

**FutureSmart Mining™  
Roundtable  
with Tony O'Neill**

Monday 20 May 2019

### **Slide 3 – We are re-imagining mining**

At Anglo American we are reimagining mining, and our Purpose as a company is to reimagine mining to improve people's lives. In some ways, if you look to the future, what will mining look like? Basically it's on the surface quite pristine, similar to farming, with really no expression of what's going on in terms of extraction of minerals. We're mainly underground, we're leaching orebodies that are surrounded by an impervious curtain. Processing is far more underground than we have today but the rock-cutting part is without vibration and the only material that we bring to the surface is the material of value.

In many ways you could argue that mining can become like farming, where people accept it as a perfectly acceptable activity to coexist beside; the normal nuisances like dust, noise, visual impacts are really no more of an issue. In essence, the FutureSmart Mining™ - which will deliver this in our view - is around footprint and is around precision. It's how we extract our resources in an absolutely predictable, reliable, and errorless manner.

To do this we need the Holy Trinity in our view. Firstly, the Operating Model, P101, and technology. In many ways it's like a three-legged stool; without one of those the whole programme essentially doesn't work in the manner that we're targeting. I think if you look across the industry, if you don't have similar things to those, then again, I think the things that are being talked about aren't reliably going to be delivered.

### **Slide 4 – Operational excellence as standard**

Let's firstly talk about operational excellence as standard. The Operating Model, Mark's talked to it a lot over the years, it's really like the chassis of a car. It's the base upon that that we put all of our innovation, that we put all our work on. It provides the structure for our work, it provides the planning, the right procedures, the way the task is to be executed, how we measure the results, and how we analyse the results and continually improve. Without this absolute predictability, the assurance in the way that we do things, we cannot run our operating businesses in a predictable manner.

Firstly, from where I sit, we cannot lay down new technologies over it. It is the glue to everything that we do. P101 is about mining and processing, and maintaining in an absolutely textbook fashion, taking out all of the mistakes, establishing new benchmarks for the industry in terms of efficiency. It's about how we push the capability boundaries towards the absolute limit.

So let's look pictorially - if we look at all our key processes to date, there is a lot of variation. Essentially, what we're aiming to do is to firstly take that variation out, step it up to another level, again take the variation out, and then go another level again. At some point in this we will establish new benchmarks for the industry. In some parts of our business, for example in Met coal, the performance of our shovels are near world-class benchmark - they're not quite there, but they're close. In other parts of our business we have to triple the output of our shovels to get where we want.

We're seeing quite a degree of change as we've undertaken P101. Generally, we're seeing uplifts of 20% to 30% already. Some of these low-hanging fruit, if you like, are being taken and it will get harder, but we can see the day coming where our key processes around excavation and processing are certainly at or either have established a new benchmark or are certainly very close to it.

## **Slide 5: FutureSmart Mining™**

We've talked over the years about FutureSmart Mining™ and we'll talk to some details in a moment. Concentrated Mine™, Waterless Mine, Modern Mine, and Intelligent Mine, to go back, it is all around footprint. Concentrated Mine™ is essentially how do we put higher grades naturally into a processing plant so that we can either have a smaller footprint or we fundamentally change the capital equation. For Waterless Mine, essentially how do we operate mines without water, but also as part of that is how do we operate mines without tailings dams? Modern Mine, essentially around safety and efficiency; and in Intelligent Mine, how do we simulate what we're going to do and take the errors out of what we're doing, before we actually put them into practise on the ground?

## **Slide 6 - Step-changing the intensity equation**

Step-changing the intensity equation - we've talked over the last few years about coarse particle flotation, where we crush the particles that we use for the processing to a size that is three times greater than we currently crush to. What does that do? It gives us a 20% increase in throughput, 35% water recovery from free-draining sand, 20% less energy, and it enables parts of our copper business to fundamentally shift their profile. Not every ore body in the world is amenable to this, it really is mineralogy-dependent. Fortunately for us, in varying degrees, we have candidates that suit coarse particle flotation.

Bulk sorting, I'll talk about in a moment, because I want to play the video at the end. Precision classification & ultra-fine recoveries: so how do we essentially get more mineral out of the materials that we mine? On ultra-fine recoveries, for example in platinum we currently lose 10% to 15% of our recovery because our grinding is simply too fine. We're currently testing two ultra-fine recovery methods and expect to increase recoveries in future by 4% as we see a solution to the ultra-fine material losses.

Let's look at bulk sorting. We've talked about bulk sorting; we've put it in at El Soldado. We expected to see a 5% to 7% lift in head grades. What we've actually seen has surprised us, we've seen north of 20% increase in head grade. In our scheme of things, El Soldado is sort of middle of the road of the suite of opportunities that we have.

Bulk sorting really relies on the variability in the ore body. Rather than in the past when metallurgists would try and average the grades so that they had stability in the processing plant, we're trying to use that variability to pick the waste out, away from the ore and lift the grade.

This is what we have at El Soldado [video plays]. Material feeding into the bin, it goes up a conveyor belt and into the sorter. In the sorter, we can change the parcel sizes, so it's working out what's ore, what's waste, and it is flicking it in different directions based upon a certain tonnage. We're able to, in this case, get down to a fineness of about 3-tonne parcels, which is a fraction of a bucket. We're not high grading. We're actually changing the very nature of what we present to the processing plant.

