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Global Portfolio Strategist

A GLOBAL VIEW FOR INVESTORS

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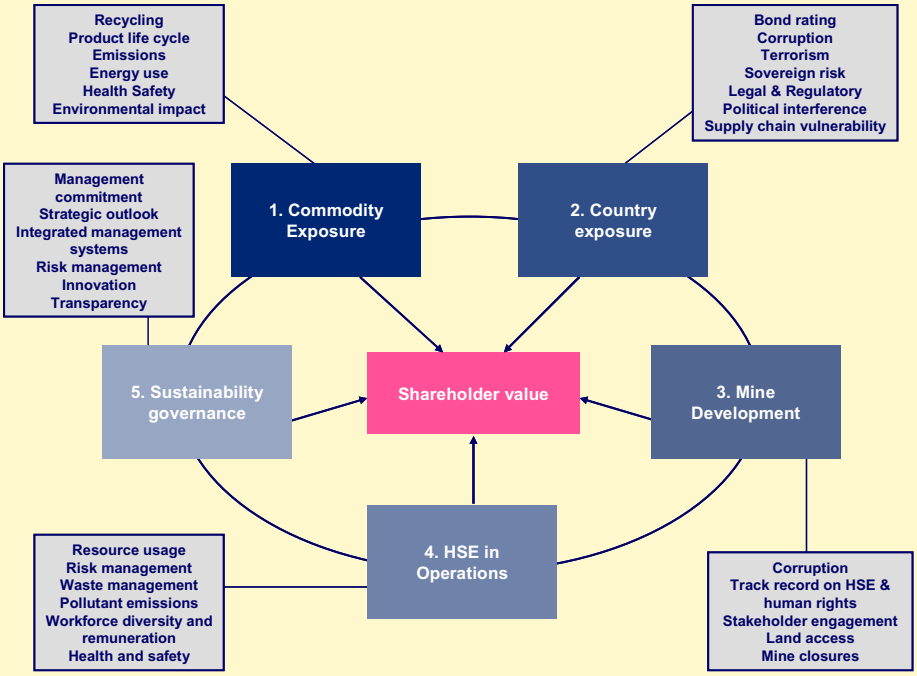
Towards Sustainable Mining

Riding with the cowboys, or hanging with the Sheriff?



Source: Citigroup Investment Research

- **The five factors of sustainable development have the potential to add or destroy value for metals & mining companies globally.**
- **We have created the Citigroup Sustainability Mining Index to help identify those companies best positioned to create (or destroy) value given their current sustainability profile.**
- **The consensus view is mis-pricing mining risk – we find mining risk to be more company-related, than country-dependent.**
- **On this basis, we recommend buying BHP Billiton, Anglo American, Alcoa Inc, Impala Platinum and Lonmin and selling Kazakhmys.**

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Figure 1. Sustainable development – The triple bottom line

Source: Citigroup Investment Research.

Riding with the cowboys, or hanging with the Sheriff?

The sustainable mining development agenda presents companies with a number of choices:

- Seek out low-regulation, low-cost environments for their future development (*riding with the cowboys*)
- Develop a new business model that places a premium on environmental responsibility and social progress (*hanging with the sheriff*)
- Try to operate in the old way in the new world and go out of business (*going to jail*)

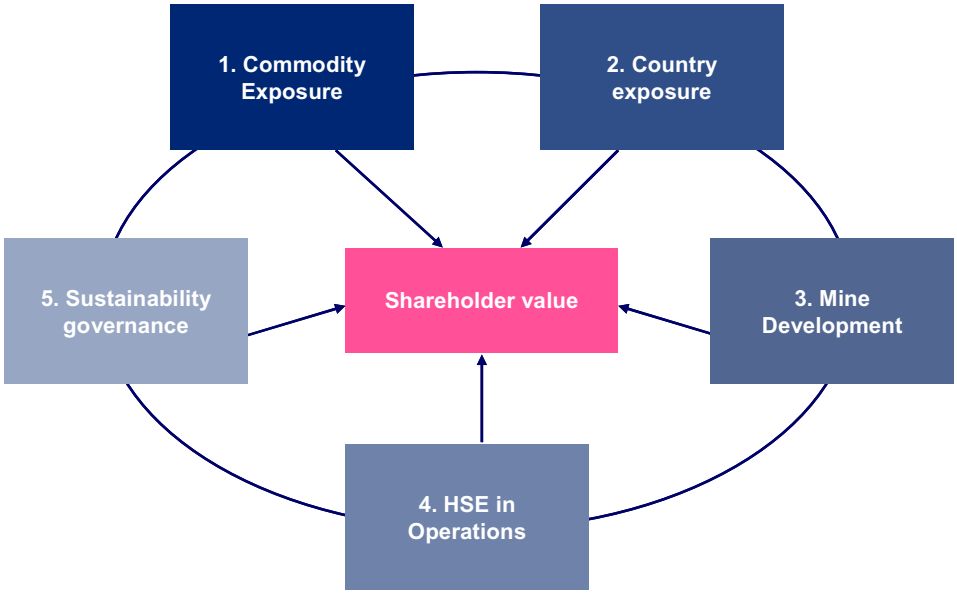
In recent years, a groundswell of public opinion has caused sustainable development to become a serious business consideration for the metals and mining companies and for their investors. The reaction of the industry has been mixed, with a wide range of responses to these emerging business risks and opportunities. We argue that the five factors that make up sustainable development will affect long-term shareholder value and that those companies which are reacting most effectively to these challenges, are likely to outperform.

Evaluating sustainable development

Sustainable development has traditionally been limited to immediately obvious issues such as environmental pollution, health, safety and human rights. However, we argue that it actually has a far broader scope and also that it has the potential to add or destroy value for metals and mining companies, and thereby for investors.

We have created five factors of sustainable development, which we believe impact shareholder value. These factors take into account broader factors including **commodity** and **country exposure** as well as **mine development** and corporate responsibility factors of **sustainable governance** and **HSEE** (health, safety, employment and environment) **in operations**.

Figure 2. Creating shareholder value



Source: Citigroup Investment Research.

