AngloAmerican

DECEMBER 2014

OPTIMA

MINAS-RIO MILESTONE

FIRST IRON ORE ON SHIP

INTERVIEW: SIR JAMES DYSON ON ENGINEERING **SOUTH AFRICA:** CHALLENGES AND OPPORTUNITIES
DIAMONDS: BRACED FOR THE DEFICIT **SMART WORK:** WHAT'S IN YOUR SMARTPHONE

VOLUME 60 NUMBER TWO DECEMBER 2014

Throughout our industry and in the wider world, we're increasingly seeing technology providing solutions to age-old problems and those caused by mankind's activity on the planet.

Picking up on the theme explored by our chairman Sir John Parker in the last issue of *Optima*, inventor and entrepreneur Sir James Dyson argues that it is the engineers at the forefront of innovation, rather than politicians, who will save the planet (page 20).

But will technology lead to a world in which machines ultimately put many people out of work? That's an issue explored in *The Second Machine Age*, reviewed by Simon Jary (page 48), which claims we are on the brink of a revolution in digital technology that will make the Industrial Revolution seem as significant as an iPhone update.

But for that technology to develop successfully, the world still needs extractive industries and the commodities they produce (page 28). As well as a number of 'rare earth' minerals, mined mostly in China, today's smartphones utilise more traditional metals such as copper and nickel.

Ensuring those resources are extracted viably is a constant challenge and here again, technology is helping us, notably in Australia at our new Grosvenor facility (page 40) but also in Minas-Rio, which recently shipped its first cargo of iron ore to China.

And while our diamond business braces itself for a widening gap between supply and demand (page 32), we learn there are fundamental issues to be addressed in South Africa if the country is to capitalise on its rich seam of resources (page 6).

MARK CUTIFANI
CHIEF EXECUTIVE, ANGLO AMERICAN

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SIR JAMES DYSON
Sir James Dyson is chairman of Dyson. He launched the bag-less Dyson DC01 vacuum cleaner in 1993 and continues to produce new technologies and improve existing ones, including the Dyson digital motor, the Dyson Airblade™ hand dryers and the Dyson Air Multiplier™ fans. Dyson invests around $2.4 million a week in R&D. The James Dyson Foundation supports design and engineering education as well as medical research charities and runs the annual James Dyson Award in 18 countries.
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Digest

A look at recent news from Anglo American and the mining industry

ANGLO AMERICAN LAUNCHES HUMAN RIGHTS POLICY

To coincide with Human Rights Day, Anglo American has launched its Human Rights Policy, in accordance with the requirements set out in the UN Guiding Principles on Business and Human Rights (UNGPs).

Throughout 2013 and 2014, the Group engaged extensively with business units, Group functions and external stakeholders to develop the policy, which is being rolled out across the Group from 1 January 2015.

"Having a dedicated human rights policy will formalise and help publicise our existing commitments to human rights, as outlined in our business principles," says chief executive Mark Cutifani. "Respect for human rights is a non-negotiable, basic value which is already embedded within Anglo American's existing standards as well as our commitment to various international initiatives."

> "Respect for human rights is a non-negotiable, basic value"
> MARK CUTIFANI

The most significant challenge will be to implement the policy at site level, so a programme of human rights due diligence will be carried out across all areas of the business, alongside awareness raising, monitoring and reporting and accountability initiatives.

GAME-CHANGING INNOVATION

Mining is on the cusp of game-changing innovation that will move the industry forward in leaps and bounds.

That was the message from Anglo American Group director – technical and sustainability Tony O'Neill while addressing Dassault Systèmes' 3DExperience Forum in Las Vegas in November.

Introducing the group's approach, O'Neill said: "FutureSmart™ is our response to the industry's global drive for a more sustainable approach to mining. It will accelerate our ability to use innovation and technology to address our critical challenges and find safer, more efficient, environmentally friendly and sustainable ways to unlock mineral value."

CALL FOR STRONGER ACTION ON CLIMATE CHANGE

John Browne, former chief executive of BP, has called on fossil fuel companies to take stronger action on climate change.

Speaking at a Critical Resource seminar in November, Lord Browne (left) said extractive industries should take climate change more seriously or face a threat to their business. He called on fossil fuel companies to accept the scientific evidence for climate change and support further development of low-carbon solutions.

The seminar formed part of Critical Resource's broader efforts to develop ambitious and practical recommendations for forward-thinking companies on climate change.

POLAR MINING BAN 'INDEFINITE'

Speculation the Antarctic Treaty, which bans mining in the region, could be revised in 2048 has been repudiated by the author of Australia's 20-year Antarctic plan.

Addressing a polar law symposium in Hobart, Tasmania, Tony Press said: "There is a ban on mining and that ban is indefinite. It is a myth that there is a moratorium on mining and it's a myth that it's going to disappear in 2048."

Article 7 of the Madrid Protocol, signed in 1991, designates the polar region as a 'natural reserve devoted to peace and science'. A clause in the agreement says that may be reviewed after 50 years.

But Press points out: "The Madrid Protocol says quite clearly any activity relating to mineral resources other than scientific research shall be prohibited."

PLATINUM PARTNERSHIP

Stimulating long-term demand and developing the global platinum investment market is the aim of a new industry entity launched by Anglo American and other leading producers of the precious metal. The World Platinum Investment Council (WPIC) is designed to help institutional, high net worth and retail investors gain a better understanding of platinum investment opportunities by providing independent data, information and insight.

Chris Griffith, chief executive officer of Anglo American Platinum, said: "The World Platinum Investment Council has been formed to help investors make better informed decisions when it comes to physical platinum. We believe greater transparency, objective information and a broader selection of investment products will ultimately lead to a more sustainable platinum investment market."

WATER, WATER EVERYWHERE

A new desalination plant at Anglo American Copper's Mantoverde operation in Chile is bringing a safe and reliable water supply to the Atacama Desert, one of the world's driest regions.

The new $100 million plant demonstrates the group's commitment to using water sustainably and means the Mantoverde operation will no longer depend on the Copiapó river basin for its freshwater supplies.

The plant consumes up to 30 per cent less energy than its worldwide equivalents and was designed with respect and protection for the environment at the forefront.

"The inauguration of Mantoverde's desalination plant is great news," says Mantoverde's head of operations Giancarlo Bruno. "Not only because it demonstrates our continuous commitment to developing and using technologies that optimise our processes in a social and environmentally friendly way, but also because it means great gains in the usage of water resources in a hydro-stressed region such as the Atacama."

PROPAGATE TO ACCUMULATE

Researchers claim future mining projects in areas not suitable for traditional mining could use biotechnology to extract minerals.

Scientists from the University of Queensland have been investigating 'agromining' using plants known as 'hyperaccumulators' that have a high absorption rate of minerals.

Dr Antony van der Ent, Sustainable Minerals Institute researcher, said: "A mature nickel hyperaccumulator tree can contain up to five kilos of nickel metal when grown in the right conditions. Trials have yielded up to 200 kilos of nickel per hectare per year, establishing a potential opportunity and income stream for future metal farmers in developing countries."

The research also suggested biotechnology could also minimise the environmental impact of mineral extraction compared with traditional mining methods. It could also be used to rehabilitate toxic sites, according to the researchers.

> "Trials have yielded up to 200 kilos of nickel per hectare per year, establishing a potential opportunity and income stream for future metal farmers in developing countries."
> ANTONY VAN DER ENT

The loading terminal at Saldanha Bay on South Africa's Atlantic coast. The port is the country's only dedicated iron ore export facility

SOUTH AFRICA – ON THE EDGE

Weak investment strategies, unfavourable energy policies and divisions between business and government are preventing South Africa from realising its growth potential. **Iraj Abedian** highlights some of the salient issues and suggests the policy changes needed for the country's economy to develop.

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South Africa's economy is in a quandary, despite the fact that it has never had it so good in terms of its national resource base and the prevailing 'Africa-rising' continental environment. GDP growth has dwindled from more than 5.5 per cent in 2006 to the current rate of around 1.1 per cent. The constitutional and institutional underpinning of the economy is resilient and has an extraordinarily rich resource endowment. Yet the country is teetering on the brink of another downgrade – this time to a 'junk status' sovereign risk rating. To avoid this outcome, and revive South Africa's growth and developmental momentum, major and urgent step-changes are required from the country's key stakeholders and its leadership.

Since South Africa's first democratic elections in 1994, it has become increasingly clear that average sustainable growth must improve considerably if positive inroads are to be made into poverty eradication, sustainable job creation and the prospects raised for trans-generational upward mobility. This necessitates a sustained average GDP growth rate of 6 to 7 per cent over a period of 15 to 20 years. Such growth levels require greater social trust as well as stakeholder convergence on matters of economic growth and social development.

Economic and public policy-making in South Africa, however, has been hindered by contested and fractured approaches over the past 20 years. No sooner is a policy announced, than organised labour or business organisations cast serious doubts on its motive, legitimacy and validity, regardless of its potential to succeed. Thereafter, every effort is made to discredit the new policy and delay its implementation. Such counter-productive policy engagements are most apparent within the ruling ANC Alliance.

"At a strategic policy level, a serious rethink is needed with regard to policies around energy, human resource development and skills policy, and labour."

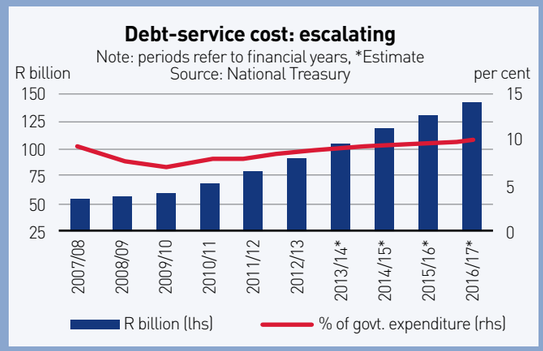
REVIVING GROWTH AND DEVELOPMENT

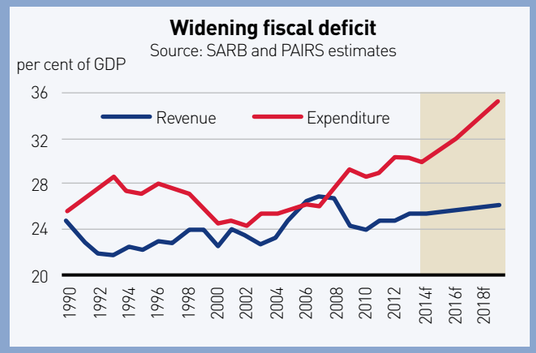
Open discussion is integral to democratic policy-making, but lengthy disputes do nothing to build confidence in the country's policy regime or improve growth levels. Ultimately, these adversarial tactics divert attention away from medium- to long-term issues and mean resources and energies must be channelled towards short-term crisis management.

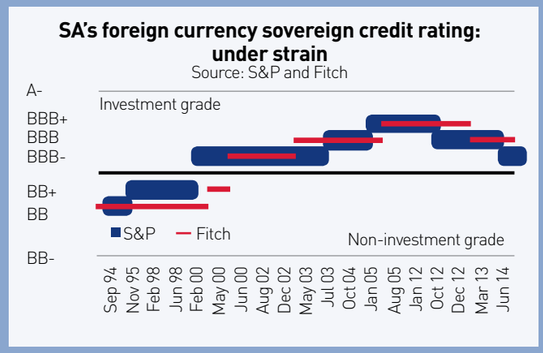
A live case in point is the prevailing controversy surrounding the National Development Plan (NDP). Notwithstanding the adoption of the NDP by the ruling party in its December 2013 Conference, and the government's pronouncements that the plan should be the national roadmap for policy framework, neither the Congress of South Africa Trade Unions (COSATU) nor the South African Communist Party supports the plan and its ideological framework. The cost for the nation of this *modus operandi* is considerable and, for the poor, it is intolerable. In effect, it amounts to a perpetual procrastination of the national development agenda.

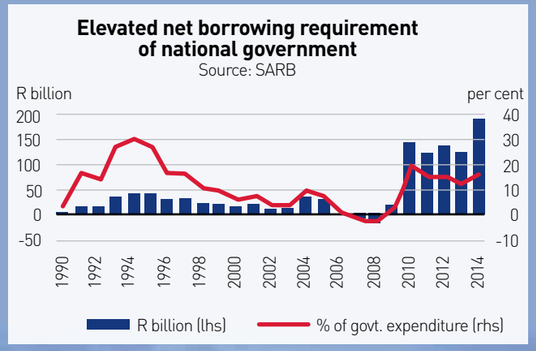
SOUTH AFRICA'S MACRO-ECONOMIC LANDSCAPE

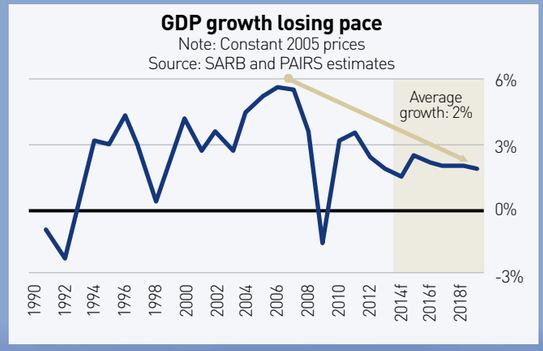
These graphs highlight the prevailing macro-economic configuration in South Africa, and illustrate how economic and industrial policy measures have been compromised by the country's approach to policy-making.