It works, and the development of it has been driven by Donovan and some partners of neutron sensors, so it's new technology that's allowed that. We have one currently beginning construction in platinum, we have another one being put in in nickel, and the aim in our business, in some shape or form—because there are other methodologies as well—is to have bulk sorting operating at all of our sites in the next 18 months; that's certainly the goal that we have.

At the end of that, as you can see, we've talked about the VeRo Crusher at length over some time. Essentially, a crusher that has blades that sit on the vertical axis, and these blades rotate around 1,000 or 1,500 rpm, so really quite quick. Interestingly, we've struggled with the durability of the blades, but I think we're getting to a point where we're starting to solve that. The interesting addition to the improved power performance on these is the breakage of the material, appears to be along the grain boundaries of the mineral, and we would expect to see another 1.5% to 2% recovery through the rollout of these.

It's not as advanced as the bulk sorters, but we've seen that they're coming. Particularly, you put these underground and you can also put them close to your excavation units. In our head, you get the mobility of these, you reduce the need for trucking, and we have this recovery advantage and a power advantage.

### **Slide 7: Recovering and avoiding water**

Water; ultimately the aim is to have dry processing. Certainly the VeRo Crusher facilitates dry processing. It's essentially how do we firstly recover much more water from our tailings dams today. We've developed some polymers that enable that, and one of the first plants is currently being installed at Orapa. Essentially, how do we move beyond, if you like, the efficient recovery of water today into mines that dry stack, and 70% of our mines are in very dry areas. Between the polymers and the coarse particle flotation in particular, we see those as the main two pathways going forward.

[Video plays] This is an example of what happens if you put water into a very fine material, and is essentially what's happening in tailings dams. You essentially contain the water in the fine material, and it becomes like a sludge. The coarse particle recovery with much coarser particle sizes: the interstitial water between the particles releases. That's really the concept behind both of them, and why we're pushing to the right-hand beaker where the water just naturally drains out of the material.

### **Slide 8: Novel leaching unlocking new value**

Leaching is the least energy-intensive method of processing, and it has disproportionate benefits to conventional processing methods, but it's really been hampered historically by the actual recoveries. From leaching you might get recoveries 40% to 65%, but generally not much higher than 65%. The new chemistries are enabling the targeting of quite specific minerals and with recoveries in the 80% to 90% range. This clearly does two things, it enhances recoveries of lower grade ore bodies, but I think ultimately it will challenge the whole design for conventional processing plants as we know them. In some ways, you could almost argue that Quellaveco could have been one of the last of the old generation of processing plants, even though it's new.

This will change flow sheets. It will remove the need for smelters because electro-winning is cheaper than smelting. There are also some reagents in these new leaching chemistries that are based on lactose, so there's also a generation, if you like, of quite environmentally friendly products that we see coming through with really good recoveries that will change the whole nature of processing. We're certainly targeting our copper work in some of this. The other advantage that we see is it will also allow us potentially to address some of the legacies of our past, particularly being able to target some of the heavy metals, some of the other things left behind in tailings dams. The aim is to do that in a manner that certainly financially makes sense. That's part of our broader technical and sustainability program.

## **Slide 9: Delivering enduring value through Smart Energy**

We've been working, for some time now, on the development of a hydrogen truck. We struggle putting together the business case for hydrogen, and in many ways I think you guys have a part to play in how people think about it. With the traditional IRR-type approach we can never get these things to the line. And people said renewables, they're all cheap, and when you actually put the numbers together it doesn't quite ever stack up.

We thought well, how are we going to crack this? We said we don't want a return; all we want to do is essentially wash our face, what does that do? Effectively, it enabled us to over-size our power facilities, and with that over-size—and I'm talking about solar power in particular—with an over-size power facility the extra power was used to generate hydrogen. The guys in Donovan's team, they went back and said okay, if we have hydrogen-powered trucks, what are the performance characteristics of those new trucks? They are certainly, if you go back to base engineering, really very different to the traditional type of trucks that we know.

With that different performance of the trucks then put back into the financial equation, we got our the returns we were looking for. It's just trying to turn it on its head and come up with something really different. There's some detailed engineering already going on. We have some strategic partners who have some serious clout. We hope that we have one of these, or are expecting to have one of these, operating by the middle of next year.

In many ways these things are simpler than a traditional truck. You're talking about a fuel cell putting power onto wheel electric motors. Providing we have logic of the wiring and the flow of power in the right place, these should be more reliable than a truck as we know it today. As I said, the aim is to have one of these operating in around 12 months' time.

## **Slide 10: Re-defining the risk profile - work**

Safety is our number one priority. There are no if's, no but's about that. We've been on a program trying to fundamentally change our safety performance, and I'm talking in particular around fatalities, firstly. What we're seeing is that there is a need for a new generation of engineered controls to reduce the exposure of people to risk in work process. What we're seeing is there's still around a 70% non-compliance factor in the incidents that we're investigating.

