CRITICAL MINERALS, CRITICAL RISKS: SECURING SUPPLY CHAINS

Announcer 00:00

Please welcome the panel on critical minerals, critical risks, securing supply chains, moderated by Vice Chairman of S&P Global, Daniel Yergin.

Daniel Yergin 00:10

Good morning, everybody. This topic, as I just said, is critical minerals, critical risks, securing supply chains. And this is a critical discussion. I don't think three years ago or four years ago, we would be talking about this, but it's obviously front and center. There have already been a couple of orders from President Trump relating to emergencies around critical minerals. It's very much in the discussion. It's very much caught up in the trade debates, and, of course, in terms of the tensions between the United States and China. So we have a great panel here that brings very important and diverse points of view. Frank Fannon was the assistant secretary of state in charge of the Energy Bureau, and really put the spotlight on minerals as an issue, and he now heads Fannon International Advisory. Vandita Pant is a CFO of BHP, a great mining company and, of course, brings the industry and global market point of view. And before that, she was in charge of, in fact, marketing, chief client officer. Kei Onishi is from Yamaha, a motor and mobility company. We all know their names, their motors are everywhere. And he'll bring the viewpoint of an industrial consumer. Nick Myers is from Phoenix Tailings, and will bring the viewpoint of technology as solutions to it. I wanted to begin with the panel by just asking each of them: Why are we discussing critical minerals? Why is it so critical? We'll just go down the line to open up the discussions. Why don't we start with Vandita?

Vandita Pant 01:54

Yeah, thanks, Dan. We're talking critical minerals because the world [with] what it's going to do, it needs the resources at a scale that we've never had, be it continuing development of the world, but now amplified by energy transition and energy security, and now increasingly amplified by need for digitization. So all this means that the commodities and the resources critical minerals and strategic minerals we are talking about have never been needed more, and the challenge to get them online is really for us to embrace. To give you a short stat on that:

copper, which is ubiquitous, be it in white goods, be it in EVs, be it in power grid, be it in data centers. Needs to grow, from a demand perspective, 70 percent to 2050: just the new application of copper in AI and data centers goes from almost nothing, [in] four—five years, back to 3 million tons of copper needed.

Daniel Yergin 03:05

Vandita, we're going to come back then and talk about what are the challenges to getting that done? Kei, why are we talking about critical minerals from your point of view?

Kei Onishi 03:12

Yeah, from the automotive industries perspective, you know, talking about critical minerals is really critical to further sustainability, sustainable growth in the auto industry in the age of electrification. When? Let's take an example of existing-engine cars. It doesn't require lithium [or] cobalt, we primarily use aluminum or steel. But now in the age of electrification, lots of air, earth, critical minerals demand sparked. So do we have enough demand? As Vandita mentioned, we don't have enough supply. So that's why we need to talk about critical minerals to support the electrification of the mobility and logistics industries.

Daniel Yergin 03:57

Why? What do you use it for?

Kei Onishi 04:03

So primarily, you know, batteries, that's No. 1. And still, like we have, we see tons of hybrid cars as well. [The hybrid] still has the catalytic converter that consumes tons of platinum group metals (PGM) as well. So for those who are for electrification, we want to have a little bit light-weight structure. To achieve that, we would probably need little more magnesium, as well. And also for the coating, maybe [inaudible] as well, or titanium. There are lots of the critical minerals consumed for the electrification, right?

Daniel Yergin 04:42

Thank you. So Nick, from the viewpoint of a, I guess if you're seven years old, you're not a tech startup anymore but as a graduated startup, a technology company, what's your perspective on why we're talking about critical minerals?

Nicholas Myers 04:57

Really echo the points already made. But ultimately, I think it boils down to the fact that we need the metal for everything that we rely on, whether it's wind turbines, electric vehicles, medical devices, or defense systems. We need it. And let's be honest, none of us have a freaking clue about how we're going to get it. China dominates this market in rare earth metals. They have 97 percent of the metal output in the world, 2 percent in Russia, 1 percent in Myanmar. How on earth is the United States going to be at all if there's an economic warfare?

Daniel Yergin 05:27

We'll come back and you'll answer that question, right? Okay, good. Frank, from a geopolitical point of view, why are we talking about critical minerals?

Frank Fannon 05:37

Yeah, just to underscore the point, I mean, we talked about the concept of an energy transition a few years ago, and critical minerals are needed for that. I think that's small ball. What we're talking about is really a forward on economic transformation of the modern economy, which requires these as the cheap inputs to AI, to electrification, to mobility solutions to modern defense system platforms. We're talking about them because China dominates them and has used their dominant, dominant position to assert leverage over the United States and others. They have them and we don't.

Daniel Yergin 06:14

So now that we know why we're talking about it, Frank, when you were in the State Department and then in the years since, how is this? How have you seen this issue evolve from a political point of view and where are we? And where do you think we are with it today, with the administration?

Frank Fannon 06:31

I think it's important. We did start talking about this issue set in the first Trump administration. In 2018 President Trump issued the first critical minerals list anywhere. And that, so I would say that that has certainly continued to ramp up attention. The issues around critical minerals have only increased part of that. Much of that was related to China's escalatory actions in that domain. And it's certainly not just in the context of banning exports of different things and reduced exports, but also their ability, which they've used frequently, to effectively dump material onto the market to undermine the economic investment thesis for Western supply chains. So they're on both sides of the trade here, really exerting an outsized degree of control. And this is, as you've written about, Dan, the commanding heights. This is the commanding heights of our position in the world, our ability to drive economic growth and security.

