Mineral Geophysics – Two Decades of Change

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SUMMARY

Over the last couple of decades, mineral geophysics has benefited from well documented advances in various technologies. Airborne gravity gradiometry, DGPS, GIS integration, radiometric noise reduction, 3D electrical / seismic acquisition, 3D inversions of potential field and electrical data are particular examples.

Less documented are the newer demands placed on mining company geophysicists. Examples include formulating safety management plans and auditing air safety compliance, monitoring field safety as much as technical details and complying with relevant legal restrictions in different jurisdictions. All the while the modern geophysicist must stay abreast of an increasing number of software applications, ensure quality communication with geologists on issues of target generation and method limitation, while geophysical staff numbers have typically decreased. The vast amount of data available in the 21st Century has added to the importance of "sorting the wheat from the chaff".

Geological and geochemical ideas have also evolved over the last two decades, and geophysicists must understand terms such as IOCG, porphyry and low-sulphidation epithermal. Geophysical responses and tools need to be evaluated for each deposit style and an objective and critical consideration maintained to constantly review whether the exploration model is appropriate or too restrictive. Pushing the search to new frontiers by proposing new, deeper and more conceptual targets as a part of the exploration portfolio is important to help limit excessive revisitation of previous outcropping targets.

As for the next 20 years, some possibilities include more airborne methods, UAVs, and better models.

Key words: technologies, mineral, geophysics, safety.

INTRODUCTION

Over the last 20 years or so, mineral geophysics has benefited from advances in various technologies. Some examples include airborne gravity gradiometry (DRANSFIELD et al , 2001), Differential Global Positioning Systems (DGPS), Geographic Information Systems (GIS) integration, radiometric noise reduction (MINTY & McFADDEN , 1998), 3D electrical acquisition (WHITE et al , 2003), 3D seismic acquisition, and 3D inversions of potential field and electrical data.

These advances have been partly enabled by advances in computing technology, including faster data processing and expanded storage options, email, internet, mobile and satellite telephony, and the move towards industry standard software and data formats for the vast quantity of government and open file data now available in some countries.

Many papers have been written about these advances, with the above references just a very small sample.

The purpose of this extended abstract is primarily to point out some of the less well documented newer demands placed on mining company geophysicists.

Some of these demands include dealing with company supply departments, formulating safety management plans for each job, checking current safety audits exist for airborne operators, monitoring safety in the field as much as technical details and complying with relevant legal restrictions in different jurisdictions.

At the same time, the modern geophysicist must stay abreast of an increasing number of software applications, ensure quality communication with geologists on issues of ground selection, drill target generation and method limitation. Over the same period, mining company geophysical staff numbers have typically decreased.

The vast amount of data available in the 21st Century has added to the importance of prioritising what is really important in the information.

Ideas in geology and geochemistry have also evolved over the last 20 years, and geophysicists must understand exploration models – examples being Iron Oxide Copper Gold (IOCG), porphyry and low sulphidation epithermal. Geophysical responses and tools need to be looked at for each deposit style and an objective and critical consideration maintained to constantly review whether the exploration model is appropriate or too restrictive. Pushing the search to new areas by proposing new, deeper and more conceptual targets as a part of the exploration portfolio is important to help limit excessive revisitation of previous outcropping targets.

THE CHANGING PRIORITIES OF MINING COMPANIES

There has been a massive change in the approach to safety in the industry over the last 20 years, which has been very beneficial in reducing the rate of lost time injuries (LTIs).

LTIs and fatalities still exist in the industry, so there needs to be constant focus on managing risk and trying to reduce incident rates further.

When the author started vacation work as a student in the Super Pit in 1987, safety was all about Personal Protective Equipment (PPE) and golden rules for dismissal, such as driving past blast guards. Safety concepts such the hierarchy of control, fitness for work, inductions, peer observations, see stop control/take 5, safety management plans and semi quantitative risk analysis were all in the future for the mining industry.