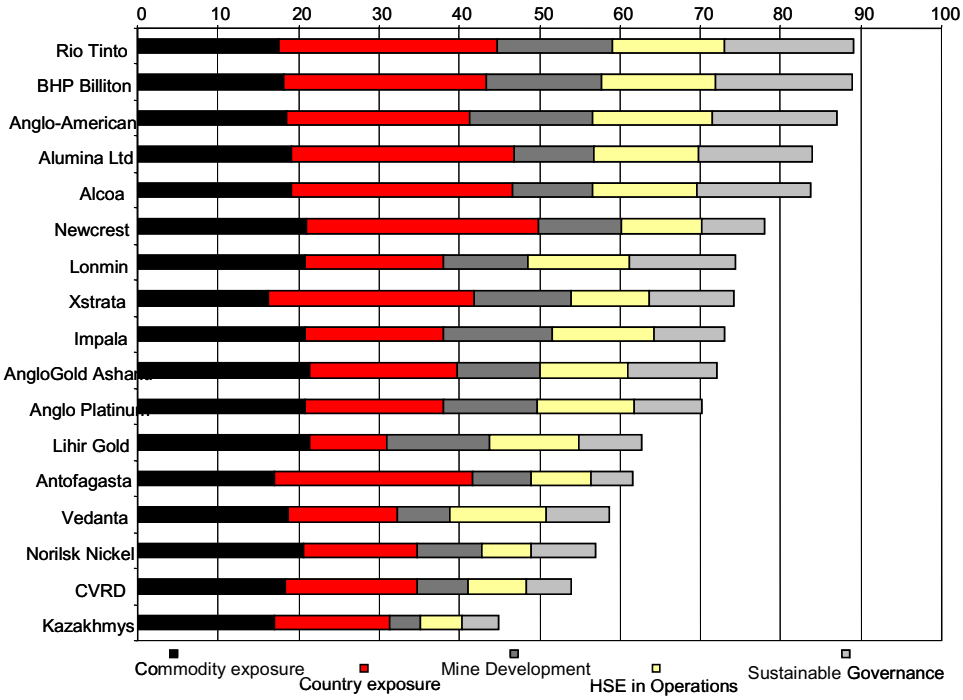
Citigroup Sustainability Mining Index

By combining these factors, we have created the Citigroup Sustainability Mining Index (CSMI) to evaluate how metals and mining companies are conducting their business relative to sustainable development priorities. The index identifies

companies that are best positioned to create value from sustainable development and those which are at risk of destroying value.

Our analysis suggests there is a trend towards accepted standards of good practice around 'Sustainability Governance' and 'HSEE in operations'. Further, we suggest that while commodity exposure can have some impact, it is the country exposure that causes most variation in the company scores. This, however, can be exacerbated or softened by the company's management processes.

Figure 3. Citigroup Sustainability Mining Index



Source: Citigroup Investment Research.

- The major positive stand-outs in the sector are: Alcoa, Alumina, Anglo American, BHP Billiton and Rio Tinto.
- Antofagasta, CVRD and Xstrata could most easily leverage strong country and commodity positions by improving their sustainability management practices.
- Likewise, Lihir Gold, Norilsk Nickel and Vedanta could use improved sustainability management to reduce the country risk and build on their commodity positioning.

Riding with the cowboys, or hanging with the sheriff?

Traditionally an unconsolidated mining sector has kept costs low by clamping down on unionisation, cutting corners with health and safety and taking risks with waste disposal etc. However, the mining sector is now moving from an externalising environment towards one where environmental and social costs typically have to be included in the cost of doing business. This is increasing the costs of mining, limiting land access and extending the lead times for developing new or expanding existing mines. The sustainable development agenda presents companies with a number of choices:

- Seek out low-regulation, low-cost environments for their future development (*riding with the cowboys*)
- Develop a new business model that places a premium on environmental responsibility and social progress (*hanging with the sheriff*)
- Try to operate in the old way in the new world and go out of business (*going to jail*)

Mis-pricing risk

The consensus view is that mining is less risky in countries where political systems are stable and transparent. In this respect, mining has been viewed as any other business or investment activity and as such the financial community has relied on bond markets as the key indicator of risk and driver of valuations.

Our analysis suggests that risk is more company-related, than country-dependent. Two mining companies operating in the same country could have substantially different discount rates based on; the **commodities** extracted, **mine development**, the ability to control **HSEE in operations** and **sustainability governance**.

As a scenario analysis, we have used a risk adjusted discount rate based on our Citigroup Sustainability Mining index. We see the largest upside to valuation to occur for the large diversified mining companies such as Anglo American, BHP Billiton and Rio Tinto, with potential upside of 23%-30%. Generally the platinum companies show valuation upside, while in contrast the gold companies show downside risk.

Figure 4. Risk Adjusted discount rate

	Current WACC	Risk adjusted discount rate	Current NPV	NPV Impact	% change
Rio Tinto	10.7%	7.5%	$36.70	$47.27	29%
BHP Billiton	10.7%	7.5%	$12.70	$16.34	29%
Anglo-American	10.3%	7.7%	$25.08	$30.86	23%
Alumina Ltd	10.7%	8.1%	A$7.20	A$8.89	23%
Alcoa	8.1%	8.1%	$35.00	$34.96	0%
Newcrest	8.1%	8.8%	A$5.40	A$4.94	-9%
Lonmin	9.8%	9.2%	£13.55	£14.33	6%
Xstrata	10.4%	9.2%	$23.72	$26.31	11%
AngloGold Ashanti	9.9%	9.4%	R144.00	R149.31	4%
Impala Platinum	13.0%	9.6%	R722.00	R945.52	31%
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Lihir Gold	9.6%	10.5%	A$1.44	A$1.35	-6%
Antofagasta	10.9%	10.6%	$31.41	$32.23	3%
Vedanta	11.1%	10.9%	$12.10	$12.29	2%
Norilsk Nickel	11.1%	11.1%	$67.41	$67.26	0%
CVRD	10.9%	11.5%	$47.70	$45.20	-5%
Kazakhmys	12.7%	13.2%	$10.55	$10.74	-10%

Source: Citigroup Investment Research.

On this basis, we recommend buying the stand out companies; BHP Billiton (BLT.L; 1M; £9.38), Anglo American (AAL.L; 1M; £19.86) and Alcoa Inc (AA; 1M; US$29.09) together with the risk adjusted upside in Impala Platinum (IMPJ.J; 1M; R1,025) and Lonmin (LMI.L; 1M; £24.54).

We recommend selling Kazakhmys (KAZ.L; 3H; £9.17).