Daniel Yergin 07:31

It's interesting, critical minerals. You try and track it down, and you can take it back to World War One, and talk about war materials. And then after World War Two is an issue. And then, kind of, I think, in about 2008 government started publishing these lists. But Vandita, from your point of view, how has the thinking changed within a—global mining company about these issues?

Vandita Pant 07:57

So Dan, what is important is that are we are very deliberate about choice of commodities. And if you look at some of these resources and the critical minerals we are talking about, they are based on mega trends. But what is the problem and the solution right now: I want to get to that from the biggest mining company in the world by market value. The way we think about this is an absolute opportunity to fulfill this demand over next 10 years, just for copper, which is one of the critical minerals we are talking about. We have a gap of 10 million tons of incremental copper supply needed just for the next 10 years, and by 2050 copper demand is expected to grow by 70 percent from now, while the underpinning of demand is so strong and so critical, it's ubiquitous and needed; on the other hand, the supply is becoming quite constrained. In last couple of decades, we have hardly had a handful of large discoveries. Why? Because, if I can say, the quick wins have been at the top 200 meters of Earth's crust, have been mined, and we know about it now. Then as the mines deplete, both in grade and in resources, they become harder, they become deeper. The technical expertise needed to bring the supply to ground is more advanced, and of course, the projects take a long time to come to fruition. All of this supply gap, if you will, means that we need to have lots of things happening together, so a mining company or the industry needs scale. These are multi-billion dollar projects, now need strong balance sheet, because financing is not for small dollars. We need huge technical capability, because projects are becoming difficult, and some of the projects never come to fruition. And on top of all this, we need the right kind of standards so that sustainably one can do mining and have license to operate in those communities.

Daniel Yergin 10:23

Nick, you wanted to come in on this?

Nicholas Myers 10:24

That's a really great point, and I would push that. I think if we do the same thing we've done for the past 200 years by building more mining projects, it doesn't actually get us to the point we need. We need to invest in the technology to upgrade the ore in a better fashion. That's the problem with critical minerals. That's different than, say, iron ore production. You need the chemical processing to take an ore into the final metallic form. US has what? Two copper smelters and China has how many? 52, I think 52—52 right? What are we talking about competitive-wise, right? We have to really invest in that refining capability so that new BHP deposits can be capitalized on better, and it's about working on a collaborative supply chain here that's not just digging new assets, but is taking the assets that we already have and maximizing the value of those by investing in the middle part of that supply chain that no one really has put the capital in, right?

Daniel Yergin 11:14

We're going to come back to that in a minute. Vandita, just to finish on that. Our numbers at S&P is that it takes 16 years to open a major new mine; in the United States, 29 years. Why does it take so long?

Vandita Pant 11:29

Yeah, so that's a very good question like Nick just mentioned, given we have such a focus on domestic mining, and I must say, in the US that has been bipartisan stance, momentum has been building the thought to see the criticality of mining, but also a recognition that the mining processes are too complex, the permitting processes are too complex. So as you said, it takes 29 years in the US, but that is improving. We have seen the current focus of the administration in taking out duplication, making it more transparent, and going with the permitting reform. But if I were to look across the nations, I think this is one of the key levers for nations to attract investment, to unlock their resources for economic development, which is needed in the countries. And a very good example. You may be surprised: here is Argentina. Just yesterday, we announced that our joint venture we entered into earlier this year, of copper mining, along with Lundin mining, that we have announced the results of the resources, and that is the largest greenfield copper resource in the world, discovered in last 30 years. But the government there, Dan, it is really very focused on attracting investment and unlocking resources like this, through better permitting reforms, through fiscal package uncertainty, and that's super

Daniel Yergin 13:06

So take that as an example. That's a pretty significant discovery. Was it just somebody stumbled over it? Was it the technology improved? Or is it just nobody had looked how come that huge deposit's sitting there? No one knew about it?

Vandita Pant 13:23

No, it's not about "no one knew about it." But as you know very well, that region is very copper rich. You know, so take that as an example. Chile has been home for BHP for a very long time, and we run the largest copper mine in in Chile, in the Andes. So that region is very rich. But of course, the drilling and the exploration is needed, as you know, for a very long time, to do, and that has uncovered this, which we think can be among the top 10 copper assets in the world. And how long will it take to bring that? So this is where the permitting, along with vendor, you see the first production is so interlinked. So permitting processes take a long time. As we are discussing, a regular project will take, from idea, another five, six years, and the payback is six, seven years. However, that asset then is of value for 30, 40, 50 years. So we are talking about long-term investment, which means the faster we can get to the front end of permitting, the better it is to unlock those resources. And second, the fiscal settings and certainty become so critical, because your risk and return is multi-decade investment of multi-billions dollars.

Daniel Yergin 14:42

Right. So, Kei, let me turn to you now and ask Yamaha motorcycles, motors of all kinds, you had a wake-up call about this issue earlier than many others, I think. Was it 2012? Tell us what happened.

Kei Onishi 15:00

So around 2010 to 2011-12, you know, China started restricting the export of rare metal, rare metal elements, and–

Daniel Yergin 15:10

And they were doing that to punish Japan for something? Yes, to punish.