In an underground sense, the way that we will address that is effectively to remove the employee from the direct working area, and that's where rock cutting comes in. The second part in rock cutting is it will enable us to undertake our strategic mine development potentially at a speed three to four times what we currently are achieving. If you look at most underground mines around the world, they are always constrained around their strategic development; never have enough stoping areas open to get flexibility of grade if the rock conditions aren't what they expected. I would expect that if we can change the whole nature of the development of underground in particular, that some of the underground mines today are stressed in terms of cost, will be much more competitive with open pits.

In our view, rock cutting is the key to that. These machines have been operating in platinum now over the last 18 months, 2 years. They've certainly come of age over the last 12 months in particular, we're now at a point where we're actually designing a bigger machine to put in as an operating unit.

They're not just for development, but of course, they've also been sized to be stoping machines as well. We're one step short of this being nirvana, and that's some sort of pre-

conditioning ahead of the cutters so that we can make them go much faster; again the penetration rates change. There are some novel techniques around and we certainly see a pathway—and I would hope again in the next 12 to 18 months that we have this well and truly resolved, and particularly from a safety aspect, to change the nature of our working in platinum.

### **Slide 11: Re-defining the risk profile – tailings dams**

Our goal is to eliminate tailings dams. We've been working on this really intensively now for about four years. It's the right thing to do, and as an operator and tailings dams are the one thing that really bother you and always will.

We developed four years ago new standards, and in many ways they are the standards now that the ICMM is working with. We've also developed a number of other techniques to try and lift the certainty of our current practices. We developed a new technique called passive resistivity, where we were able to do a geophysical survey of tailings dams and work out where the water was in the tailings dam. We can do that remotely, and certainly some of the dams that people were worried about, when we put the technique over we saw them in a totally different light, because it gave us essentially a 3-D view of what was going on inside of it.

That's one; we've also been putting fibre optic installations onto our tailings dams now for about three years, so looking for real-time monitoring of strain, deformation, and seepage. In Quellaveco, we're taking that to the next step, where we're introducing micro seismic monitoring of the tailings dam foundations. That will mean at a micro level we will be told by the sensors when the wall is deforming, if in fact it is. I think that's actually one of the futures of tailings dams in their current sense, is how do you make them so that you have real-time monitoring? - because at the moment it is a little bit of a black art in a general sense on how they're monitored. As we're seeing data we'll unlock, a lot of the areas of poor performance in these areas and we think this is part of the future.

### **Slide 12: Engineering dry stacks**

Ultimately, as we've talked before, we've talked about coarse particle recovery, we've talked about dry processing, but the reality is—and we've been doing work on this—is that tailings dam design will fundamentally change. Tailings dams will become much more akin to truly engineered structures. For example, and this is a bit of a schematic on the slide, how do you have parts of your tailings dam that provide drainage for the water internally? How do you contain the parts of the fines in your tailings dams that won't release water? And if you put all that together you end up with an engineered structure that is really precise in the types of material that you put in, and where you put it.

No one's doing this at this point in time. I think it will certainly add a little bit of cost because we're going to have to be much more precise as an industry as to where we put it, but when you're building a dam like this, rather than just coming out at the end of a spigot and material running into a broad impoundment, these things will be engineered for drainage and for stability. Certainly, it's our view that that's the future of tailings dams in a wet format.

### **Slide 13: Authoring the optimal mining system with digitalisation**

We have a crew of about 40 people working on digitalisation at the moment and have had now for over 12 months. The aim was to develop digital into a format that would allow us to play the perfect match, so that we could work out what was going to happen before it happened. We spent a long time working out a business model for digitalisation - what we did ourselves, who we partnered with, because it's clear with a lot of this work - and

whether it's this work or hydrogen trucks—the business model between us and a lot of our providers is fundamentally changing, so who's going to get the right share of the pie? We put a lot of work into this area. If you have a look at this, it's some really quite interesting numbers.

As part of this programme with digitalisation, we've been rolling out advanced process control across every site in the company, and our aim is to have a footprint on every site by the end of this year.

[Charts not included in presentation] The top left graph on here, a couple of weeks ago we turned on advanced process control across the three sag mills at Los Bronces. We almost immediately saw an 8% absolute reduction in power across the three sag mills, and then 12% reduction in specific energy on certain sag mills. You can work out what we can do with that extra power but essentially, that came simply from having advanced process control on some of our facilities. The next chart, that's Minas-Rio when we put it on, a 3% reduction in primary power, a 45% improvement in power stability - again, some pretty fundamental steps. This next chart, Greenside, throughput increase of 5%, energy saving of just under 4%. And the final chart, Kolomela, 80% reduction feeder stockpiles, 6.5% improvement in throughput. If you put those sorts of things right across the company, and we're seeing them right across the company, then the cumulative effect is obviously going to be quite significant. Early stages, but as I said, by the end of this year we would expect to have every facility in the company to have some form of advanced process control.

#### **Slide 14: Data analytics platform**

In the end it will go from imaging of material in the ground, tracking of the material in every part of the process through to the marketing, so it's end-to-end. As I was touching on earlier, what really, I think ultimately will differentiate us is that we really determined early on to own the solution. It was clear when we talked to other providers that they all wanted a slice of our lunch, and by the time you added up all their slices there wasn't much left.

That's one part of it, but I think there are also some quite strategic areas in the ore bodies and in the processing that we want to absolutely have control of. Our approach, as we've gone and talked to these partners, we've said - whatever you think, we are owning the data. The data is ours because we really are about developing our own capability in this space. We've made a lot of progress in this space. I would think over the next 12 months it will mature into something a lot more coherent than we have today, though.

