EXPLORATION RADIO

Episode 19

SKATEBOARDERS AND BASEJUMPERS
with
John Vann

EXPLORATION RADIO is a podcast focusing on the past, present and future of exploration. Hosted by Ahmad Saleem and Steve Beresford, the show is impartial with the content produced, intending to unearth fresh perspectives on issues and challenges faced by the global resources industry. This podcast is free from vested interests, is self-funded with limited sponsorship, and is freely available on iTunes, Apple Podcasts, Stitcher Radio, Google Play, Spotify, or through our website:
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He holds Adjunct Professor appointments in Geology at the Centre for Exploration Targeting, University of Western Australia & the WH Bryan Centre at the University of Queensland and keeps a wide interest in strategy, technology, systems and mathematical geology.

Ahmad: Hi, my name is Ahmad.

Steve: Hi, my name is Steve. And this is Exploration Radio, a podcast focused on the past, present and the future of exploration. Today, we're going to talk with John Vann, who's the Head of Geosciences at Anglo American. Welcome, John.

John: Thank you.

Steve: Can I get you to introduce yourself and tell us a little bit about your background?

John: Okay, thanks. I started life studying geological engineering. I got three years into that and suddenly I had this epiphany that I didn't want to measure cracks forever. And I actually saw Ian Plimer give a very inspirational talk about Broken Hill. And I thought, "That sounds interesting, I'll become an exploration geologist." So I went off and did an Honours year with Ian and then I joined RGC Exploration, one of those many companies that don't exist anymore. Actually I started my career there as a mine geologist, and in those days they had really structured graduate training schemes. All these companies did. It's one of the things that sort of evaporated I think and needs to come back. So I did a year working in mines, and then a year working in exploration, or something like that.

Steve: A couple of inspiring people early on?

John: Pretty inspiring yes, which is another kind of theme that goes through all of this you know. Mentors are really important, and they don't accidentally come along you seek them out actually. So I did that for a couple of years, and then I went into the exploration division of RGC. I was involved in the discovery of a couple of modest-sized gold resources around Mount Magnet. And that caused me to slip into the dark side. I was given the task of doing an initial estimate of resources. And this was just addictive for me because of my two interests in life: I'm very interested in geology and I'm very interested in numbers. And so suddenly, I saw these two things collide. And I thought this was brilliant.

So I ended up going off to the UK, I did a Master's degree in geostatistics. And I came back and worked for a while with RGC, and then went off on a consulting career. I worked initially for the French, as a consultant for a division of the Paris School of Mines in Australia. And then, I worked for SRK. After a couple years, I set up my

own company with a colleague, Scott Jackson. And for a dozen years, we worked as bespoke geostatistical consultants for large corporations, mainly for the BHP's and the Rio's and so on. That was great because I got to go around the world, looking at the world's great deposits. And even though I was there to look at their kriging models and simulations and things, I always got to look at the geology. And the geology of course is the main thing you can get wrong in a resource estimate – actually that's the truth of it.

After a dozen years of running a consulting company, I was headhunted for being VP of Mineral Resources for AngloGold Ashanti. AngloGold Ashanti at the time was being run by Mark Cutifani, who's an Australian and many of your listeners would be aware of Mark. I worked for them, and disappointingly Mark left a couple of months later - I don't think I had anything to do with that. And about 18 months later, there was an ad in the paper saying they wanted a Group Head – is the English title, it's a Senior VP role - to look after geosciences. And in Anglo American, Geosciences was the mining geology, reconciliation ore control systems, mineral resources, all the resources and reserves public reporting, you know the geostatistical stuff, but also the geometallurgy. It was a very exciting prospect for me, and another kind of step up in responsibility and scope. So I took that job and it was just brilliant.

About two years after I joined, Tony O'Neill said to me, "Do you think we should put the operational geoscience and the exploration together. Would you be up for running exploration?" And my first response was, "Well, I'm not really an explorer, right." And he said, "Well that might be an advantage." So I took it on and I've been in that role now for two years. And the last two years has been an amazing adventure. So, that's the story and the journey of where I got to.

Ahmad: To provide a bit of context, this interview was completed just after PDAC in 2018.

Steve: One of the things that's always interested me about your new role is, you're somewhat unique. They're both geology. They're all geoscience. But mining and exploration can be a bit siloed and have very different cultures in some companies. And you now have a perspective, especially a fresh perspective, of

coming into exploration from the mining side.

"...I think (mining and exploration) are not only siloed and different in their mode of operation, to be successful in them requires fundamentally different psychology."

John: Yeah I think they're not only siloed and different in their mode of operation, to be successful in them requires fundamentally different psychology. Exploration is all about finding value and discovering value. And while there are components of that in a mine geologist's mind, "How do I make the process better?" and so on, it's a relatively risk-averse environment. You have to be very careful. Safety is involved in a very different kind of way. You're trying to protect the resource and deliver it very carefully. So, what I often say to my team – I have actually two leadership teams, which also come together and join. So I have an operational leadership team and a discovery leadership team. And the psychology of exploration geologists is a risk-taking psychology. People who don't like putting probability on things are people who don't know much about probability usually. And they'll say, "I don't have enough information to think about probability." And I go that's exactly why you need to be thinking about probability, because you don't have information. If you have all the information, you don't need probability. You just have a plan. So, that's really interesting.

"Good exploration geologists are very imaginative and take significant risks. Not risks in a safety sense, risks in the sense of they're placing bets actually - it's probabilistic."

And being in a position to hop between those two now for a while, I can now see what the connections are really clearly. And really simplistically, what's missing in the mine geology world is good science. Mine geologists get lost in delivering the plan, and the ore control, and the business element of what's going on. And the science often suffers. If you've been to mines where they show you a map of the district that was made in the exploration days and hasn't been updated, this is just routine. It's just not part of the thinking. So, what exploration geology can give to mining geology is science and that scientific-thinking mode. What is missing in the discovery world is an understanding of techno-economics and the fundamental business. If you ask a lot of exploration geologists, "What does good look like? What does discovery look like?" They'll talk about tonnes and grade. "I want to find something that's this many billion tonnes of this grade." This is not a value proposition. Because if I put that same thing into the Highland of New Guinea it doesn't make money. And if I put it under 2m of cover in central Queensland, it's a roarer. It's not about tonnes and grade. It's about the techno-economic context of something: how far is it from infrastructure, etc., etc.

"What's missing in the mine geology world is good science...What is missing in the discovery world is an understanding of techno-economics and the fundamental business."

So, putting those two things together is really interesting. Taking that techno-economics from the mining side and

putting it into the exploration side; and taking the science from the exploration side and putting it into the mining side. I think there's a really fertile space there for us to develop over coming years. And the industry has forgotten it because it's not new. If you go back to Roy Woodall's day, the geologists in Western Mining moved freely between those two worlds. Most of the exploration guys had a stint in mines, many of the mine guys were pulled into exploration – it wasn't unusual. That was true in Geopeko, which was another one of those companies that found lots of stuff in the seventies. It was true in RGC, that people moved across the boundary. It stopped sometime in the eighties. These things just drifted apart, and people became career explorationists without ever having seen a mine, or vice versa. I think this is a loss.

"Putting those two things together is really interesting. Taking that techno-economics from the mining side and putting it into the exploration side; and taking the science from the exploration side and putting it into the mining side."

Steve: In terms of behavioural differences, one is the techno-economics. What are the other behavioural differences? Do you think that exploration geologists are more comfortable with uncertainty?

John: They should be. They should logically be. I'm not sure they all are, but the ideal exploration geologist is very comfortable with uncertainty. And if you work in a mine… you know I used to make jokes about this right. I once did an exercise, which actually was written up as a paper, where we got three people to interpret the same data. One was a mine geologist, one was an exploration manager, and the third one was a resource geologist – I used to say it's the balanced kind of guy in the middle right – and we got them to draw lines on the basis of very wide-spaced drill holes at the Stawell gold mine in newly drilled extensions of the deposit at depth. The mine geologist drew the volumetrically smallest volume you can think of. Because they're used to going into production meetings, and saying, "I think the ore goes there." And then, three blasts later you're either right or you're wrong. So, they're very reluctant to make wild extrapolations. Exploration geologists have a different character. They're willing to join any two intersections in the Yilgarn Craton – there's a bit of that. And it's laughed at as being an arm-waving thing, it's not. It's about being… it's more a kind of Indiana Jones boldness. There's an element of that.

"The ideal exploration geologist is very comfortable with uncertainty...They're willing to join any two intersections in the Yilgarn Craton"

Steve: Don't you think it's also the philosophy of science has two ways of generating hypothesis. One is from data from which a hypothesis was generated. One is the hypothesis initiates the process, and then is tested by data. Your comfort with uncertainty means, as an exploration geologist it means, you're comfortable

launching into hypothesis and then searching for data to test it. Whereas I find a lot of mine geologists who are in the opposite way. They're inside an engineering framework where the uncertainty they're dealing with is a far lower number for a start.

John: They're in a more data rich environment… far more data rich.

"We're not failing fast enough."

Steve: Yeah. And the price they pay for being wrong is higher, whereas –

John: It's more immediate.

Steve: It's more immediate. Whereas an explorer is actually trying to create something from nothing, and they're very tolerant therefore with failure. So there's a failure tolerance, complete failure tolerance difference between the two.

