cyclical explorer and thereby ensure that your discovery comes into production as the metal price heads for its peak ensuring rapid capital repayments, early profits and increased exploration budgets. I do not know why it doesn't always work this way although one could argue that exploration in the period 1990-1993 **has** followed a counter-cyclical trend in base-metals. This aspect could bog us down for the rest of the day; the most important thing to remember in terms of mineral commodities is that the best ore bodies are the ones from which the metals can be produced at the low end of the cost curve. Market price will determine the size of your profit or loss but if you can outlast your competitors and survive by producing metals cheaper than all or most other mines, you'll live to find another one. High tonnage/low grade = economies of scale and long life, but exposed to cost pressures/price drops. High grade = more metal (dollars) per tonne of ore and lower unit cost.

The risks associated with exploration and mining must be considered. Are there sovereign risks, environmental risks,

indigenous-people risks? All these factors may mean that a discovery, with all its costs (people, lost opportunities and dollars) may be worth nothing at the end of the day. Coronation Hill, uranium mines in Australia, Bougainville - the risks were weighed up before commencement, with variable results. It is worth remembering that the mining industry does not have an unfettered right to explore and mine anywhere and you must judge where the risk, of having what rights that do exist expunged, is too high to justify proceeding.

TECHNOLOGICAL CHANGE

Consider the possibility of technological change. Will lead consumption continue to fall; will increased use of optical fibre erode copper's market; will packaging move away or toward metals? Will future developments create substantial markets for metals which now are barely used? Technological change is often impossible to predict - but stay abreast of new developments, read widely and, in the field, look beyond your immediate targets. Vermiculite, zeolite and clay mines have been the result of base-metal, gold or mineral sand exploration programs that came into their own because changes in the building and environmental industries were observed, and the potential recognised, by geologists with nous who looked beyond their immediate target objectives.

WHERE to explore. We can return to our earliest ancestors and, following their lead, stumble about until we find it. This is **not** a cost-effective approach. 18th century Cornish tin miners said "where she be, there she be". I guess it worked for them, but

perhaps pushed the limits of intuition and empiricism.

The intuitive prospector or empirical geologist will go to those areas with known mineralisation. Our academic theoretician will ponder long and hard and announce that, given various physical and chemical conditions, an ore body will occur in a certain setting. Typically, the rest of us are, once again, somewhere in between.

PROSPECTIVE ENVIRONMENT AND MODEL CREATION

We select a 'prospective environment'. We know it is prospective because it has mines in it or our theoretician has postulated a deposit. We create a model or paradigm for our deposit - its geological setting, the structural components, the alteration patterns we are likely to see, the geochemical halo which may exist and the sorts of geophysical responses we are likely to find. We may extend or refine the detail to include other signs such as vegetation changes or geomorphological features that could be expected, based on our model. We consider its genesis; how could it have formed, how big could it be, is there 'room for ore'?

Our research will include a detailed assessment of our prospective region. I am imagining here a belt of country maybe several hundred kilometres long and maybe fifty kilometres wide; a defined 'metallogenic province'. We start collecting geological data - regional maps in Australia, as you are aware, are amongst the best in the world, but it is reasonable to state that most of the globe has been geologically mapped at some scale. Your primary data base, to start exploring anywhere, is in good shape. We are doubly-blessed

in Australia with the State Mines Departments' Open File Records.

OPEN FILE

All explorers, on relinquishing an area are required to report their findings. There is no point in re-inventing the wheel and subsequent explorers can build on the existing data base. Compilation of Open File data is a crucial exercise. Many discoveries have been made in the third, fourth or even fifth pass of exploration.

One of the most important skills you can develop as young exploration geologists is to find your way through the Open-File System. As an exercise, I recommend that you select an area (within your state) which you think prospective for any metal you choose, then go to the Mines Department Library, access the Open File system and review all the past work in that area. Once you have mastered the system, you should feel entitled to include this fact on your resume when seeking employment - it will indicate you are a useful person, possessed of common sense.

Having established, in your mind's eye, giant gaps in the programs of previous explorers, and, having your confidence increased by observations noted by your predecessors but who missed the significance of what they were seeing, it is now time to check the ground availability. This task can also be accomplished at the Mines Department while you're working through the Open File Data. Ask at the front desk; tell them you're there to learn the system. Tenement locations are usually plotted on 1:100,000 scale topographic maps and include many or all relinquished titles, as well

as those currently in force.

