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Reviewing historical trends of geological training in the mining sector

Geoscience Society

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This article examines the historical trends of geological training and development for students and industry professionals in the mining sector.

It reviews the history of geological training and looks at what is common in business today. A series of recommendations is suggested to improve the state of geological training in the industry in order to maximise the value of professional geologists.

The underlying message in this article is the importance of a strong scientific foundation based on field observations, continuous challenges and varied experiences for career success. Unfortunately, history indicates that many universities and companies have let down geologists, resulting in fewer high-performing and well-qualified geologists entering the industry over the past 25 years, followed by underdevelopment once within industry. This in turn has resulted in fewer geologists in executive roles at major mining companies and a downward trend in significant exploration discoveries.

Throughout this article, the term 'training' is used, which should not be confused with external courses or classroom work. In this context, the training is a combination of university degrees, hands-on experience and on-the-job training, all supplemented with professional coursework.

A short history lesson

Geological field observations are the heart and soul of geology as a science. Mathematicians have their formulas, chemists have their laboratories and geologists basically have the outdoors (the parts that are not covered by concrete at least).

It all can be traced back to Georgius Agricola's *De Re Metallica*, published in 1556 (Figure 1). This is commonly considered the first scientific work in the field of mining geology. He presented the fundamental principles and considerations for mining and discussed the benefits of understanding what would later be termed 'economic geology'.

The science of geology began to consolidate as a discipline in the late 18th and early 19th centuries as the pioneers of the science applied their meticulous sense of observation and scientific thought to 'problems' observed in the countryside. In 1785, Scottish physician James Hutton's observations led to the *Theory of Uniformitarianism*. Hutton's work greatly influenced William Smith as he created the world's first geological map in 1815. Fifteen years later, *Principles of Geology* by British lawyer Sir Charles Lyell was published. By then, the science we know as geology was in full stride based on detailed field observations and interpretations of the Earth's processes over time.

