BAYES BUSINESS SCHOOL, MSC SHIPPING, TRADE AND FINANCE, INTERNATIONAL COMMODITY TRADE MODULE, 11 NOVEMBER 2025

THREE MINING STORIES ON AFRICA AND CHINA

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SLIDE 1

Good afternoon.

Thank you for inviting me to deliver this half of the lecture Professor Tamvakis.

My name is Bernabe Sanchez.

I am a mineral economist focused on Africa. I am also a former student of Professor Tamvakis on the MSc on energy trade and finance.

After graduating in 2009, I joined the mining industry. First in the central economics function at the World's second largest mining company, Rio Tinto, for 12 years. And since 2022 working on mineral public policy in Guinea.

Professor Tamvakis invited me to come and share some of my experience in the context of Project development, shipping and logistics requirements in mining.

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I thought I would do that by first presenting what I see as the key trends shaping the mining sector globally.

And then I wanted to move on to discuss three specific case studies:

- The first one being A story on copper in the Democratic Republic of Congo.
- The second is about bauxite in Guinea.
- And finally I wanted to talk about the world's largest greenfield Mining project: Simandou iron ore, also in Guinea.

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So let me start by showing you the three key trends in the mining sector as I see them.

The first trend is the shift in the value of mined production from Iron ore to Copper over the past five years, a trend that is expected to continue.

This chart shows:

- Along the horizontal axis the average annual growth in the value of mine production over the past five years.
- Because I'm focused on Africa, on the vertical axis I am showing the share of that Global mine production value that accrues to Africa.
- And the bubble size represents the Total value of mine production of these commodities.

I have plotted some of the commodities I am most interested in. The main points I wanted to highlight are:

- Iron ore has historically been the largest market in terms of mine production, and that was still the case in 2024 with an estimated value of $288 billion.
- But gold and copper value has grown much faster in the past five years, at 12% annually compared to less than 5% for iron ore so that gold will likely be larger this year and copper is expected to continue closing the gap.
- Although at $14 billion bauxite is small, as shown in the legend to the right it is the mineral input into aluminium production which is the third of the main industrial metals.

So that's the first trend, a shift in industry value from iron ore towards copper.

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The second trend that I want to highlight is the well-known fact that China has built a dominant position in many metal markets. Metal processing particularly is highly concentrated in China:

Over the past 25 years. China has invested in steel mills to transform iron ore, and refineries and smelters for copper and bauxite.

This chart shows the main producer for raw mineral and processed metal across each of those three value chains, with their production shown as a % of the global total and Chinese production highlighted in red.

Even though China is not particularly well endowed with any of these minerals, the world now relies on it to transform well over half of those raw ores into usable metal.

The reason why I highlight Guinea as the World's top producer of bauxite and the DRC as the second largest producer of mined copper is because as shown in the next slide …

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Not only has China developed a dominant position in processing but it has also financed much of the upstream investment in other countries.

This chart shows the destination of China's foreign direct investment over the past couple of years:

- The top destination for Chinese FDI is Indonesia where we have seen a huge nickel mining and processing boom.
- The second destination, I was surprised to see, is Hungary which I now know is all to do with investments from Chinese battery manufacturing leaders CATL and BYD.
- The final point I wanted to make on this slide is that the DRC and Guinea both make it into the top 10 of recent Chinese investment destinations globally.

So those two slides illustrate the second key trend in the industry: China has built a dominant position in processing and has financed much of the upstream incremental growth.

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This Chinese investment has also been a key driver of the third trend that I wanted to highlight: Africa being increasingly responsible for additional mine production globally.

The middle chart shows the rise of the DRC in the copper industry, with its production tripling from just over one million tonnes in 2015 to 3.3 million last year, going from number 5 producer globally to number 2 only behind Chile.

The right hand chart shows the even more dramatic case of Guinea's bauxite sector, which went from 20 million tonnes in 2015 to 145 million last year, from number six global producer to number 1 overtaking Australia in 2023.

Finally, the bar chart on the left shows forecast production of iron ore in Guinea in 2029 relative to today's top 4 producers. Over the next five years it will add 120 million tonnes

of iron ore to the market. That compares to the largest net additions in past five years from Brazil and India which have been just over 30 million tonnes each.