Kei Onishi 15:13

Japan, yes. And like us currently, what's happening within China and us, I think we can learn a lot from that, what happened. And how Japan reacted from the 2010, what happened in 2010, so that was absolutely the wake-up call. As a system, so motor industry, especially original equipment manufacturers (OEMs), we are like a system integrator. We source lots of materials and components from tier one, tier two, tier three suppliers, and we have been super focusing on optimization, assuming that, you know, the current geopolitical situation, supply chain, and also supply will not change. And we optimized our supply chain based on the three criteria: quality, cost, and time—lead time, but 2010 was a serious wake-up call. Okay, these three are not enough. We need to also look at the resiliency. Back then, we were using a different term, like a business contingency plan or sustainability. Those words. So we got the first criteria to make a decision. And we started working with the tier one, tier two, tier three suppliers to visualize where the layers came to — our supply chain first. You know, mapping, visualizing our supply chain is the first and still, it's ongoing. It's never ending. Effort always, every year, supply chain changes, so you need to keep updating the map. That's one. Two, identifying the critical single point of failure. Where is it? And can we work? Can we solve the challenge only with our effort or partnerships or leveraging the government- industry partnership? What we realized is, Yamaha is so tiny, we cannot have any control power or buying power to influence the entire supply chain.

Daniel Yergin 17:15

I mean, you're not that tiny.

Kei Onishi 17:18

Still there are multiple, you know, actions you could potentially take. One, you know, finding an alternative source: non-China rare earth, that was not really there. Two, vertical integration, which is currently Tesla or Toyota, or lots of European OEMs, is taking, owning the refining capabilities or investing into the mine. Vertical integration. Third, finding substitute after 2010, Toyota or Hitachi metals successfully developed rare earth-free magnets for especially hybrid. That was great. Fourth, recycling or circularity, but it requires technological advancement [en bloc]. Fifth, I think that was huge for Japan. It was the formation of geomech. You know, Japan, Japanese government worked intensively with industry to strategically pile up the rare earth reserve as a country, and also financing to build reserves within the country, and also access to the source as well, you know, financing the development of the mines or supply. I think that was huge for company like us, we are not small, but not big enough to influence the industry. So partnership is absolutely critical as a core of our strategy since then, right?

Daniel Yergin 18:54

And how is it? How do you feel about where you are today?

Kei Onishi 18:57

So after that, what happened? China started, you know, also exporting again. And so we go, like, "okay, supply is there, so maybe we can go back to the, you know, that what the operation, what we had in the past." So, we started losing the sense of urgency, and now it happened again.

Daniel Yergin 19:21

Happened again because of, why? What?

Kei Onishi 19:24

Because of two things: US, China. The geopolitical tension like US and Japan had with China in the past, No. 1, but No. 2, the second point-this is a fundamental change from 10 years ago, 15 years ago-which is electrification demand for their critical minerals. And those critical minerals are highly concentrated, especially the refining capability, as Nick mentioned, over 90 percent is in China. So now, customers want to buy more e2-wheelers or E cars. India is important market. You should take a look. Last year, India sold over 1.1 million e-motorcycles, and the penetration is 5K for the last three years, is 87 percent. It's huge. So do we have enough supply? Well, we need to work together.

Daniel Yergin 20:30

Well, that gets us to Nick, because Nick is trying to change the supply equation in a very dramatic way. Tell us about what you're doing, but tell us it came, like many miraculous things, out of a lab at MIT. Is that right?

Nicholas Myers 20:49

Give or take, happy to share. So I met my co-founder, who has a PhD from Boston University, undergrad MIT. I'd been working on technology for the past, like, 20 years before that, but I met him at a Bible study seven years ago or eight years ago now, I guess. And we started talking about the biggest problems in the world, as one does, right? late at night at a Bible study. Yeah, one of them being actually how we get raw material to the final metal form that we need for all these amazing technologies. And we saw that in China, they do this today. What we were focusing on then was less the geopolitical issue, which has come up more now, but actually more on the human rights issues. Right? They have 2,000 tons of waste for every ton of metal and it's a lot of HF gas emissions, - just really, really bad stuff. And there's a lot of worker-safety problems that happen in this ecosystem. I'll let you all Google what that is. It's not good. And we said, look, we don't see anyone trying to solve this problem.

Daniel Yergin 21:42

So by the way, I mean, sometimes when people talk about clean energy, they forget that all that stuff is not clean, correct?

Nicholas Myers 21:49

Yeah. So I think the biggest thing actually, the onshoring of rare earth metal processing, or metals, critical metal processing here in the US is probably the best thing we can do from a sustainability standpoint and a clean tech standpoint, an environmental standpoint, simply because the US has such better standards for how we process things - like we don't discharge HF gas emissions here, right?

Daniel Yergin 22:06

So you guys were talking about this at the Bible study, okay? And then what happened?

Nicholas Myers 22:10

And we said, All right, well, no-one's solving it, so let's go into it. So we pulled together our entire life savings, which was $7,000. You can laugh at it, fine! And we built the first prototype in the backyard in Cambridge, Massachusetts. So we've worked extensively.

Daniel Yergin 22:22

You saw a technology path.

Nicholas Myers 22:24

We saw a technology path. The first tech we used was not the right one. We iterated and built it up. That way our growth path is different than what traditional technologies are. And this is the message I would give to everyone who's looking at investing in technology and looking at the sector as a whole. It's not about spin-outs of universities any more with these critical metals companies, right? If you do that, they license to a big corporate and then they struggle a fair bit to scale up.