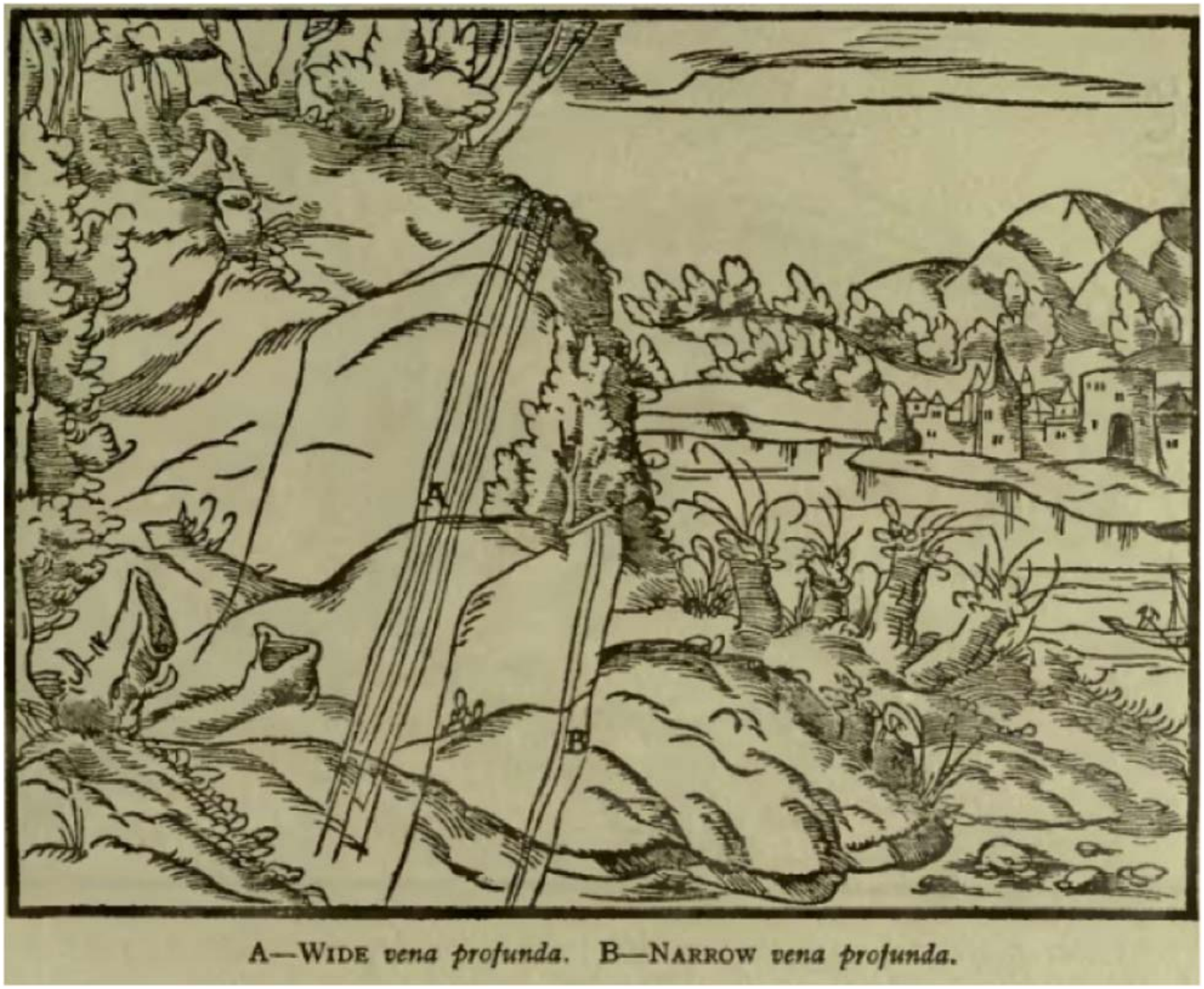
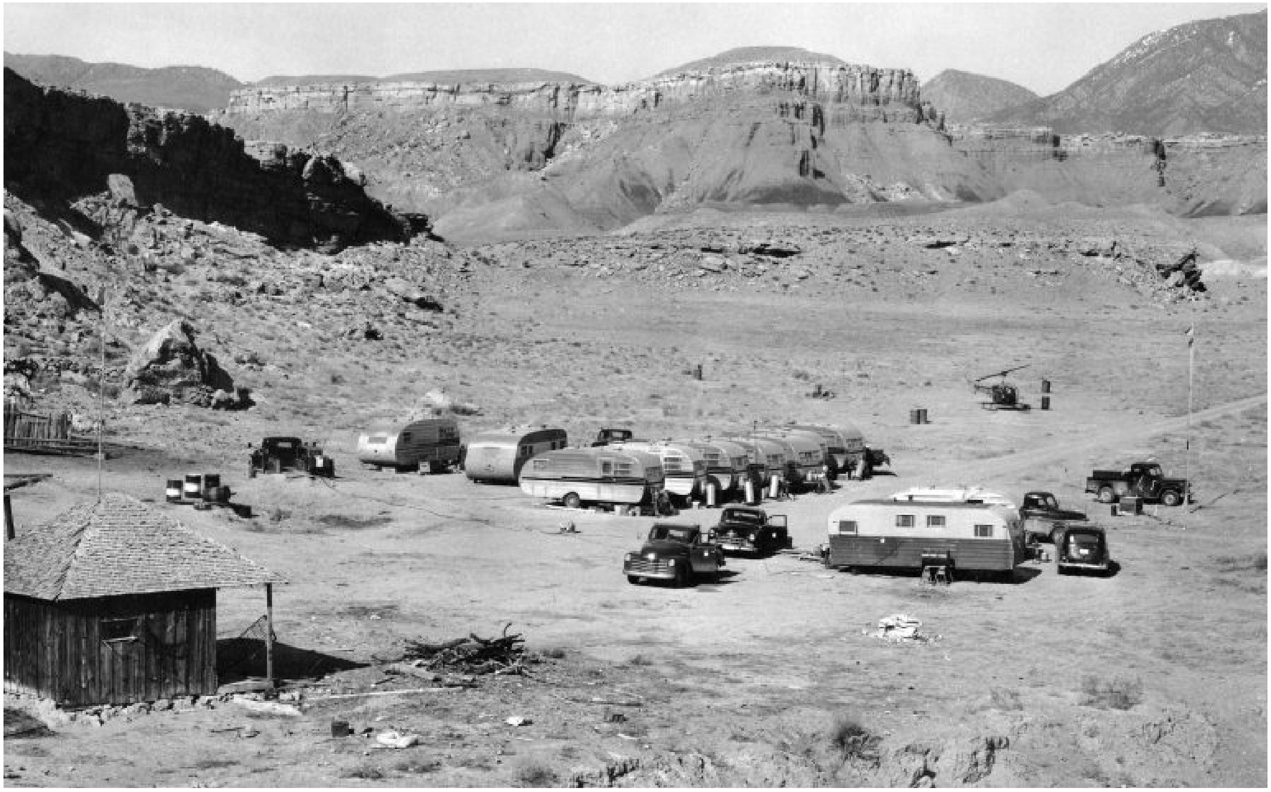