Valuing sustainable development

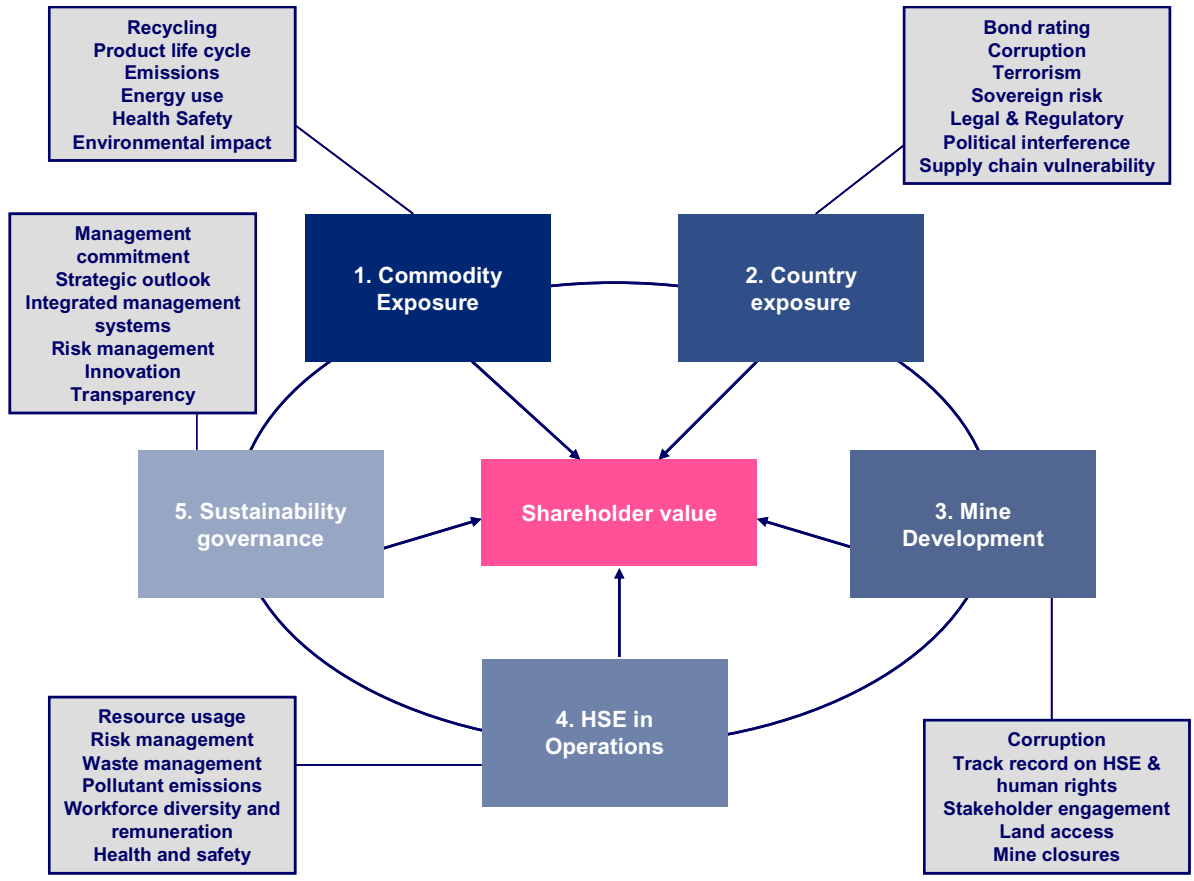
The purpose of this report is to assess the risks arising from sustainable development that face mining companies and, by understanding how companies manage these risks, we have:

- Created a ranking of companies – the Citigroup Sustainability Mining Index (CSMI) and
- Derived alternative discount rates for valuation of the companies which incorporate sustainability risk.

To do this we take a broad view of sustainable development that encapsulates not only sustainability governance and human rights, health, safety and environment (the traditional aspects of sustainable development) but also commodity issues, country risk aspects, mine development prospects and companies' ability to access capital. This way we believe that we capture all aspects of sustainable development that have potential to create or destroy value.

We have set out to evaluate the sustainability performance of the mining companies under our coverage on the five broad measures of sustainable development that we believe are most likely to drive value. In each case we have developed sustainability indicators to measure the exposure and response of individual companies to each area.

Figure 5. Five forces of sustainable development



Source: Citigroup Investment Research.

1. Commodity exposure

Sustainable development pressures are likely to impact the supply and demand for commodities.

In terms of supply, the sensitivity of each commodity to an increased emphasis on sustainable mining and smelting practice is likely to depend on the extraction techniques deployed, energy intensity, atmospheric emissions and rehabilitation measures required.

On the other side of the equation, demand for some commodities is likely to increase (due to light-weighting, recycling, pollution abatement etc.) or reduce due to health & safety or pollution concerns.

We have combined these supply and demand factors in an attempt to compare the impacts (positive & negative) of the sustainability issues on commodities.

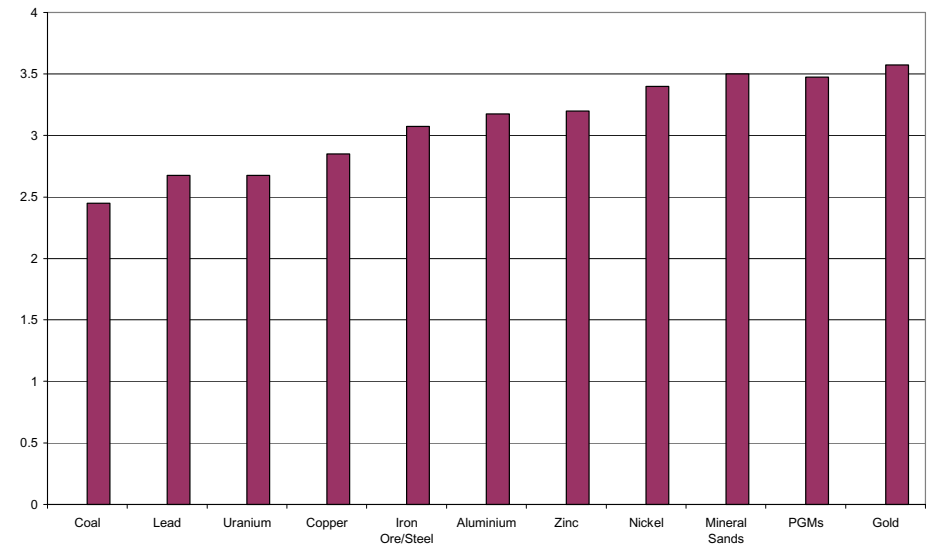
Commodities which benefit most from sustainability pressures are:

- Platinum Group Metals (PGMs): demand from pollution abatement catalysts.
- Gold: long life cycle, high recyclability.
- Mineral sands: prolongs product life cycle, light weighting, low impacts from minerals processing.

The major losers are:

- Thermal coal: greenhouse gas emissions, environmental impacts of mining.
- Lead: health and safety, emissions.