Daniel Yergin 22:47

Vandita doesn't like that. But go ahead.

Vandita Pant 22:50

I would challenge that. For example, for BHP, we are not only dependent and looking, as the largest copper producer in the world, at how we can get more out of Earth, which is needed. You can't refine what you don't have. So that is needed. But equally, we have our corporate venture capital arm which scours the world for new ideas. And in fact, 75 percent of our corporate venture arm investment is right here in the US.

Daniel Yergin 23:21

So afterwards, you two can get together. Yes, but now that I've interviewed your train of thought, let's pick it up again.

Nicholas Myers 23:28

No it's okay. So that's actually my point. So BHP is one of the very few mining companies in the world that has a proper corporate venture capital (CVC). And they are one of the best. They are very good. Most mining companies don't have that capability, but Silicon Valley Technology's approach is- really, what we're seeing is a growth path here, which is that style of investment. It's a little different than it's pronounced. So we built that way, right? We built the first prototype in the backyard. We now have 34 patents and trade secrets around our company. Well, we raised a little over $90 million in total. Capital raised so far. We just closed $76 million last week. We're very excited about it to scale up. That's why you could come hear this, that's why I'm a lot out of the office. Yeah, it's great. Yes, it's good. Yamaha came on board. We're very honored to have them, as well as Intel Partners and Sumitomo, some of our biggest backers. But we, we scaled up since that backyard. We run one of the only rare earth metal-processing facilities outside of China today. So we ship metal today. We have a $200 million signed contract where you ship metal to customers producing magnets for the electric vehicle sector today. We've built that in Boston, Massachusetts, and we currently operate sustainably in Burlington, Massachusetts, 20 minutes

outside of Boston, close enough. We produce metal consistently there, 24/7 operation, and we're scaling up to our new facility in Exeter, New Hampshire.

Daniel Yergin 24:39

And so you're taking rare earths, so they're being mined somewhere, correct?

Nicholas Myers 24:46

Yeah. We process both recycled and mined material. Today, we do what's called the refining stage. So after you dig a hole in the ground for rare earths, you produce a concentrate, traditionally, that's all been shipped to China to process into the final metal. The way we intervene in the market, we saw that gap. We started building our own refining capabilities, avoiding emissions, doing a lower cost, and making sure we can do it here in the United States, cost competitively. And we buy material from normal mining companies and recyclers and process that to the final metal long term, we look to leverage our refining capabilities to process material from tailings, which is a waste product in mining. And we have our own tailing site in upstate New York that we work off, which is an old iron ore tailing site, - ore tailing site, and we can recover rivers from that. But that's scaling up long term. Right now, the key gap in the world is specifically the refining concentrates to the final metal and metal alloys, and that's what we focused in on today. And we're scaling up pretty aggressively. We're only producers, and with more folks like ourselves, we'll be able to actually –

Daniel Yergin 25:40

This is an entirely different path than the traditional?

Nicholas Myers 25:43

Correct. The traditional path for Chinese processing of rare earth metals produces 2,000 tons of waste for every ton of metal, and it's fluorine gas that's the major discharge. You really can't operate that anywhere in the United States, under any circumstances. You can put as much insulation around as you want. It's never going to really operate at scale. So we took an entirely different chemical approach, and that's what we built in the backyard, and it's fully permanent. Operate in Boston, Massachusetts, which has way stronger environment [regulation?].

Daniel Yergin 26:10

So this didn't then come out of a lab at MIT. This came out of—

Frank Fannon 26:14

Divine intervention at a Bible study.

Nicholas Myers 26:18

Yeah, so we built it up in the backyard. We do work very heavily with MIT. So MIT actually, in the vein of Silicon Valley, the corporate venture-capital arms, they actually work with BHP quite extensively. They have startup groups, and this is where we leverage, so it's not out of a proper lab at MIT, right? We don't have, like, joint ownership of IP and stuff like that, but we work with the startup groups called Venture mentoring service and the industrial liaison program to leverage the MIT network, available to alumni and founders that are approaching ecosystem, and they've been extremely supportive of us, and they're very, very helpful. We got some of our first grant funding.

Daniel Yergin 26:50

And you don't produce 2000 tons of waste? Do you produce any waste?

Nicholas Myers 26:56

No, it's a zero waste, zero emissions process designed to compete cost competitively with China, while operating here in the United States.

Daniel Yergin 27:02

Are people beating the path to your door?

Nicholas Myers 27:04

It's going well. We sold out our entire—well, three years of production. Now we're looking to expand more.

Daniel Yergin 27:09

And where do you get the raw material? US, Canada, and Australia, primarily. So no shortage of the raw material.

Nicholas Myers 27:15

There's some challenges with some of the more rare materials, like terbium or yttrium, they're a bit, – a bit trickier. But for the majority of rare earth metals, or rare earth concentrates, the US actually is one of the largest producers in the world outside of China, and China only controls about 50 percent of the global mining of rare earth metals.

Daniel Yergin 27:33

So let me ask you and Frank, the question, is it correct that there is a panic about rare earths right now?

Nicholas Myers 27:41

I would say so, it's a bit, a bit of a challenge, right? Remember that 97percent of the rare earth metal supply- not the rare earth concentrate, but the final metal - comes from China, and they shut off exports of this, or they restricted exports, a few weeks ago. So that means that in six months, no car company in the world is going to have access to raw material.