During the early 1990s, mine sites started introducing inductions. Random drug and alcohol testing was also introduced to some mine sites, but was just about catching people, not as part of a wider fitness for work education program (which also includes fatigue management and illness management).

Into the mid-1990s, and it was finally recognised that "learning lessons the hard way" and "work hard, play hard" were not healthy attitudes to have in an industry with heavy machinery, light vehicles, aircraft, and remote areas. Pit permits were also introduced for driving light vehicles.

State mines departments in Australia started introducing "risk managed" style legislation, where mine management had to have risk management systems in place, rather the department prescribing "safety fuse will be 2m long", as an example.

Early in the 21st century, many of the DuPont safety systems were introduced to the industry, and included peer observations, safety management plans for each job, and see/stop/control processes, where individuals think about and document the risk before they start on a new or different task.

There was also a focus on leading indicators, such as serious potential incidents (SPIs), where a golden chance has been given to learn from an incident without an injury occurring. Minor injuries (MIs), could also be a useful leading indicator towards more significant injuries around the corner.

Airborne survey companies were also required to do a job safety analysis for each job done at "Australian altitudes", often less than 40m above ground level.

These measures led to a reduction in lost time injuries in the industry, but did not really reduce fatalities. As a result, the industry started to think about Semi Quantitative Risk Analysis (SQRA) for the big and fatal risks, and bowtie flowcharts of the actual accident process. This led to certain critical controls for each type of incident, an example being the audit of aviation companies before an airborne geophysical survey.

At about the same time, supply departments were introduced into mining companies, to optimise costs, reduce the number of contracts, increase scope, and identify synergies between different sites and departments. The mining company geophysicist needs to work with supply departments to achieve the best outcomes for the company.

The net result was that in the space of a few years, initiating a group of geophysical contractors was more than a bit of technical thinking, and signing a carbon copy purchase order or service agreement supplied by the successful contractor. It became a concept of design, involvement with supply departments in tendering, ensuring relevant audits were in place, formulating a safety management plan in consultation with site personnel, and supervision on site for safety as much as technical aspects.

This applied whether the activity was on a mining lease, or a remote exploration lease well away from a mine site.

Recently, some jurisdictions in Australia have also started to heavily regulate how electrical geophysical surveys can be conducted. This type of survey has "flown under the radar" for many years, partly because it was often done in remote areas away from mines inspectors, and partly because of the good safety record. The industry is currently formulating standards in response. Until these are finalised and accepted in most states, there will be a period where companies have to persevere with their existing standards, and liaise with relevant authorities in the relevant jurisdiction.

THE CHANGING WORLD OF TECHNOLOGY AND DATA

During the mid-1990s, access to a geophysical workstation with a 4 MB graphics card and in house company software was a blessing for a geophysicist.

The acquisition of a new dataset was an occasion to be celebrated for days, weeks or more, and data was imaged and analysed from every sun angle possible on a shaded surface display on the workstation as an example. A0 colour printers were rare, so the selected best image was often written onto expensive film at external photo houses. So much of the world was a "blank page" from a data point of view, so that the main skill was how much could be interpreted from the existing data. Often the company had one geophysicist per site, so that the entire universe for that geophysicist was a 60km radius from his office.

Today, emails come through every few minutes with drill intercepts and other press releases from around the world. The datasets that can be downloaded from government websites (both government and open file data) in a number of countries are vast. A new important skill is now required in the 21st century – sorting out what is really important from what moderately important. It is a skill that can only be learnt on the job, and not taught at an academic institution.

This explosion in data has only been possible by the geophysical industry moving towards industry standard hardware, software, and formats, as well as the internet and email becoming mainstream.