Figure 6. Ranking of commodities on sustainability criteria



Source: Citigroup Investment Research

The impact of sustainability issues on long-term pricing includes: Higher or lower demand growth rates, higher production costs and full life-cycle costing.

Commodity exposure by company highlights the potential positive impact for the PGM and gold producers (Norilsk, Lonmin, AngloGold Ashanti, Newcrest and Lihir) and a possible negative impact for large thermal coal producers (Xstrata).

2. Country exposure

The financial community has relied on bond markets as the key indicator of transparency and stability in assessing the risk rating on mining companies. However, even in countries where political and economic systems are stable such as the US, Canada and Australia, mining is complex and challenging.

In some developing countries, companies have been able to adopt weaker standards due, amongst other things, to scarcity of enforcement resources or less stringent operating regulations. However, all countries with a significant mining industry are now developing similar, stringent regulatory frameworks.

Instead of just relying on bond markets we have looked to insurance and corruption indicators as more relevant indicators of risk for mining companies. This composite risk ranking that emerges takes account of the actions or inaction of foreign governments, political violence, changes to royalties, taxation, terrorism or embargoes and supply chain vulnerability.

On a risk rating Australia, the EU and North America are the clear leaders on all measures. On the downside, Papua New Guinea (PNG), Congo and Zambia are the laggards. Interestingly the insurance risk market places a lower risk rating on Chile and Brazil than the bond markets. Additionally, the Perception of Corruption Index places a higher risk rating on Russia, Kazakhstan and India than the bond markets.

Figure 7. Country risk analysis

	Bond rating	Insurance risk	Corruption index	Average
Australia	30	30	26	29
EU	30	30	24	28
Nth America	30	30	24	28
Chile	22	30	22	25
South Africa, Namibia, Botswana	19	18	15	17
Brazil	14	24	11	16
Russia/Kazakhstan	17	18	8	14
India	15	18	9	14
Peru, Argentina	11	12	9	11
PNG	10	12	7	10
Congo, Zambia	6	6	7	6

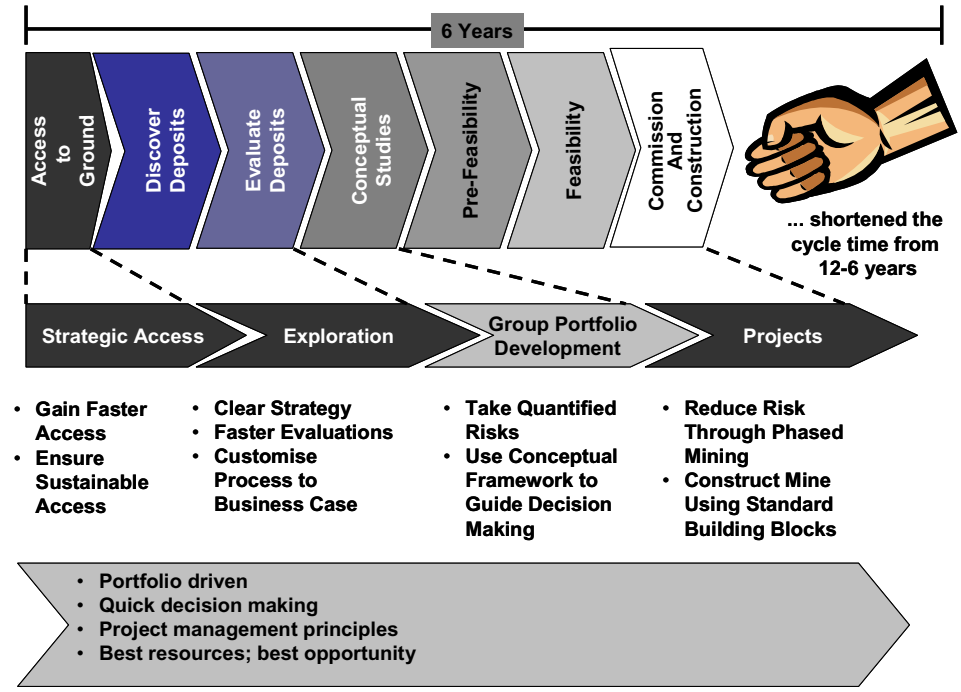
Source: Citigroup Investment Research, AON, Oxford Analytica, Transparency International

3. Mine development

Gaining mineral rights and ensuring access to land are key elements of the mine development process. In addition to the technical, pricing and negotiation skills required, 'softer skills' around stakeholder consultation and environmental impact assessment can also be critical.

We argue that integrating these sustainable development issues into the company's capital allocation process can result in reducing lead times in mine developments. We estimate that the normal lead times in mining development can be reduced from around 12 years to 6 years.

Figure 8. Reducing the lead times



Source: De Beers

In this category, the global diversifieds, BHP Billiton, Rio Tinto and Anglo American stand out as the three leaders, with notable highlights:

- **Anglo-American** – whose Socio-Economic Assessment Toolbox (aimed at existing operations) is a structured way of ensuring that consultation with, and contributions towards, local communities are effectively delivered.
- **BHP Billiton** – where formal community relations plans are in place at 98% of operations and where 40% of operations have undertaken a Human Rights Self-Assessment.
- **Rio Tinto** – where all operations are required to have closure strategies (reviewed at least every five years) in accordance with a group-wide closure standard.

4. HSEE in operations

The wide range of sustainability issues that contribute to the overall operating efficiency of a mine can usefully be divided into cost management and risk reduction issues. Cost management issues include levels of employee turnover and resource efficiency; risk reduction relates to any issues that could halt production and/or incur significant expenditure to maintain operations.

- **Health and safety** - In this area, there is a wide discrepancy between the leaders (low levels of Lost Time Injury Free Rate (LTIFR), continuing improvements and few fatalities) and the laggards (no reporting, high fatality rates and no improvement trend). Interestingly, this discrepancy crystallises most clearly in the different performance of Anglo American (4 fatalities in 2004), Anglo-Platinum (24 fatalities in 2004) and AngloGold Ashanti (32 fatalities in 2004)
- **Employees** - Although most scores clustered around 3 out of 5, we highlight Vedanta on account of a recent site visit from which our analyst reported "a higher level of engagement by skilled and semi-skilled employees than anywhere else in the industry".
- **Environment** - In the environmental dimension, we were surprised by the laggards. As pollution and waste control are such obvious and critical environmental issues, we were surprised by how little reporting there was in this area (and therefore how many companies scored '1 out of 5'). With respect to water consumption, we were also underwhelmed by the companies' responses, with the exception of the long-term targets of BHP Billiton and Rio Tinto's 'Water Position Statement'.