So that's the final trend I wanted to highlight: Africa is contributing disproportionally to additional mine production.

And the examples in this chart are the ones I will focus on, but first…

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I just wanted to show a map with the table of Africa's top mineral and metal exporters in 2023, with the DRC at number 2 with $22 billion and Guinea at number 3 with $14 billion.

While most people are aware of where the DRC is, I find many people struggle with Guinea's location, this small country further West than Ghana and Ivory Coast.

With that out of the way, lets move to our case studies.

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The first example is the Kamoa-Kakula copper complex in the Democratic Republic of Congo, shown here with its owner tagline "the World's fastest-growing, highest-grade, lowest-carbon major copper mine". In previous presentations they have simply called it "the World's best copper mine".

I will apologise in advance, by saying that most of the material I will be showing is simply taken from Ivanhoe Mines' investor presentations and technical reports available on their corporate website.

I haven't had time to format them into my own template.

With that said, let's start.

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The first question is "why look at Kamoa-Kakula"? What makes it interesting?

I can give you three reasons:

- First is obviously its size: a huge underground mine, three concentrators, and now a smelter, targeting production of 550kt of copper a rate they achieved at the start of this year. It is the single largest contributor to the DRC's production growth between 2019 and 2024.
- Second, it is operated by a Toronto Stock Exchange listed company, Ivanhoe Mines founded by Canadian billionaire Robert Friedland. Because it accounts for most of this company's $13 billion market cap, it has significant reporting requirements which means easy to access information. This is true even though as shown in the left hand side of the chart more than 50% of the mine's capital is owned by Chinese State-Owned Enterprises Zijin Mining and CITIC Metal.
- And finally, for a mine of this size it has gone through the whole mine project cycle of exploration, technical studies, construction and starting operations in what is considered a relatively fast 10 years. This is illustrated together with Ivanhoe Mines' share price in the right hand side chart.

This combination of factors makes it a perfect example to illustrate that mine project cycle, which was something that Professor Tamvakis asked me to do.

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So, mines of course start with exploration drilling and mineral discoveries. As late as 2018, the emphasis in Ivanhoe's investor presentations was exploration, as illustrated in this picture with two workers and an exploration drill.

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Once a discovery is made, exploration continues as geologists delineate the orebody underground in order to provide estimates of reserves and resources. For Canadian companies, the standard used is called the National Instrument NI 43-101. The equivalent standard for Australian companies is called the JORC code. Both standards are broadly interchangeable and are the most widely used in the industry.

In the process they produce maps and tables like these, taken from the 2020 Integrated Development Plan for the mine, available in Ivanhoe's website:

- On the left I show a heatmap of copper grades. You can probably not see it, but anything yellow, orange and red is over 3% copper, which is a remarkable grade

in an industry where the average grade going into the concentrator mills has been trending to just half of a percent.

- The tables show the geologists estimates of resources, over 40 million tonnes of contained copper at the time, and reserves of over 20 million tonnes of copper. Reserves are resources that are assessed to be economically viable with a higher degree of confidence than resources.

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The next stage is for mining and metallurgical engineers to develop a mine and metal processing plan.

This and the next two slides also show charts and tables taken from the same Ivanhoe plan document as the reserves and resources data shown before.

What makes this document interesting is that it is the last plan produced before the mine started operating in 2022. It also contains three different types of study for each of four deposits assessed. From lower to higher degrees of confidence, the document presents a Preliminary Economic Assessment (PEA) for two of the deposits, a Pre-Feasibility Study (PFS) for one deposit, and for the fourth deposit a Feasibility Study (FS) sometimes also called a Bankable Feasibility Study.

One of the key outputs of the work of these engineers is the production profile, as shown here. This profile provides estimates of both mineral ore volumes and expected ore grades which can be used to forecast contained metal production.

This plan shows that Kamoa-Kakula could reach 800kt on its ninth year of operation, which would make it one of the world's top 3 mines.

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These engineers will also provide detailed estimates for capital expenditure and operating cost.