The ascent of this standardisation and widespread internet technology in the late 1990s, also coincided with many of the big cutbacks in mining company geophysical staff starting around 1997. This started in the big multi-commodity mining houses, and then spread to many of the mid size companies through takeovers. A number of these geophysicists were lost to the industry forever, some went into the pool of consultants,

while others went into junior companies, often in management. The main trend of centralisation in a few capital city offices started, and this trend has never really reversed, and may never reverse. However, this has allowed some consultants to work from home at their preferred rural or coastal retreat.

This trend meant that mining company geophysicists' workloads were spread across a number of sites, often the entire company.

While there has been an increase in standardisation of formats, there are nevertheless many new software applications to learn.

In the mid-1990s, a mineral geophysicist was fairly happy to have some basic geophysical processing and imaging software, perhaps a 2.5 D potential field modelling application, and often interpreted Induced Polarisation (IP) pseudo sections qualitatively.

With the advent of widespread GIS, the geophysicist was expected to integrate data into GIS, and be more creative with how it related to geology and geochemistry. There was now a requirement to be an expert in projections and datums, as it became obvious that previous inaccuracy was often corrected by fudging the layers of paper on the light table.

In recent years, the increased acquisition of geophysical datasets in 3D and the use of 3D software by most geologists have led to an expectation that all models will be able to be displayed in a 3D format, or at least a series of sections in 3D. Even where a 2D or 2.5D model may be quite appropriate for day to day exploration purposes, there is an expectation that 3D will be better in some cases.

It is important to continue to communicate the pros and cons of modelling approaches for different methods, as well as the difference between forward modelling, smooth model 3D inversion, and other approaches.

THE CHANGING WORLD OF GEOLOGY

There is a common perception that geology as a science was pretty much locked down in the early 1970s after plate tectonics became mainstream, and hasn't changed since – nothing could be further from the truth, especially in the exploration world.

Many exploration models have changed from syngenetic to epigenetic – i.e. mineralisation now believed to have formed post deposition or eruption. Terms such as IOCG came into widespread use in the late 1990s. Before that there was knowledge of very significant deposits at Olympic Dam, Tennant Creek, and Cloncurry, but no widespread term to focus exploration personnel on the style, hence appropriate geophysical and other tools.

Geologists have started to understand to a greater extent that geophysical exploration tools in areas of post mineral cover can "leap frog" to a discovery faster, as it allows a percentage of the drill holes to focus away from the same known outcropping prospects, many of which have been visited by 10 or more companies.

Keynote speakers for the last 20 years have talked about exploration going deeper. While this is certainly true in some cases, and some great copper-gold deposits have been found at around 500m depth with a view to cave method mining, this does not seem to have been the overall case in the last 20 years. Mining companies have decided they still prefer the economics of open pit mining, and have used many of the same basic methods, expanding the search to what were once considered high risk countries.

THE NEXT TWO DECADES

Predicting the future has always been difficult, and is becoming more so. In the past, people could take comfort from notions such as "most of the tooling for the next 10 years production has already been built". The advent 3D printers mean that it is very difficult to predict what products will look like in 10 years time – except that they will be optimised for cost and efficiency.

Unmanned Aerial Vehicles (UAVs) already have a wide awareness in the community, mainly from the publicised military use. Their use will increase for geophysical survey work. Legislation is lagging the technology, but is catching up in countries such as Australia and the United States. The UAVs will evolve to be bigger than people think, to reduce instrument noise, and allow carriage of safety features where possible such as mode S transponders and Automatic Dependent Surveillance Broadcast (ADS-B). These safety features will allow enhanced situational awareness for other aircraft and air traffic controllers. Backyard operators are being eliminated from the UAV industry as the cost of liability insurance premiums is factored into business models.

There will be advances in other areas of geophysics also, but physics can only bend so much – the earth will always be a giant low pass filter, and weathered hard rock areas will still present some limitations for some of the electrical and seismic reflection methods.

CONCLUSIONS

The last two decades have had great change in mineral geophysics. The rate of change will increase in the future, and there are many "Eureka Moments" to come.

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