#### **Slide 15: Assisted hyperspectral core logging**

Hyperspectral core logging through machine learning. This is the first stage of the process that I talked to and now that we digitally determine what's in the ground and then track it, whether it's through a bulk sorter or we've developed a wrap-around for pipes where we can track flow and material movement.

The aim is ultimately to have the tracked material run through. Then also start to change the design of processing plants so that they become much more reactive, much more just-in-time, and so that they can be bespoke for each material that's flowing through. That alone, I think will give another 4% to 5% recovery.

#### **Slide 16: Cavity prediction during longwall operations**

Another area just as another example on data analytics is that we've done a lot of work on cavity prediction in the Met coal long walls. In the past, it's been a mixture of people's knowledge, some fairly coarse data, learnings etc. Looking at the before and after on the

slide, where we've used artificial intelligence and we've refined the ore body models, we're now at the point where we can predict 80% of the cavities in here that we didn't predict before. We now are very close to having a working tool that will enable a substantive stabilisation, and potential increase in production from the long walls in our Met coal operations.

Our entire digital programme has been around chasing money, effectively, and they are all quite discrete, small projects, but with a master plan, ultimately, to bring them all back into an absolutely matrix-like integrated design. From a practical sense, there was also how do we get all of the business units to buy into this? We've tried to pick examples from across the board, so the level of engagement is higher. The reality is I can't keep up with them.

### **Slide 15: \$3-4bn cost & volume improvement**

This is a slide that Mark generally shows, that with technology and other projects, pieces of work that we would expect to 3 billion to 4 billion uplift in earnings by around the end of 2022.

### **Slide 16: FutureSmart Mining™**

FutureSmart Mining™, it's not just about technology or the financial balance sheet; it's also clearly a social or a sustainability balance sheet. FutureSmart began as a purely technical programme, but it didn't take long to understand that environmental impacts, with people impacts, communities, that it was really an integral part of our sustainability plan. In many ways, FutureSmart in a technical sense grew a heart and is driving us towards our sustainability and responsibility goals.

It's clear if we're going to change the nature of mining we have to take our constituents in every level along with us. I think what surprised us a little bit is this isn't so much technical. I think in many ways a lot of the technical solutions are out there, there are certainly a lot of smart people in different industries that we can learn from, pick stuff up from. The real issue is going to be taking our constituents along with us at every level, and for them giving us the license to both innovate and execute.

It's about the way we engage, how we find solutions not just for ourselves necessarily, but for the broader interest groups. It's how we also develop our professionals. What are they going to look like in five, six years? They're clearly going to have to be very different, I think than what we have today—with no disrespect. They will need to be certainly very savvy in all the things that we've talked about today, potentially less hands-on, be much more data articulate, but in an overarching sense they will become more reputation, community managers than technical managers. I think that's what we're seeing as the way of the future.

Finishing, I've talked broadly about the programme. Its impact clearly is substantive, and it's very broad in its scope and ambition. It will certainly retool and redefine Anglo American over the next three to four years. It will also lead in changing the nature of mining and its place in the world, and certainly in our view, for the better.

We'll take questions.

## Q&A

**Paul Gait, Bernstein:** In thinking this through you're saying this is essentially the end of open pit mining as we understand it, and if we pull these pieces together, to your very first slide, this is now a future in which basically all mining is underground.

**Tony O'Neill:** I think the future will trend far more below ground.

**Paul Gait, Bernstein:** If you look at the rates we're seeing the minute there is a slow increase in the amount of underground mining but it's not so dramatic - but thinking about Quellaveco, if you're putting \$X billion into building an open pit mine, should you actually be just waiting until all this technology is actually proved out before making that investment decision?

**Tony O'Neill:** I think Quellaveco is probably a touch early. A couple of things that we've already picked up are being put into Quellaveco. We have autonomous capability. The operation will be digital end-to-end. Interestingly, a lot of our discussion is around precision, so how do you also start to be much more precise in how you mine?

The thing that we learned out of this is that a lot of automation—because they're in such big mines, you don't see the benefit that you'll get out of something a bit smaller. The ability to stand to all angles that much steeper is certainly actually worth more than the prize of automation per se. It's actually being able to get deeper, with less waste, than you would normally do with the traditional approach.

The push to bigger and bigger trucks for us is a little bit of folly, so how do you have smaller units so that when you lose one unit out of your system, your whole system doesn't collapse? We saw it at Siemens, at the factory they had near Nuremberg, where they had deliberately made the factory smaller, modular, and when something went out, it simply just reconfigured itself around the loss and kept going at almost its full capacity. I think that is the future of mining. The swarm robotics work that Donovan is doing is around the same concept, having smaller, cheaper, replicable units that you can simply plug-and-play, mix and match, and reconfigure, at quite short-term intervals to change the settings.

We have a project that Donovan is working on to also look at our processing plants in the same format. How do we develop them in a way that is more modular that we can literally push something in, pull it out, and put it somewhere else if the need is there? This flexibility, this smaller modularity, we certainly think is the way of the future.