"A success is something that ends up producing cash flow. And there is no other definition of success. If you find the world's greatest deposit, and you can't mine it because it's environmentally not permitted, or socially not permitted, it's not a success."

John: Well, there should be. But it's interesting, because one of the things that I started talking about really quickly when I took over the job in Discovery was the logic of fail-fast. We're not failing fast enough. It worked with some people, but it knocked some people off balance. There is an element to say, "Well, that's not really a failure John. That's kind of a technical success but…" blah, blah, blah, blah, right? And I'm going, "No, no, no". You've got to be really clear about this. A success is something that ends up producing cash flow. And there is no other definition of success. If you find the world's greatest deposit, and you can't mine it because it's environmentally not permitted, or socially not permitted, it's not a success. We made some mistakes along the way. They're not geological and technical mistakes, but there are other kinds of mistakes.

Steve: Well I quite often frame that in terms of how we learn; the difference between a skateboarder and a base jumper. A skateboarder is somebody who has to fail in order to find the limit. Whereas a base jumper cannot fail, and therefore must entirely be within themselves in terms of how they better themselves. And they are fundamentally different ways of learning. One of the differences between them is the real risk of fatality. What we do in exploration is very, very low risk. People quite often use the term risk, but it's so low risk that we're actually closer to skateboarders. But people don't like the concept of failure. Your average skateboarder is failing 90 something percent of the time.

"In base jumping, the consequence is binary. Whereas in skateboarding, there's a whole distribution of consequences. Very, very different."

John: We're talking about two different axes of risk here, because the two axes are probability and consequence. In base jumping, the consequence is binary. Whereas in skateboarding, there's a whole distribution of consequences. Very, very different. You can get everything from scratching yourself to actually dying – you can fall off that thing and break your skull and die. But it's very unlikely. So, that taints how you approach the risk. And it's interesting you say the learning modes because before we came on here we were talking about Sam Harris and his podcast, he talks to Max Tegmark about AI. Did you hear that one?

Steve: Yeah, I did.

John: Very interesting because he actually pursued the same line that you're presuming, saying, "With AI, we can't have a 'learn by failing' approach." Because once the thing is in the system and out, you're not going to be able to learn anymore right. It's out.

"Failing quickly is actually a benefit. So, lots of failure is a sign that it's working well. If you go to the innovation world and you talk to people working in tech innovation, in technology innovation in Anglo American, we have 90-day cycles of tech innovation."

Steve: So, it's fascinating. I've been reading a bit of literature on base jumping because I'm fascinated as to how you would teach those opposite modes of learning. I think we're closer to skateboarders and I wish that we would learn to fail fast, and not associate the word 'failure' with doing your job properly. But instead associate it with doing your job well.

John: I agree completely. Failing quickly is actually a benefit. So, lots of failure is a sign that it's working well. If you go to the innovation world and you talk to people working in tech innovation, in technology innovation in Anglo American, we have 90-day cycles of tech innovation. So the idea is, from conception of an idea to having something that we decide we're going to fund and pursue, is a 90-day cycle. But lots of those fail in 10, or 12, or 15 days. So the idea is, get it to the point of failure really, really quickly. Going back to philosophy and philosophy of science, the Popperian view of science is that it's all about falsification. You have a hypothesis and you're out there falsifying. In fact, lots of geologists fall in love with their hypotheses and spend their life defending them to the death. That's not actually different. You're supposed to be out there, falsifying the hypothesis. Now if you're falsifying hypotheses, you're in the business of testing them and failing, testing and failing. You're looking for the failure. You're looking for the weakness. Drill holes are gigantic… drill rigs are gigantic hypothesis testing devices. And it's very rare to see people site drill holes deliberately

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to invalidate their models. This is an extremely healthy thing to do.

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Steve: It is. You just mentioned earlier –

John: Do you think that happens?

Steve: Not enough.

John: Do you think people, by and large, are thinking, "Okay, I've got three drill holes. I can test my model. Where would I drill them?" Not in order to guarantee that I get results necessarily, but to demonstrate that the hypothesis could be incorrect.

Steve: This is one reason I wanted to have this conversation is that, as much as you've got this great perspective now from mining to exploration, if we just pull apart the exploration part of it for a second.

John: Yeah.

Steve: This idealistic world that they should be comfortable with uncertainty and that they're actually the scientific end, and therefore the discussions that we need to have about philosophy of science, this is the idealistic world of where exploration geologist should be – but they're not there. In fact, one of the reasons why I think we have issues, is that there is a behavioural issue around, "Do we really understand the philosophy of science?" And you once wrote a paper for the mining industry on philosophy of science – which is a fascinating thing in its own right because a lot of geologists would think philosophy is a four-letter word. Philosophy in the end is just articulate, clear thinking. And if you really understood the process of what you were doing, so fail fast and test it, then you would take those three holes and fail that project. And that's a fundamentally different way of approaching it than trying to succeed. It would be an incremental step out. And I think the vast majority of our industry is in mining extension mode, not in discovery mode.

"Language really matters... we don't talk about exploration as a function, we talk about discovery as a function. And exploration is the activity to get to the discovery...The other one that's really critical in the exploration industry is this brownfield/greenfield distinction is crap."

John: So I have restructured the language around Discovery. A lot of people think that that's nonsense as well. But actually language really matters, right. So firstly, we don't talk about exploration as a function, we talk about discovery as a function. And exploration is the activity to get to the discovery. I think that's critical because you can explore forever and find nothing. And I put my proverbial

on the block with the board of Anglo American that I'm going to find things. I've put NPVs around them, and I've been really clear about what we're doing. If you come back and interview me in three years and I've still got my job, then I will have been successful. Otherwise, I'll be looking for a job as a podcaster or something. But I do think that that's one piece of language that's important. The other one that's really critical in the exploration industry is this brownfield/greenfield distinction is crap.

"Near-asset exploration is the same as greenfield's exploration, except for that you don't have to prove the fertility of the district. You know it's fertile."

Steve: Yeah I know.

John: So, the way I think about it is: you can either explore near to assets that exist, your assets, or somebody else's assets, where there's infrastructure and so on, sitting around there. Or you can explore away from those places. Near-asset exploration is the same as greenfield's exploration, except for that you don't have to prove the fertility of the district. You know it's fertile.

Steve: You've already answered that question.

John: You've already answered that question, so it's a subset. In that near-asset environment, there are two types of activity. One is to find new deposits, whether they feed into your existing infrastructure or require new infrastructure. New deposits, separate system. They may be part of a cluster of systems and porphyry copper districts are a classic example of this. Another one is to extend the life of mine and find the depth extensions and so on. I call that 'risk reduction drilling'.

Steve: And they're very different.

"..around each major asset, there's usually a donut of neglect because it's a zone where mine geologists are not particularly interested in looking there because they've got 25-year mine life - why would they? And the explorers don't particularly want to go there because it's right next to the headframe."

John: It's not exploration, whereas looking in the district, looking for new deposits is exploration. It's near asset exploration. So that distinction is clear in my head. And it's another interface between mine geology and exploration geology. One of the guys who works with me, Tom Paterson, looks after a function called "Endowment". Endowment is all the knowledge we have of our asset base in districts that can't be reported publicly. It's the 'below-the-line part' of the iceberg if you like, that is models and ideas and concepts that say that the district has a certain kind of endowment that we can't put into resources and reserves terms. And Tom talks about the 'donut of neglect'. This is around each major asset, there's usually a donut of neglect because it's a zone where mine geologists are not particularly interested in looking there because they've got 25-year mine life - why would they? And the

explorers don't particularly want to go there because it's right next to the headframe, and really you know they've got a self-image of the wind in the hair, standing at the top of the Andes with nobody in sight. These areas are wonderful places to go exploring with greenfield's thinking, because they've been neglected often for 20 years!

Steve: I like the word 'greenfields thinking' as well. Because it is a different way of thinking. I mean you're looking to transform an asset. You're trying to create something that isn't there. It's not an extension of what is already rather obviously there. It requires the same mentality of trying to create something out of nothing.

John: Yep. So there are two components that I think are really critical for me in greenfields… there are many… but there are two really front and centre components of greenfield thinking. One is, it's a district scale process. If you want to explore districts for a number of reasons but one is that you produce sets of discoveries. The first prize is not finding the Golden Mile, although it would be a great first prize. First prize is finding the next Eastern Goldfields - that's the first prize.

"I think mineral systems operate at every scale, down to the microscopic. So that integration of all the different scales of that becomes critical and moving up and down the thinking scale."

Steve: Agree.

John: That's number one. Number two is that you bring to that a framework, and the framework is mineral systems. So people talk about mineral systems and they think about it at the belt scale. I think mineral systems operate at every scale, down to the microscopic. So that integration of all the different scales of that becomes critical and moving up and down the thinking scale. And you find, just as an aside, in searching for geoscientists to work in a team, one of the things that's really interesting is, take structural geologists for example. Structural geologists fall into two groups - it's a bimodal distribution. There are either people who work at the scale of the pit and the deposit, or people who work at the scale of entire belts. And what you actually want, is you want that really unusual person who can do both - who can run up and down the scale right. That's where the value is running up and down the scale.

Steve: Those people are really unusual. A lot of structural geologists have to put a compass on something. Most of the value is in the scale between the belt scale and the deposit. That's where the data uncertainty is at its greatest, and that's actually where…

John: And that's why people don't want to play in that sandpit.