Again, it is difficult to see, but just as an example the Feasibility Study for the Kakula deposit only in this 2020 Ivanhoe plan showed a total initial capital cost of just over $600 million, with about $250 million for the underground mine and also more than $200 million for the concentrator, power and other infrastructure.

The study expected this investment to result in operating costs of just $1.26 per pound over the Life of Mine, compared to current copper prices of $5/lb.

I guess you can imagine where we are going with this now…

SLIDE 14

Forecast production volumes, initial capital expenditure, operating costs, prices…

It is the turn of the financial analysts to use their Discounted Cash Flow Models to estimate the project net present value and internal rate of return.

This is the final table I will show you from that 2020 Ivanhoe Plan: it is a matrix showing the Net Present Value of the Kakula deposit at different discount rates on each row, and different prices across the columns.

The final row also shows the Internal Rate of Return of the project at different prices.

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Finally, Industry and Strategy Analysts will put the project forecast costs in context for decision makers. In this case taken from a 2024 Ivanhoe Investor Presentation, Kamoa-Kakula is shown in the copper operating cost curve.

The operating cost curve illustrates the costs of every producer in the industry on the vertical axis, and on the horizontal axis their production volumes are shown ranked from lowest to highest cost.

This particular chart shows that Kamoa-Kakula was operating at $1.40 per pound, firmly in the cheapest half of the global distribution, but also had a pathway to move even lower with the start of the smelter.

In terms of my own personal experience, over my twelve years in the central economics function of Rio Tinto my main role would be to produce the price guidance that would be used to estimate project returns. This price guidance would be the result of demand forecasts and cost curve models very much like this one.

So, having gone through that lengthy process, you have a project to take to the bank, to investors, or indeed to your company's own investment committee.

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Provided you get the funding from any of those sources, you can proceed to construction!

This will of course require the involvement of many other professionals, including procurement specialists and construction engineers.

This picture shows the construction of the 500kt smelter at Kamoa-Kakula, that will start operating this month and result in the operation exporting 99% copper blister instead of 50% copper concentrate.

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And finally you will be ready to operate your mine!

This picture shows the three concentrators in operation at Kamoa-Kakula earlier this year…

SLIDE 18

And finally, but certainly not least you have to move your product!

This will of course require logistics and shipping, and sales and marketing specialists.

This rather messy slide from one of Ivanhoe's Investor Presentations shows their inland logistics options to get their copper to port. You will find that there is much excitement at the moment with the recently upgraded Lobito corridor across Angola.

Kamoa Kakula has managed to cut its time to port by half using this corridor, from an average of 40 days before to under 20 now.

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But, as exciting as Copper in the DRC is, there are a couple of reasons I also wanted to cover Bauxite and Iron Ore in Guinea:

First, because that's where I have been working for the past 3 years.

Second, and equally important with this particular audience, because shipping and logistics are a relatively minor factor determining the competitiveness of a copper project.

The left hand chart shows that:

- For copper production from the DRC going to China total logistics costs are just 6% of the average delivered price in 2024.
- In contrast, just the shipping costs of bauxite and iron ore from Guinea amounted to 36% and 23% of the average 2024 delivered price in China.

Further, as the right-hand chart shows, volumes shipped are much larger for bauxite and iron ore than for copper concentrates. Iron ore is by far the number one commodity shipped in capesize vessels, and I think it is right that this year bauxite has overtaken coal as the second most transported cargo on those larger vessels.

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So let's talk about Guinea bauxite…

The picture here shows a China-bound capesize vessel being loaded off the coast of Guinea from an 8,000 tonne barge.

Despite the costs associated with the distance and the need to tranship from barges, Guinea has emerged as China's largest bauxite supplier.

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Bauxite mining in Guinee is a very competitive and fragmented industry. Some observations about this chart:

- Bauxite is now being exported from five distinct port areas, with four of them operating on a transhipment model. Only Kamsar can accommodate larger, oceangoing vessels.
- China has a strong footprint, but it is not exclusive. The historical producers are CBG with Rio Tinto and Alcoa capital, and Rusal's operations. Indian corporates are now in the game also, and the Emirati mine was recently expropriated.
- The more opaque nature of these operations means information on costs and production plans is not as readily accessible as they were for Kamoa-Kakula.