**Dominic O'Kane, JP Morgan:** When you talk about coarse particle recovery and the metallurgical characteristics required, can we just get a bit more detail? Then, when thinking about a new ore body in situ, you were talking about the improvements in recoveries and throughput, is there any impact on geological losses? Are we talking about smaller over projects to optimise NPV?

**Tony O'Neill:** Coarse particle flotation is really driven by the coarseness of your minerality. How do you grind as coarse as you can and still have the chemistry pick up? You need a certain size distribution. If the ore mineral is very fine, then coarse particle doesn't work.

With coarse particle flotation and sorting in some format the efficiency of the ore body will actually be improved because you can lift the pick out material in the ore-grade areas - because there's ore-grade material in the waste; all the lower grades. I think it will enable us to tackle that in a much more effective manner. I suspect there will be less material of economic value going into waste dumps or these medium-grade stockpiles. I think the efficiency of delivering it into the processing plant up front will be improved.

**Donovan Waller:** This is about horses for courses. What we'll find is there'll be a portion that's really amenable to coarse particle, we'll take that. There will be some of that in the fines, and we'll take that because we have a solution there. There will be some that's really amenable to the leaching and we'll pop that in there. So, it's starting to become like what agriculture has done - instead of treating everything the same you're getting more and more down to the plant level, where you treat everything on its own merits, and that's kind of the level that what we'll be getting to with the precision. When we talk precision that's what it's about. The magic is in how do you get the right proportion of each one, to treat the pieces that need to be treated the way they should be treated, and that's about finding that magic balance. That's what will determine what the future will be.

**Dominic O'Kane, JP Morgan:** So for example, are refractory ore bodies not amenable to coarse particle recovery?

**Tony O'Neill:** I think that it goes into the mix, because you still have to deal with refractory recovery. It will enable us to concentrate the refractory material for further processing. It'll actually help in the concentration phase. Whether you pressure oxidise, or roast it, that's a question further down the chain. I think bulk sorting and coarse particle will certainly work in refractory.

**Myles Allsop, UBS:** To your slide 17, what does that look like before Paul cut it back? What's the blue sky technology upside?

**Jason Fairclough, BAML:** Can I ask that a little bit differently? If you think about the mining company's biggest source of value today is in the sunk capital \$40 billion worth of assets, what proportion of your asset base could see some uplift from these technologies? Is it all? Is it that everything could be retrofitted, or is this mostly stuff for new mines?

**Tony O'Neill:** That's a good question. I think everything can be retrofitted. I'll give you another example. There are new flotation cells that we've just started at an early stage in coal, where it takes the recoveries on the fines in a more efficient way. It's just a matter of prioritising the prize and the ease of implementation. There's almost no no-go areas that I can see across the company.

**Jason Fairclough, BAML:** Then you get into so what is your budget, and how quickly will you put money to work? You're saying \$1 billion, so I think you're not really doing anything for the next three years.

**Paul Galloway:** The budget is \$100 million to \$500 million a year, and that's in your capex slide as what we spend on technology innovation over the period to 2022. I'll just come back to the point that 2022 is the cut-off, not because that's when Tony's team stops but because that's the period we've given you so far. So the numbers are then \$100-\$500 million per year depending on success and rate of roll out to 2022.

**Paul Gait, Bernstein:** For all of those technologies you spoke of, you get a 4%, 5% 8% recovery for every one of these and then you add that all up and get to an aggregate group level recovery figure. Why doesn't that just report from the revenue lines and essentially straight down into the profit that's attributable to that because you multiply the revenue by an X% uplift, and the recovery, and that gets you to just a number that from the top of the head is significantly bigger than \$1 billion.

**Tony O'Neill:** I guess the other thing that does that, Paul, is for example in iron ore or coal it actually changes the issues of the business. It will become a logistical exercise in terms of how you get it down the line or the port. In terms of being able to shove this stuff out of the ground, being ready for distribution, I think we're certainly solving a lot of that - but it does change the issues.

**Myles Allsop, UBS:** Where do you think you are relative to your peer group? We hear from Rio about biggest computer in the world, and all this sort of stuff. Do you feel—it must have been hiring lots of people. Do you feel that you have a meaningful edge, or is this actually just what everyone is doing, maybe there's a slight edge?

**Tony O'Neill:** I think that we're in front. But I would put it differently - our program is much broader. The others are focused on automation and we've always thought that our sweet spot was our ore body and our processing plants, not because we're not interested in automation but having third world labour issues, getting stuck on those up-front around automation programme didn't make a lot of sense. In saying that we've certainly been automating drilling processes, for example, opportunistically right through our business.

P101 - it's quite an interesting step if you can see it for what it is. P101 is almost taking everything to the true automation decision. When you cannot absolutely get anything out of a manned piece of gear, then you automate. Now, I'm not sure everyone's made those decisions in the same manner, but as we get to a point where we need to retool the current fleet it's certainly our intention to really robustly look at automation when we get to that stage. We'll push it as close to it as we can today, and then when we need to retool a fleet, get to a critical mass of the fleet, we will put the fleet in autonomous-capable, and when we get the critical mass of numbers we'll flip it.