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GOVERNMENT RESPONSIBILITIES

Under the Zuma administration, a statist approach to government policy has gained currency under the rubric of the developmental state – although no one has clearly defined what this means. Political ideologues and technical operatives interpret the term as they deem fit. For some, it is about using fiscal resources and state capabilities to benefit their target groups, political cliques and partisan allies. For others, it is a paradigm shift away from the so-called neo-liberal policy framework, which they claim prevailed during the Mbeki presidency. And for others, this is simply a convenient label for engaging in conduct that amounts to the extraction of fiscal resources for self-enrichment.

The statist approach sidelines private-sector investment in key sectors of the economy – notably, economic infrastructure, such as energy, transportation logistics and urban amenities. Consequently, the state is burdened with more and more responsibility for developmental delivery at a time when its capacity is under severe constraint. Over the past few years, there has been a continuous decline in the operational capability and financial integrity of public service infrastructure and the majority of state-owned enterprises and state agencies: the consecutive annual reports of the Office of the Auditor-General of the South African government bear testimony to this trend. Likewise, the financial and operational crises facing electricity supplier Eskom, South African Airways, the Post Office, the South African Broadcasting Corporation and other public agencies attest to the declining capacity of the state to deliver socio-economic development. This is even more dire at local government level.

To encourage growth and development, and in support of a more realistic and nuanced public-policy approach, the government must consider a number of reforms.

The South African public sector is in need of an urgent second-generation transformation. Whereas the first generation of transformation prioritised the racial composition of public-service and state agencies, the future focus must be on skills, experience, accountability and probity in office. The complex interplay between poverty and inequality cannot be truly considered until fiscal resources are invested in quality education, public health and protection services.

Just as importantly, the quality of living spaces, particularly for the poorer segments of society, cannot be improved unless the local government is staffed by competent, accountable and committed professionals, as opposed to many of the current figures, who are largely appointed on political criteria unrelated to expertise and experience. Such practices exacerbate the legacy of apartheid and are cruel to the poor and marginalised masses.

Related to the state's capability is the need to enforce effective fiscal-management principles within the public sector. Despite the enactment of the Public Finance Management Act (1999) and the Municipal Finance Management Act (2003), public-sector operations are undermined by the absence of basic financial management skills. The culture of mediocrity that has taken root as a consequence obstructs capacity for getting value for money and promoting small- and medium-sized businesses.

CLEARER ENERGY POLICIES NEEDED

At a strategic policy level, a serious rethink is needed with regard to policies around energy, human resource development and skills policy, and labour. The South African economy's second golden growth period (2003-2008) came to a sudden halt in the first quarter of 2008. It was precipitated by a severe electricity shortage, thanks to Eskom's poor planning and maintenance capability, coupled with political interference. More critically, the country's energy policy proved to be inappropriate and unsustainable. Notably, the mining sector, as the cornerstone of the economy, suffered the most in this period, registering stagnation despite the prevailing super-cycle of commodities. The lack of adequate energy and mix of other unfavourable policy and administrative measures shackled the sector's performance.

"To encourage growth and development, and in support of a more realistic and nuanced public-policy approach, the government must consider a number of reforms."

Spring forward six years later to today: after much irreparable damage to the economy and considerable loss of social welfare, the country's energy policy remains unclear, *ad hoc*, inconsistent and unfavourable to a modern and sophisticated economy such as that of South Africa. This remains the single most important and binding constraint on the economy's short-term growth. The resource endowment of the South African economy is such that it requires a reliable, cost-effective and sustainable electricity baseline.

For the medium- to long-term sustainability of growth and social development, the country's human resource development and skills generation need a fundamental shift. If critical socio-political objectives, such as black economic empowerment, inter-generational upward mobility and the

The central business district in Johannesburg, South Africa's economic powerhouse. The business sector is central to reviving the country's growth

systemic narrowing of income inequality are to be achieved, there is simply no substitute for a qualitative transformation of the education and skills system.

Labour policy is another contested and dysfunctional sphere that needs urgent attention. While the Labour Relations Act (LRA) of 1995 served the country well in its first decade – and many of its provisions remain constructive and relevant – there are aspects of it that require review and updating. Given the considerable technological changes within the economy over the past two decades, the LRA's provisions relating to, for example, sector-level (national) collective wage bargaining and the lack of deadlock-breaking mechanisms, need substantial reforms.

ENGAGING THE BUSINESS SECTOR

The business sector is central to reviving South Africa's economic growth. Yet, ever since the late 1990s, it has slowly but consistently disengaged from political economy debates, agendas and priority-setting. A complex mix of political and technical factors has been at play. Globalisation and diversification of investment portfolios have played a clear role, too. Unless the business sector re-engages with the policy-setting agenda and regains its pivotal legitimacy in the promotion of investment and growth, a significant turnaround in the economy's fortunes remains unlikely.

To this end, there is a need for open discussion around the role of business – especially in the mining and manufacturing sectors – as well as corrective measures.

"Once again, success calls for close collaboration and co-ordination between policy-making departments and the country's mining-energy-manufacturing complex."

Business in general – and, again, mining, manufacturing and agriculture in particular – have left painful socio-environmental scars on the national landscape. The recent revelations of collusive and unethical conduct in industries such as construction, steel manufacturing, pharmaceuticals, banking, telecommunications and petrochemicals, among others, have further tarnished the image and legitimacy of the business sector.

There is a need for more structured policies developed through close discussion between government and business leaders. Closely allied to this, it is critical that business in the 21st century is conducted within a constitutional democracy framework. The business sector in general needs to recognise the imperative of a social licence to operate. Compliance with regulations and legislation is vital, but sensitivity to the socio-environmental impact and circumstances of business operations is as critical.

For mining in particular, this calls for a paradigm shift. A case in point is the mining companies' social labour plans (SLPs). Since 2002, mining companies have adhered to the required SLP commitments – yet, operationally, very few have complied with the spirit of the law. They have seldom delivered any effective SLP schemes. At times, they have even corrupted the social community networks for short-term compliance convenience. Consequently, far from mitigating their operational risks, they have compounded the complexities.

CHALLENGES FOR LABOUR UNIONS

Labour unions in general, and COSATU in particular, have been facing technical and organisational headwinds. The changing structure of the South African economy has created serious challenges. Coupled with the rapid rate of technological innovation, which has led to continuous labour-replacement technologies, the unions are facing serious threats to their *raison d'être*.

The country's economy has experienced considerable technology deepening since 2000. Nearly half of the jobs created in this period are either highly skilled roles or non-union employment opportunities. Meanwhile, labour-replacement technologies have meant COSATU has lost well over one million members. The splintering of affiliate member unions has caused further membership losses for the labour confederation. In the mining sector, the

REDRAWING SOUTH AFRICA'S MINING POLICIES

Together, government and business leaders can create effective policies that enable the resources sector to play a major role in South Africa's economic growth.

The business sector is the only stakeholder with the capacity to unlock South Africa's potential in mining, manufacturing, agriculture and skills generation/augmentation. The country's resources, both under and above ground, are rich and diverse. Its mineral resource base alone has been estimated at more than $2.5 trillion; its agricultural and agro-industrial base is on a par with the best globally. The country's natural-resource endowment has great potential for creating socio-economic development, both in the short and long term.

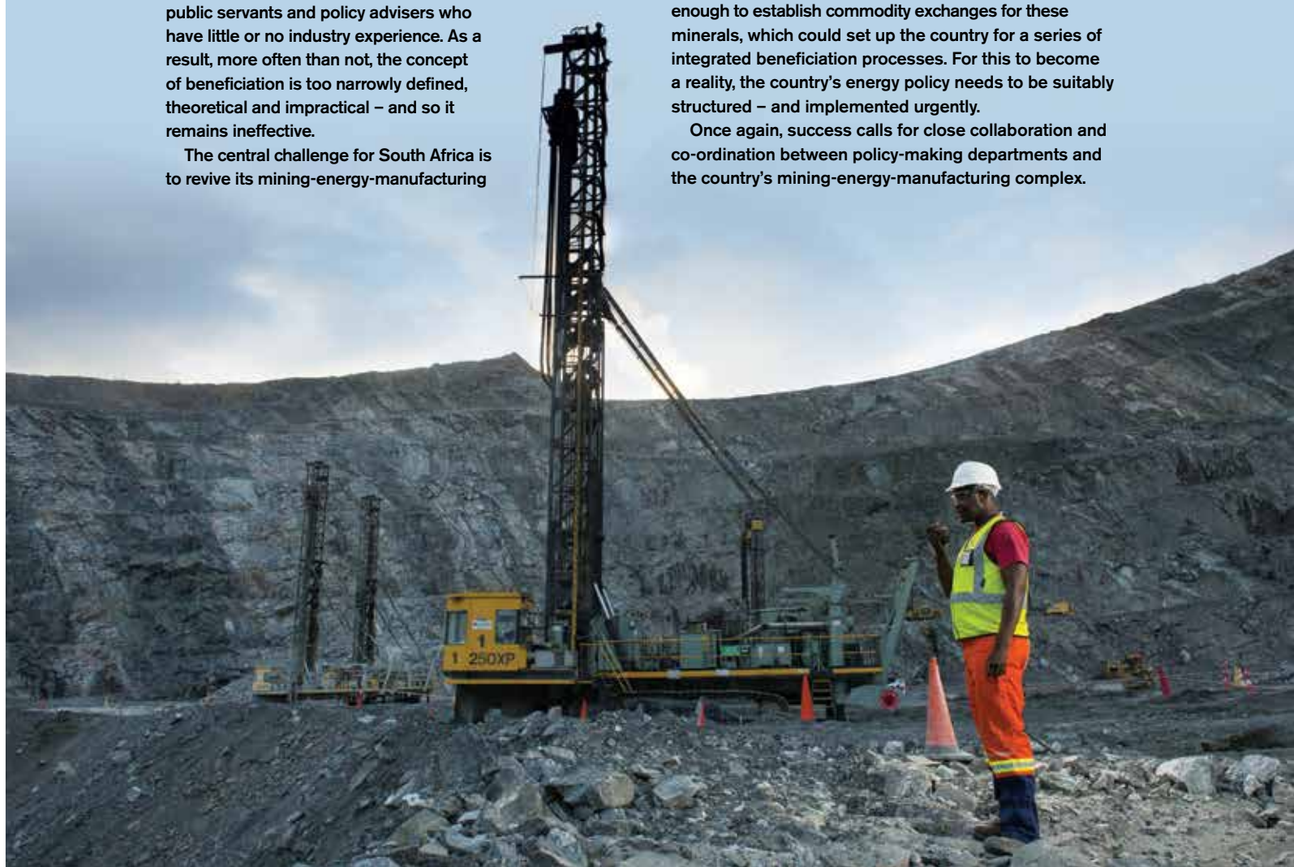
However, since 1994, much of the debate around beneficiation (the process of processing raw materials to yield higher-value products) has been left to politicians, public servants and policy advisers who have little or no industry experience. As a result, more often than not, the concept of beneficiation is too narrowly defined, theoretical and impractical – and so it remains ineffective.

The central challenge for South Africa is to revive its mining-energy-manufacturing complex, notwithstanding the prevailing down-cycle of the commodities market. Unless the country takes urgent action, it is bound to lose out once again when the global cycle turns.

Unlocking the socio-economic potential within South Africa's resources sector, however, requires a radical and complex change of approaches by both the government and the key mining-manufacturing players. Many of the required regulatory changes relate to the lack of a single licensing window, issues around exploration permits and Section 11 of the 2002 Mineral and Petroleum Resources Development Act, and the efficiency and accountability of general administrative procedures. Such reforms lie at the door of the government. Unless they are resolved, they remain obstacles to growth.

At the same time, the private sector's leading players need to rethink their traditional approach. South Africa has a more than sufficient share of global known ore reserves, and current production, in certain strategic and key commodities, such as platinum, chrome and manganese – enough to establish commodity exchanges for these minerals, which could set up the country for a series of integrated beneficiation processes. For this to become a reality, the country's energy policy needs to be suitably structured – and implemented urgently.

Once again, success calls for close collaboration and co-ordination between policy-making departments and the country's mining-energy-manufacturing complex.