The issues covered in this section should be clearly visible to management, solutions should be actionable and investment in remediation measures should pay back quickly. Accordingly, while we are disappointed by any company that scores less than 10/20 in our indicators (of which there are 5), we expect to see rapid progress over the coming years.

5. Sustainability governance

'Sustainability governance' ensures that good practice lessons from projects can be replicated around a company's portfolio.

As might be expected, there is a good correlation between the companies that score well on 'sustainability governance' and that score well on 'Mine Development' and 'HSEE in Operations'.

The global diversified players tend to have more comprehensive and robust sustainability governance systems than their smaller counterparts. They are also more likely to be actively engaged in innovation to drive sustainability forward within the sector. In particular, we noted:

- **Alcoa/Alumina:** Which scores a '5' for its long term '2020 Strategic Framework' and its full and active engagement with the ICMM. We were also impressed by the direct and ongoing communication between Alcoa's Public Issues Committee and a number of NGOs.
- **Lonmin and Xstrata**: Which have made considerable strides over recent years (in Xstrata's case since admission to the London Stock Exchange) particularly in respect of communication with investors.
- **BHP Billiton:** Which has completed lifecycle assessments for all of its major mineral products and is also actively engaged in pilot projects to develop mine certification processes.
- **Rio Tinto**: Which has lead the sector from the start in the development and adoption of industry standards including ICMM and the GRI (Global Reporting Initiative).

This reinforces our thesis that such centralised governance systems enhance performance at the sharp end of the business.

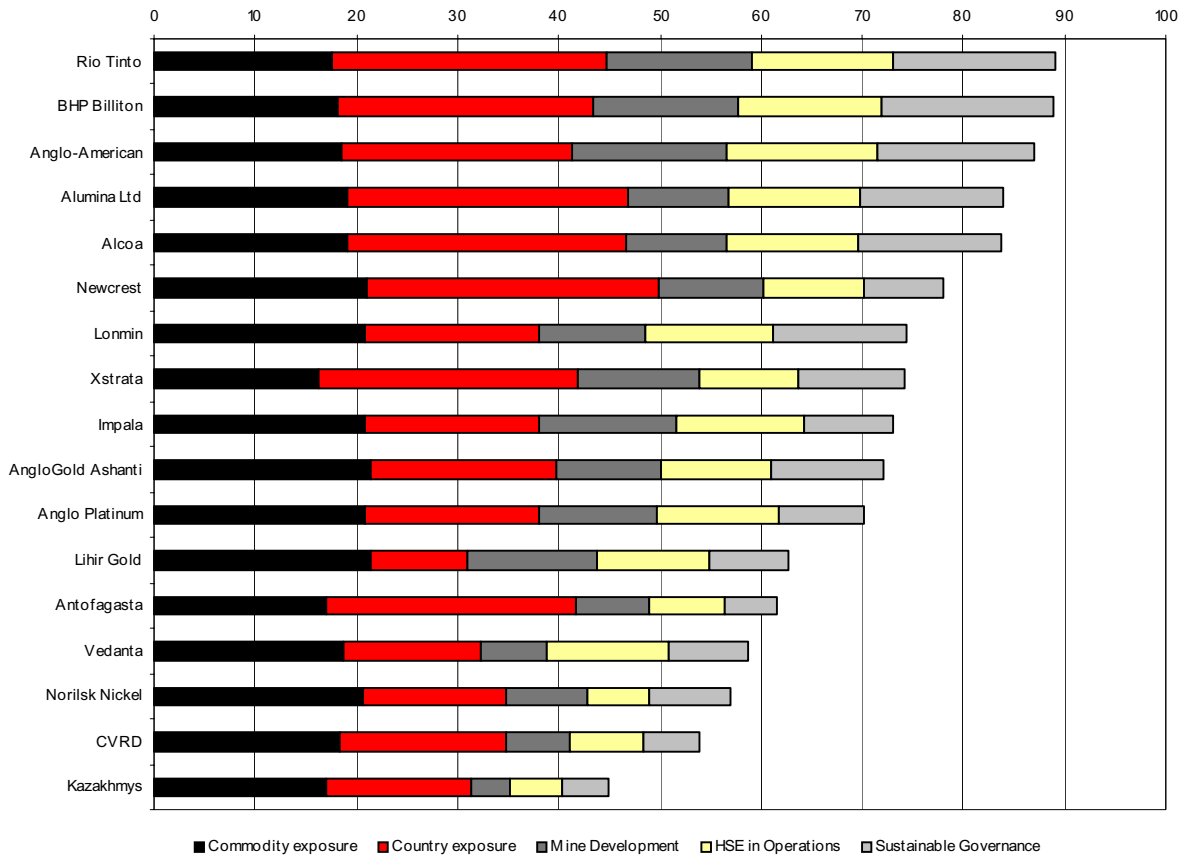
Citigroup Sustainable Mining Index (CSMI)

We have combined the five indicators to create the Citigroup Sustainable Mining Index (CSMI). Our mining index is based out of 120 and is split 50% between commodity and country exposure (i.e. 'what you do') and 50% towards mine development, HSEE in Operations and sustainable governance (i.e. 'how you do it').

We have weighted our 5 Sustainability Factors as follows;

- Commodity exposure out of 30
- Country exposure out of 30
- Mine development out of 20
- HSEE in operations out of 20
- Sustainability governance out of 20

Figure 9. Citigroup Sustainable Mining Index



Source: Citigroup Investment Research

Our analysis suggests there is a trend towards accepted standards of good practice around 'Sustainability Governance' and 'HSEE in operations'. Further, we suggest that while commodity exposure can have some impact, it is the country exposure that causes most variation in the company scores. This, however, can be exacerbated or softened by the company's management processes. (Consider how

Lonmin leaps above Antofagasta in the overall ranking because its broadly strong management practices compensate for the location of its operations.)