**Tyler Broda, RBC:** Are we still going to run out of copper?

**Tony O'Neill:** I don't think so.

**Tyler Broda, RBC:** The question being how much of the impact of all of this - increasing recoveries as far as industry goes - how much does that affect the supply/demand balance? Is that not deflationary, I guess on the revenue side? Then I guess secondarily, are there any plans to try and monetise this from a third-party basis?

**Tony O'Neill:** To the last question - I think it will take us into a different discussion on copper. We have other opportunities in our portfolio, and with these new technologies and starting to layer them across some of those opportunities, I think there will be other potential opportunities come through our portfolio that you haven't seen today. I think also that the nature of discovery, I could quite readily see with some of these new leaching opportunities, lower grade ore bodies being developed, because they don't need the same capital infrastructure that you need for a traditional processing plant.

Going back, Tyler, to your point have we overtly looked at monetising - no. But over the years as Anglo American has developed some of the kit — which has appeared in some of our competitors, by the way — if it doesn't make sense in the development of that technology then we've tended to sell it on. Now, today we have a much broader ecosystem of things that we could do but that's not a current discussion.

**Dominic O'Kane, JPM:** In the context of copper you say on slide 11, 80% increase in water recovery. Have you boiled that down to a dollar per ton, i.e., similar cost? Are we saying that 20% reduction in the opex associated with it?

**Tony O'Neill:** It'll be less than that, but you can do your own sums, but less than that but significant.

**Jason Fairclough, BAML:** Just coming back to this idea of unlocking the value from the existing asset base, we're going to call it \$40 billion capital. It sounds like—just keeping numbers simple—you're going to spend \$1 billion over the next three years, and that \$1 billion is going to give you a \$1 billion uplift in EBITDA. Is that 100% return on incremental capital, is that the way to think about it?

**Tony O'Neill:** Yes, that's about right.

**Jason Fairclough, BAML:** So, why aren't you spending more?

**Paul Gait, Bernstein:** Is it that you're constrained by the portfolio that you have? And in which case the question is then, are there other assets out there that exist in other people's hands that are sub-optimally run that don't have access to this, where you could then deploy the capital that you have on someone else's assets — that way you see the obvious read through is that you buy up everybody else's land.

I suppose the flip side of the question is you're overcoming the solutions for the copper market but there's also the question that does this raise the barriers to entry for people that don't have. I'm thinking a midcap/junior. Can they do any of this?

**Tony O'Neill:** I think there'll be a window of time for us to, if you like, reap the benefits of what we've done. Whether that's three years, whether it's five years, but sooner or later the industry will work it out and largely follow. That's the first point.

The key to success in all of this, though, is how you put it together as a system. If you go back to the earlier slide where we had the Operating Model, P101 and technology together, that's the lens that gives you the deliverability of a system. I think others will be able to cherry pick bits and pieces. You will need—unless you're really lucky—you'll need almost that Holy Trinity to be able to go and deliver.

**Dominic O'Kane, JP Morgan:** Whilst you've got the edge on this technology are you more amenable to M&A?

**Tony O'Neill:** For Duncan Wanblad, the Head of Strategy, the lens in which they are looking at opportunities has certainly now changed to include the sorts of things that we talked about.

**Paul Galloway:** I think the important point here, especially in the timeframe that we're talking to about you today, is the internal options that we have got. The direction of progression that we're going is very, very interesting, but for the time being we have options internally, we don't need to go externally to try and use those parenting skills with other people. We've got to roll it out everywhere and I come back to that 2022 goal.

**Paul Gait, Bernstein:** Just something like Collahuasi for example. Presumably there's huge optionality with all of this but how does that work with Glencore? And how are you thinking about protecting that or does that mean Collahuasi is further down the pecking order as it were?

**Tony O'Neill:** I think it's the same issue that face with all our joint ventures, and we have a lot of them. I think we will go through and work out what's the right technology suite to put in. We haven't landed that in terms of Collahuasi. Clearly it's an area that we know that some of this technology potentially has opportunity. It's not the priority today because we don't own all of it. But we'll certainly get to it in the next couple of years.

**Jason Fairclough, BAML:** What's your limitation on your ability to put capital to work in this? Is it you don't have enough people to supervise the projects? You can't get the equipment fast enough? You can't get the money fast enough?

**Tony O'Neill:** The Board and executive have been really in support of this for a while, so it's not the money. For example, in the bulk sorting, it's been lead time on equipment. It's been an interesting discussion with a lot of the OEMs too, because we're trying to do this at pace, so how do we bring them along quicker. So I think it's almost the environment that we're in. It's not money. Just how do we accelerate?

**Jason Fairclough, BAML:** Along with that, do you have a deal with the OEMs so that they don't put other people ahead of you in line? So, for example, say a small silver company from the United States wants to get one of your ore sorting machines. Do you get priority on that machine?

**Tony O'Neill:** At this point we do. We have clearly an order book that the OEMs are aware of and they certainly don't want to lose the first part of the discussion. In terms of the VeRo Crusher, we partly own the company – about 15%. So, we've tied up certain classes of crusher, so if anybody else wanted them, they couldn't get them.

**Paul Gait, Bernstein:** So just on the bulk sorter point. Presumably, this changes then the economics. So, have you rerun the resource base on the basis of what the bulk sorting does for things, for example, like recovery? Should we expect to see next year, for example, a redefined reserve & resource base for these assets where these technologies will be rolled out. So then we come and we'll just multiply A by B and work out what the contained uplift in value of the endowment of the company is.