Figure 1. Wide and narrow veins as illustrated in De Re Metallica circa 1556.

Beginning in the late 18th century, new universities were being established around the globe that focused on providing engineers and geologists to support the mining and petroleum industries. These specialist schools were born out of the need to understand the Earth and train young men (as was the case at the time) to work in the mines. Some of the first mining universities included St Petersburg School of Mines in 1773, the Royal School of Mines (Imperial College London) in 1851, the Colorado School of Mines in 1874 and the University of Witwatersrand in 1896 (random fact: the world's first 'school of mines' was established in 1716 in Joachimstal, Czech Republic).

Little changed until the early 20th century as geologists roamed the countryside or ventured underground making observations, maps, cross-sections and interpretations about the Earth. They inferred the processes, hypothesised on formation, speculated on ages and were largely focused on the economic benefits that the Earth could provide. Training was more applied than scientific at times but was continuously evolving and advancing.

Golden age (1950s through 1980s)



US Geological Survey 1950s field camp.

During the post-war years, especially in the Anglosphere (US, Canada, Australia and South Africa specifically), economies were strengthening, commodity prices were high due to industrial demand, mining was profitable and jobs were available for returning servicemen. Men returning from war flooded universities, and geology departments were training students in classical field methods.

There was still a strong geographic emphasis based on regional job demands such as coal in the eastern parts of both the US and Australia; underground mining in South Africa, the Rocky Mountains and Eastern Canada; and copper in Arizona and Chile. Students obtained a strong foundation in the science, learning how to think, record data and make sound observations. Universities were relied upon to supply the new engineers and scientists directly to the mines. This resulted in curriculums including courses in mining, surveying, assaying and so forth. Additionally, many students could work part-time during the school year as junior geologists, surveyors, assayers or miners. This work experience, along with a highly applied course curriculum, resulted in students immediately ready to jump into industry.

Once hired by a company, the expectation was that the geologist would stay with that company for most, if not their entire career and the company would develop the geologist to be a productive member of their exploration or mining team. For example, when geologists started with Anaconda Copper Mining Company during the 1950-1970s, they were immediately shipped off to Butte, Montana to learn the 'Butte mapping method'. After a year or two of learning and leading mine production crews along veins, the competent geologists would be sent around the world to put their practical knowledge to use elsewhere in either another mine or to explore in Australia, Africa or South America.

Training was applied and practical, but by now the science had advanced to gain a new understanding of orebody genesis, new research was more easily shared through publications and classical field observations supported by science were still the foundation of learning. Investing in an individual's development was of great benefit to both the company and the geologist, with long-term views held by both parties.

Earth systems age (1990 through 2000s)

Beginning sometime around 1990, a paradigm shift occurred in university geology departments around the world. It is unknown whether this was a trailing response to the early 1980s crash in metals, the environmental movement in the Western world or many 'first world' mines closing due to exhausted ore, but traditional geology departments were falling out of favour and struggling with enrolment and support. The classical 'hard rock' geology courses and professors were slowly being replaced with 'Earth systems' classes loosely covering any Earth-related science, from climatology to meteorology to soil contamination. Universities were under pressure to 'modernise', with many of the 'old school' professors whose work was primarily field based replaced with environmental generalists, laboratory geochemists, GIS specialists and other disciplines more traditionally found in geography, cartography or environmental science departments.

Field courses, the capstone of university geology, declined due to costs, liabilities and the perceived need to generate generalist Earth scientists. Additionally, many students experienced a squeezing of core geology subjects, resulting in many petrology/mineralogy classes condensed into a single semester. These graduates, who have taken one or two courses in multiple subjects such as environmental science, geology, hydrology and a myriad of other physical sciences, become qualified for one thing – attending graduate school to further specialise. Unfortunately, they tend to be ill prepared to enter any specific industry or field without years in technician-level roles to learn the trade.