Steve: It's also one of the areas where science is at its weakest as well. And I think that's the reason why our research scientists struggle. Because once the data quality drops off, so does their ability, or at least they think their ability, to test hypotheses. What it does is of course, just means you have to go out and create new data, which is what I think greenfield's explorers do. And I wish that a lot more people had that attitude.

John: Let's take that as an interesting thing to talk about. Anglo American has been out of Australia for the last few years really. We've been exploring in New Guinea, out of our office in Brisbane. But we've recently come back to Australia and we've acquired a big slice of ground south of Mount Isa under cover, looking at the other end of that covered inlier. And one of the thoughts in the back of my head around how we approach something like that is that you can approach that by looking at what does a model – say you want to go and find a Mount Isa Inlier, or you want to find IOCG, or whether you're going to find under that cover – what does the model for that deposit is one way to think about it. But the mineral systems way to think about it is what are the elements that I need to form that deposit. It's a different way of thinking.

"There are lots of false positives under there, right. So the architecture becomes very important. And it may well be that what you actually find is not the style of deposit you're looking for. We know that that's part of the story of some of the great discoveries."

So, I'm not necessarily "Oh, yes, I'm looking for a signal from a deposit", but I'm also in the first instance - you talk about collecting data sets - the first thing I want to do is to identify the architecture and the basic ingredients of the mineral systems that point me in the right places to go look for that. There are lots of false positives under there, right. So the architecture becomes very important. And it may well be that what you actually find is not the style of deposit you're looking for. We know that that's part of the story of some of the great discoveries.

Steve: Serendipity is a real part. As far as I'm concerned, we should be maximizing it. And I like this architecture-driven approach because its a lot more honest about what we don't know. And we need to take that into account that there's an awful lot of discoveries that have evolved as a result of being in motion. The iterative knowledge that they gain is how the discovery was made, not the plan from the beginning.

John: And the case example of that is Olympic Dam. Because I've heard the Olympic Dam story from several ver-

sions of the horse's mouth, and it's always different. But the thing is that it doesn't matter, because it was found at the end of the day. So I'm not hung up on that. And going back to what we know versus what we don't know, I like the idea of not knowing. I think this is an opportunity. Take Mount Isa. The debate about how Mount Isa forms, how the copper deposit relates to the zinc - it's just like huge right. This is a HUGE environment. Another place we're exploring in the world that I like the lack of understanding is Zambia. The Zambian deposits, if you read through the literature, there's a wide range of views and elements in those. To me, this is a huge opportunity.

"I like the idea of not knowing. I think this is an opportunity."

Steve: So I have the same mentality. I look at sediment-hosted copper, and I see it as the weakest understood deposit style of the major deposits. And that's no offense to those experts in that field. It's the opportunity that I see…

John: It means that the degrees of freedom are high. And the 'degree of freedoms is high' means it's permissive.

Steve: So I don't think many people will think like this, John. I've had very few peers or bosses that would want to work like this. This is how I like to work and this is how I think we should be working.

John: But moving again back into philosophy and linking this to what you said about mentors, I've had some absolutely stellar mentors over the years. And a number of those mentors in common, and they were all extraordinarily bright individuals. But there's lots of bright people. What they had that really was appealing is that you could go to them with a really interesting question – this is what you should do with mentors - go to them with really interesting questions. "I don't understand X." And what I really liked about some of the mentors I had was, they would say, "Neither do I." That's really interesting. I always get nervy around people who understand everything, because I don't. I think I'm reasonably bright, but I don't. So I get very worried when people have this overconfident sense. I think one of the things you have to put with serendipity and good data and all these other ingredients is, we can have a little bit of humbleness about this too and say what we don't know. Because what we don't know will lay out what we need to find.

"I always get nervy around people who understand everything, because I don't."

Steve: So, the statistics on our discovery rate would suggest that the vast majority of us don't know a lot.

John: Yeah.

"I think we understand one mineral system moderately well and that's porphyries, the porphyry system at large with epithermal and high-sulfidation systems..."

Steve: And I think that's humbling and worth reminding everyone that even the most strongly advocated hypothesis is actually still just a hypothesis, where actually the best expert you know still knows very little. There's so much uncertainty around mineral systems.

John: I think we understand one mineral system moderately well and that's porphyries, the porphyry system at large with epithermal and high-sulfidation systems and the bits and pieces. We have a reasonable straw man of what that system looks like now, and I'm not an expert in that field as you know but that's my reading of it. Elsewhere, it's just oceans of opportunity to learn things and understand things.

Steve: This leads me to motivation and this business of constant learning I think. What I tell my staff is that, "you will never know enough." The intrinsic motivation should always exist to learn. Because you can never be good enough.

"...but one of the advantages I have in coming to the job in Discovery in Anglo American is that I've not been steeped in the thinking of discovery over the last 30 years. I think this is an advantage...Looking at a problem with fresh eyes."

John: There's a flipside to that though, which is really interesting and we were kind of talking a bit about this before we started as well, but one of the advantages I have in coming to the job in Discovery in Anglo American is that I've not been steeped in the thinking of discovery over the last 30 years. I think this is an advantage. So yes learning is really important, but sometimes I think coming at something with a relatively intelligent but uneducated eye – 'new eyes' is what I call it right. Looking at a problem with fresh eyes. How many problems have been lying around in science for a long, long time, and then they're solved by somebody from outside the field?

Steve: Oh, completely.

"And then somebody comes along and reframes it (the worldview), and twists the axes, and looks at it in a really different angle, and sees something totally different. So, this is an opportunity."

John: It's just frequent. Even in our own field, you look at the origins of plate tectonics, comes from Wegener who was a climate science essentially as we would call him now. And it's because you look over the fence, and you don't carry the anchoring of that worldview. It goes back to Thomas Kuhn and the idea that they're living in a paradigm, have a certain picture and they're incrementally touching up the edges of their worldview is what's going on at some point. And then somebody comes along and reframes it, and twists the axes, and looks at it in a really different angle, and sees something totally different. So, this is an opportunity. And I think, going back to innova-

tion, the example of innovation everyone throws around is Uber. Uber came along and then just killed the taxi industry worldwide. Or Netflix. Netflix is just an incredible story of how a company is actually disintermediating the content makers. They don't need Disney and those guys anymore, they're making their own content. They started off shipping DVDs to people in the mail, and now they're bigger than Disney!

"The question I asked my team quite explicitly is, "How do we 'Uber' ourselves?"..I'm asking (my team) to think of a radically different way of thinking about how deposits form. The Holy Grail is to think of a deposit type that people haven't even looked for. That's out there, you can't spend all your time in that space. It's a very specific space, but the prize in that space is enormous."

The question I asked my team quite explicitly is, "How do we 'Uber' ourselves?" No taxi driver ever would have thought of the idea of Uber, but that's actually what I'm asking you to do. I'm asking you to think of a radically different way of thinking about how deposits form. The Holy Grail is to think of a deposit type that people haven't even looked for. That's out there, you can't spend all your time in that space. It's a very specific space, but the prize in that space is enormous. Because if you go looking in places people haven't looked before, you'll find the biggest one first.

Steve: I just gave a talk on this just last week, and what was interesting, some of the comments from the audience was, "Can you mandate this kind of thinking?" "Do you need to create time for this kind of thinking?" Because you are right, you can't have everybody thinking like this or the business would fall over. But if you're not thinking like this, then those transformational options are not open to you as well.

"Teams that are entirely composed of stars often fail."

John: So I was at my son's eleven-year-old soccer game last night, and I was talking to a guy who's an engineer and he knows that I'm interested in this sort of stuff. He said to me, "I've just read an interesting study on how high-functioning teams work." And it was comparing sporting teams to business teams, which is an old analogy. But he said, "If you look at sporting teams" – and he was talking about soccer in particular – "teams that are entirely composed of stars often fail." The Argentinian soccer team is just an enormous example of this. They're all first-rate players. They have Lionel Messi in the team. But the problem is that when Lionel Messi is surrounded by entirely other first-rate players, nobody wants to give him the ball.

"In a business team, you do need "out-there" thinkers, but you need just a few of them seeded through the system. You also need people who can collect the data and do the work..."

In a business team, you do need "out-there" thinkers, but you need just a few of them seeded through the system. You also need people who can collect the data and do the work, and so on. And often, your out-there thinkers are not ideal people to curate data. They have a different form

"(creative thinkers)...are codependent with the people who collect data and do the other work. This is not lesser of work. It's essential, and needs to be respected."

of thinking. So, you need these different elements. What you also need is you need for your stars... 'star' is not the right word… but… the really creative thinkers in the team, need to understand that they can't exist without being codependent with the people who collect data and do the other work. This is not lesser of work. It's essential, and needs to be respected. The classic is just fundamental observational skill. The person with the best imaginative skills may not be the person with the right observational skills to recognize their own ideas, if they fell over them in the field.

Steve: I agree completely as I fit very squarely into one of those categories - I won't point out which one. But I know what complements me and I'll search for it in people. Because it's the complement of myself for a start. Do you think our industry is tolerant of that kind of diversity? Because I agree that's how we should idealistically put together teams, but I don't see teams that look like that. I see teams that are heavily favored towards doing rather than creative.

"The way we think is a strategic advantage. Now you can say that, but then acting on it is something different. Acting on it means that you may want to connect your teams with disparate thinking deliberately."