Daniel Yergin 28:02

I heard one car company say in a week and a half.

Frank Fannon 28:06

So, yeah, yeah, I would just like to go back to the to this 2010 issue, just for everyone's awareness, the conflict in 2010 was over a maritime fishing dispute where Chinese vessels were illegally fishing in Japanese waters, and Japan repeatedly said, stop doing it. And finally took action. That was what, and the response by the Chinese was to ban the export. Overnight, prices went up 350 percent, and I agree that it was a wake-up call, but I would suggest that we hit the snooze button.

Daniel Yergin 28:45

That's sort of what Kei said, that people got more comfortable again.

Frank Fannon 28:48

Because the response, particularly of the US, Europe, and Japan, was to do what has always been done: file an action in the WTO; and it took about three years for that case to be litigated, and in that intervening three year period, China went from banning the earth to dumping them on the market and helped facilitate the one rare-earth company in the United States Chapter 11. So what the wake- up call really is, you can't go into business like that any longer, we can't abide by a certain set of traditional rules where the dominant player ignores them, so we have to chart a new course. And I think that's what we're doing in terms of the rare earths. The other thing that's important is that it's not a big market, it's tiny. What is it? Globally, $14 billion value, it's nothing. [bad static] But you only need a little bit of error in a product. But if you don't have them, it doesn't work. So F35 the [—]– uses the—you need to be able to land the plane. So it's going to be quite – [Inaudible] and I think that's a whole other question of valuation as we go forward.

Daniel Yergin 30:03

You bring up that in December, when the Chinese started to put controls on, they invoked something that the US had been invoking restrictions on trips to China that is being used by the military as well. So they deliberately [inaudible] aimed at the—

Frank Fannon 30:25

They're going after the defense platforms dispensing time. [Inaudible] They're mobilizing Taiwan. So that's been an impact on how does this play out within that context? I think, most of these criminals are exempt, but this does not manifest, and I think they're starting to see various negotiations, are very much the broad case and Liberation Day kind of announcements particularly interested in last month and interested in, last month, 232, investigation into the processing dimension. And that's going to note to the pilot of this river China's extraordinary confer of processing. And so there's also these things moving this very fast. So I think that that is further effect we need to start understanding. And let's talk about the mission. Emissions and some of the other costs that are not evident that would be evident if they were producing US supply chain. So we need to expose that and then stretch of some of these companies. Because I think once we do that, we can then understand how that's another form of dumping, and then we can impose some type of type of measures. Again, this is about investment, and we need to clear the conditions for these industries to be no better investment. [Inaudible]

Daniel Yergin 32:39

Has it gotten more complicated for you?

Vandita Pant 32:42

It is complex in terms of uncertainty and volatility, no doubt about it. I think the first-order impacts for a company like us are minimal. However, it's not about first order impacts as we've been discussing. What we need to work through is where the policy, trade policies and realignment of trade, the impacts on economic data, their views

around recession and inflation that comes through, and what are the structural curves? But — if I were to sort of step back from the noise of here and now on the topic of the day that we are talking about, nothing changes on that the narrow trends that the world needs around development, around digitization, around energy security and energy transitions are very much needed, just from slow to not spend years. The reality is 10 million tons of more copper is needed, which is a quarter of a trillion of investment.

Daniel Yergin 33:51

Well, as you know, some people refer to copper as Dr. Copper, because copper diagnoses whether we're in an economic slowdown or recession. What is Dr. Copper saying to you?

Vandita Pant 34:02

Well Dr. Copper has been resilient, and not only copper, but commodity set, in spite of the volatility we have had, has held up all that. Having said that, of course, copper being the bellwether of economic growth, and given the financialization of copper, does mean that there is an overhang of the prizes and the sentiment which can come through in the prices, which is what we are seeing. However, fundamental demand for copper has not shifted, really materially. What is important, of course, is to see how do we make sure that the structural gap which is going to emerge by the end of this decade in copper, and which almost does not close, does not close, in spite of very aggressive recycling assumptions that we are able to use the kind of resources already had. We have a huge gap to fill.

Daniel Yergin 35:05

Well I know we did a copper study three years ago that BHP participated in, and we said to meet the kind of 2050 goals of a Biden administration, or the EU copper production would have to double by about the middle of the 2030s. And when we're talking and we we're looking at the numbers, we actually see that the energy transition demand is ahead of where we thought it would be three years ago, plus all these new data centers and so forth, and all the extra transmission, so that suggests that the growth of copper is going to be critical to meeting data centers and all the other things that people want to do.

Vandita Pant 35:18

And this is not a small gap to fill. In dollar terms, we are talking about a trillion, quarter of a trillion investment for the next decade, and our run rate as an industry on copper investment has been around 150 billion for last 10 years.

Daniel Yergin 36:00

The inevitable question, I suppose it runs through everything: Does AI make a difference in terms of exploration?