Venetia diamond mine, where a $2 billion investment capital expenditure programme – the biggest investment De Beers has ever made in South Africa – is under way to develop an underground mine that will extend the mine's life by some 20 years

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01 Against the backdrop of Johannesburg's skyline, a woman carries water to her home in a run-down area of Soweto. Rebuilding South Africa's social fabric is a prerequisite for economic growth

02 President of South Africa's Association of Mine workers and Construction Union (AMCU) Joseph Mathunjwa addresses striking mine workers in Johannesburg. The union's emergence has caused huge changes in the labour movement

emergence of the Association of Mineworkers and Construction Union (AMCU) has caused tectonic changes within the labour movement and, to some extent, within the sector. This has also transformed the structure of unions in general – and of COSATU in particular, which has diminished to becoming a confederation of public-sector unions. This poses additional challenges for its role in the ruling alliance of the ANC.

The systemic challenges facing organised labour stem from the rise of effective automation options, rising skills intensity and the fast-changing workplace. Given the 21st century business environment, the unions need to redefine their roles if they are to avoid the current thrust towards their becoming increasingly irrelevant.

In this milieu, COSATU and AMCU have increasingly demonstrated an ability to obstruct policies, slow down implementation and embroil themselves and the broader macro-investment environment in controversy and instability. Such tendencies and tactics have considerably damaged 'brand South Africa' as an investment destination and, more significantly, have accelerated the pace of automation and labour-substitution.

While collective bargaining remains an important negotiating tool in any modern economy, the manner of such bargaining is just as critical. Clearly, based on the experience and empirical evidence of the past 15 years, South Africa's collective-bargaining architecture needs urgent revision. At the same time, union leaders' working practices and socio-political objectives should refocus on job-creation, employment stability and the working class's material and social welfare. Transforming the labour unions into a constructive force for the stability of the business environment and the promotion of investment, employment creation and poverty alleviation is the relevance test facing South Africa's labour union leadership.

REBUILDING SOCIAL CAPITAL

Alongside and integral to all these challenges is an obligation to rebuild South Africa's social capital as a prerequisite to sustainable economic growth and social development. This is a long-term project – multi-pronged, complex and indispensable for the country's ability to overcome the triple evils of poverty, unemployment and inequality.

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Of its many aspects, two merit special highlighting. One is the adoption and promotion of a clear values system – a set of ethical norms – for society. This is critical for changing the current culture of sub-optimal, if not counter-productive, national-resource utilisation by both private- and public-sector role players. The other is a systemic deepening of the nascent democratic processes governed by the principles incorporated into the country's constitution.

While social activism has been integral to South Africa's modern history, it is evident that, in the post-1994 era, the building and augmenting of social capital stands out as the overarching challenge facing civil society.

Once again, South Africa and its economy find themselves near the edge, needing to pull back from the brink. In general, the economy acts as the centrifugal force that separates workable policies from unsustainable ones. The distribution of income and wealth is at its least effective. Meanwhile, South Africa is one of the countries in which corruption and the abuse of national resources are on the rise. It is high time to heed the warning signs, arrest the downward spiral and focus all collective energies, once again, on unlocking the considerable potential that South Africa's natural and national endowments offer.

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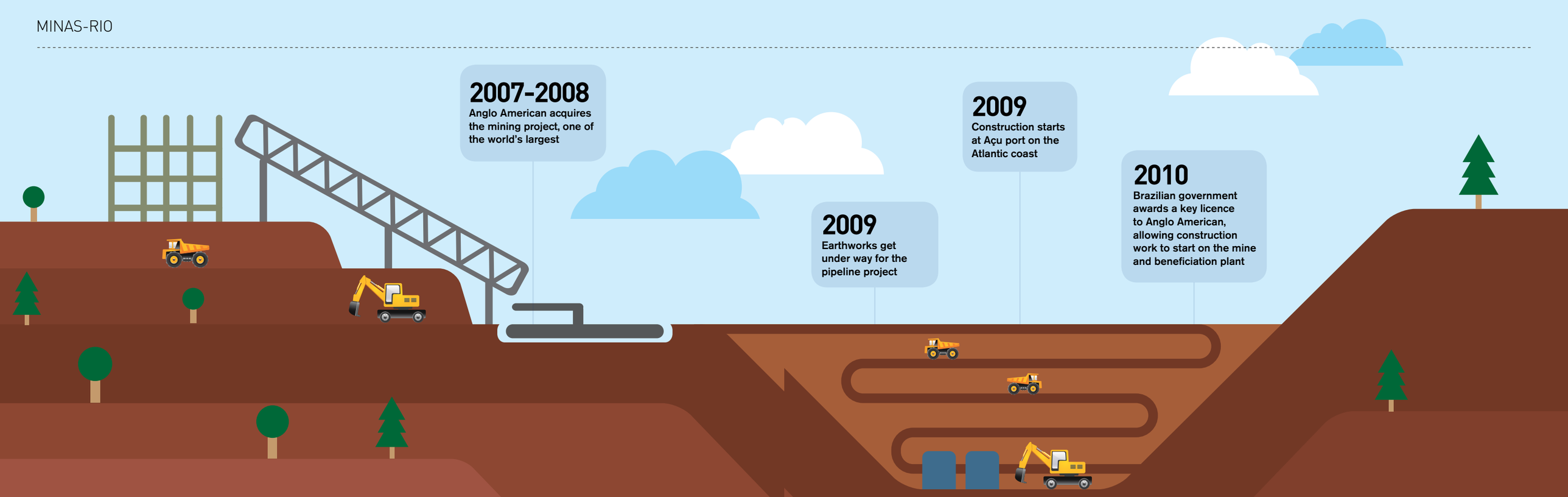
Dr Iraj Abedian was professor of economics at the University of Cape Town before entering the business sector in 2000. Since 1993, he has been involved in macro-economic policy development in South Africa; including being economic advisor to the Minister of Mineral Resources from February 2010 to July 2012. He is the founder (in 2005) and CEO of Pan-African Investment & Research Services and is a member of the Advisory Board of the Auditor-General of the South African government.



MINAS-RIO

ANCHORS AWEIGH...

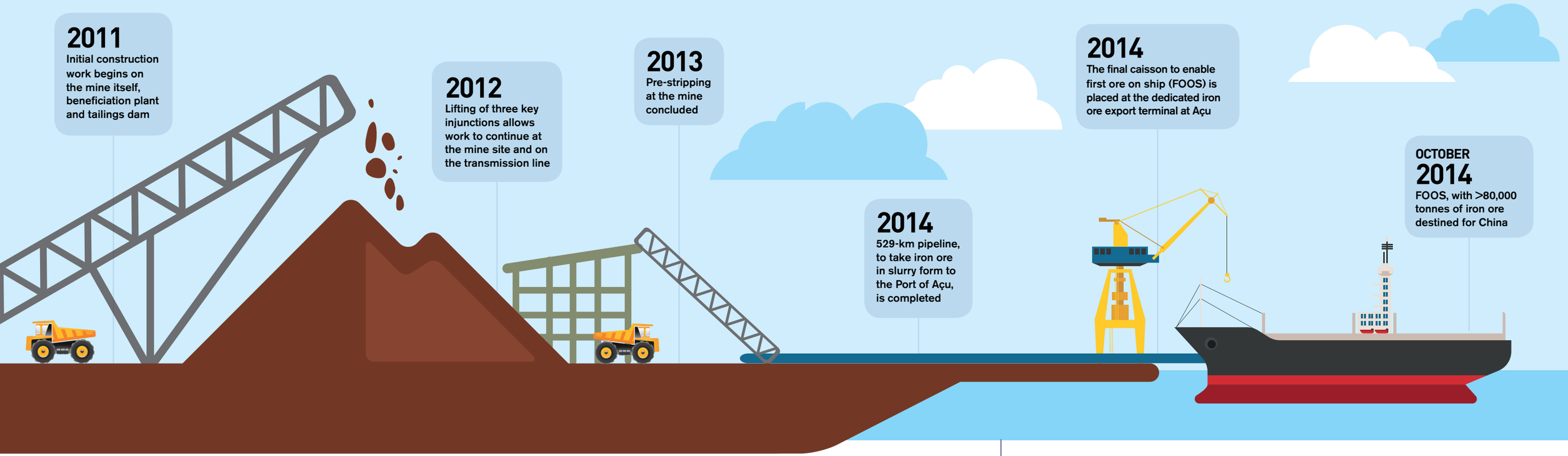
With the loading of its first iron ore on ship in October this year, Anglo American completed the project phase of Minas-Rio, one of the world's biggest mining developments. Here, **Norman Barber** takes a look at some of its major challenges and milestones.

Minas-Rio was acquired by Anglo American in two tranches in 2007-08. The capital outlay amounted to $5.5 billion, and included a 70 per cent interest in the Amapá iron-ore system in northern Brazil (Anglo American subsequently sold its stake in 2013), as well as a 49 per cent shareholding (upped to 50 per cent in 2014) in the export facility of the Port of Açu.

Initially planned to enter production by mid-2012, the project was beset from inception by an increasingly stringent permitting/licensing regime, which increased the cost and time taken in achieving environmental compliance, as well as dealing with the land claims of more than 1,400 landowners, mainly along the 529-kilometre route of the project's pipeline from the mine site in Minas Gerais to Açu port in Rio de Janeiro state. These delays were exacerbated by project-execution difficulties and cost overruns, including spiralling costs in construction and labour as Brazil started to build the infrastructure needed for its hosting of the World Cup in 2014 and the Olympics in 2016.

Welding a section of the 529-kilometre pipeline that transports iron ore in slurry form to the Port of Açu

In early 2013, Anglo American's new management team confirmed the project's timeline and cost estimate to deliver first ore on ship (FOOS) by the end of 2014, with a revised capital budget of $8.8 billion.



THE PROJECT'S SCALE

Minas-Rio is a world-class integrated iron ore project of rare magnitude and quality. It comprises a series of open-pit mines and a beneficiation plant at the mine site, a 529-kilometre pipeline to transport iron ore in slurry form to Açu on the Atlantic coast, a filtration/dewatering plant at the port, and the port itself – a dedicated deepwater iron-ore export terminal that has necessitated, *inter alia*, the construction of a long pier and breakwater.

THE RESOURCE AND THE PRODUCTION TRAJECTORY

Minas-Rio has one of the world's biggest undeveloped iron resources. Its resource base has increased more than fourfold since acquisition and is currently well over five billion tonnes. Mineral Resources, in addition to the estimated Probable Reserves of 1.4 billion run-off mine tonnes, are estimated at around 3.9 billion tonnes, with further conversion to reserves expected through the project's ongoing infill-drilling programme.

Minas-Rio is ramping up and expects to produce 11-14 million tonnes of iron ore in 2015 and to reach its annual run-rate target of 26.5 million (wet) tonnes of saleable product of iron ore pellet feed the following year. Thereafter, there is potential optimisation to 29 million tonnes per annum (Mtpa).

QUALITY AND COST-COMPETITIVENESS

Although Minas-Rio has a higher cost/lower margin than its Australian peers, it has a premium product, with a high iron content of around 67.5 per cent (against a 62 per cent benchmark spot price), and low impurity (alumina and silica are below 3 per cent), and is expected to capture a significant portion of the pellet-feed market. Cash costs are likely to be around the $33-35/tonne mark, placing it among the world's major low-cost iron ore projects.

"We are now focused on achieving a safe and responsible ramp-up so we're up to our 26.5 Mtpa capacity run rate during 2016."
PAULO CASTELLARI, CEO, IRON ORE BRAZIL

In October 2014, the first iron ore export from Minas-Rio was loaded at Açu on to a vessel bound for China

THE IMPORTANCE OF MINAS-RIO TO ANGLO AMERICAN

Minas-Rio is favourably placed on the global cost curve and provides Anglo American with a major long-life asset with which to compete in the global seaborne iron ore business, as well as the optionality and the marketing benefits from being able to supply iron ore from two continents.

For the investor and analyst, however, the encouraging news is that over the past two years or so – under Iron Ore Brazil CEO Paulo Castellari and later Anglo American chief executive Mark Cutifani and technical director Tony O'Neill – the project has met all its major milestones, and has also stayed within its revised budget.

The successful completion of Minas-Rio, along with the restructuring of the Group's Platinum business, and the operational turnaround of its Sishen iron ore and Los Bronces copper mines, is key to Anglo American's turnaround strategy and long-term success.

As Castellari says, there is still a long way to go: "We're now focused on achieving a safe and responsible ramp-up so we're up to our 26.5 Mtpa capacity run rate during 2016. We are also continuing to build on the relationships we've established with the government and the regulatory authorities in ensuring a regular cycle of licence and permit renewal as we transition to operational mode at Minas-Rio."

AUTHOR
NORMAN BARBER

Norman Barber is editor-in-chief of *Optima*.

WHY ENGINEERING?

Engineers, not politicians, will be the planet's saviours, according to world-renowned British inventor and entrepreneur **Sir James Dyson**. *Optima* spoke to him about how innovation will shape our future.