John: Which is dangerous for another reason. I have a limited perspective on this because my only perspective on actually being in a living, breathing Discovery team is the one that I'm in now. Since the last time I was in a team like that was 1987. I was a senior geologist on a rig, so I have a different view. Certainly where I am, that's the thinking that we have. And I have permission right up to board level, I report to the board regularly, and I've engaged them in the idea that thinking is a strategic advantage. The way we think is a strategic advantage. Now you can say that, but then acting on it is something different. Acting on it means that you may want to connect your teams with disparate thinking deliberately.

"...if we're going to convince the board and everybody that report to us that we've got a game plan, it's got to be a game plan that we can articulate really clearly."

Process is really important. I don't dismiss that. In fact, I think the guys who report to me, they got sick of me really quickly. Because when I rolled in, the first thing I did was I asked them all to draw flowcharts of what the discovery process looked like. And this is not something that discovery geologists do. They wondered what I was up to. But the point that I was making is that they all had a different flowchart, which is interesting. They had common elements for sure, but they had different conceptions of how it worked. And my mantra was if we're going to convince the board and everybody that report to us that we've got a game plan, it's got to be a game plan that we can articulate really clearly. So now we can articulate that really clearly. But the dynamic tension of this is really

interesting.

"How do you manage the tension between being totally ordered and anally retentive about process, and completely freewheeling and imaginative at the other end? Because you've got to land somewhere in the middle."

When I first got this job Tracey Kerr said, "The most important thing you can do in the first three months is go to PDAC and meet all your peers." So I went off there and I sat with Steve McIntosh and all these guys, and I knew some of them from my travels as a consultant. And I had meetings. And I had a couple of questions, framing questions, just to chat about. And one of them was, "I'm interested in developing some systems, ranking systems and targeting systems and so on. But I also know that creativity and imagination is critical. How do you manage that dynamic tension?" That was my question. How do you manage the tension between being totally ordered and anally retentive about process, and completely freewheeling and imaginative at the other end? Because you've got to land somewhere in the middle. And you've got to have a mixture of people and systems to do that. It was really interesting. There's this whole spectrum of answers come back: from one side you know… it's like from albite to anorthite and I'm trying to sit somewhere in the middle there. I think that tension is real. There's no solution to that by the way. It's not something with an answer. You have to navigate it and you'll oscillate around getting to the right place with that.

Steve: I like the word tension, at least I am taking it as a healthy tension.

John: Positive, absolutely.

Steve: Yeah, so that there's some sort of slight discomfort that exists in an organization, maybe respect for each end of the spectrum, but a realization that the end members can look fundamentally different.

John: That's interesting too. Whenever you take a senior executive role, one of the questions you should ask when you're offered the job is, "Do I have the mandate a) to clean house?" If I don't think I've got the right team, I want to get the right team. Because all your performance will be judged by the performance of your team. So if you think you have a team that cannot do it, you need to be able to adjust it. That's number one. Number two, "Do I have the mandate to reorganize within that team?" So when I arrived, I reorganized how the Discovery and the Operational Geoscience functioned. And I created a piece in the middle, Paul Hodkiewicz runs that group, which is called Specialist and Integrated Geoscience. And it works both with Operations and with Discovery. And it is designed

to have a dynamic tension element to it. Because it's the group that will have to some degree a kind of check on what's going on technically, but also it'll be the group that's pushing new ways to do things.

"The days of people logging kilometers and kilometers of core are coming to an end. With the right scanning equipment and machine learning, we will do the first pass logging of all this stuff highly effectively – better than we will with most humanized ways. And very consistently, repeatedly and quantitatively, so we can actually use the data in a whole different way."

To give you an example, going back to you need people who can do stuff. One of the problems we face going forward is the technology is changing very, very rapidly. And I don't think everybody's completely up to this. In the mine environment, you see it really, really clearly now. The days of people logging kilometers and kilometers of core are coming to an end. With the right scanning equipment and machine learning, we will do the first pass logging of all this stuff highly effectively – better than we will with most humanized ways. And very consistently, repeatedly and quantitatively, so we can actually use the data in a whole different way. That doesn't mean that geologists won't log a core, they will. But they won't spend days and days and days saying, "Is that actually fluorite or quartz?" This is just going to be a non-question. We've seen already examples where highly experienced geologists have misidentified minerals. I'm talking about world's best category loggers.

Steve: Of course, that's the reality…

John: And sometimes, these misidentifications reverse the arrows to the core of the system. These are major and serious things. Once you learn that, you have to move to a new place. That's going to cause some people to be very uncomfortable because if you think about, you know, there's psychology and philosophy but there's also the sociology of this. How do geologists regard themselves as being better or worse geologists? And historically that is, "I can identify the stuff I look at in the core?" That self-worth is attached to that.

"(automated scanning equipment)...is going to cause some people to be very uncomfortable because if you think about, you know, there's psychology and philosophy but there's also the sociology of this. How do geologists regard themselves as being better or worse geologists? "

Steve: An example from my own family, Michelle with Dave at REFLEX are one of the company's leading the charge on this, and here's myself as a trained what I would consider to be an expert field geologist. My wife's trying to put me out of a job. She's always saying, "What is your skill set?" Well, it's field identification. That really…

John: No, that's not your skillset. No that's not your skillset sorry.

Why this is good… Paul Hodkiewicz has a nice diagram, which is a circular diagram and it's a flow of how our work

works. It starts off with generating ideas, testing those ideas by collecting data, modeling that data, questioning the data, coming up with results. It's like a Plan-Do-Check-Act cycle, and it comes back to now let's revisit the question. And he's divided it in half, into a human-dominated half and a machine-dominated half. The half that is about collecting data and building models is going to become a machine half. But the half that is about the beginning and the end of that, which is about framing the question and about interpreting the results is going to remain human. So, what's required of geologists in the future is that they have higher-level cognitive skills but not necessarily the more mundane skills that we associate with the job.

"...what's required of geologists in the future is that they have higher-level cognitive skills but not necessarily the more mundane skills that we associate with the job."

Steve: I agree with very much of what you're talking about. But one of the things that I note is, when you're in the middle of a transition, noticing what's going on can be quite challenging because there's a whole spectrum of awareness out there. There are people like you and me who are well aware that what you're talking about is already in place in certain groups. And then there are some people who are essentially a long way from it in terms of their daily job, who not only would they disagree with you they'd probably be angry.

John: I asked one of my peers at PDAC a couple of years ago, "Where do you see the automation of logging going?" And the answer was, "Logging is a job for geologists with a hand lens John." So, I moved to my next question about safety, or helicopters, or whatever it was – I just moved on! Because, where do you go with that? I think it's a false construct to think that this is somehow replacing geologists or demeaning our work. The interesting part of geology is not logging core. I've logged kilometers and kilometers of core, and I love rocks. My office is full of rocks. My house is full of rocks. I've got no lack of love for rocks. But the really exciting part of my job is the interpretive and the questioning part of the job.

"The interesting part of geology is not logging core...But the really exciting part of my job is the interpretive and the questioning part of the job."

Steve: So the way I put that is, we've never been interested in the rocks per se, it's the stories they tell. If you are mechanical in the sense that you are about the rocks, then you are going to be replaced.

John: There's a danger in that. There's the rabbit hole that Alice disappears down on that one. It's that you become interested in the rocks and you forget about the system that the rocks exist in, and the four-dimensionality of that system. One reason why mineral systems is really interesting is because the system is much bigger than

the deposit. So your targeting footprint looks bigger. But it's also interesting because I can think about what the deposit would look like at various stages during its formation. I can think about what might be lying underneath the deposit. I can think about what the hidden toes of that deposit would look like if they stuck out on either side of a valley covered with colluvium, etc., etc. I can start to really think about the systemic part of it. I think that's where geological thinking in the future lies largely, in that system's thinking mode not in a kind of identifying diagnostic mode.

"...geological thinking in the future lies largely, in... system's thinking mode not in a kind of identifying diagnostic mode... Mine geologists should be systems thinking."

Steve: So the system's thinking, do you think that's radically different to how a mine geologist is trained?

John: Mine geologists should be systems thinking. But having said that, the reality of it is that at many mines… when I worked as a consultant, I remember going to mine geologists and saying things like, "What's the contract spec for the concentrator?" That's a very important thing for a mine geologist to know because they're going to be mining ore which has arsenic or antimony, or whatever in it that is deleterious and has a penalty attached to it, and so on. Do they understand what level the concentrator can tolerate before it starts getting out of spec? And, therefore, can they calculate that back by thinking about the upgrading factors to what should be in the ground? Frequently, geologists didn't know this. They lived in the geology world, and maybe connecting to the mine planning world, and maybe delivering into the plant world, but they weren't living in the concentrate world or the smelter world. So, real systems thinking would be broadened. I think we're pushing into that now.

"You have to think about the entire value chain system, and there's a huge technological revolution underway actually in mining...So how do you...build a mine that is responsive to the market? Now, that's an interesting concept."

You have to think about the entire value chain system, and there's a huge technological revolution underway actually in mining. At the moment, we build enormous factories that are fixed high-capital inflexible bits of kit, and we feed orebodies into them and out comes metal. If you think about what's happened to every other industry in the world, we will end up with much more bespoke, modularized approaches to that. So, we will build bits of kit that scale up and scale down and deliver to market. We live in a world now… my kids they press the order button on iPhone and expect it to pop out of a speaker or something. It's an instant world where everything kind of happens. Think about how mining looks in that context. It's just totally different. So how do you build something, for example how do you build a mine that is responsive to the market? Now, that's an interesting concept. If I can see

that the market for iron ore is going to change such that it will tolerate this in a six-month window next year that it did not tolerate now, how can I potentially adjust what I do and my processing to produce more of that product? And therefore, maximize my cash flow next year?