Vandita Pant 36:05

I think AI is both a big driver of demand, and a big unlocker of resource. It's a big driver of demand from nothing to becoming 3 million tons of demand, driver for copper. Just to put things in perspective, 3 million tons of copper is three times the largest copper mine in the world, which we run in Chile, in the Atacama Desert. That's the demand factor, which is very exciting. In fact, if there is no copper, there is no AI, there's no data centers, there's no pooling, there's no transmission. Everything that's needed. In terms of unlocking resources, very exciting. Dan, for example, we are already using machine learning and big data sets from a multi- science perspective to look at more targeted ways in exploration, and that has been very useful both in Australia and, in fact, for a small deposit here in the US as well. Equally, the technology unlock on AI for higher recovery, lower use of water, for production-throughput mechanisms, is a big unlock in mining, and for us, that's been the reason that for a long time we're digitizing all our 100 years of data. Because once you have that, then AI unlock for the mining is needed. For a company like us, we need to use every tool in the toolkit, be it our organic, big resources. We have the world's largest copper resource in the world to unlock that supply, use technology fully in existing terms, use AI, use new technologies which are not even within BHP. This is not going to get done by one company or one industry. This will be a partnership across mining with the investors, with the governments as well.

Daniel Yergin 38:09

So on investors, you know, there's, there was a lot of ESG. I remember one big investor in France saying that, in Europe it was hard for him to invest, not in oil and gas, but mining, because there were ESG considerations. Gotgo to ask you, and then Frank, just what you see as investor added engagement. And of course, you have a different point of view Nick, because you need to raise money.

Vandita Pant 39:02

Yeah, so I would say just two, three things to that. Dan, what a great opportunity. If the thematic for an investor was just economic development as people, you know, population growth, standards of living higher, copper being really critical. Or, be it the future-facing mega trend of taking exposure to AI, copper and mining is a very good central hold in the portfolio. The second thing is, as I was mentioning earlier, we have projects that we put billions in, and then the cashflow comes in over decades, multi-decades. For patient money, the returns here today and value tomorrow is a very good match of the liabilities and assets for mining things, and I would say, from an ESG perspective, sustainably done mining is the core enabler, for everything that the world will need as well. Of course, what that does mean is that the scale of companies, the strong balance sheet element, technical capability, have to be the motos and have to be the way investment can be done, because these are the things which enable through-the-cycle resilience. You need strong balance sheets to be able to not just weather the storm, but be able to continue to invest in the businesses that you find.

Daniel Yergin 40:32

Do you find institutional Investors are more focused and want to learn more about mining?

Vandita Pant 40:38

For sure, I think not just investors, but the governments. I think the criticality of, you know, things like copper and mining is now very much center of the table, and that is exactly right, because, as I said, we haven't had this kind of a need for resources ever, and the scale needed to ramp that is important, is very important, right?

Daniel Yergin 41:06

Frank, what do you see about investors?

Frank Fannon 41:08

I think there's, as a general matter, an aversion to mining. The ESG component is one, but also the risk profile. Aa lot of —the new developing areas are outside of the OECD, and there's a certain degree of perceived or actual risk, whether that's political risk or reputational risk, what have you, but I think that's changing. It's changing for a few different reasons. First, I think, as we've been talking about, the criticality of critical minerals is new and the evolving nature of the economy and the growth trends, but also you've got this policy tailwind pushing some of the adoption and accelerating that demand curve a little bit. Similarly, you have the geopolitical headwinds in the context of the dominant producer. So, how do you think about that, and I think for the first time, the government is seeking to take a meaningful role in affecting that market dynamic, dynamic and capital formation. You know, President Reagan famously said, "If you want more of something, subsidize it, and if you want less of it, tax it." Under the Biden administration, the focus was to accelerate deployment of clean-energy technology. So they subsidized it through institutions like the Inflation Reduction Act and everything else. The Trump administration is continuing on various mechanisms for subsidization in the United States, fast tracking, permitting other things, but they're also starting to really deploy these sticks. And we talked about the tariffs, we talked about the 232 investigations, and so I think you're going to see more and more of that, which creates, I think, an enormous opportunity for investors. And last, I would point out, you know, Vanita is right, some of the big mining companies are tried and true, and they, you know, it's like a good return, steady. They tend not to be the drivers of critical minerals outside of copper, notwithstanding—they're the biggest. But some of these other minerals, like the nascent shale revolution, which was all developed by independent producers and entrepreneurial wildcat kind of approaches. That's kind of the critical-minerals producers of today. I think they're all eventually—and we are starting to—see some of that. They'll be acquired over time by the majors, just like the oil companies acquired the early hydraulic fracturing pioneers.

Daniel Yergin 43:39

So Nick, how do you find venture capital?

Nicholas Myers 43:45

The venture markets in the fall were very tight, right? So I think all of my friends that run venture companies, I think eight out of 10 of them went bankrupt in the fall, and that's the reality of it, because the market was over-allocated to venture, so they pulled back, and it was very tough to raise capital. —Now what we're seeing is a real big push towards critical minerals, all the sustainability funds, once President Trump came into office, started approaching that. Now I think there's a bit of a challenge, because what they're using is orders from the president and different initiatives that are coming forward from the government to say, cherry-pick on new investments, which is not necessarily the best way to approach, but they're trying to find a way to vet and understand it. I think the corporates in the world actually have a good opportunity here to really pave the way for the future. Mining does some investment into critical minerals as a whole. I think there's a couple of companies that do that. But where I do see a lot of pull is from the downstream producers. So there, sorry, downstream players like Yamaha motors, BMW, General Motors. Aa lot of these companies on the downstream side have been putting money into startups and really helping them scale and leveraging their capability to de-risk the price volatility that happens there, which is the ultimate scare for everyone, but also the oil producers. I think there's a lot of opportunity in the oil and gas sector to deploy into critical minerals, because they understand how the infrastructure operates. Critical-minerals technology is much more akin to oil processing than it is to other types of traditional mining operations. And it's a really good environment, I think, right now, to be able to enter in the sector?