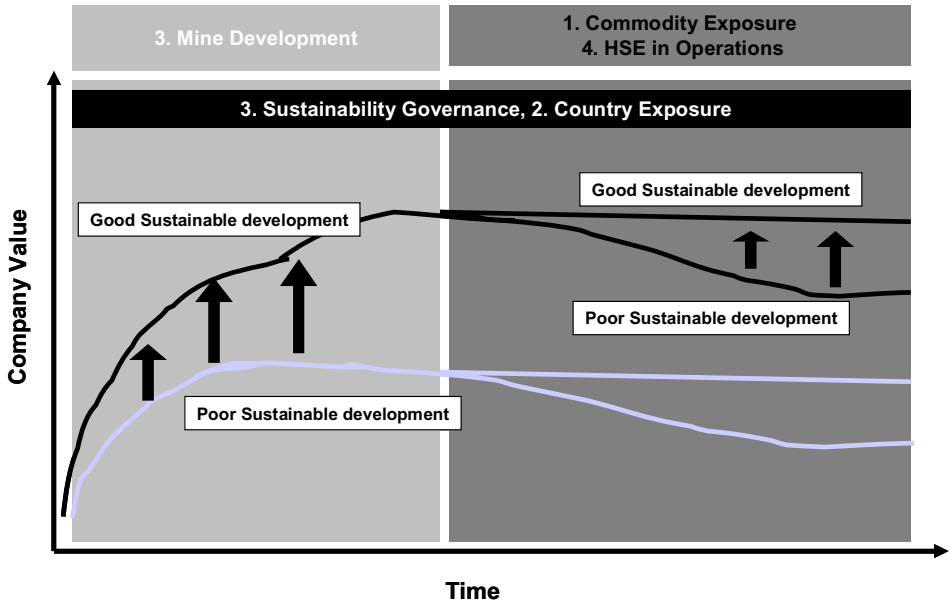
- The major positive stand-outs in the sector are: Alcoa, Alumina, Anglo American, BHP Billiton and Rio Tinto.
- Antofagasta, CVRD and Xstrata could most easily leverage strong country and commodity positions by improving their sustainability management practices.
- Likewise, Lihir Gold, Norilsk Nickel and Vedanta could use improved sustainability management to reduce the country risk and build on their commodity positioning.

Valuation impacts

The consensus view is that mining is easiest in countries where political systems are stable and transparent. In this respect, mining has been viewed as no different from any other business or investment activity.

In our opinion, mining companies that manage environmental and social issues and have a demonstrable track record will benefit from reduced lead times for mine development and additionally reduce the threat of the erosion of the company's value from existing operations.

Figure 10. Valuation impact of sustainable development



Source: Citigroup Investment Research.

To assess the financial impact of sustainable development on mining projects we have constructed a generic copper mine. At a discount rate of 8%, production of 250kt, cash cost of 40c/lb and a long term copper price of 95c, we calculate that our copper mine would generate a DCF valuation of around US$1.9bn by 2012.

- Shortening the lead time of our generic copper mine from 12 to 6 years would bring forward around $6.8bn in future value for a mining company.

- A 1% change in the discount rate would change our valuation by $147m or by around 8%.
- A -/+20% change in costs would change our valuation by $261m or by around 13%.
- A-/+5% change in the taxation rate would change our valuation by $80m or by around 5%.

To assess the impact of sustainable development on existing operations we have used a risk adjusted discount rate based on our Citigroup Sustainability Mining Index. We see the largest upside to valuation to occur for the large diversified mining companies such as Anglo American, BHP Billiton and Rio Tinto, with potential upside of 23-30%.

Figure 11. Risk adjusted discount rate

	Current WACC	Risk adjusted discount rate	Current NPV	NPV Impact	% change
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Source: Citigroup Investment Research

The future – transparency and access

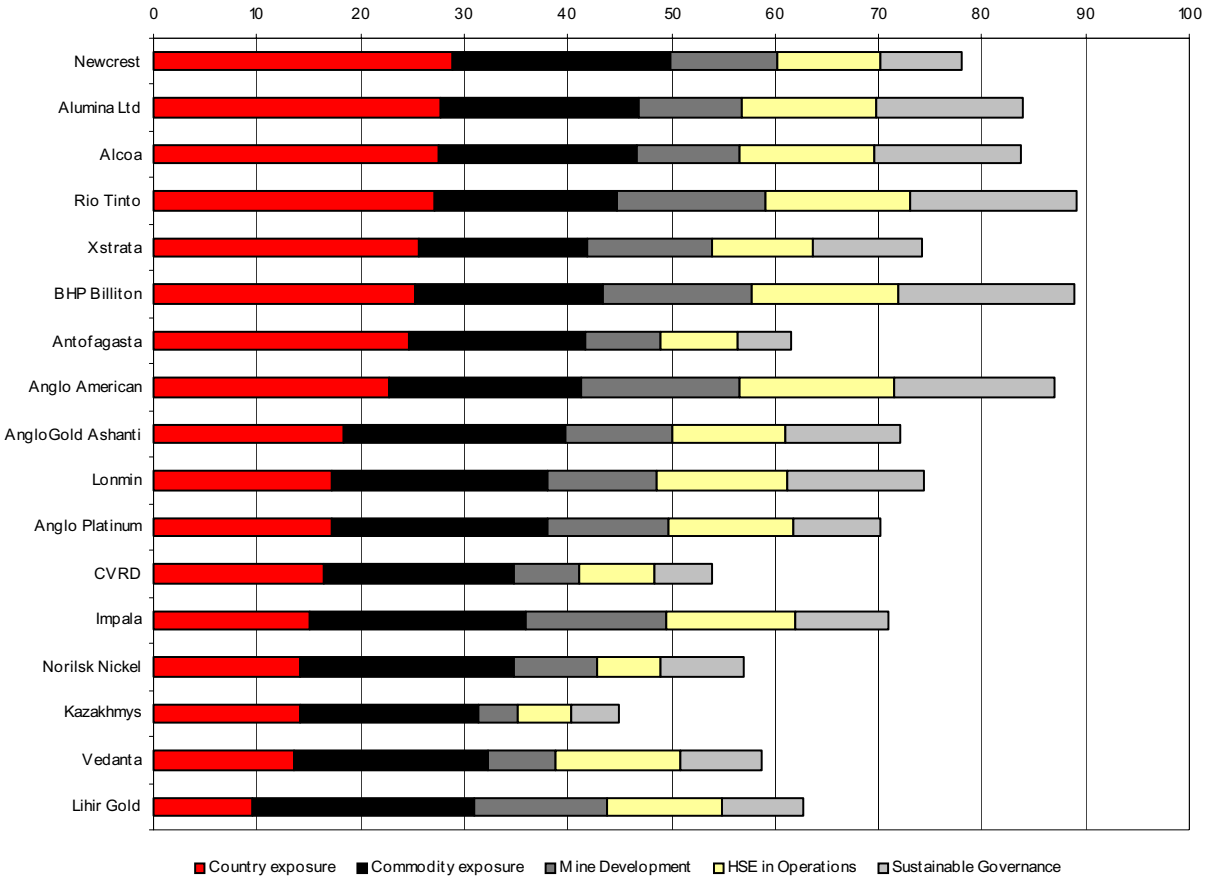
Strong sustainability performance enables companies to convert opportunity-sets to revenues, companies will need to embed sustainability disclosure as part of their broader efforts to communicate with capital markets. If they can do this, the sustainability valuation upside that we have highlighted to the global majors may also be accorded to these emerging players.