What do you see as the greatest challenges of the 21st century?

Doing more with less. Sustainable power, the environment and the demands of a growing population all pose problems that require engineers to use fewer materials and less energy while delivering high-performing technology at the same time.

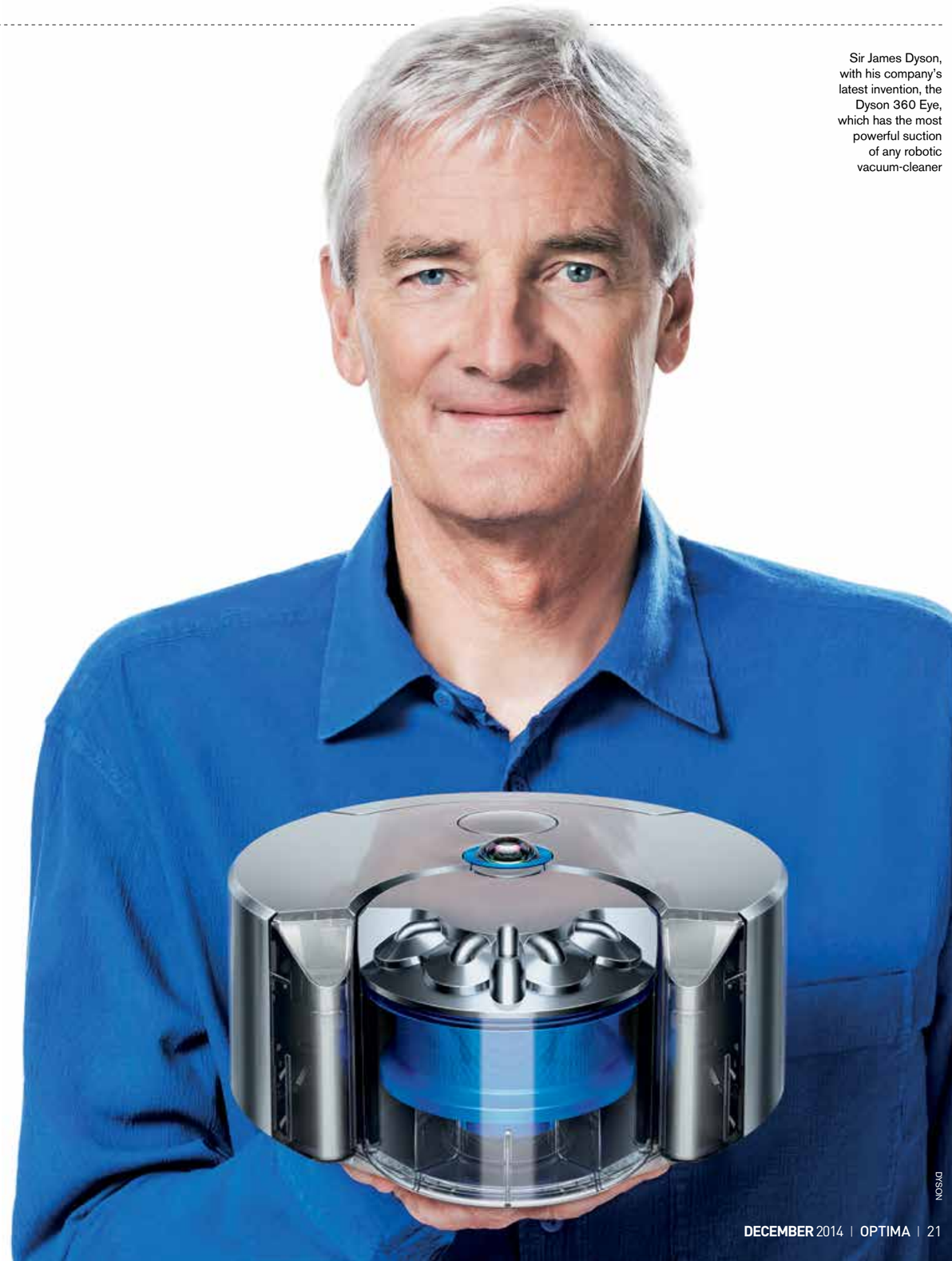
It's the people to whom this task falls, the engineers, or lack thereof, that worries me the most. The UK's yearly deficit of 60,000 engineers is growing all the time. If we don't develop the next generation of engineers, we won't have enough people capable of tackling the world's problems.

It's essential we encourage invention at school if we are to foster the kind of skills that will let Britain earn its place in the world and develop the technology we so desperately need. Without armies of design engineers, we'll simply be left behind.

You have repeatedly stressed: "We need more engineers to solve 21st-century challenges." How do we get more people into engineering? Are we doing enough to connect with governments, universities and business?

More could be done to encourage students to take up design and technology because Britain is desperately short of engineers. I was encouraged by the efforts made by Michael Gove, during his time as Secretary of State for Education[1], in reforming the curriculum by putting more of an emphasis on product-making skills and invention, as suggested by the James Dyson Foundation. My Foundation has been campaigning vocally to ensure the design process better reflects the real world of engineering and excites the naturally creative instincts of young students.

[1] This interview took place shortly before Michael Gove was appointed Chief Whip in July 2014

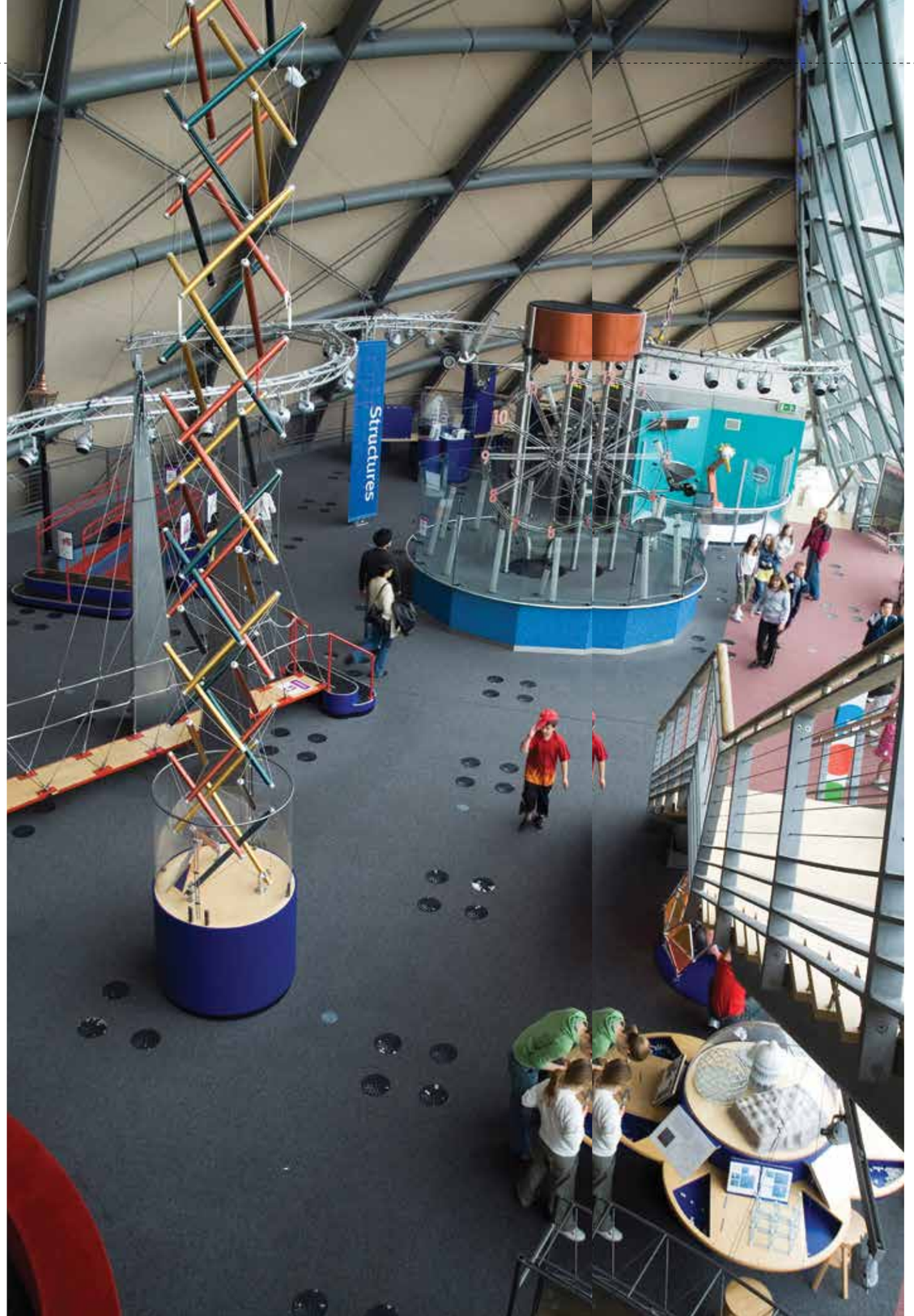


Sir James Dyson, with his company's latest invention, the Dyson 360 Eye, which has the most powerful suction of any robotic vacuum-cleaner

DYSON

01 Schoolchildren looking round a mechanical engineering display room at the Science Centre in Glasgow, Scotland. Dyson fervently believes more needs to be done to encourage young people into engineering

02 Dyson's innovative bladeless fan channels airflow efficiently to reduce noise and use less power



01 ALAMY

02 DYSON

"It's essential we encourage invention at school if we are to foster the kind of skills that will let Britain earn its place in the world and develop the technology we so desperately need."

Design and technology shouldn't be about wooden blocks and a linear process of development. Instead, students should be introduced to new technology and encouraged to prototype and test their ideas – going back to the drawing board and testing new prototypes all the time. They need to learn to fail; it spurs new ideas and gets students thinking differently.

The Foundation has been trialling a project with five schools in Bath in the UK, providing them with a suite of industry-standard resources such as 3D printers, lasers and scanners. Making the curriculum more relevant and encouraging prototyping through new machinery and technologies has inspired the children – we've seen a 200 per cent uptake in design and technology across the schools. A new generation of inventors is in development.

How do you go about developing/ nurturing engineering talent, and which fields of engineering do you consider to be priorities?

All fields of engineering are priorities! We are especially interested in motor and electronics engineers to work on our digital motors – small, fast electric motors that use Artificial Intelligence to spin at up to 110,000 rpm. These motors will power our future pipeline of technology – beyond vacuums and hand-dryers.

At Dyson, we place faith in youth and inexperience, chucking our engineers in at the deep end right away. Young minds are unafraid to take risks and are willing to try different ideas – they aren't sullied by other companies. These young engineers quickly pick up new skills and engineering insights down in the research and development labs. Graduates have always been at the core of Dyson – I developed Dyson's first vacuum cleaner in a coach house in Bath with three graduates from the Royal College of Art.

And how do you keep your engineers not only 'constantly innovating' but focused on the economics of getting commercialisation right?

Our focus is always on the technology. People want machines that last longer and work better than anything else out there – and it's something they are willing to invest in. So that's what we focus on – developing technologies that keep us ahead of the pack.

Are we being innovative enough to meet the world's future energy needs?

The entrants in my Foundation's annual design competition, the James Dyson Award, give me hope that there are plenty of clever ideas out there. Last year's national winner in the UK, Sam Etherington, invented a multi-axis energy-harvesting device that harnesses wave power from any direction – not just the waves that come in perpendicularly to the coast. He's got a bright future.

ANGLO AMERICAN

As mining operations go deeper, they become potentially more hazardous. A relatively recent innovation in the industry is the application of automated technologies to do underground mining tasks that are unsafe and extremely challenging for humans, and to reach mineral deposits that cannot be economically extracted under existing methods and mine layouts

There are clearly limitations to what the market can deliver – if we look at the fitting of autocatalysts... legislation and regulation were needed to deliver environmental benefits the market on its own would not have achieved. Do you see a greater role for the state in R&D and the commercialisation of technologies in the future?

I've always believed that engineers rather than politicians will save the planet. Regulation is only good when it incentivises technological improvement or furthers research and development, challenging engineers to look to new horizons. It should direct engineers to create high-performing technology that uses fewer materials and less energy. Too often, it becomes a box-ticking exercise or a legal hurdle for companies to jump, undermining the very aim it set out to achieve.

One of the recurrent themes throughout your career has been the battle to protect your intellectual property. How has copyright infringement affected the growth and development of Dyson?

Copying is a vile business strategy, but plenty of companies have tried to do it to Dyson technology. Of course, we'd rather focus on inventing than fighting cheats, but it's essential we defend our inventions.

A prominent competitor tried to copy our first bag-less vacuum cleaner. The UK High Court saw through it and ordered it to cough up c.$6 million to Dyson. But it hasn't ended there. Our Air Multiplier fans have been constantly copied by companies, predominantly in China. Last year, there were more than 350 new issues of copycat fans and we spent more than $2.7 million just defending our technology.