**Tony O'Neill:** We're in that process now and one of the challenges that you come up with is how fast can you push the vertical sink of an open pit or then develop an underground faces. We talked about El Soldado—it's currently sinking, for example, at about 80 metres a year. There's a limit to how much upside will go on that to be able to safely increase the sink rate. So we're starting to have to dial it back into all our mine planning because it will reconfigure essentially how they all work. There'll be some mines where it doesn't apply so much - it's not all straightforward. But it does mean in some shape or form, you'll be able to get more concentrated feed, and then you can go into your low-grade stockpiles or somewhere else if you have to. Because your mining can't accelerate.

**Myles Allsop, UBS:** Do you really kind of need to do this more than other companies in some ways? Because you do have some structural disadvantages, where the assets are located and grade profile - now you have some fantastic assets - but you're further away from China than Australia is, and you don't own your infrastructure. I mean, I just wonder whether this is, it's super interesting and a really interesting part of the story, but is it just going to be lost in inflation as others benefit from all the automation work?

**Tony O'Neill:** Anybody who has a technology programme, the speed of which you implement it drives whether you step-change. Because if you drag it out, then clearly you get caught up by inflation. Our aim is to retool the company by the end of 2022. And if you look at that, the broad programme, that we're talking about, that's a pretty major step-change. So if you don't innovate beyond then, I think you go back to the average but you've reset your starting point.

**Myles Allsop, UBS:** When did this investment start in a meaningful way?

**Tony O'Neill:** In a meaningful way, probably 12 months ago. The reality is we've been working broadly on this for about four years.

**Dominic O'Kane, JP Morgan:** Those continuous cutting machines shown in PGMs - which mines do they operate in and what do they do to headcount per reef?

**Tony O'Neill:** We've been running them on industrial trials scale at Twickenham, in Platinum. I think for those it's probably a five-year journey before you really get those to a point where you would put them underground. Clearly, there's a big labour issue that has to be resolved as part of it. Different is you're opening a new mine to retrofitting a brownfield.

**Hunter Hillcoat, Investec:** Hydrogen trucks, where do you think you're going to stick the first one? How long do you think you need to observe it before you you're happy? Obviously, there's a geographical issue where it might work great in the equator where you catch lots of sunlight so how is it geography going to impact?

**Tony O'Neill:** Our first one will be put in in South Africa. Once we have the design, we have the right partners, I'd be quite keen to aggressively put them across the key jurisdictions. We actually haven't worked out what a logical timeframe is. I don't think they're that complex. Once you have the hydrogen power, the actual units are quite simple. So there's nothing to stop us being able to put them in fairly aggressively.

**Myles Allsop, UBS:** Surely battery trucks are going to be much more efficient, because you lose so much of the power of the electricity through converting to hydrogen. There is a platinum play here, which is great for yourselves, but in terms of the simple economics, surely battery trucks are going to be significantly more efficient?

**Donovan Waller:** We started with a battery and it's suboptimal to the fuel cell. It's to do with the size of the battery pack, rates of charge - those types of issues.

**Myles Allsop, UBS:** What's the biggest game changer in the mix of the things we've talked about, is there one that really stands out and is making a meaningful difference in terms of the bottom line?

**Tony O'Neill:** I think it will all change, I think the first one will be bulk sorting in some shape or form. I'm pretty confident it will work in our nickel ore body. We're putting one in Platinum, as I said earlier, and that's technically probably a little bit more complex than some of the other stuff that we have, but I'm sure Donovan and his people will work that one out. So, I think bulk sorting in the very first term. I think slightly behind that will be the novel leach and the coarse particle flotation. And the rest will just come in behind that. Data analytics and the advance process control will also be short-term.

**Myles Allsop, UBS:** Advance process control's been in the industry for 20 years. Is it just, you haven't had it across the whole business, or is it kind of more real-time monitoring data points?

**Tony O'Neill:** Anglo American has been good at advance process control in parts of this business in pockets, but not across the broader spread, so it's one of these untapped low-hanging fruits that we're just picking.

**Dominic O'Kane, JP Morgan:** Can you give an update on your tailings dam disclosure and how frequently you'll update?

**Paul Galloway:** We're working on the request from the Church of England and we'll be ready for the disclosure deadline which is towards the start of June.

**Tony O'Neill:** Yes, so certainly we're almost ready to go with it. Our records are in pretty decent shape. But I'm not sure how frequently we have to update it. I can't answer that.

**Myles Allsop, UBS:** A slight tangential as well, around dams, on Minas-Rio and the lift – so is that complete?

**Tony O'Neill:** It's still in train.

**Paul Galloway:** Just not we're all on the same page on this. First, we'll finish the work through the third quarter. We will then submit to the authorities and we plan to get the licence by the end of the year.

**Myles Allsop, UBS:** What's the incremental cost of dry stacking? Obviously Vale's looking at it across their portfolio – is it going to meaningfully change their cost position, or do you think they can do it? And if you do it, do you think it will impact your cost position?