"...any decent mining engineer has a sort of inner geologist. And any decent geologist needs to have an inner mining engineer and inner processing engineer."

Steve: This podcast is called Exploration Radio but we talk a lot about mining, and we've actually had a few people on the podcast talking about this very approach, as to where we're going. What we're trying to do is talk about the past but in terms of things that are still relevant to the future. But also articulating to this group of people, whose awareness of the future is not there because of their day job, where we're going. And talking about especially those who work in smaller companies, who are going to find some of these aspects of shock. And one of the things that I caught often say to a lot of young geologists is, if you want to be treated like a sampler and be unaware of where the world is going then that'll be the end of your career.

John: The way I put this is, my boss is a mining engineer but I joke with him that any decent mining engineer has a sort of inner geologist. And any decent geologist needs to have an inner mining engineer and inner processing engineer. They need to be interested in… I joke as well that there's type A and type B mining engineers. Type B are interested in boring, blasting and bogging, and everything else is bullshit. Type A, they are interested in anything else. But the same applies to geologists. There are type A geologists who really are only interested in minerals and rocks.

"...if you're an exploration geologist, what you should be looking for to fit that future world is not the same as what you should be looking for now."

If you go back to our conversation about where the mining is going in the future; if you're an exploration geologist, what you should be looking for to fit that future world is not the same as what you should be looking for now. There's this line that the deposits are the deposits and they're where they are, and so on and so on. But you get a high-level, strategic choice, whether you're a junior or a major about where you look and what you look for. It's the first level of decision making you make. People think about the decision around commodities for example. "Should I look for lithium? Should I look for cobalt? Should I look for copper?" But if I'm going into that space, maybe it will be much better to be in the sedimentary copper space than to be in the porphyry space. Or maybe when I have bulk sorting and all those things working, certain types of lead-zinc deposits become really interesting that are not particularly interesting now. You need to be thinking that

"Only two really interesting questions for geologists in the business. One is, "Where are we in the system?" And the other one is, "What will happen to this stuff when I put it through a particular value chain?" That defines the whole of geological thinking, mine and exploration."

space. You can't do that if all you're interested in is the rocks and you don't know what the technology is that the rocks will be passed through.

Only two really interesting questions for geologists in the business. One is, "Where are we in the system?" And the other one is, "What will happen to this stuff when I put it through a particular value chain?" That defines the whole of geological thinking, mine and exploration.

Steve: **Do you think enough of your peers are considerate of tomorrow? Because… I'm going to reframe that. Most of your peers are not considerate of where we're going.**

John: I don't know that's totally true. I think you know for example, I was talking to Steve McIntosh in Toronto a couple of weeks ago. And there's no doubt those guys are, they've just put their discovery function together with their business development and their technology which is a huge sign of what's happening.

Steve: I do like the way that Rio are going.

John: But there's a spectrum of how people are doing this, and that's fine. In an ecological sense, there'll be people who run fast and people who come to the end of the gene pool. There's a survival of the fittest component in this.

Steve: But that's two specific big companies we're talking about. There's not a lot of that kind of thinking left in our industry. There's a large amount of our industry dominated by juniors and mid-tiers now.

"At my level in the organisation, my level of thinking should be decadal. But how can you be 'decadal' in your thinking when you're a junior?"

John: Very hard for juniors to think the way that big companies do, because the imperatives they have to report to market and be successful are so different. I have the luxury of being able to say, "I want to have success tomorrow." Don't get confused about my urgency for success - just in case my boss is listening like Cutifani or somebody. I'm really urgent to find things, Mark. But I have a vision. At my level in the organisation, my level of thinking should be decadal. But how can you be 'decadal' in your thinking when you're a junior?

Steve: **My expectation of you John when you took this role is, I expect great things from you. I expect you to change, not just Anglo American, I expect you to be front and center of changing our industry. I think it's**

somewhat laggard in its focus in the future. And that will take time, that will take time to judge you on results.

John: I don't feel that I have time. And that's not a bad thing. I feel there's a lot of pressure to move quickly. We have been moving really quickly in our thinking in what to do. And it's interesting because the pieces were: rethink the strategy. So we've done a piece about rethinking strategy. Strategy is really important and my kind of a throwaway line… I mean, I'm the only person in our senior leadership team without a PhD, which is really interesting. My boss actually said to me, "All you geologists have a PhD" one day. And I said, "No, I don't actually. But I do have an MBA". I think that was quite useful. I'm not sure I'd do it again if could do it again. Probably just read a few books I think. But strategy is really interesting. People talk about strategy and it's a bit like philosophy of science. They talk about science without understanding philosophy of science. They talk about strategy without understanding what strategy is. Strategy is primarily about what you're not going to do.

"Strategy is primarily about what you're not going to do."

Steve: I couldn't have said it any better.

"I want to paint a whole lot of the map black and ignore it, so that I can be really focused."

John: So what I want to do is, I want to paint a whole lot of the map black and ignore it, so that I can be really focused. And it's really important that you have a very small number of things to focus on. There's a magnificent book called "Engineers for Victory" by Paul Johnson, which I recommend you to read – I know you've got too much to read anyway – where he talks about World War II and the famous meeting between Churchill and Roosevelt. 1942, the whole of Europe is Nazi-occupied except for the UK. The Japanese Empire is at its maximum extent and they're bombing Darwin. It looks like everything's failed. And these two guys get together and go "Okay, what are the five things we need to do to unconditionally win the war?" And then, they stopped doing everything else. And those five things were, if I can remember them: they needed to be able to stop the U-boats… and they were ranked, that's important as well. Thats the important thing. Stop the U-boats because if you don't stop the U-boats, Britain starves in eighteen months. They had no solutions to any of these problems by the way.

Steve: They were just problems.

John: Stop the U-boats. They needed to be able to bomb Berlin and the Ruhr. At that stage, fighter escorts could get 70km into France and they had to return to base. They

needed to be able to land a million men and their armaments on a beach in five days. The largest-ever landing in history before that was 30,000 people at Gallipoli and we know that that went well right. A million! They did all these things by the way in 18 months – solved all these problems in 18 months. Stop the blitzkrieg, which was going on in Russia. And how do you island-hop your way through the Pacific to reinvade Japan, because at that stage they couldn't rely on nuclear weapons. They solved all five of those problems in 18 months. And Paul Johnson's book is brilliant about how they did that.

"Decide what not to do and concentrate on those things. There's an element on that in exploration, really front and center for large companies. For small companies, it's kind of obvious."

I think there was only one fundamental scientific breakthrough involved in that. The rest were just innovative and strategic things. Decide what not to do and concentrate on those things. There's an element on that in exploration, really front and center for large companies. For small companies, it's kind of obvious. You just got one thing you're going to do. But for a large company you could do lots of stuff, so you got to say, "Okay, what am I going to do? What's the set that I'm going to put all the energy into?" And less is more.

Steve: So you create competitive advantage. It's far better to not compete with somebody that it is to compete with somebody. If you could choose to be good at something and therefore choose not to be good at something else. I articulate this all the time within my own company and it's like, "We're going to do this. We're going to be the best at this in the world." That might seem like a stretch, but this is the thing that we're going to be the best at. That means we're not going to be good at this and that's going to be the ramifications.

"...a surefire way of success in any business is to operate in an unoccupied ecosystem. So, number one is identify something that somebody just can't see."

John: And some people shy away from throwing down the challenge that you're going to be the best. I think this is wrong as well, because who wants to stand up and say, "I'd like to be mediocre, or third best, or fourth best, or fifth best." If you're going to choose a small set of things and do them really, really well. The other one is if you're going to do things, a surefire way of success in any business is to operate in an unoccupied ecosystem. So, number one is identify something that somebody just can't see. Again, all the technical thinking in the world is really useful and I don't undervalue any of that. I'm a very technical person. But the imagination to actually do what others are talking about is important. How can I go and peg all that ground south of Mount Isa now? A few months ago? How can you do that?

Steve: Exactly. So you have got to be first.

John: Everybody's been talking about it for a long time. How can you do that? It suggests that people think it's a good thing to do, goes back to taking risks and having some courage. Now that may not turn out to be a good decision.

Steve: The courage is a big one under uncertainty. I've certainly had a couple of failures in my career, from moments of lack of courage that have gone on to be very successful mines. And the way I usually describe that is, I drove my Alfa to this meeting today instead of my Ferrari as a direct result of my lack of courage.

John: Maybe that's why you're still alive though because you would be driving much faster.

Steve: I can remember those moments of just not having enough data and certainty and therefore, confidence to push the button at those appropriate moments, and then moments arrive at a later point. And I always pride myself on trying to do something that others either aren't doing or can't. I think there is also, if you're going to do something that someone isn't doing because they haven't thought of it, or there's something that you are uniquely qualified for. So maybe you have a competitive advantage because you have spent the last five years doing something X, or you've got experience that's unique, etc. But either way, you're trying to do something that only you can do, or only a small subset of people can do. The next question is how do you push the button when you're in that position? I think I've been in that position several times. And the way I put it is, I lack the complete diversity around me to complete me and enables me to finish the job.