I am not suggesting that the various Earth sciences mentioned in this article have no merit, far from it! They are all important disciplines in modern life and society. But my argument is simply: do not label a degree 'geology' if the courses to obtain that degree are not actually geology but instead generic Earth sciences.

If a degree program is in geology, then the university should aim to produce graduates who are scientifically-sound general geologists with a fundamental understanding of mineralogy, structure, petrology, field mapping, geomorphology and stratigraphy. This understanding should be further refined with upper-level courses in disciplines such as petroleum geology or economic geology. In short, if a student wants to learn geography, GIS, environmental science or another discipline, that's great! Just please don't try to pass it off as geology.

During this time period, many of the larger, well-funded mining corporations stepped up their graduate programs and became increasingly selective as to which universities they recruited incoming graduates from. It wasn't all negative though as much of the applied 'real world' training shifted from universities to companies, meaning that the geologists lucky enough to land a role in a graduate program during this time greatly benefitted from the development. Unfortunately, many did not have this luxury. Additionally, students were further hampered by several bust periods, where companies simply did not hire. This in turn resulted in many geology graduates seeking careers outside mining or geology entirely, evidenced by my old postal delivery guy had a degree in geology from a lower-tier school.

Data processing age (mid-2000s to today)

The biggest and most defining change during the current period is the accessibility and use of personal computers to process massive data sets. The trend began in the late 1990s, but today we see almost everyone with laptops, tablets, smartphones and interconnected devices on nearly every mine and project site across the globe. We now possess the ability to rapidly model the Earth in four dimensions (3D plus time) and the capacity to process a previously unheard of amount of data. As a result, it would be a logical conclusion that our observations, understanding and models of the Earth are more robust, better informed and overall closer to 'the truth' than ever before. Unfortunately, we have become data rich and knowledge poor in many cases.

The reliance on data processing and technology, instead of a fundamental understanding, is a serious problem that the industry is facing. There has been a trend in the mining industry, likely accelerated by the recent boom, toward the geologist's role being reduced to a well-paid technician tasked with collecting basic data then inputting it into a semi-automated system for use in mine planning. The norms are shifting away from scientific thinking, innovation and creativity to efficiency and increasing the speed in which outputs are produced, while at times compromising quality (ie intrinsic models, automated sections and black box software).

Whether it's the chicken or the egg isn't clear, but one has to think that if your geological workforce isn't capable of creative, innovative and generative work, you certainly won't see them leading companies. Alternatively, if there are no geologists in upper management, how does one expect proper development and succession planning to train geologists to be tomorrow's leaders?

Over the past 15 years or so, I have had the unfortunate personal experience of working with multiple graduate geologists that made me suspect their attendance at university. Not only were some grads hopeless in the field, many of them wanted nothing to do with stepping away from the comfort of their cubicle and computer screen. Somewhere in their education, they believed that staring at endless spreadsheets or 3D wireframes would be sufficient to work out complex geological problems and effectively communicate their recommendations to management. The good news is that I've also had the privilege of working with some highly competent graduates, most of which were advanced degree students working under great advisors at select universities.