Daniel Yergin 45:08

And Kei is a venture. Basically, — you're the venture arm. Is that right? Yes. So are you venturing?

Kei Onishi 45:15

I think venturing enough, you know, as you can imagine, mining or refining is very far away from, very upstream from — the way we are, and mining industry is requires different, completely different kinds of engineering expertise, from assembly cars or assembly motorcycle or assembly robots. So the reason why we still like—even we had a discussion at the IC meeting, Investment Committee meeting, about the amount of ventures. Do we really? Should we really make investment? Do we have enough? You know, the internal expertise to distinguish best ones from the others. And the reason why we still made the investment in Phoenix ,stating this first, we love the team and Nick, that's one, absolutely one. Two, my current boss, who is the Chief Strategy Officer of Yamaha motors. He has been working in the Mitsui cooperation, doing metal trading for over 15 years. He knows the space third. Knowing, going back to the 2010 conversation, we proudly admitted that we are not big enough to control or take the vertically integrated approach to secure the supply. So one thing we can do is write a little bit of a check to the startups, and knowing what's going on upstream and using that information to form our strategy to swim through this, the chaotic situation. Also, in some cases, we haven't done that yet, but one option is an offtake agreement to secure the supply. So I think that lots of the downstream players are putting money into venture startups to secure the supply with an offtake agreement. That is a very new trend we've seen in the last three to four years. But

again, still on mining, the industry is not an industry that many people understand. So it's still challenging to attract lots.

Daniel Yergin 47:36

So Kei, has Japan also been subjected to these controls by China, or is it only on the United States?

Kei Onishi 47:43

At this moment, we haven't seen the real impact, but are pretty sure it will happen, because China will see Japan as a sort of strong ally with us. So we and Japan will be in the same bucket.

Daniel Yergin 48:00

Nick, there are two questions—. One , why is the processing so concentrated in China? And maybe Frank might want to comment on that. And then, if you are successful, will there be supply constraints in terms of resource?

Nicholas Myers 48:22

Great question, actually. So the reason it's primarily concentrated China today is the waste associated with the processing. Now, I don't mean waste necessarily, from a climate control standpoint of permanent regulations—of course, those things—but waste in this context really equates to worker safety as well as cost. And so nobody in the United States, under any state, no matter how Republican or Democrat, wants safety issues for their workers. And they all— everyone on the downstream side, the automotive supply chain, Defense supply chain, etc.—wants to pay lower cost. So back in the '80s, this shifted away from the United States to China, and China has been strategically investing in the sector, as well as subsidizing the processing capabilities to ensure that all the rocks, all the mine concentrate, all of it goes through China to process the metal. That's how they control their trade war, — the trade negotiations. Now, as we scale up, if we're successful, as of right now, we do not anticipate really any supply chain issues. The US produces 30,000 metric tons a year of rare earth concentrate, and they can ship that out to China. They've recently stopped the exports of it because of the supply-chain issues. But that's currently being mined and operated here in the US and right at Phoenix's large scale operation, when we were at 4000 metric tons of output on an annualized basis, that's roughly about 20,000 metric tons of concentrate feeding the system. So even just operating on the current US producers, assuming nobody gets up and running, we have that capability. Now, that being said, there's always more and more trace materials: rare earths area group of 17 different elements, all with completely unpronounceable names, but that are about, that are found in small different quantities, right? It's not big mass quantities, right? The highest amount you're seeing is like 1.5 weight percent on some of these trace materials. So there's more and more of that that we need to be able to get access to, like terbium, yttrium, scandium, and a few other ones as well. And so that's where we see more.

Daniel Yergin 50:10

Can you pronounced them all?

Nicholas Myers 50:11

I can.

Daniel Yergin 50:12

Okay, sounds like a song. It's very nice.

Nicholas Myers 50:15

Some of my investors can't, even though they invested seven years ago. It was always fun.

Daniel Yergin 50:20

Frank, do you want to add anything to that?

Frank Fannon 50:22

Yeah, I think, —it was part of the time when the US was happy to offshore, a lot of you know, coinciding with WTO session, by China. And in this concept [was] that the US was going to maintain the IP and let's just offshore. Let's offshore manufacturing and low-skilled things to other places, whether that being in the Maquiladoras and the border region of Mexico, or to China. It was the thing to do at the time. It also happened to be at the same time that Deng Xiaoping famously said that the Middle East has oil and China has rare earths. It was an industrial. It was a strategic investment that they made because they saw it. They're prescient in the future, but this is going to be a leverage point that they could assert a degree of control, and then they finally are now playing that card today.

Daniel Yergin 51:21

So one may be wondering why, if Nick is focused on rare earths, why he has tailings in the name of his company? And I want to ask Vandita and Nick about tailings as a source of additional supply. Vandita, do you want to explain what tailings are and whether there is more to recover from them?

Vandita Pant 51:44

Yeah sure. So tailings are used in the mining process, and these are the tailings, which is nontoxic waste, but it includes quite a bit of residual metals, which can be recovered.

Daniel Yergin 52:01

Tailings: the volumes can be quite large.

Vandita Pant 52:03

They can be quite large. And in fact, we were just talking about it, that in one of our sites in Australia, we've done those experiments on how to recover more and more of metals out of it, but equally, how to make them less liquid so that you can get into dry tailings—. There's a lot of technology and experiments going on around tailings. Not just that, in our Chile operations, we are experimenting with five types of leaching technologies, and all of them - some of them are very useful because they do not have tailings as an issue.