John: That's interesting. So again, it goes back to systems. Maybe, rather than thinking about how do I get the best possible geologists? The way to think about it is, how do I identify the best possible team here. And that's a really important thing. Actually, going back to a thread that we started before: the first step is clean sheet thinking about strategy which is not as easy as it sounds. But it was easier for me than for a lot of people because I actually didn't have any anchoring to anything else. So I just rocked in and my line was, "Well, I don't know anything about this, so how would I do it right?" And then with the team said that "Well if you had no constraints…" and the exact framing I gave, I said, "If this was your own money and your

own company and we got this much money a year, what would you do?"

Steve: I ask that question all the time.

John: Your own money in the game, what would you do? And forget everything we've done, forget our footprint, forget where we've got offices, forget where we're exploring, forget all of that. I'm just going to give you the money and let's go. Where are we going to go? What are we going to do? And it didn't look like what we were doing. So then, you have to change the portfolio to match strategy.

Steve: How quickly can you do that?

John: Well it's like turning around an ocean liner. You can do it, but you can't do it overnight. Because one of the things you need to do is make sure that you have relatively no-regret exits from some things. So yes, we had a portfolio. It wasn't that the portfolio was bad. It's that we could see our way to a better portfolio. So yes, we're in a process of doing that. The next piece is with your new portfolio and your new configuration, do you have the right skills? Do you have the right stuff to actually drive that portfolio and deliver from it? You have to put that piece in place as well. There's a number of sequential steps and I think it's taken us where we're probably halfway through the journey in year two.

Steve: That sounds about where I am as well. I think this is fairly standard. You can't just turn off the lights on day one. So how much was the timing and the cycle helpful for you, given that it was a downtime?

"I rolled into my boss' office, and he said, "I want you to look after the exploration job." I said yes. And then the next day he cut the budget in half... So when you are forced into a corner like that and you have to deal with very limited resources, you have to be highly adaptable and agile..."

John: I rolled into my boss' office, and he said, "I want you to look after the exploration job." I said yes. And then the next day he cut the budget in half. He did tell me he was going to do that before he offered me the job. So when you are forced into a corner like that and you have to deal with very limited resources, you have to be highly adaptable and agile, and do those things that we talk about when there was lots of money but you can't really do. I think there's a great advantage to doing that with the flame to your feet, or again using an expression my boss once used, "The best way to wake up is to be dangled over the cliff and look at the abyss." Then you're awake, you're fully awake and you say, "Okay, we'll do this."

The other one is, you've got to be a bit audacious. I think often times, one of the negatives of scientists and engi-

"...one of the negatives of scientists and engineers is that they want to conceive a path to get from A to B. Sometimes you just kind of intuitively know that you want to get to B and you start. And you may not start in the right direction, you may not do the right thing."

"...strategy is drawing a map as you traverse the landscape. So, you can't wait to have a good map and then go."

neers is that they want to conceive a path to get from A to B. Sometimes you just kind of intuitively know that you want to get to B and you start. And you may not start in the right direction, you may not do the right thing. You may have to pivot and turn all over the place. But if you try to work out the whole journey and build the map, you're just too slow. So, one of my other sort of analogies is that this process of strategy is drawing a map as you traverse the landscape. So, you can't wait to have a good map and then go. That's not how you do it.

Steve: **That's not how any discovery of anything has ever worked. You have to be in motion. This is way I describe it: you have to be in motion in order to iterate in the first place. If you look at this example with the uncertainty frame on it, if you're constantly waiting for the certainty to arrive then the opportunity disappears. You actually have to be in motion in order to take it.**

John: That's a perfect segue. My other analogy with the leadership team was, when we are building a new system, a new strategy, and so on; and there was a lot of talk about how we do this in the team which is good. And I said, "Understand that what we're doing here is building a bike out of bamboo, and string, and sticky tape." And we'll change out the parts once we're rolling down the road for carbon fiber and titanium. But all it needs to do at first, it's a minimum viable product concept that they use in innovation. It just needs to roll, get rolling. And then, we'll start changing it out and it'll become slick. But if you don't get rolling, you never actually move. You can't do it.

Steve: **So I think there are a number of examples in history of people sitting back and waiting for more certainty when we'd be better off starting the process. I had this theory – I had a hypothesis – that some of the most successful discoverers are people who just got moving. And they allowed serendipity, they allowed iterative science to develop. But if you sat back and guessed your way through the process, you would choose not to start.**

John: That's interesting. Certainly in the discovery domain, I can't count myself as a successful person. Because I've been at this for two years, I think we've got some really interesting early results and things are shifting really quickly, but I haven't landed the big thing on the table – and my bosses know that. But I think I can see how it's going to happen now. Whereas I couldn't necessarily see that a couple of years ago. But I do believe that you need

"...the first thing you've got to do is actually kind of throw your hat over the wall, and then worry about how you're going to climb over and get it..."

"We need to have fewer things but bigger scale thinking. We need to go undercover. We need to go to frontiers. We need to do all the stuff people are talking about but do it!" And then, I said all that. I went off to the board and told them."

to set the goal and go. And I know it's a very hackneyed example, but the perfect example of that is John F. Kennedy saying, "We're going to send a man to the Moon and return them safely within this decade." They had no clue how they were going to do that! Absolutely no clue! They had none of the engineering, none of the science, none of the risk assessment, none of the technology. I mean, it was just nothing! But they did it.

And I think the first thing you've got to do is actually kind of throw your hat over the wall, and then worry about how you're going to climb over and get it. You've got to stake a claim in the ground, saying, "We're going to do this." And in my case, that was to say, "Okay, I think the strategy can change. I think we need to have a much more district scale. We need to have fewer things but bigger scale thinking. We need to go undercover. We need to go to frontiers. We need to do all the stuff people are talking about but do it!" And then, I said all that. I went off to the board and told them. I was going to find all these gigantic deposits and things, I had to work out how to do it. Because now, I'm on the hook right.

Steve: **Better to go down swinging. That's always been my viewpoint too. Jon Hronsky puts it like this, which is, "Are you taking enough risk in your exploration portfolio?" "Is the level of risk you're taking commensurate with the size of the opportunity that you are looking for?" I actually think the answer to that is usually no. A lot of people are trying to be safe because we are measured on a frequent basis.**

John: So I have an advantage in that regard because my portfolio includes the district scale positions around some world-class assets: around Los Bronces, and around the northern limb in Mogalakwena one of the world's great platinum deposits along with Norilsk. So I've got these big district scale positions and, as I said with the donut of neglect, they can be explored. I've got this domain where I'm almost guaranteed to find some things if we drilled the right holes if we did the right work. It's never a guarantee but almost. I can work in a space where I've got some deliverable over the next few years for sure, so I can afford to be a bit riskier on the other side because it's a portfolio thing.

Steve: And it **allows the time for the more transformative options to take place. One of the things I'm always fond of is the grassroots thinking where the transformative exploration is not a linear payoff. You can't**

spend 10 hours and get 10 hours back. It could be one hour and lots of response, or it could be 10 hours with zero back. That mentality doesn't wash with a lot of engineers, but that's the kind of freedom that is required to deliver that longer-term...

"...there's no doubt that there's a cultural recognition that geologists are different to the rest of the engineering and science fraternity in companies."

John: I don't know what it's like in other big companies, but there's no doubt that there's a cultural recognition that geologists are different to the rest of the engineering and science fraternity in companies. And that's why geologists are the butt of jokes in that context. These arm-waving geologists come in and, "Blah, blah, blah." Because people know that we are imaginative out-there, risk-taking. It's very different to building a pipeline where you're engineering for zero failure. It's a really, really different example.

"I have no reluctance to steal every idea I see...But that idea of search space is absolutely fundamental."

So going back to your first question about that gap and the opportunities between the operational world and the exploration world, I think I found that one of my connections that's really interesting is the connection to technology development inside Anglo American. They are the group that actually think a lot like we think. I know it's a throwaway line, but an example would be pharmaceuticals where they're searching a finite search space. They think about it as search space, I think about it as discovering things in search spaces - this is exactly the language that Jon Hronsky would use. So I'll just pick that language up. I have no reluctance to steal every idea I see, I am quite happy to do that. But that idea of search space is absolutely fundamental. Until you think about search spaces… prior to taking the job to look after discovery at Anglo American, I went out and I talked to people like yourself and Jon Hronsky and people that I knew were different thinkers. And I was just like… I just collected all these shiny things and stuck them in the back of my head and started thinking about them. And now I get to play in the sandpit, I've actually got a budget to do it. So, it's been brilliant.

Steve: One of the things that we talk about on the podcast is about change. And how our industry is in transition. And one of the biggest areas of transition is a move towards undercover exploration. It's a fundamentally different way of working. Different companies and people are in different stages but it is a big transition. And talking of Thomas Kuhn and transitions, this is what they look like. You get some people who are early adopters, you get some people who are laggards. What have you learned about our industry in terms of

how we are dealing with change?

"...85% of the Earth's crust is covered by some sort of post-mineral cover. It's significant and it says that you have to move there."