LAND TENURE - AVAILABILITY AND ACQUISITION

You can explore to your heart's content and have the most radical and potentially-successful new geological model ever created but it's little use to you if someone else holds the ground. You can wait them out - leases and licences don't last forever - or you can seek to farm-in to the ground by way of a joint venture. There's no need to go into the combinations here (except to remind you that joint ventures are a frequent occurrence in exploration geology and you should investigate how they're structured) so for the purposes of our exercise today we'll assume the ground is vacant.

Find out whether your chosen ground is open or not and how to apply for title to explore for minerals. Find out the costs and obligations in regard to work programs, expenditure, rehabilitation, environmental protection, landowner rights and reporting obligations.

Having got through these stages and then obtaining title to an Exploration Licence it's time to start exploring. Your education here has taught you the variety of techniques that will be used. Experience will help you refine them and I wish only to offer some more general advice based on my observations over the years:

SKILLS REQUIRED

Good geological observation and interpretation is critical - understanding the signs revealed by the rocks is a skill that you must work at on every field trip. Keep the blinkers off. You must

have objectives and by all means focus on achieving those but every so often, step back and look around to see what else may be happening. Look for the large-scale structures that may be revealed in outcrop or hand specimen, or vice versa. Use every tool available - satellite imagery, air photos, existing maps - verify previous interpretations, try and overturn them - be critical and questioning. Walk over the ground before mapping. Collect and analyse as many rock chips as possible for geochemical responses and petrology. Relate your assays to the rock - it's the start of your own internal database that will create your geological intuition. If you suspect subtle alteration or find a 'mysterious' rock, examine thin sections - keep your petrological skills high.

IGNORE ARTIFICIAL BOUNDARIES

Look beyond the boundaries of maps and tenements - too many people fall into the trap of restricting themselves to artificial boundaries. The clues to ore in your ground may lie elsewhere.

CURIOSITY

Be curious. Look for solutions or explanations to geological problems. Think about the environment that created the rock you're looking at, what changes have been wrought on it and what that means to the surrounding area and potential ore deposition. Be sceptical - having geological arguments is an essential aspect of being a geologist and is often a good excuse for another round of drinks. Dogma does not sit well with most geologists.

SKILLS REQUIRED

You should try to develop skills that as well as being useful generally will make you more employable.

Exploration geologists should have some bush skills and be useful around a camp. Some mechanical/electrical aptitude is helpful for vehicles and equipment. Diplomacy in dealing with land owners is frequently required. (Leave gates as you find them, check stock movements, don't drive on boggy tracks or through crop paddocks). Four wheel-driving skills, first aid knowledge, surveying techniques and bush crafts should all be developed. Financial skills are required - from budget planning to understanding the practicalities of a mining operation. Exploration geologists should visit as many mines as possible. Enquire about tonnes/grade, consider grade variations, ore body geometry and the effect on mining technique and rate. Consider production rates and what determines them as well as production per man, costs, equipment and mining methods. Be aware of the metallurgical problems that can arise - what costs do they add to an operation. Consider the complexities of metal marketing - almost a black art, certainly arcane but essential. Look at the differences between marketing precious metals versus base-metals or coal and the different approaches - concentrates, smelter products or refined metals and the combinations and permutations of these products. What tolls or penalties might be imposed for contamination metals or credits for, say, gold/PGM's in concentrates.

Own (at least) your own geology hammer, hand-lens (20x), and compass. Buy the Field Geologists' Manual Monograph 9 and both volumes of Geology of the Mineral Deposits of Australia and Papua New Guinea from the AusIMM.

ON GEOLOGY/GEOCHEMISTRY AND GEOPHYSICS

Someone was discussing remote sensing at a conference and it prompted one individual to remark that geological thinking is the deepest penetrating remote-sensing technique we have. In a sense it can be extended to the centre of the earth or out into the solar system. In exploration, that kind of far-flung extrapolation is not required but whether we go to the science fiction end of geology or try to predict what's under the ground, we have to start from one premise. That is, the more data points we have from surface and near-surface techniques the more accurately and further we can extrapolate. I might as well air some personal prejudices here for you to take on board and consider. Magnetic and gravity data are more **directly interpretable** than electrical geophysical data. Drill sooner rather than later; there will be very few wasted drill holes provided you maximise your use of the information that comes out of a drill hole. If the data doesn't fit the model, change the model. Let us have a look at as many examples of ore body discovery as time will allow and how the extrapolation process, and the other features I have mentioned, apply to them.

Olympic Dam

Jabiluka

Escondida

Mercur

Pine Grove

Maureen

Starra

Elura