Daniel Yergin 52:47

Can you explain that word leaching, because it may not, everybody may not know what it means.

Vandita Pant 52:51

Yes,— there are different ways in which you can extract metals from the ore body, and leaching is a chemical way in which you can do so, and there are different ways we were talking about technology and mining companies looking at that. We are looking at five pilot technologies of leaching with different footprints of usage of water, some without tailings, but some in which the byproduct doesn't get realized. So there are many considerations of these emerging ways in which to recover tailings, or not to have tailings so that you can make the process even more efficient.

Daniel Yergin 53:35

So why did you put tailings in the name of your company? Of course, that you're doing rare earth.

Nicholas Myers 53:39

Yes, because tailings are actually one of the best sorts and sources in the world of critical minerals, and they're readily available. We have more tailings available here in the United States than we ever could process in mine. And in the tailings themselves, you have a very good content of the rare earths of the other critical minerals, because simply, it wasn't the material they were going after originally. Right in upstate New York, we have currently signed 4 million tons of iron ore tailings, with another 60 million tons under MOU right nearby, all of which has a very high amount of terbium, dysprosium, neodymium, precidimium and yttrium, all rare earth metals.

Daniel Yergin 54:14

Well done!

Nicholas Myers 54:15

Thank you. Appreciate it comes up. And so our long-term vision here is to empower companies like BHP, Rio Tinto, Alcoa, etc, to be as successful mining operations as they possibly can by working with them to process the tailings, making them non-hazardous, eliminating that liability on their balance sheet, and allowing the recovery of these rare earth concentrates from that discarded secondary ore, as we like to call it. But it's a new age of mining. It's a different type of technology than you approach it. You can't use the traditional mechanical processes. You have to approach things like leaching or biological approaches or different other things to be able to upgrade it from, say, 100 ppm of terbium to the 45 percent weight content that you need to actually go to the final product.

Daniel Yergin 54:59

So is it the same technology you're using for rare earths that you're using for the tailings?

Nicholas Myers 55:04

Oh, no, it's different stages. So we have, there's numerous different types of technology that approaches it. So we have 34 patents and trade secrets around all of our processes for the rare earths. There's extraction, separation, and metallization. Separation and metallization are both on the refining. Extraction is what you look at for the mining side, and that's what we were talking about with leaching and different things. There's variants of leaching technologies that you can put in place that don't have the emissions or discharge, etc, that would be a major problem. If you're going after tailings for our refining, we use separation and metallization technologies, our metallization being the best in the world, because we don't have any emissions from the process, and entirely clean, super low cost for the process, and we leverage a modification of technology on the separation capabilities.

Daniel Yergin 55:49

So Vandita, you started off by saying the world's going to need a lot more copper, and you've also indicated it's not going to be easy to achieve that. What happens if it isn't achieved?

Vandita Pant 56:01

We don't want to be in the world in which it is not achieved, because, as I was saying, copper is ubiquitous, and all the things that we are doing will not get achieved if we don't. But what happens is that, in case the structural gap doesn't get met, of course, the prices can fly up for the commodities like copper. So inducement price keeps going up to bring more supply in, and the prices fly up. This is not the place that we need to be in, and hence to make sure that inducement prices will be higher, but we continue to increase the supply to match the demand which is needed.

Daniel Yergin 56:46

So the price signals are important –

Vandita Pant 56:49

Are super critical. Are super critical. As I was saying, each of these projects are multi-billion dollars. The paybacks can run into 5, 7, 80 years. And the beauty, of course, is that these assets last for multi-decades, Hence, to unlock these resources is absolutely critical. And the price signal does mean that the inducement price will be higher, but we do not want the material gap between supply inducement coming to the market and demand signals, because that can cause –

Daniel Yergin 57:24

Because the imbalance in other side. Do you see, are the price signals sufficient now to call to bring the investment that's needed?

Vandita Pant 57:34

I think the capital intensity of mining has certainly gone up very clearly, and it has gone up also because, as I was mentioning, you have to mine deeper and more complex ways, which means there is more dirt to be moved to get to the mine that you need, and which means all capital is higher.

Daniel Yergin 57:54

And the quality is going down. Is that general?

Vandita Pant 57:58

So quality is not going down. What happens is, as the mines mature, the grades come down, yeah, and the mines deplete. So think of it this way, that even to stand still, we need to continue to replenish the supply. And we are not standing still on demand for copper. We are actually growing copper by 2 percent, 2.5 percent half percent per annum, very conservatively speaking, k-guards over decades to come. And if that's the case, that divergent jaws open up, that's the one which is a challenge. But I think it's a fantastic opportunity to be able to do that with the right kind of collaboration, by mining companies, by investors, by governments, because it is the underpinning of the world that is what we want to live in, which is data enriched, which is decarbonized, and which continues to develop as we need to continue to raise the standards of living in the world.

Daniel Yergin 59:01

Well, we started with the question of, Why—why is it critical to have a discussion about critical minerals and supply chains? And I think we've answered that. In this we've also answered the questions, or have a sense of what the responses are, which are in terms of technology, in terms of investment, also, though very much colored by what happens geopolitically among nations. It's a complex picture, and I want to ask you all to join me in thanking our panel for a great discussion.

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