John: I think there's lots of different stages of people thinking about this. From our perspective, what I can talk about is that I inherited a portfolio that had some undercover exploration – significant undercover exploration already. Particularly in Zambia where we have large land positions to the west of Zambia, under Kalahari Sands which we're exploring. Exploring for deep porphyries in Arizona undercover. But we have increased the number of those. And they're not the only new search spaces, you can go to countries that are opening up, and so on, and so on. But what it is that 85% of the Earth's crust is covered by some sort of post-mineral cover. It's significant and it says that you have to move there.

But the most important thing about those is it will change the structure of our industry. The cost of it and the scale of it, and the technology required is such that it's not easy to see how you do that as a junior. Not easy at all. If you look at, take the Mount Isa district as an example, there's been exploration down about 200m along the main stripe that you would explore. So really, when we're talking about undercover in this case, we're not talking about drilling 100m holes. We're talking about really trying to find things say between 300 and 1500m. You know the Mount Isa deposit would be wildly economically attractive two kilometers underground. So, that's a whole different ballgame.

"We're going to need to develop new tools, new drilling technologies, new geophysics. It's very exciting... we're going to go undercover and there's going to be some spectacular discoveries undercover."

We're going to need to develop new tools, new drilling technologies, new geophysics. It's very exciting. It's a classic that we've seen the efficiency of our industry decline and decline and decline. And I'm talking about the exploration. The discovery rates are falling off, and you can look at all these classic charts that people talk about. Whenever you see a jump in that, if you look back through the historical charts, it was because something fundamental changed in the thinking, or in the technology, or in the invention of diamond drilling with discovery of the Witwatersrand Gold Reef, or whatever it is. We're on the cusp of something. It's very exciting to live through something like that. Where we're going to go undercover and there's going to be some spectacular discoveries undercover.

Steve: So we did this episode with Dave Kingston, who was part of the Rover Boys and he was one of the last surface petroleum explorers. And he finished his career by recognizing the significance of going offshore in the Gulf of Mexico and single-handedly brought about the

end of surface petroleum exploration; and his own career. And a lot of people have pointed back to that episode and said, "Yes, but our industry is not ready for that." And one of the things that I'm always fascinated with is this concept around transitions. As a totality, I have been part of leading the charge on this concept around undercover exploration. I was very fortunate that my first job was undercover in Western Mining and therefore it's part of my ethos. I never had to learn it from scratch. I was very fortunate. But what I learned from this change is that, at an individual basis, each individual is finding it difficult to move across. And the way that I look at it is, the individual psychology of if I want to change is "Will I benefit as an individual today as I move?" Not will as we snowball, will we all benefit as an industry. But will I benefit? And one of the things that I feel is that, at an individual basis, the geologists are struggling with suddenly becoming maybe worse at what they do. Or certainly more expensive in the way that we find things. And that causes the mentality to challenge sovereign risk but it also creates a mentality which is, "Do I really need to change?"

John: So I think about change models, if you think about, just on a personal level, people you know who have undergone absolute epiphanies and changed their lives for some reason. That's usually they have been through a divorce, or been mortally ill, or had a near-death experience in a car accident or something happens, a crisis occurs. And it's like the wake-up moment, "I can't do this anymore. I've got to change." We will reach that point in this industry. The rate of finding the sort of deposits we need to find, with upward demand curves, and declining and deeper and lower-grade resources – you look at the great porphyry discoveries of the last 40, 50 years, they are all transitioning underground and are seeing lower grades. If we don't find Escondida's and Mount Isa's, and these great deposits undercover, we will be facing a depleting resource world while we have increasing demand. The crisis will come and we will be forced. The real trick is, how do you generate the mentality of crisis before the crisis hits. That's the real trick. That's why you know it's about throwing your hat over the wall and saying, "We've got to do this" BEFORE you're in the crunch.

"...you look at the great porphyry discoveries of the last 40, 50 years, they are all transitioning underground and are seeing lower grades."

Steve: So are there enough people that are throwing their hat over the wall? That's what I mean by transition is that, I recognize that and people say this to me often, "You're almost talking to yourself sometimes, Steve. You're talking to the people who think like you." And

everybody who's relatively early adopter has already thrown their hat over the wall.

John: In some ways, they're not forced to because there are other options. The other option is to go and find something in the jungles of Colombia or Ecuador. They're great places to find things, in these sort of frontiers. But they have a different kind of risk. The risk is around the politics and whether you can develop things, and so on, and so on. If you find something undercover, a 1,000km from the nearest city in the middle of Australia or in the middle of Canada you almost certainly are able to develop it. No problem. So you face a technical risk. There are two types of frontiers, there are technical frontiers and there are geopolitical frontiers.

"There are two types of frontiers, there are technical frontiers and there are geopolitical frontiers."

Steve: But isn't it just about portfolio balance in terms of different types of frontiers?

John: It is. You want a bit of this and a bit of that. But the smaller you get, the more you have to put in. It's like I have the luxury of being able to bet on the roulette wheel by – well, I can't actually bet on red or black, but I can kind of bet on quadrants and take larger bets. Most juniors have one number to put on the board. They have to make a choice. And given the choice of, go to Ecuador, or Myanmar, or whatever. And go undercover, I think that's an easier choice for them to make to go to the frontier. They can see some way of getting results they can give to the market. It's viable. I'm not sure it's viable to be exploring under 500m of cover.

"...the smaller you get, the more you have to put in. It's like I have the luxury of being able to bet on the roulette wheel...I can kind of bet on quadrants and take larger bets. Most juniors have one number to put on the board."

Steve: I would agree but the vast majority of exploration is done by juniors and mid-tiers.

John: So that's why I said it's going to change the structure of the business.

Steve: We've got this mismatch between who's exploring and where they need to explore.

John: One way to think about this is, "Is the current way that we put capital into this business actually going to work? Or is it broken?"

"...an interesting way to approach any problem is to ignore all the practical constraints. Throw all that stuff out of the door. And say, "In an ideal world, if you could do anything you wanted to, what would you do if you're a junior?""

Steve: Clearly it's broken.

John: How could you ignoring all the constraints… an interesting way to approach any problem is to ignore all the practical constraints. Throw all that stuff out of the door.

And say, “In an ideal world, if you could do anything you wanted to, what would you do if you’re a junior?” Well, you wouldn’t be listed. You would get funding that comes from investment that doesn’t require you to report back to market. From people that understand that you have a decadal process to follow whatever and they have a portfolio of those investments.

“...walking around the stands at PDAC, it’s a distribution with a long tail.”

Steve: Mark Creasy, Robert Friedland, and I don’t think it’s any surprise that those are two of the most successful explorers. Neither of them are geologists. But they are able to raise money. Privately-owned. It’s like a big family in terms of the way they run as businesses, instead of reporting straight through to ASX or something.

John: It requires a different kind of credibility, market credibility, than a proportion of juniors can have. You know walking around the stands at PDAC, it’s a distribution with a long tail.

“...as much as you can do all sorts of appraisal work remotely, you need still to actually get out there. Now undercover it’s a different concept to walking up the creeks in Ecuador. But you need to be in the game and on the ground.”

Steve: Definitely. So I want to sort of wrap up the conversation with a whole bunch of one-liners that we like to ask people. I’ve asked you one before but I’m going to ask you another line, which is: what idea in exploration or geoscience do you think needs to die?

John: Cam McCuaig would say, “Boots on the ground.” I’d push back on that a bit and I’d say, the idea that we can do this stuff without boots on the ground is really difficult. Because at the end of the day, economic discoveries are drilled intersections. Eventually you’ve got to actually put your foot in the water and do it. So as much as you can do all sorts of appraisal work remotely, you need still to actually get out there. Now undercover it’s a different concept to walking up the creeks in Ecuador. But you need to be in the game and on the ground. I think there’s an idea, not so much with geologists but with senior executives in the mining industry, that technology will mean less and less and less people. And I think geologists are going to be extremely important in the future. But they’re not going to be just data collectors. They’re going to have to really push themselves differently. I think to kill an idea, I’d kill the idea that somehow all this technological revolution is going to get rid of geologists because it’s not. But it’s going to demand and create another big problem for us. We need much, much smarter people going into geology universities. It’s not good enough at the moment.

“We need much, much smarter people going into geology universities. It’s not good enough at the moment.”

Steve: What do we do about the skill set that are need-

ed versus the skill set that we perhaps have?

"I'm not so much worried about whether graduate geologists understand hyperspectral technology or whatever. What I'd like them to have is a better basis in physics and chemistry and mathematics, as well as in geology."

John: I had this conversation with Paul Hodkiewitz and it's interesting. I'm not so much worried about whether graduate geologists understand hyperspectral technology or whatever. What I'd like them to have is a better basis in physics and chemistry and mathematics, as well as in geology. I think that there's a tendency to think that we're going to move more and more towards technological education for geologists. I actually differ from that. I think fundamental thinking and skills is more important. Technology is something you can acquire, and we need basic technical skills. But I don't think any of that compensates for a rounded-scientific education.

"I think you're training thinking in the future, not technology."

And going back to one of the things you've said earlier, when Mike Stewart and I wrote that paper on philosophy of science for geologists as a tool for geologists, I had done lots of surveying. Because I did a geostatistics course for a few years back and used to do a 2 hour module on that. And I used to ask people, all these geologists – 4000 geologists over 10 years – "Put your hand up if you studied philosophy of science as part of your undergraduate degree?" 5%. I think this is a mistake. I think you're training thinking in the future, not technology. People think it's going to become more and more technical, but actually think about an iPad and all the stuff you do on an iPad. You don't understand any of that but you can do all sorts of extraordinary things with it. You don't have to understand how the glass works and how the touchscreen works and all that stuff, you use it as a tool for thinking. It's the same in our field, we need to understand the fundamental science and the thinking. The hyperspectral and stuff, it's just going to be another tool, it's going to be like we thought about thin sections. It's just there. That's an opinion but you asked me.