**Tony O'Neill:** If you engineer the stack, I would imagine you might be talking \$3 or \$4 a tonne of tails. But you have to put this into quite a moving feast. Then you've got to factor in coarse particle recovery and its impact, bulk sorting and its impact. So the whole thing is almost like a Christmas pudding of moving opportunities and a couple negatives.

**Paul Gait, Bernstein:** Have you spoken to any regulatory agency about, for example, some of the stuff on the dams? To actually make this a mandated standard across the industry and then see what the impact would be in terms of the competitive environment and on some of the juniors?

**Tony O'Neill:** But the debate on tailings dams within the ICMM has been really active. I think when they agree on a base standard that everybody signs up for, then potentially after that, there's opportunity for this discussion. But I think in that environment, it's too early to confuse everything when we're trying to get people on ground zero at the moment.

**Paul Galloway:** Obviously, safety is the most important part of all that, rather than making money - but making money safely is obviously what we want to do. So yes, I think there probably will be a challenge for smaller companies going forward, just generally in my view from a permitting, etc., point of view. But the priority here is safety.

**Tony O'Neill:** Whether it's tailings dams or the whole issue of footprint, ultimately, it'll start to catch up with the smaller guys.

**Ian Rossouw, Barclays:** In terms of the early looking at what the potential returns, do you look at the return element of any new technology quite early so it's not just innovation for innovation sake, not necessarily looking at returns.

**Tony O'Neill:** There's two parts to it—we have a detailed register for every opportunity by technology and by site, whether it's applicable or not across the entire business. Before it can even get on that register, if it's really early stage TRL (technology readiness level) innovation, we have an innovation committee. Unfortunately, I don't carry the weight on the committee, so I have to convince them either a) it has a reasonable chance of getting through and b) that it's worthwhile doing.

When they get up to around TRL level five or six, a little bit more mature, that's when they go to our investment committee. So as part of the programme that we've had over the last few years has been around trying to solve, not for the knowns but the unknowns and having a really robust business case. And for those things that don't look compelling, killing them really quickly.

**Myles Allsop, UBS:** How many people do you have working for you now in this area of technology & innovation?

**Tony O'Neill:** If you look at our broader key technical functions there's probably around 250. It's much broader, because we actually provide all sorts of services and planning into the business. But if I looked at the technology part, it would be about 250.

**Myles Allsop, UBS:** And 12 months ago, that was a handful?

**Tony O'Neill:** No, we've been working on this now for four years. I remember standing up in front of you guys and you guys were listening to Mark and Stephen, you guys were never listening to me above this technology work - I felt really unloved.

**Dominic O'Kane, JP Morgan:** Can you talk about the execution - give us a sense that is what you're doing and then in 2022 this is what you will have done? What are the risks?

**Tony O'Neill:** I think the challenges your scratching on around execution are how do you disconnect the innovators, like Donovan, from a project early enough that you can put it into a project execution format? How do we get it so at TRL three or four we start to disconnect Donovan and his team's hands from it and put it in people's hands whose job

is just around delivery. So we actually have a structure around it. So, for example, novel leach techniques will work, some will fall away and we've found that with some of our programmes. But the sort of things that we're talking about today, we're pretty confident on. For me, the issue more for Donovan is what's our next wave behind this? What's coming after it? Because if we're going to keep ahead of the competitors, as we say we are, then how do we stay there? We're on a treadmill and how do we keep running.

**Dominic O'Kane, JP Morgan:** Do you share any of this information with Coldelco?

**Tony O'Neill:** They're certainly aware of the work, because in the end they have to approve the funding. We do share it with our joint venturers.

**Sergey Donskoy, Société Générale:** Speaking about competition and how easily it all became somehow distributed across the industry. How quickly do you think, starting from, say, stage zero, some of your larger competitors can proceed to the point where it will be basically enacted at every single large mine?

**Tony O'Neill:** We've been involved in coarse particle flotation now for three and a half to four years. I would think if someone starting from scratch, building it up themselves, it would take three to four years to get to the same point.

**Sergey Donskoy, Société Générale:** But some knowledge has already been distributed right? So there are people outside of Anglo American who know something about it. And those people will be willing to talk and share their knowledge.

**Tony O'Neill:** I think again, you've got to look at it as part of a broader system. The point of coarse particle flotation is actually pretty easy. But how you balance the mass flows is actually where the trick is. And then how do you put it into the broader system? It's actually the nuances of the system that is really going to be the key. I think it's still three to five years from someone starting to catch up.

**Paul Galloway:** This is an increasingly important part of the company, it's an increasingly important part of sustainability as well. Just to remind you, Mark's first appointment when he arrived was Tony. We had to rebuild the skills within this company that we think the industry itself had lost. It is the key to sustainability in mining, others are doing it by getting rid of the bits and pieces in their portfolios that they don't want. We're doing it differently. We're doing it by capabilities within this organisation.

We, along with everyone else, has a Finance Director that's on the Board and responsible for the financial balance sheet, but I think—somebody correct me if I'm wrong—but we are unique in having a Technical Director who's on the Board that's responsible for the mining balance sheet for the company and quite frankly that's how I think about the difference between us and our peers at this moment in time.

So thank you for joining us and we'll follow up on this this once a year. I'm not going to do it every six months, because these things take time, but we will plan to update you as we go forward.

**Tony O'Neill:** Thank you.

*[END OF CALL]*