Slope-stability radar at the edge of Anglo American's huge iron ore open pit at Sishen in South Africa. The radar monitors any changes in the slopes of the pit and warns of impending or potential pit-wall failures

ANGLO AMERICAN

"I think developments in 3D printing and mapping technology could have a big impact in the mining industry."

What impact will the consistent copyright infringement by certain territories have on world trade?

For invention to flourish, companies must invest heartily in research and development. But they need to know that pumping cash into invention won't leave them short-changed by cheats who simply come along and copy their ideas. Copying is far cheaper than making new technology. We need to take a strong stance on plagiarists; otherwise, invention becomes pointless.

What can be done to ensure a level playing field?

Courts need to give inventors stronger protection on new designs and technology – give them a chance to recoup the time and money they've invested in their invention. Copycat companies are being disingenuous with designs in order to persuade courts they've not infringed any patents. In general, we should punish all sorts of copying – mimicking packaging and materials as well as stealing technology and designs is wrong.

The patent system would be helped by a clearer international system that brings together the major patent offices and introduces a really rigorous patent-search system so that all prior art comes to light at an early stage.

How can you avoid 'patent games' – companies buying up patents to slow down rivals?

I'm not really interested in what other companies do. At Dyson, we are focused on developing our own technologies, rather than looking to buy those of others.

As a constant innovator yourself, are there particular areas where you feel the mining industry could learn things from other industrial sectors?

Mining is not an industry of which I have specialist knowledge, but I think developments in 3D printing and mapping technology could have a big impact. At Dyson, we are now able to digitally conceive a complex prototype – and to test it digitally before we even start to put it together. Mining is of course on a much bigger scale – but I think the same lessons may apply in many cases... such as being able to test a model digitally before even putting a first shovel in the ground.

Earlier this year you were quoted as saying: "We are on the brink of a 'brave new world' where robots will be able to do anything a human can." How far away is this world?

Research and development is a slow burner. Dyson engineers are working flat out on new robotic technologies alongside Imperial College in London – but to make genuine improvements in technology takes time. It's difficult to put a timeframe on these things.

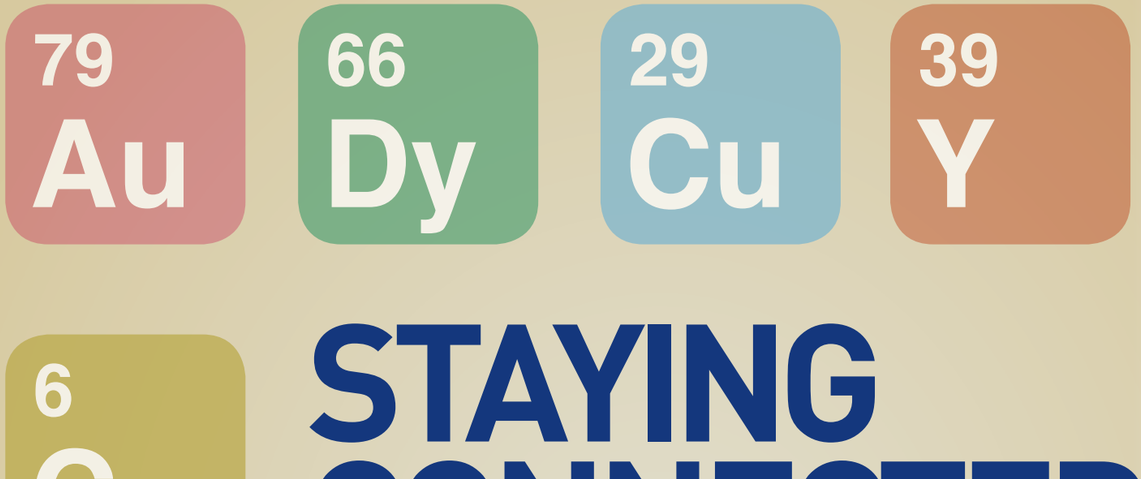
That said, we have already brought our robotic technology to market in the form of the Dyson 360 Eye, a vacuum cleaner that uses the kind of vision technology we believe will have other, more significant applications in future. The project's fruition comes as the result of more than £28 million worth of research by more than 200 of our engineers.

What are the implications of it for humanity? Mass unemployment? Poverty? And how can these be avoided if robots can carry out any of the kind of menial tasks currently done by people?

Robotic technology won't be developed to its potential unless we have armies of bright engineers to build them. The workforce will need to become highly skilled and inventive. The research and development behind these machines will create jobs – millions of them.

SIR JAMES DYSON

Sir James Dyson launched the bag-less Dyson DCO1 vacuum cleaner in 1993. Within 18 months, it became the best-selling cleaner in the UK. Dyson's new and improved technologies now include the Dyson digital motor, the Dyson Airblade™ and the Dyson Air Multiplier™ fan. The company invests around $2.4 million a week in R&D. His registered charity, the James Dyson Foundation, supports design and engineering education as well as medical research charities and runs the annual James Dyson Award in 18 countries. James and the foundation have donated around $55 million to selected causes.



STAYING CONNECTED

Despite the global mining industry being on the receiving end of continuing criticism from some quarters, the world as we know it today would not exist without it. **Ben McCormick** reports.

In the 1980s, electronics manufacturer Intel needed just 11 minerals to make its microprocessors, the chips that would be the heartbeat of the world's computers. Nowadays, that figure is closer to 60 and growing all the time.

Much of the technology we consider essential to our everyday lives – from smartphones and computers to cars and aircraft – relies heavily on the products excavated and processed by the world's mining companies. Yet despite taking huge steps towards responsible mining, the industry is still given a bad name in some circles.

Anglo American chief executive Mark Cutifani points out: "Mining is the world's most important industrial activity (apart from agriculture, which in turn is dependent on mining to produce key fertilisers such as potash and phosphates)."

Of the Periodic Table's 118 elements, 70 are used when making an iPhone. It's safe to say modern society would not function in the same way were it not for the minerals mined throughout the world.

"Around a quarter of the world's copper supply goes to the electronics industry."

HENNIE FAUL, CHIEF EXECUTIVE OFFICER, ANGLO AMERICAN COPPER

"Without the metals and minerals that we discover, extract from the ground, process and ship to our customers, the basic ingredients of our modern lifestyles would not exist. No smartphones, no aeroplanes, no railways, no cars and no diamond engagement rings," added Cutifani.

Take smartphones, for example. The screen, electronics, casing and battery all contain mined elements that help give them all their useful properties.

Screens contain a variety of substances, including indium, tin, aluminium and potassium. Oxides of indium and tin are used in a see-through film that conducts electricity, turning glass into touchscreens. The glass used in most of them is an alumina-silicate, which also contains potassium to help strengthen it. Finally, a range of so-called 'rare earth'[1] elements, including yttrium, lanthanum, europium and terbium, help produce the display colours and reduce UV light penetration.

Four mined minerals are used to make up most smartphone batteries too. Positive electrodes are made from lithium cobalt oxide, while graphite (carbon) or, in some instances, manganese is used for the negative electrodes. Battery casings are generally aluminium.

Inside the phones, the electronic systems are a network of elements and mined materials, including copper, gold, silver, nickel and a range of rare-earth metals.

Wiring in the phone is made out of copper, which is also used along with gold and silver for the device's tiny electrical components. Nickel forms a large part of the microphone and is used for other electrical connections too. Micro-capacitors are mostly made from tantalum.

Meanwhile, a range of alloys, including neodymium, praseodymium and gadolinium, make up the speaker and microphone. Neodymium is also used in the unit that makes the device vibrate, along with terbium and dysprosium.

Chips in the phone are made from silicon, which is oxidised and made to conduct electricity using other elements such as gallium, arsenic and phosphorous. Soldering in the phone is traditionally done with tin and lead, while more modern solders use a combination of tin, copper and silver. Phone casings are usually made from either magnesium compounds or plastics, which can also contain flame-retardant bromine and nickel to reduce electromagnetic interference.

CHINESE DOMINANCE

While many of the elements are readily available and excavated commercially by the world's mining companies, the rare-earth metals that make up a significant proportion of the average smartphone are almost exclusively produced in China, which accounts for more than 95 per cent of the world's supply. These minerals are also critical in the automotive, renewables and other electronics sectors.

China has a highly developed rare-earth processing industry backed up by a formidable community of experts in the field. With its dominant market position, it has the ability to massage the cost of such minerals by imposing export restrictions that drive up the price, which it did in July 2010 in a move that saw their values soar by 40 per cent. While the US, Japan and Germany have invested in their own rare-earth mining facilities, these could take years to start bearing fruit.

What exacerbates the issue is that most of the elements have no viable substitutes and 12 of them have no known replacements at all[2]. Then there are the environmental considerations. If not done responsibly, mining, processing

[1] 'Rare earth' elements are relatively plentiful, but are seldom found in large areas of concentration where they are economically exploitable.

[2] On the materials basis of modern society, T. E. Graedel, E. M. Harper, N. T. Nassar, and Barbara K. Reck, Proceedings of the National Academy of Sciences of the United States of America, October 2013.

COLOUR
- Y YTTRIUM
- La LANTHANUM
- Eu EUROPIUM
- Tb TERBIUM

MICRO-CAPACITORS
- Ta TANTALUM

GLASS
- Al ALUMINIUM
- Si SILICON
- O OXYGEN
- K POTASSIUM

TOUCH SCREEN
- In INIDIUM
- Sn TIN
- O OXYGEN

CASING
- C CARBON
- Mg MAGNESIUM
- Br BROMINE
- Ni NICKEL

ELECTRONIC SYSTEM
- Cu COPPER
- Au GOLD
- Ag SILVER
- Ni NICKEL

RARE EARTH ELEMENTS

VIBRATION
- Nd NEODYMIUM
- Tb TERBIUM
- Dy DYSPROSIUM

WIRING
- Cu COPPER
- Au GOLD
- Ag SILVER

BATTERY CASE
- Al ALUMINIUM

BATTERY
- Li LITHIUM
- Co COBALT
- O OXYGEN
- C CARBON
- Mn MANGANESE

SPEAKER MICROPHONE
- Ni NICKEL
- Nd NEODYMIUM
- Pr PRASEODYMIUM
- Gd GADOLINIUM

Of the Periodic Table's 118 elements, 70 are used when making an iPhone

and recycling of rare-earth minerals has huge environmental implications. The refining process also uses a range of toxic acids that have reportedly been leaked from some operations into the local water supply.

That said, major steps have been taken in China and elsewhere to improve the environmental responsibility of rare-earth mining and processing. In May 2010, the Chinese government carried out a major crackdown on illegal rare-earth mining in the country, mainly in the south where the operations were particularly prone to pollution. It is now spending billions of dollars cleaning up the damage caused in the country by rare-earth mining operations, which it admitted in a White Paper in June 2012 had contributed to major environmental emergencies in China.

But rare-earth minerals are only part of the story. The kind of modern technology that underpins society is also reliant on more readily available elements such as copper, nickel and magnesium. Anglo American is one of the world's biggest copper miners and a major producer of nickel, both of which are used extensively in high-technology applications.

A highly conductive metal, copper is mainly used in high-end printed circuit boards and electrical wiring, but has other applications vital to modern society, including electro-magnets, vacuum tubes, magnetrons and agricultural fungicides.

Hard, ductile and with anti-corrosion properties, nickel is used in everything from circuits and batteries to fuel cells and decorative applications.

"Around a quarter of the world's copper supply goes to the electronics industry," said Hennie Faul, chief executive officer of Anglo American's copper business. "And China – where many of today's smartphones are manufactured – is the world's biggest consumer of copper, accounting for approximately 40 per cent of global production. Our operations contribute significantly to an industry that provides the products we now take for granted and that have changed the way we live."

DE BEERS

A selection of rough diamonds in a brilliant cut shape. Chinese retailer Chow Tai Fook has bought polishing facilities in southern Africa, partly so it can source more rough diamonds from De Beers

THE DIAMOND DEFICIT

Against a backdrop of forecasted rising demand for diamonds and diminishing supply, global diamond industry leaders are now focused on establishing sustainable business models while bracing themselves for a decade of transformation. What's next for diamonds, asks **Claire Adler**.

Thanks to the soaring rise of China's middle classes, coupled with the slim chance of a major new diamond mine being discovered, the diamond industry is now preparing itself for a widening gap between supply and demand.

The world's supply of diamonds is expected to plateau by 2020 and then drop off significantly in the decade that follows. Between 2014 and 2017 alone, demand for diamonds is expected to expand at a rate of 11 per cent, while the global natural supply is expected to increase at only 5.3 per cent[1].