Steve: I did. Creativity is undervalued in our industry?

"...one of the reasons creativity is undervalued is because people don't feel safe to be creative... You can only have dynamic tension if people feel safe."

John: Yes. Move on, next. But one of the reasons creativity is undervalued is because people don't feel safe to be creative. One of the things as leaders that you have to do is generate an environment… we talked about dynamic tension which is an important thing. You can only have dynamic tension if people feel safe. You can only have fail fast if people feel safe. If they think I'm going to shoot them for having a bad idea or asking a stupid question, they'll never have a bad idea and then they'll never ask a stupid question. You can't tolerate repeated incompetence, that's a different thing. But you want to tolerate

people who live a bit dangerously and can actually get out there and say, “Look, here’s an idea. It sounds crazy but let’s follow this idea up.” And have somebody engage with that, and say, “Yep, let’s do that.” And if it doesn’t come out, it doesn’t come out.

Steve: Roy Woodall used to call this ‘psychological comfort’ that you need to have sufficient comfort to be free with your own thinking that you’re not concerned about safety.

“...it’s always about the outcome and not about people. And a lot of stuff in badly run teams is about people, not about outcomes.”

John: It’s a sense of safety. Even in a leadership team, this is actually the most important level. When you have peers in a leadership team, sort of team that I lead, you want to have an environment and a culture where in the middle of a conversation about what you do with project X or project Y – one guy is defending his project in Zambia and the other guys are asking him questions – he understands that the motivation of all these hard questions is to get a better outcome. That it’s always about the outcome and not about people. And a lot of stuff in badly run teams is about people, not about outcomes.

Steve: Do you think the cycle is partly responsible for some of this lack of safety? Or is this actually just people in general?

“...my goal as a leader is to have people believe that they can interrupt me, and correct me, and challenge me in the same way that they would deal with anybody else. The fact that I’m their boss doesn’t stop that happening. Now that requires safety.”

John: I don’t know what the old world… if I could rent a time machine, and go and sit through some of Roy Woodall’s conversations with his team in 1970, I’d really like to do that. And there are guys who can remember that stuff but memory is always unreliable. As much as you talk to people, they all have a slightly different view of this stuff. But I do think that my goal as a leader is to have people believe that they can interrupt me, and correct me, and challenge me in the same way that they would deal with anybody else. The fact that I’m their boss doesn’t stop that happening. Now that requires safety. I mean, it doesn’t mean that I’m not going to argue against them, they all know that. But I don’t think any of them think they’re going to be shot, or that they’re worried about showing me up. I’m quite happy to be wrong if it progresses the greater goal.

Steve: I think this is really important. I think especially if you’re… so I talked a little bit earlier before about you’re trying to create these transformative ideas. They aren’t necessarily an endpoint of linear thinking. And therefore they aren’t necessarily the endpoint of normal day-to-day jobs. They won’t necessarily become

outcomes from that. How do you create the space for this to happen? And part of it is creating this comfort. And that might include for example the possibility of the first 10 ideas are terrible. So I liken it to a baseball batting average. Or basketball. It's not an accident that Michael Jordan has the largest failure rate for failing to win a game with the last play in basketball history. He also has the largest success rate for winning a game at the end. Or Babe Ruth, it's the largest strikeout record in history. And he also led the leagues in home runs. And the same person can have completely bimodal distribution of failure and success. And that person inside your own team will therefore also potentially have failure in the idea generation as well as success. And you tolerate that.

"...people talk about culture, I'm not sure I even know what culture is. But I know what behaviour is. And behaviour is the visible part of culture."

John: I think that there's a component of, as people say you can only manage what you can measure. You've heard this throwaway line. It's just nonsense. The most important things to manage is the stuff you can't measure, around human psychology and behaviour. And people talk about culture, I'm not sure I even know what culture is. But I know what behaviour is. And behaviour is the visible part of culture. So if you want to surface that kind of trusting behaviour, firstly you have to actually lay down this is what you want and be really explicit. Then you have to demonstrate that you are authentic, and what you're saying is authentic. And you can only do that repeatedly.

"...one of the very first things that I said to our team when I was put in charge of discovery was, "We will know that the culture here is right when we have people from Peru arguing that we should spend more money in New Guinea. And when we have people from Zambia arguing that it's better to spend the money in Arizona.""

To give you an example, like a lot of companies if you go back historically sometime ago, Anglo American had a very regionalized view of what was going on. We could pick any random company. If you have different groups and different teams competing for exploration budget, they will compete hard for their own budget, for their own projects. So one of the very first things that I said to our team when I was put in charge of discovery was, "We will know that the culture here is right when we have people from Peru arguing that we should spend more money in New Guinea. And when we have people from Zambia arguing that it's better to spend the money in Arizona." Because then they'll realize that a discovery in Australia is a victory for the team in Canada, and that it becomes very collegiate in that sense. You can only build that over time and I think in two years, we've gone huge strides towards that. We've seen those behaviours in my team now. And that's about safety. They know that we've had situations where people have said, "Look, we'll transfer this part of the budget over there because we think it's going to be better off." I'm not asking for that to happen. It's being

driven from the team. That's what I want.

Steve: I've had that a couple of times in my career. It's so rewarding to realize that everybody is on the side of the one company. It's easy to say that in a PowerPoint slide, but to actually live it?

"So you can only judge by what you see. I can't actually tell what you're thinking no matter how much I stare at you. But I can see what you do."

John: It's going to be demonstrated by behaviour. Culture is the tip of the iceberg, behaviour is all you ever see. So you can only judge by what you see. I can't actually tell what you're thinking no matter how much I stare at you. But I can see what you do. If I want people to be trusting like that, I have to demonstrate that kind of trust and behaviour. I have to actually be demanding and say, "I demand that kind of behaviour." And then over time, we will get that kind of behaviour.

"...if you've ever played team sports, there's something about being in a team that clicks that is really exhilarating. You actually lose yourself, literally lose yourself in the moment of it. That's a feeling that is just exhilarating. That's what you want. Exploration is a team sport."

But one of the things about that is, it has a momentum. So, there's a momentum effect. If people start behaving that way, there is something about… if you've ever played team sports, there's something about being in a team that clicks that is really exhilarating. You actually lose yourself, literally lose yourself in the moment of it. That's a feeling that is just exhilarating. That's what you want. Exploration is a team sport. You want everybody to almost lose themselves. I imagine that those teams that Roy Woodall led, there was a real element of that. When you've interviewed some of these people and looked back historically, they all have that sense even if they were at the tail end of that, that they were at the tail end of something really special.

Steve: I have lived through that. And I don't think I appreciated it at the time. That the people I worked with, and now I look around, where they are and who they are, and realize that I was part of something amazingly special. And I was only at the end of it. And a lot of how I think, I don't think is actually just my own way of thinking. It's influenced by the culture that I was part of.

John: What I've said to our team… this is me speaking to myself, just saying it out loud. What I really want to do in this role is the ideal landing place for me is the 10 or 15 years down the track, People are interviewing people from my team, asking what it was like to be part of that team that found that stuff. Now that's creative visualization. It's just like a bit of geo-fantasy. But I think you have to have that. If I don't really believe that this team can find stuff, then I shouldn't be leading it. I'm just going through the motions. I'm taking my salary on false pretenses. And I'm not going to do that. I've been really clear to everybody

"The only moment you ever have to do anything is this split second now. So act now, and then later on, we can look back."

that we need to build a culture and a team, and we're in a process now of doing that. But we're out of starting blocks, where we can kind of think in the future, we'll look back and think, "That was something really special to be part of that." You can only act now. The only moment you ever have to do anything is this split second now. So act now, and then later on, we can look back.

Steve: There is only now.

John: There is only now, yeah. And it's gone now, you've just said now.

Steve: One final question, somewhat controversial, is exploration in decline?

"...when you think you've worked out all the details of something and you've pretty much got the model right, is when it's ripe for total disruption. We are sitting in a moment like that in history, where we're going to go undercover."

John: No. I think we're on the cusp of an incredible future. But it's like all of these things, you've got Thomas Kuhn's book The Structure of Scientific Revolutions – funnily which I saw lying there when you came in – and that book is really interesting. There's too many books recommended on podcasts, but I encourage your listeners to read that book. The idea of a scientific paradigm shift - and the word paradigm was invented by Kuhn in that context - is that when you think you've worked out all the details of something and you've pretty much got the model right, is when it's ripe for total disruption. We are sitting in a moment like that in history, where we're going to go undercover. One of the questions I have is, how many times in recent years have geoscientists sat with fundamental physicists and said, "What aspects of the physical properties of hidden mineral deposits are we not measuring? Rather than refining the ones we know about?" So there's an opportunity here to have major breakthroughs in how we seek these deposits conceptually and technologically. I think it's very exciting time. But it's always a bit bumpy going through a process like this, so its going to be bumpy going through it.

Steve: Thanks for coming on the podcast today.

John: Thank you. It's been great fun chatting about a million things.

Steve: Thank you.

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