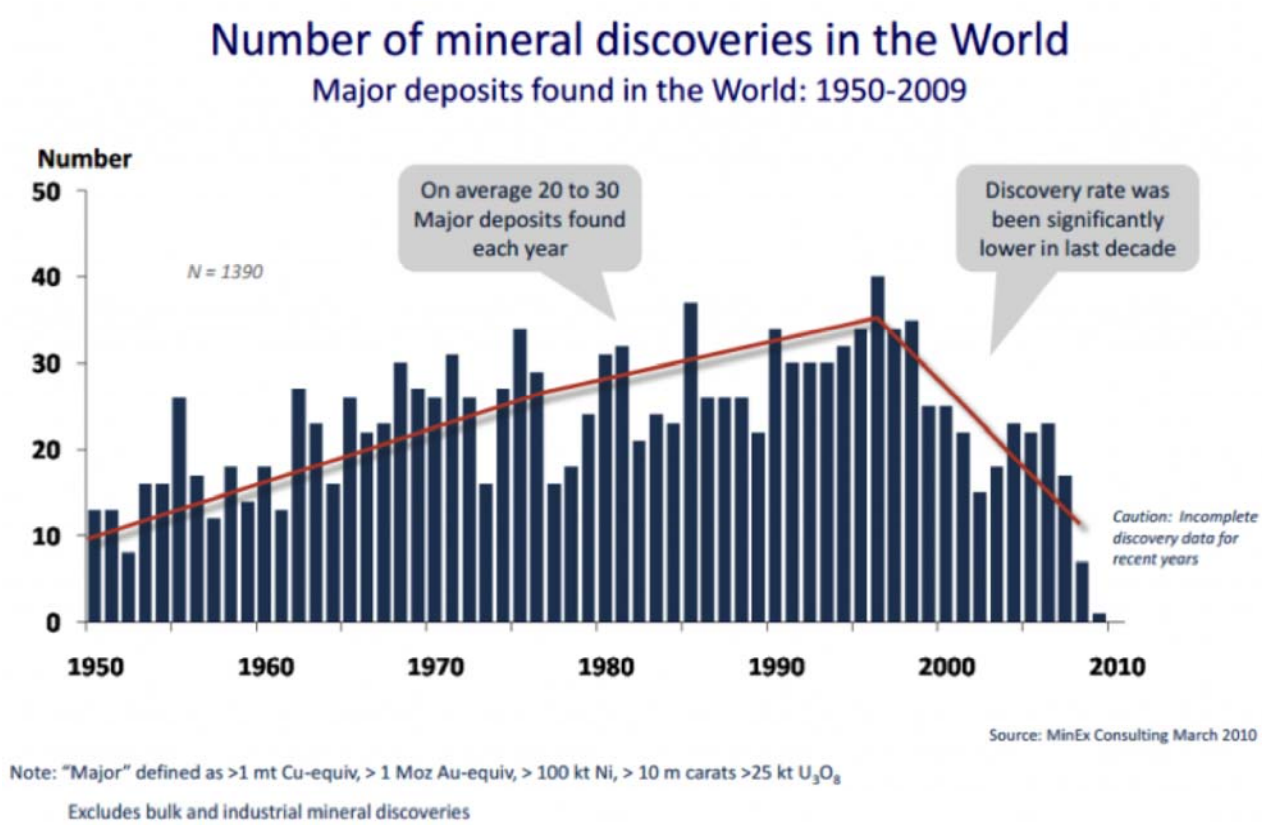
Figure 2. Which environment would cultivate creative thought and fundamental understanding of the Earth and be likely to lead to new discoveries?

Future trends

So this brings us to today and a look at where the industry may be headed. Undergraduate programs have been underdelivering classically-trained geologists for more than 20 years, company graduate programs seem to be a distant memory due to cost cutting and orebodies aren't getting easier to find. Yet the industry continues to ask 'where is the next major discovery?'

If we don't train our geologists in the fundamentals of the science, teach them to be creative thinking scientists and spend time to mentor and develop them, but instead task them with mind-numbing technician or data entry work, is it any wonder that we see a decreasing amount of geoscientists in upper management and that global mineral discoveries are on a downward trend?

A paper presented at the 2010 Prospectors and Developers Annual Conference looked at the trends of major mineral discoveries from 1950 to 2009. Though this data isn't quite up to date, the trends are obvious.



Source: Schodde R, Prospectors and Developers Annual Conference 2010, MinEx Consulting.

The reasons for the sharp decrease could be the subject of an entire conference in itself, but the recent insufficient training and development of geologists are likely a contributing factor. The industry as a whole must demand more of geologists but, in the same breath, be willing to support the training, mentoring and development of individuals if the expectation is to find the next world-class orebody. If current expectations were to simply tick checklists of logging data, create graphs of assay values and ensure workplace safety, then I'd say we've already achieved that today. But if that was truly the case, why hire university-trained professionals when most of that work can be automated or outsourced to unskilled workers? If the industry wants scientists to make discoveries, we need to start doing something to change.

The sky isn't falling quite yet

Of course not all is lost! The fact that you are reading this article and have persevered this long with it means that there are geologists out there who recognise this troubling trend and want to address it. The good news is that there are still a few post-graduate university programs that are producing highly-qualified, classically-trained geologists, with many dynamic junior explorers making discoveries around the globe.