All of which has left industry leaders questioning what the diamond industry of the future will look like. From the rising costs of digging deeper for diamonds in harsh climates and remote, inhospitable locations, to competition from other luxury goods, the squeeze on profit margins amongst wholesalers, jewellery manufacturers and retailers prompted by the transparency of the internet, the necessity of working in closer partnerships with governments of diamond-producing countries who are seeking to create jobs and retain increased social and economic value from diamonds, the need for fresh technologies to discover, detect and sort diamonds, and increased consumer demand for branded, ethically sourced jewellery, this is a historic industry facing new challenges.

Addressing these pivotal challenges, De Beers, which sells a third of the world's diamonds and has spent $50 million in the past two years in its quest to find new areas to mine, published its inaugural *Diamond Insight Report* in September this year.

At the heart of the diamond industry, the report claims, there is only one driver of value and that is consumer demand for diamond jewellery. "In contrast with precious metals and other natural-resource industries, which rely on multiple sources of demand, the diamond industry derives practically all its value from consumers' demand for diamond jewellery. Even under scenarios of volatile or weaker global economic growth, demand for diamonds is expected to show positive real growth over the next decade," says Bruce Cleaver, De Beers' executive head of strategy.

"However our industry cannot afford to take this situation for granted. We need to understand changing consumer preferences and the challenges of competition from other luxury categories to ensure we keep the diamond dream alive."

[1] De Beers *Diamond Insight Report 2014*

"The diamond industry derives practically all its value from consumers' demand for diamond jewellery."

BRUCE CLEAVER, EXECUTIVE HEAD OF STRATEGY, DE BEERS

In 2013, consumer demand resulted in $79 billion of global diamond jewellery sales, up three per cent from 2012. The De Beers report shines the light on the need to invest in three main areas – branding, production and technology.

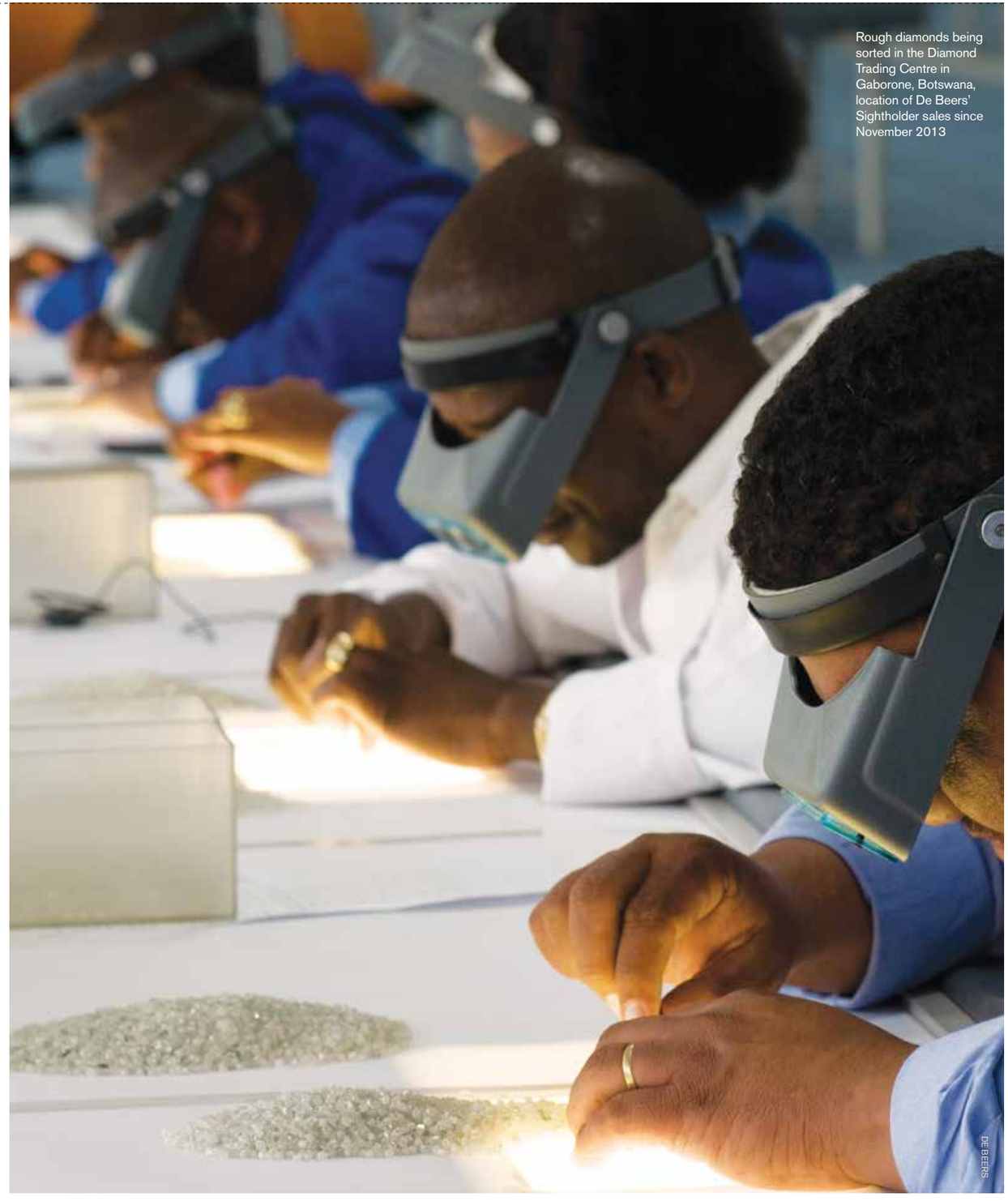
In the United States, sales of diamond jewellery face fierce competition from alternative luxury goods and experiences. When American women were asked about the top gifts they would like to receive, fine jewellery was not a top-five priority. Holidays, electronics, furnishings, spa days, handbags and clothes came first. However, diamond jewellery trumped other kinds of jewellery for all age categories.

While fashion houses Chanel, Dior and Louis Vuitton have ushered in a new era of sophisticated jewellery retail in recent years, their focus on head-turning high jewels and the branding to match has raised the bar for others to follow. Chanel has created stores dedicated to fine jewellery with specially trained staff and accompanying security and communicates with its customers via its regular e-newsletter *Chanel News*.

Demand for branded diamonds, especially in the US and China, is on the up. In 2002, seven per cent of American consumers reported buying a branded engagement ring; in 2013 that figure was 36 per cent.

"While Chinese consumers prefer to buy from trusted domestic retailers like Chow Tai Fook and Chow Sang Sang, since 2008 Chinese sales of diamond jewellery from Cartier and Tiffany to the more affluent Chinese have grown by eight to nine times," says Stephen Lussier, CEO of Forevermark, the diamond jewellery brand created by De Beers, reserved for the top five per cent of diamonds and bearing a laser-inscribed code guaranteeing provenance and quality.

Consumers are also showing a preference for jewellery that is ethically sourced. In November, president of CIBJO, the World Jewellery Confederation, Gaetano Cavalieri, met



Rough diamonds being sorted in the Diamond Trading Centre in Gaborone, Botswana, location of De Beers' Sightholder sales since November 2013

the chairman of the UK's independent Committee on Climate Change, Lord Deben, to discuss an education programme for a carbon-free jewellery industry. Meanwhile Tiffany & Co., noting consumers' growing interest in corporate social responsibility, became a founding participant of the Initiative for Responsible Mining Assurance, established in 2006, which aims to introduce initial certification of responsible mining in 2015.

RETAIL CONSOLIDATION

The De Beers report suggests that the fragmented diamond jewellery retail sector, with more than 200,000 retailers selling jewellery worldwide, could see consolidation in the future. It cites Signet Jewelers' acquisition of jewellery chain Zale, worth approximately 10 per cent of the US diamond jewellery market, and the closure of 2,000 retail locations in the last five years in the US, as examples.

But not all agree. "I do not envisage much consolidation (in the midstream) in the next five years or so. However, I do see the competitive landscape getting tougher, which will lead to those less sustainable businesses disappearing," says Erik Jens, chief executive officer of ABN Amro international diamond and jewellery clients.

While no significant retail jewellery chains have emerged to replace closed ones, Tiffany maintains one of the highest profit margins, while online jeweller Blue Nile has built an enviable business model whereby consumers pay for jewellery before Blue Nile has acquired it. Online jewellery sales accounted for more than one in six diamond-jewellery purchases in the US in 2013. In China, the internet is still used primarily for researching purchases.

When it comes to diamond production, more than $7 billion has been poured into diamond exploration since 2000 according to De Beers, with no significant finds. So much so that the world's biggest miner, BHP Billiton, turned its back on diamonds in 2013, when it sold its Canadian Ekati mine, having previously also hunted for stones in Angola and the Democratic Republic of Congo (DRC). Meanwhile, Rio Tinto, which had originally wanted to dispose of its diamond interests, has decided to retain them for the foreseeable future, and has begun underground operations at its Australian Argyle mine, best known for its prized pink diamonds.

"We need to understand changing consumer preferences and the challenges of competition from other luxury categories to ensure we keep the diamond dream alive."
BRUCE CLEAVER

Jwaneng, probably the world's greatest diamond mine, is a highly successful joint venture between the Botswana government and De Beers

"The odds of finding an economic kimberlite are stacked against you," says Johan Dippenaar, CEO of Petra Diamonds. In 2013, Petra spent $2.1 million looking for new mines after abandoning prospective projects in Angola.

With southern Africa almost fully explored, the new frontiers of exploration are the frozen Arctic of northern Russia and Canada. At Snap Lake, a De Beers underground mine beneath a frozen lake in the Canadian Arctic, 220 kilometres from the closest city, temperatures plummet to minus 45 degrees Celsius.

De Beers has taken major steps to respond to the diamond industry's changing landscape. Under the leadership of CEO Philippe Mellier, who took over the reins in 2011 following three decades in the automotive and transport sectors, the company has begun expanding Venetia mine, the largest diamond mine in South Africa. A $2 billion investment will see De Beers convert the open-pit mine into an underground mine. This represents the largest investment De Beers has ever made in South Africa, extending the life of the mine by approximately 20 years and supporting some 13,000 jobs. Meanwhile, in neighbouring Botswana, Debswana (a 50:50 joint venture between De Beers and the Botswana government) is developing a $3 billion project to extend the life of the 32-year old Jwaneng mine, the world's largest diamond mine by production value, to 2031.

DIAMOND CITY

Last year, De Beers moved its international sales force from London to its new rough-diamond sorting and sales facility in Botswana's capital, Gaborone, turning it into an international diamond trading centre in the process. "The transfer of economic activity from north to south, resulting from De Beers moving its international sales


CORBIS

A variety of 'specials', rough diamonds of more than 10 carats, from De Beers' Venetia mine, including (centre) a 174.25 carat white diamond

DE BEERS

$2 bn

INVESTMENT TO CONVERT VENETIA OPEN PIT MINE INTO AN UNDERGROUND MINE

function to Botswana, has reinforced our five-decade-old partnership with the government of Botswana for a new generation," says Mellier, referring to Debswana.

Mellier has also overhauled the way De Beers mines its diamonds, enabling the company to tweak its mining to reflect demand, varying production at times by 20 to 30 per cent.

New technologies are impacting on exploration techniques, such as a device that measures magnetic fields as an alternative to airborne and ground exploration systems. More investment in technology is needed to discover new viable sources of diamonds in challenging locations, including the Arctic, to mine and sort diamonds efficiently, and to ensure these activities are safe and minimise environmental impact.

In its mission to safeguard consumer confidence, De Beers has invested around $65 million to develop detection technology to identify all types of synthetic diamonds, including small melée diamonds. Its Automatic Melee Screening device can automatically test 360 small stones an hour.

Unsurprisingly, when it comes to future demand, the entire diamond industry has its eyes on China, which currently lags behind only the US. In the first half of 2014, 27 per cent of diamond jewellery retail sales took place in China (including Hong Kong and Macau). But, globally, 49 per cent of diamond jewellery purchases are made by Chinese clients, whether shopping at home or abroad. The Chinese are predicted to spend a cool $154 billion on jewellery and luxury items in 2014 during an estimated 93 million trips, more than five times the number of trips they took in 2002, according to McKinsey. By 2016, Chinese travel abroad is expected to reach 135 million trips.

"A confluence of factors is pointing to the increased attractiveness of considering precious natural diamonds as a means for wealth preservation."

EHUD ARYE LANIADO, MERCURY DIAMOND

In contrast with their American counterparts, when Chinese women were recently asked to choose from a list of items or experiences they most coveted, fine jewellery came out on top, with handbags clocking in at a distant second. While one in 100 Chinese brides received a diamond engagement ring in 1994, that figure is now one in two. Over the next six years, China's middle class is predicted to grow from 200 million to over 500 million. In anticipation of this demand, Chow Tai Fook, whose revenues are more than double Tiffany's, has established diamond polishing factories in southern Africa, enabling them to source further rough diamond supply from De Beers.