The following chart orders the companies firstly on country risk rating and then on our other risk measures. From this we discern that:

- A number of companies rate strongly across each category eg Alcoa, BHP Billiton and Rio Tinto.
- Anglo American, Impala and Lonmin have low country ratings but offset these with strong risk control measure.
- Companies with strong commodity and country positions that stand to benefit most from improving their sustainability management practices are Antofogasta, CVRD and Xstrata.

- Finally, some companies need to improve their sustainability risk management to enable them to manage comparatively weak country positions – although of these, we note that Lihir Gold, Norilsk Nickel and Vedanta have relatively strong commodity positions to support this effort.

Figure 12. Companies ranked by country risk versus our overall sustainable development risk



Source: Citigroup Investment Research.

How does this report fit with previous literature?

Much of the literature on the implications of sustainable development for metals and mining relates to the social and economic responsibilities of the mining industry.

The 2000 Mining, Minerals and Sustainable Development (MMSD) project was intended to develop an understanding of how to maximize the contribution of the mining and minerals sector to sustainable development at the global, national, regional and local levels. Managed by the International Institute for Environment and Development in London, under contract to the World Business Council for Sustainable Development, MMSD produced a report (*Breaking New Ground*, 2002), working papers, and promoted debate on mining sector sustainable development issues.

Since then, a series of programs, mostly under the auspices of the International Council of Metals and Mining (ICMM), have further developed these issues on a

number of fronts, including socio-economic issues, environmental stewardship, materials use, and health and safety.

An important aim of our report is to bring these sustainable development issues out of the political and economic arenas and into the investment world – to translate sustainable development issues into conclusions which have real investment implications. In particular, we identify those mining companies which are taking steps to mitigate the risks inherent in unsustainable practices.

Mining, sustainable development and investment

- **The mining sector is diverse, relevant and changing rapidly in response to a range of new challenges, one of which is 'sustainable development'**
- **Although sustainable development is not a new issue for the sector, its economic, environmental and social dimensions are becoming ever more relevant to the financial performance of companies**
- **Key areas of downside risk include: the loss of mining licences or refusal of new licences, increased costs or fines and litigation; key areas of upside opportunity include: new applications for metals (such as light-weighting for aluminium, fuel cells for PGMs etc.)**
- **Sustainable development has the potential to add or destroy value for mining companies at a number of different stages via companies' commodity exposure, country exposure, mine development, operations and governance procedures**

The mining sector

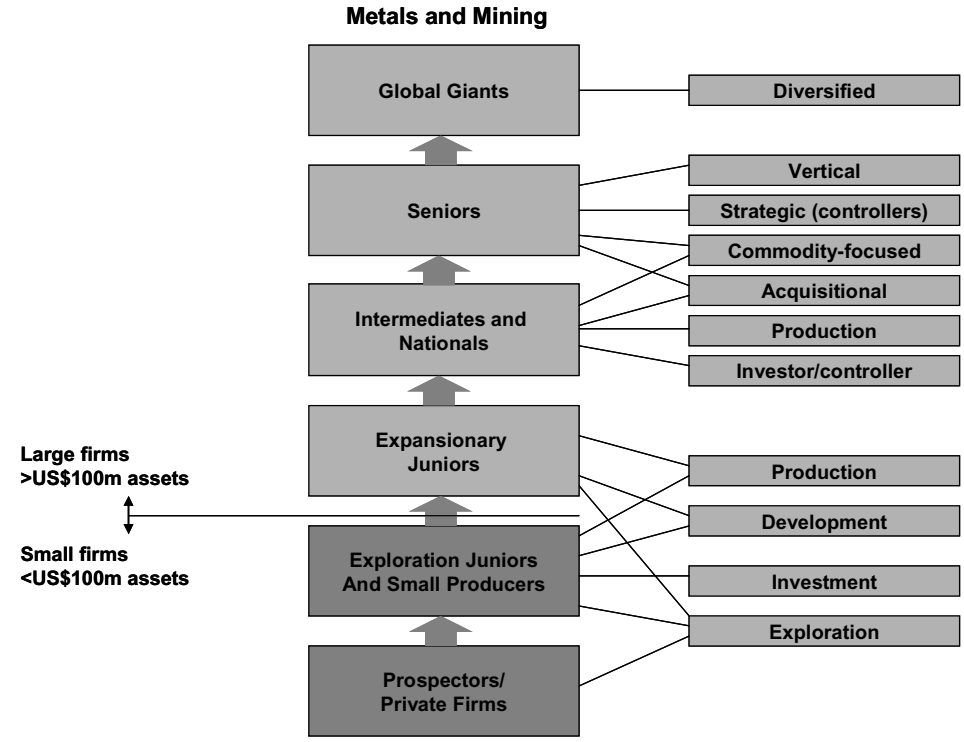
The metals and mining sector covers a broad spectrum of commodities and companies. Mineral commodities are generally grouped into base metals, ferrous metals, precious metals, energy minerals and industrial minerals but are diverse in terms of extraction methods and end use demands.

Consolidation a key trend

A feature of the mining industry has been a rash of mergers and acquisitions in the mining sector, over the past ten years. This has created the presence of very large global companies as well as very small companies. The number of mining and metal companies in the world has been estimated at over 10,000, operating some 20,000 individual mines, processing plants and smelters.

With such diversity in the sector come wide ranging commodity and country exposures, asset qualities, and a variety of different management approaches. Some of these will create value and others will destroy it. As investors review these different factors, we argue that the sustainable development factor be added to the list.

Figure 13. Corporate structures of the metals and mining companies



Source: MMSD

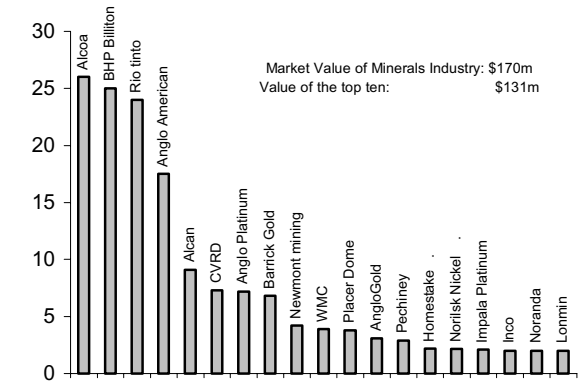
Mining- no longer a struggle to be relevant

In the late 1990s, the metals and mining sector was struggling to be seen as relevant against the rise of service-orientated companies. The old economy was giving way to the new economy and the internet boom. At the same time the mining sector was coming to grips with oversupplied markets following from lower demand levels, and increased supply from large-scale investments and a flood of exports from the FSU.