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Lack of transparency does not mean that there have not been positive changes. Investment in in-land transport infrastructure has been significant, with several new railway spur lines on the old rail track built.

An entirely new 135km rail line has also been built by SMB, the largest producer shown in the previous slide.

The picture being shown here, which I took at around this time last year, is of that new rail line.

SLIDE 23

Although barge ports are not the optimal solution, there have also been significant efficiency improvements in these over time. Barges have become larger, and loading equipment improved from simple cranes with grab buckets to conveyor belts.

This picture shows one of my visits to a transhipment port in July this year.

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This slide is simply an opportunity for me to use a picture of an alumina refinery deep inland in China. I took the picture during a research field visit in 2018, which we carried out as part of the update of our bauxite and alumina price forecasts in Rio Tinto's Economics team.

At the time we thought refineries so far inland would always use Chinese bauxite sourced nearby.

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However, the continued investment in Guinea's bauxite sector resulted in imported bauxite travelling up to 1,000km inland in China.

As you can see in this chart that rise in Chinese bauxite imports has been mostly satisfied by Guinea's production, which over the past couple of years has accounted for about 75% of total imports.

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And so we arrive at the final mining story I wanted to share with you today: the 120 million tonne Simandou iron project in Guinea, which after a 30-year story is finally entering into production this month.

The story flows seamlessly from bauxite. As this artistic rendition of the port shows, the bauxite transhipment experience is being applied to this project.

12,000-tonne barges and larger 45,000-tonne transhipment vessels will be operating at this new river port.

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This slide provides more context and detail on this $20 billion project, the largest and most costly mining project in the world today:

- The project consists of two separate mines, each expected to produce 60Mtpa of high grade iron ore.
- These are far inland, and will be connected to the port by a new 600km railway.
- The ownership structure is complex, but Chinese interests control over 60% of the capital with Western interests represented by my old company, Rio Tinto. Their lead role in the project also means that there is a greater degree of transparency about the project than what we saw in the bauxite sector.

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Before I share three specific examples of this additional transparency, another picture to illustrate why the project is so costly. I took it in February this year during a field trip along the new rail corridor.

Because of the terrain, the 600km rail line includes over 200 bridges similar to this one and almost 30km of tunnels, both contributing to the elevated cost of the project.

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But back to transparency. Because Simandou is not as significant a contributor to Rio Tinto's $100 billion market cap, the company does not need to publish the detailed studies that we saw in the case of Kamoa-Kakula.

Yet, it is material enough that at an investors seminar at the end of 2023 the company shared estimates of capital and operating costs, as well as the tax settings, all of which I summarise in this table.

As you can see from the question marks, that same data is not available for the fully Chinese owned mine.

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The company's annual and half-year financial results also allow investors to track expenditure progress in the project.

This enabled me to put together an estimate of the capital expenditure profile overtime, and together with the cost estimates and tax settings produce the only publicly available forecasts of government revenue from the project.

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I wanted to highlight just one more area of transparency that Rio Tinto's participation in the project allows: Environmental and Social impacts.

The assessments for the Rio Tinto part of the scope have been made public. Just for their mine and 70km rail spur connecting to the main line, there are 8,000 pages of technical chapters, annexes and risk management plans.

This busy table shows the main chapters covered, going from:

- mineral waste, to water, noise and air pollution impacts,
- to biodiversity,
- and socio-economic and human rights considerations.

The last chapter of the ESIA deals with the management of the eventual mine closure, an appropriate place to wrap up this presentation. So let me conclude…

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I started by sharing three key trends shaping the global mining industry:

- First value moving from iron ore towards copper.
- Second, China dominating mineral processing and playing a lead role in upstream financing.
- Africa supplying a disproportionate amount of additional mine production.

I then moved on to talk about mining project development, logistics and shipping, and my personal experience in the context of three African case studies:

- The Kamoa-Kakula copper mine in the DRC, “the World’s best copper mine”
- The remarkable ascent of Guinea’s bauxite sector
- Simandou iron ore in Guinea: the largest greenfield mining project globally.

I hope you found that interesting and useful for your studies and perhaps even for thinking about your future careers.

The floor is open to questions and comments!