RADICALLY DIFFERENT INDUSTRY

Cleaver, too, anticipates rising diamond prices. While Indian consumers prefer stones under 0.08 carats, De Beers forecasts increased competition to secure large stones, triggered by growing demand for larger and higher-clarity diamonds in the US and China. "With growth in diamond demand expected to outstrip growth in supply, there are a number of different possible outcomes, but we believe higher diamond prices would account for a significant amount of the gap. However, we also anticipate that improved efficiency and use of technology in the midstream sector will play a role as diamond polishers are able to extract more polished carats from the available rough supply," says Cleaver.

Diamond industry consultant Ehud Arye Laniado believes the diamond industry could look radically different a decade from now: "A confluence of factors is pointing to the increased attractiveness of considering precious natural diamonds as a means for wealth preservation and I believe this could transform the diamond industry of the future. Meanwhile, the internet is exerting price pressure on diamond wholesalers, jewellery manufacturers and retailers.

"Precious natural diamonds will always be in demand by the wealthiest and most discerning customers in the world. But, in the future, greater transparency of diamond pricing will unlock an opportunity for the most savvy and sophisticated consumers to view diamonds as a potential store of wealth in ways not yet possible today."

AUTHOR
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Claire Adler is a communications consultant and writer in the jewellery, diamond and luxury sectors. Her clients include Montblanc, Piaget and De Beers. Claire is a regular contributor to the *Financial Times*, covering jewellery, watches and diamonds. Her work has also been published by *The Washington Post*, *The New York Times*, *The Economist Intelligent Life*, *The Guardian* and the Open University.

Engineers at the cutting edge of Grosvenor's pioneering tunnel boring machine

ALL IMAGES: ANGLO AMERICAN

BORING BORING BORING

To maintain its position as a leading player in the international metallurgical coal market, Anglo American is well advanced on its $2 billion Grosvenor project. Key to its success will be a giant tunnel boring machine, writes **Vanessa Davies**.

Metallurgical coal is an essential raw material in blast-furnace steel production, which accounts for around 70 per cent of global crude-steel output.

Australia supplies some 60 per cent of the international seaborne metallurgical coal market (around 300 million tonnes a year), with Anglo American being the country's second-biggest producer and number three global exporter.

Greater mechanisation in mining is key to that success. Around 160 metres beneath the ground of Anglo American's new Grosvenor mine site in Central Queensland in Australia, tunnel boring machine (TBM) Lucia, which entered service at the mine in October 2013, is accumulating a number of world and Australian firsts in TBM mining construction and thereby helping Anglo American retain its prominent market position in metallurgical or coking coal.

60%

OF THE WORLD'S SEABORNE METALLURGICAL COAL COMES FROM AUSTRALIA

Out of the 60 TBMs used in mining construction across the world since 1957 (which includes one at Anglo American's Los Bronces copper operation in Chile), the eight-metre diameter, 110-metre long earth pressure balance machine (EPB) at Grosvenor is the first to be deployed in the world coal industry, and the largest TBM that has been used to construct underground drifts (near-horizontal underground passageways or tunnels).

"TBMs offer an alternative to the traditional drill and blast or road header methods of tunnel excavation, the main benefits being savings in time and safer working environments," explained Grosvenor's underground construction manager Adam Foulstone.

STABLE EXCAVATION

The EPB, appropriate for soft ground conditions with high water content, controls the stability of the tunnel face by monitoring and adjusting the pressure inside the front cutterhead chamber to ensure the pressure in front of the machine is balanced. The rate of spoil excavated remains equal to the rate of the advancing machine, which creates a stable excavation option in Grosvenor's softer rock conditions. Safety is provided by the concrete segments grouted into place as the tunnel is excavated, creating a more durable and stronger support system than the traditional road header method.

160 m

BENEATH THE GROUND OF ANGLO AMERICAN'S NEW GROSVENOR MINE

"The safety benefits created by this controlled environment made the EPB the machine of choice for the Grosvenor team," added Foulstone.

TBM Lucia will construct two drifts; the conveyor drift to transport coal from the longwall to the stockpile at the surface, and the people and equipment drift, so efficient access is maintained. Each drift is about 1.1 kilometres in length and, when completed, Lucia will have excavated a total of 100,000 cubic metres.

Excavation of Grosvenor's conveyor drift began in October last year after the $40 million Robbins-manufactured machine was assembled on site, though construction activities had been under way since 2012.

Seamus French, chief executive of Anglo American's Coal business, sees great potential in TBMs in the coal industry. He said: "The use of TBMs may well allow projects to be developed up to 18 months quicker than using traditional tunnelling-excavation methods."

Foulstone added: "Following the successful launch of the TBM 14 months ago, the resultant time-saving benefits have enabled the team to reach the coal seam earlier and keep longwall production on track to the expected end-2016 start

Tunnel boring machine Lucia arrives at the Grosvenor site in Queensland, Australia in late 2012. The machine will eventually excavate 100,000 cubic metres while constructing two drifts at the mine

date. Utilising the TBM in the construction of Grosvenor mine will potentially help us achieve our goal faster – and, with its array of built-in safety mechanisms, more safely.

"Globally, the shift to TBMs in mining construction is happening and Anglo American is a front runner in Australia. Grosvenor is the first mine site in Queensland to use a TBM in drift construction. As a project team, we were excited to have pioneered this innovative tunnelling method here in Queensland as we build the new Grosvenor mine. We're confident this will set a new benchmark for coal mine drift construction."

CRITICAL REVERSAL

After nine months of tunnelling, the team successfully reversed Lucia out of the drift and back to the surface in a well-executed and smooth operation completed over one night shift in July 2014.

Foulstone said: "To the best of our knowledge, this is the first time a TBM has been reversed back out of the tunnel it has just excavated. Until recent times, if a TBM was unable to be extracted linearly from the tunnel, it was generally left in the ground. Extracting Lucia via reverse retrieval was a critical activity to keep to our timeframes, and we're proud of the achievement."

After the successful retrieval from the underground, the TBM was soon on the move again, when the team split Lucia in half on the surface and loaded it on to specialised transportation equipment using self-propelled mobile transporters, a heavy lift crane and lifting jacks. The operation was planned with safety at the forefront, with an exclusion zone set up around the machine and detailed contractor management risk assessments and plans in place.

The people and equipment drift is next on Lucia's hit list. This tunnel is approximately two kilometres away from the conveyor drift and Lucia will undergo a revamp before tackling the challenge. The refurbishment and recommissioning should take approximately four months, with excavation of the second drift starting in November 2014.

With the conveyor drift excavated and the people and equipment drift scheduled to be completed in March 2015, the countdown to Grosvenor's first longwall coal production remains on track for the end of 2016.

AUTHOR
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Vanessa Davies is a communication specialist in the Brisbane office of Anglo American's Coal business unit.

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TBMs USED IN MINING CONSTRUCTION ACROSS THE WORLD SINCE 1957

GROSVENOR: A BEACON OF LIGHT

Grosvenor mine is located next to Anglo American's existing Moranbah North operation and will target the same Goonyella Middle Seam. The 300-metre longwall cutting face will produce five million tonnes of hard coking coal for export per year. In a challenging market with depressed coal prices and coal mine closures and attendant job losses, Grosvenor's construction has been a beacon of light promoting a strong future for the coal mining industry in Australia.

Anglo American Coal chief executive Seamus French explained: "While it's no secret we are facing difficult times, we have taken a long-term view when it comes to Grosvenor as the cycle will eventually come full swing and we will face better market conditions and stronger demand.

"We have stood by our strategy to invest in and develop Grosvenor because we know we have a quality asset – the metallurgical coal produced by mining the Goonyella Middle Seam in Moranbah is renowned as some of the highest quality globally, so for us it makes sense to invest in an operation that is going to produce an attractive product well into the future.

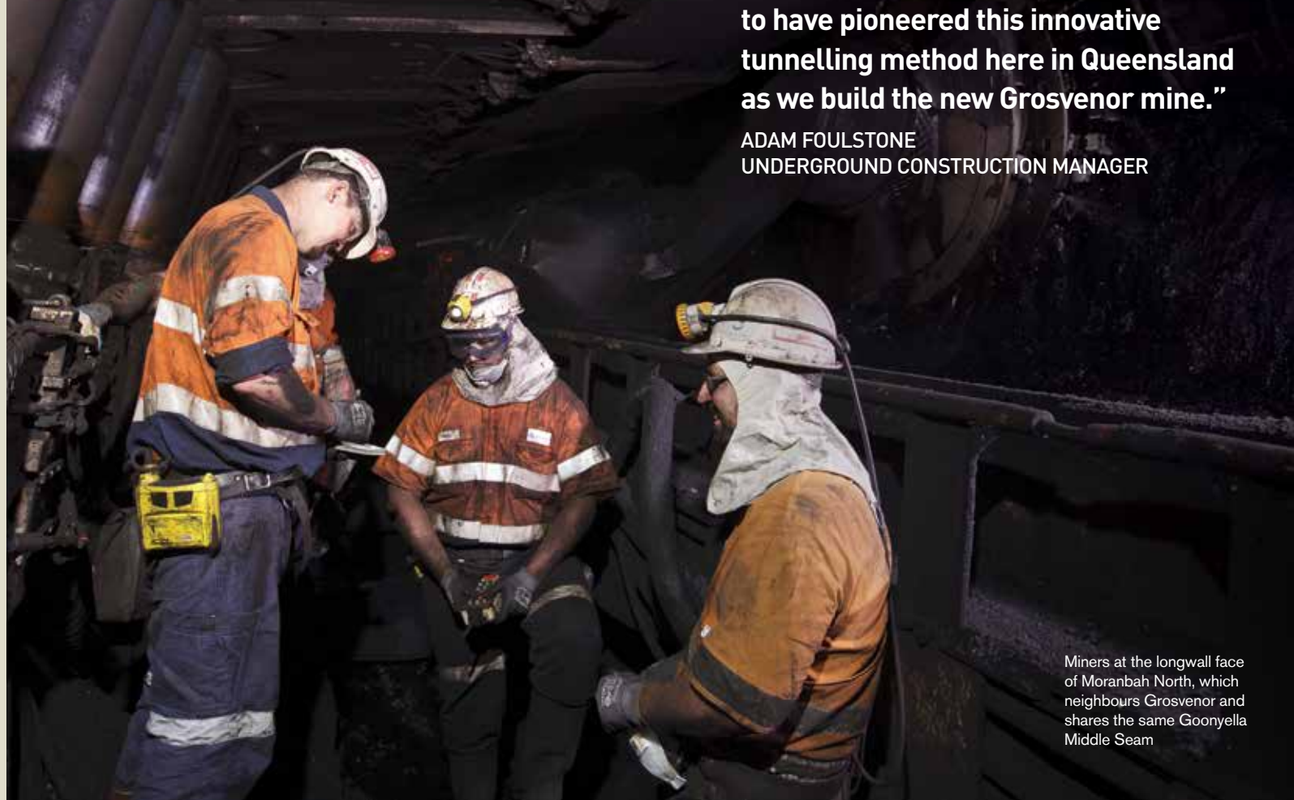
"We have proved through our Moranbah North and Grasstree mines that we can run longwall mines that are among the best and most productive in the world, so our focus has been on ensuring our equipment at Grosvenor is world class, improvements are built into the way we work and our crews understand their roles and perform from the moment we switch on that longwall and start cutting coal at the end of 2016.

"We are very excited about the opportunity and seeing what we can achieve once Grosvenor is commissioned."

Grosvenor's tunnel boring machine is expected to set a new benchmark for coal mine drift construction

"As a project team, we were excited to have pioneered this innovative tunnelling method here in Queensland as we build the new Grosvenor mine."

ADAM FOULSTONE
UNDERGROUND CONSTRUCTION MANAGER



Miners at the longwall face of Moranbah North, which neighbours Grosvenor and shares the same Goonyella Middle Seam

196.966569 79
Au
Gold
[Xe] 4f¹⁴ 5d¹⁰ 6s¹ 18.9

THE MIDAS TOUCH

The allure of gold has captivated mankind for thousands of years and the precious metal is woven into the historical fabric of civilisations around the world, reports **Paul Derby**.

To delve into the history of gold is to take a journey into the cultures, beliefs and customs that have helped shape the world as we know it today. Gold's associations with wealth, status and the divine are well documented: the Incas referred to it as 'the tears of the sun', Egyptian pharaohs were buried with it and this most famous of natural resources is recognised as the first metal known widely to the human race.

The oldest known gold mine was discovered near the Georgian capital Tbilisi and is reckoned to be about 4,000 years old, underlining that, while society has evolved immeasurably since that time, the intrinsic value of gold remains to this day.

Anglo American's connections with gold stretch back to its founding in 1917, when Ernest Oppenheimer, with £1 million in capital from the UK and the US, set about investing in gold mining businesses on the East Rand in South Africa. It was a shrewd move, laying the foundations for the growth of Anglo American into an international concern.