To start, I've presented a checklist of recommendations to consider if you want to obtain well-qualified, highly engaged and capable geologists who will make discoveries, improve your business and lead the industry forward. It doesn't happen by itself, it's not free and it takes a long-term view and commitment by companies and professional societies.

Recommendations for companies

Commit to long-term graduate training

Graduate geology programs must expose the geologist to mine geology, resource geology, exploration and production leadership roles in the first few years. Additionally, they should gain an introduction to mine planning, surveying, metallurgy/processing, logistics, finance and management. Similar to mining engineering graduate programs, the individual needs to experience a wide range but be held accountable to produce with high expectations. Graduates are not for getting coffee or doing the meaningless tasks; challenge them hard and both the company and individuals will greatly benefit.

Screen your people well and only hire the best

Set high expectations and don't settle for underperformers. Each graduate should be viewed as potential upper management or the next chief geologist. When you view the new hire as your potential next boss, it starts to hit home. If an individual does not thrive in a graduate program or rise to the challenge of a role, you're only doing the company and the shareholders a disservice by continuing to employ them.

Provide a mentor

A mentor can't be someone who drew a short straw, it needs to be a person who's keen to develop someone and willing to spend the time and energy required. This may be a senior geologist, a manager or even someone from outside the company. But the importance of the student-teacher relationship is key and will separate out those determined to succeed in the industry. A mentor should be someone who has seen career success, not someone that has just been promoted due to attrition. Additionally, companies must reinstate the old 'bag carrier' roles that allow high-potential geologists to gain insight into the upper workings of management and the challenges that the business faces.

The geologist who sees the most rocks wins

This has never been truer. For a geologist to succeed, they must be exposed to various terrains, field conditions, commodities, exploration techniques, mapping and as many field trips as possible. It's rare these days to hear of a company-sponsored field trip to allow geologists to gain a broader understanding of an area, mine site or district. Additionally, presenting at conferences and attending talks are crucial to facilitate learning, share new ideas and collaborate with other professionals, which is what science is all about. Denying geologists the ability to attend industry conferences greatly inhibits their ability to learn from others outside their immediate network or team.

Recommendations for geologists

Obtain a graduate degree

If you're serious about a career as a geologist, obtain a graduate degree (that means a Masters or PhD). Seek out a university with a strong applied focus and healthy ties to industry. Use the connections, internships, research projects and alumni to leverage a broader exposure to the industry. Take as many field trips as humanly possible. If you're already a working professional, consider a part-time program or graduate certificate, but keep learning.

Define a development plan

This should be at least a five-year plan with options to vary depending on changing interests. This may be a graduate development plan or a late-career plan; the important thing is to just have a plan. The simple analogy is true that you won't get to where you want without a map. A mentor comes in handy here when you're stuck.

Challenge your comfort zone

Comfort is the antithesis of innovation and original thought. This point is more geared towards mid-career professionals, but may also apply to many. As soon as your job becomes second nature, find a new job. Learn as much as you can from other disciplines and about the mining business in general, get exposure to various commodities and never stop learning. Personal and professional growth does not happen while in your comfort zone. Learn to be comfortable with the uncomfortable.

Find time to stop, think and question

Many times, we get caught up being busy and mistake it for being productive. We must stop to think about what value we're providing or why we're collecting the data, how it is being used and ask if there is a better way. Schedule time to think big picture, and ask yourself if the work you're doing is directly contributing to the company's goals (first, make sure you know what the company's goals are!). Is your daily work akin to the creativity and innovation of Google or more similar to a Ford assembly line?

Consider your peer group

To quote Jim Rohn 'we are the average of the five people we spend the most time with'. Consider that your peer group heavily influences your work habits, drive, ambitions and, especially, your expectations. If you look around and find that you're the smartest or hardest working person in a room, it's time to change rooms.

To recap, ensure that you have a sound understanding of the fundamentals and feed your curiosity daily with new challenges and creative thought. Take time to make a development plan, seek out advice from respected peers and ensure you're being challenged. If you lack the fundaments, find a way to get back to basics and get a mentor to guide you on your journey.

Thank you for taking the time to read this article, and I hope that it helps open some eyes to the broader industry trends and that we start reinvesting in people and science going forward. I encourage you to comment and provide feedback. Be sure to check out similar articles and supporting information at www.mininggeologyhq.com (http://www.mininggeologyhq.com).