The company's position in gold has since evolved substantially. Following the discovery of gold on South Africa's Far West Rand in 1937, and around Klerksdorp and in the Orange Free State in the early 1940s, Anglo American's involvement in gold mining expanded substantially. The companies in which it held an interest were regarded collectively as the world's largest gold producer from the 1950s to the 1990s.

However, against a background of institutional investors – and indeed Anglo American itself – seeing more value coming through in 'pure play' gold mining companies, Anglo Gold (now AngloGold Ashanti) was formed in 1998 from the separately listed gold companies in which Anglo American had interests, and the Group took the decision to gradually unwind its shareholding in AngloGold Ashanti, completed in 2009.

REMAINING PRESENCE

Yet Anglo American still has a presence in gold through its Platinum operations, where the refining process for platinum group metals (PGMs) realised 100,000 troy[1] ounces (more than three tonnes) of gold in 2013, providing not only a useful revenue stream but also preserving an unbroken connection to the inception of the business almost 100 years earlier.


ISTOCK

[1] The word "troy" comes from the French city of Troyes, where this was a unit of weight in the Middle Ages.


01 CORBIS

01 "Sitters" at the US Federal Reserve Bank in New York count gold bars in the bank's vault 25 metres below the city's financial district

GOLD'S ENDURING INFLUENCE

Gold occupies a unique space in the global economy; even a cursory examination of periods of recession and associated turmoil in the financial markets reveals that investors view gold as a safe haven for their capital, making it a very effective and often-used barometer of economic sentiment.

Perhaps the most striking case in point to illustrate gold's influence sits beneath Manhattan in the shape of the vault belonging to the Federal Reserve Bank of New York, which was built in the 1920s and houses the world's largest accumulation of monetary gold. Here, the US Government, international governments and other official international organisations store their reserves of monetary gold in a location that is, unsurprisingly, protected by one of the most comprehensive security regimes on earth.

Resting on the bedrock of Manhattan 25 metres below street level, enabling the tremendous weight of the structure to be supported, the vault houses more than 500,000 gold bars, weighing over 6,000 tonnes. Much of the gold was deposited after World War II as countries sought a safe location for their reserves.

Despite all the discoveries, new projects and expansions in production in recent years, gold remains a rare and highly prized commodity. The world pours more steel in an hour than it has poured gold since the beginning of time. Looking at it in another way, at the end of 2013, there were 177,200 tonnes of stocks in existence above ground. If every ounce of it were placed next to each other, the resulting cube of pure gold would only measure 21 metres in any direction.

The Latin name for gold is '*aurum*', meaning 'glowing dawn' from which the element derives its chemical symbol, Au. The properties that have made gold so prized a commodity over millennia include its lustrous appearance, ease of working and capacity to conduct both heat and electricity.

Gold is both ductile and malleable – one troy ounce (31.1 grams) can be beaten out to around 28 m^2, while its resistance to corrosion makes it valuable in a wide variety of industrial and commercial uses.

Gold is mined in all continents except Antarctica. The leading producers are China, Australia, the US and Russia, which between them account for more than 40 per cent of global newly mined output.

OUR INSATIABLE DEMAND FOR GOLD

The appetite for gold among consumers worldwide shows little sign of abating. Jewellery remains the number one market segment, accounting for around 53 per cent of demand in the second quarter of 2014, according to the World Gold Council. The power-houses behind this demand remain India and China.

Beyond the jewellery market and perhaps less well-known, gold has a wide range of industrial uses, including in the automotive industry in catalytic converters, in circuitry and increasingly in nanotechnology applications, such as in medical diagnostic devices.

Gold has even played a part in our quest to conquer space. Satellites orbiting Earth carry gold-plated mylar sheeting to protect them from solar heat, while an ultra-thin layer of gold is applied to the visor of astronauts' helmets to guard against solar radiation.

It just goes to prove that the early prospectors drawn to the Sacramento Valley when traces of gold were discovered there in 1848 really were on to something. The Gold Rush might have peaked four years later, but man's appetite for gold has never gone away.

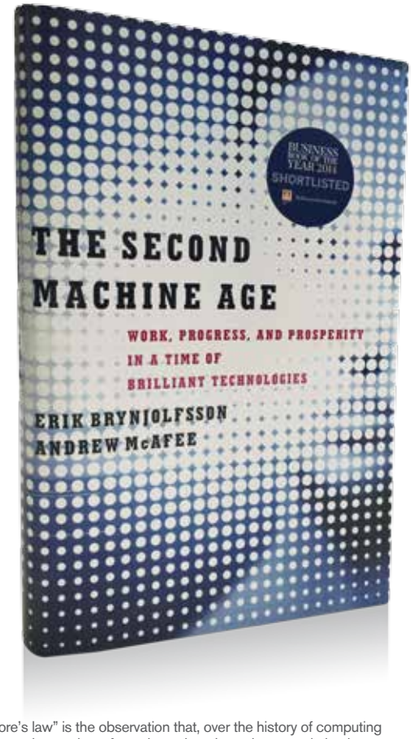
AUTHOR
PAUL DERBY

Paul Derby is a business writer and communications specialist who has written extensively about sectors including aerospace, energy, natural resources and pharmaceuticals during a 20-year career in newspapers and magazine publishing.

RISE OF THE MACHINES

SIMON JARY

THE SECOND MACHINE AGE: WORK, PROGRESS, AND PROSPERITY IN A TIME OF BRILLIANT TECHNOLOGIES
ERIK BRYNJOLFSSON AND ANDREW MCAFEE
W.W. NORTON & COMPANY, 2014



[1] "Moore's law" is the observation that, over the history of computing hardware, the number of transistors in a dense integrated circuit doubles approximately every two years. The observation, made in 1965, is named after Gordon E. Moore, co-founder of Intel.

We are on the brink of change so great it will make the Industrial Revolution look like an iPhone iteration rather than the difference between a steam train and a horse and cart.

Digital rather than mechanical advances have the potential to take us to the realms of science fiction and such leaps forward are within reach in just the next few years. We are entering the Second Machine Age, argue economists Erik Brynjolfsson and Andrew McAfee, who believe what we are about to witness will make a mockery of all that came before.

Steam allowed us to overcome the limitations of muscle power – human and animal – and generate massive amounts of useful energy. Modern life was mass-produced in the first machine age of the late 18th and early 19th centuries. The Second Machine Age, the authors propose, sees computers and other digital advances doing for mental power what steam did for muscle power.

In the next two years more computer power will be added than has ever existed. Innovators, entrepreneurs and scientists will take advantage to build technologies that "astonish us, delight us and work for us".

In their highly readable but not wholly comforting book, Brynjolfsson and McAfee believe digital advances put mankind at an inflection point – in the early stages of a shift as profound as that of the Industrial Revolution.

Most of the gains are ahead of us, they propose. Digital progress has been growing for the past few decades. The authors dismiss most advances as inconsequential until a few years ago, when computers started diagnosing diseases, listening and speaking to us.

The authors use Hemingway's quote about how a man goes broke – "gradually and then suddenly" – to describe the progress of digital technology.

EXPONENTIAL GROWTH

There are three characteristics of today's rapid technological progress: exponential growth, digitisation and the re-combination of innovations.

Constant doubling is no longer easy to grasp. "Moore's law[1]" of exponential growth affects not just computer processors, but memory, storage, sensors and energy efficiency – a notable exception, as any smartphone owner knows, is battery life.

Digital has a close-to-zero marginal cost of reproduction. Digital goods in industries such as music and media can be duplicated at will. 3D printers remove the man from manufacturing, but may bring back the opportunities of customisation and personalisation so long rejected in favour of economies of scale. Digitisation yields truly big data. The authors speculate that, at its current rate, we will actually run out of a metric system to describe it.

Digitisation and exponential growth aren't enough to drive truly radical progress, however. Recombining existing innovations is key, with each new development becoming a building block for future innovations.

"Progress doesn't run out; it accumulates," and such recombined innovations are the driving forces of the second machine age.

Brynjolfsson and McAfee are confident productivity will continue to soar, driven by artificial intelligence and global interpersonal networking. They are also optimistic about the potential of such change to convert science fiction into everyday reality.

Machines are catching up with humans, but we are still not at the point of machine learning and artificial intelligence leading to properly thinking machines.

Moravec's paradox is the discovery that, contrary to traditional assumptions, high-level reasoning requires very little computation, but low-level sensorimotor skills require enormous computational resources.

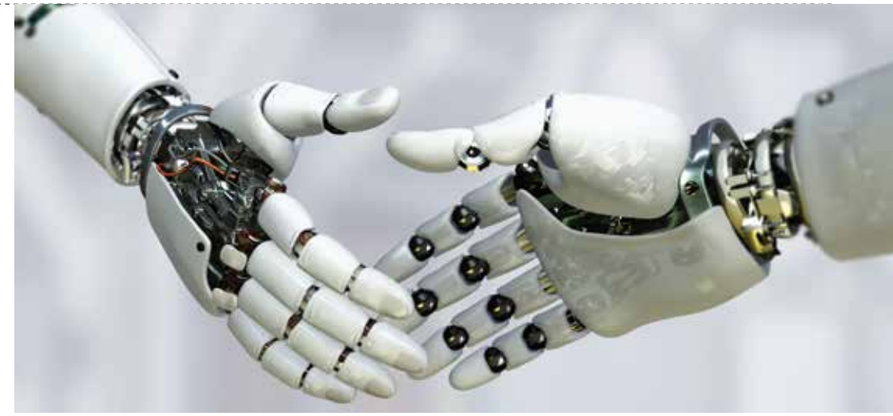
Today's robots are actually rather dim. Folding a towel, for example, would take the most sophisticated robot hours to complete. As such, gardeners, cooks, carers, and dentists have little to fear of robots taking away their livelihoods.

POST-WORK ECONOMY

The same cannot be said for the majority of human labour. The second age will be defined by relentless automation leading to a largely post-work economy, with potentially severe consequences for much of mankind. The "bounty" of digitisation is countered with the "spread" of employment disruption.

Digitisation brings with it massive challenges. Economic disruption will be greater than during the first machine age and technological progress will leave behind a great many people.

Brynjolfsson and McAfee sketch out various economic solutions to the problem of a post-work world, but are not prescriptive, and this



Robotic handshake... But simple tasks such as folding a towel can take today's most sophisticated robots hours to complete

leaves the reader rather less sure all this technological progress will have a happy ending. Some solutions are radical and others are already nascent, such as the peer economy of crowd-sourcing companies like Airbnb and Uber that provide previously unavailable economic opportunities.

Humans have struggled with rapid technological change since the Industrial Revolution, which brought forth both dystopian and utopian scenarios. These science fictions are now close to reality, for example, Google's driverless car and 3D printing.

Fans of the Terminator might shudder at the thought of high-functioning humanoid robots. And what is Google Translate if not the Hitchhiker's Guide to the Galaxy's Babel Fish?

Brynjolfsson and McAfee recognise the challenges of such rapid change, especially to the economic system, where a vicious cycle of increasingly pervasive digital labour leads to higher unemployment and less investment in human capital.

"In the next two years, more computer power will be added than has ever existed."

Other dangers counterpoint beneficial advances. While we eradicate illnesses, we ease the 'weaponisation' of diseases. But digital progress is both a target and a tool for terrorists, spies and criminals.

While such dangers will need to be addressed, the transformations brought about by digital technology will be profoundly beneficial ones, according to this book. Technology can bring us more choice and even freedom – bounty instead of scarcity, freedom instead of constraint.

Compared to the negatives of the first machine age – pollution, child labour, species extinction and climate change – the second machine age will be cleaner and, ironically, more human-focused.

The androids are coming, but can we ever protect the past from the future? The Luddites of the Industrial Revolution couldn't and the rate of current progress suggests we won't be able to either.

Humans can retain control by thinking outside the box. Tomorrow's winners will be those with ideas, as that is the human advantage over computers. Computers bring answers not questions.

Technology is not destiny. We shape our destiny, this thought-provoking book reassures us. Humans need to race with machines instead of against them.

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Simon Jary is Publishing Director of IDG, the world's leading technology media, events and research company. In his time as Editor of *Macworld* magazine he was present at the launch of various ground-breaking innovative products such as the iPod, iPhone and iPad.

ORAPA DIAMOND MINE – SAMPLING PIT
1970

Following the discovery of diamonds in central Botswana by De Beers in 1967, sampling pits were dug at intervals across the main diamond pipe at Orapa. The pits were sunk to a depth of around 40 metres and the kimberlite transported by road to the pilot recovery plant. Orapa mine, which came into production in 1971, and is part of the Debswana partnership between the government of Botswana and De Beers, produces more than 10 million carats of diamonds annually.

ANGLO AMERICAN