In the past four years, the mining sector has rebounded in a spectacular fashion, with the market value of the industry rising by 240% from around $170bn to $580bn. The outperformers, have been the diversified players in multi commodities, currencies and countries. This has been at the expense of the vertically integrated producers such as Alcoa and Alcan, whose market capitalisations have remained relatively flat in the past four years.

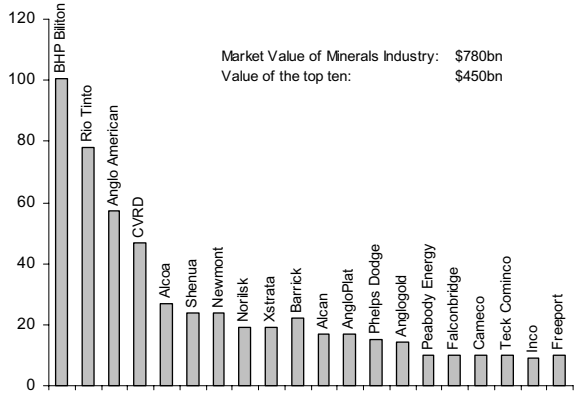
In 2001, Alcoa was the largest metals and mining company with a market capitalisation of around $25bn. Today, Alcoa has fallen to number 5 in a list, which BHP Billiton now leads with a market capitalisation of around $100bn.

Figure 14. Top 20 companies in 2001



Source: Datastream, Citigroup Investment Research.

Figure 15. Top 20 companies in 2006



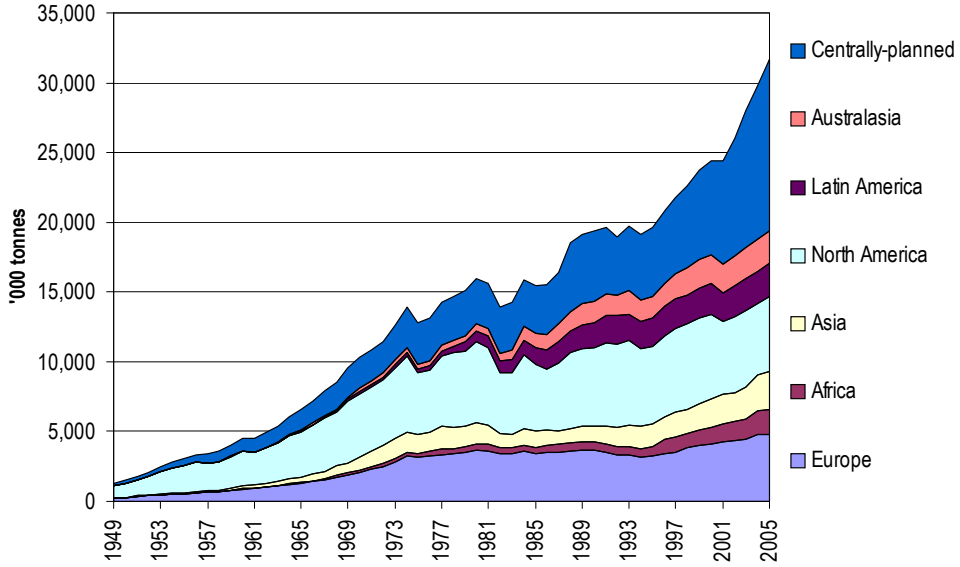
Source: Datastream, Citigroup Investment Research.

The move from the Wild West to the Wild East

Traditionally an unconsolidated mining sector has kept costs low by clamping down on unionisation, cutting corners with health and safety and taking risks with waste disposal etc. The mining companies have migrated away from developed countries to lower cost regions such as Latin America and Asia to develop new mines.

The center of production is shifting. For example in aluminum

Figure 16. Aluminium production since 1949



Source: Metallstatistik; WBMS; Citigroup Investment Research.

Nevertheless, environmental and social factors are globalising at a much faster rate than mining companies can relocate. This has heightened risk such as; native title, supply chain vulnerability, strikes, riots, civil commotion, taxation & royalties changes, etc.

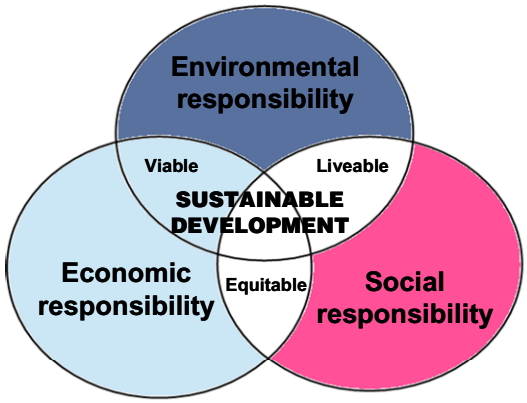
The mining sector is now moving from an externalising environment towards one where environmental and social costs are internalised in the cost of doing

business. This is increasing the costs of mining, limiting land access and extending the lead times for developing new or expanding existing mines.

Sustainable development

Sustainable development can be defined as "meeting the needs of the current generation without compromising the ability of future generations to meet their own needs" (Gro Harlem Bruntland, World Commission of Environment and Development, 1987). Alternatively and more colloquially, 'sustainable development' could be defined as "all the problems in the world and all of their solutions".

Figure 17. Sustainable development – The triple bottom line



Source: Citigroup Investment Research.

Sustainable development and the mining sector

MMSD a turning point

In many respects, 'sustainable development' is not a new issue for the mining sector. Companies have been involved in tackling issues ranging from environmental liabilities to union relations and from acid mine drainage to health and safety for a number of years. A turning point at which the industry began to take a more holistic view of sustainable development was the Mining Minerals and Sustainable Development project. This project which was catalysed by Rio Tinto and co-ordinated by the International Institute for Environment and Development (IIED) and the World Business Council for Sustainable Development culminated in a benchmark report, *Breaking New Ground (*2002). This report went a considerable way towards developing a coordinated response to addressing the most important sustainability issues.

Since then, a series of programs, mostly under the auspices of the International Council of Metals and Mining (ICMM), have further developed sustainability issues on a number of fronts including socio-economic issues, environmental stewardship, materials use, and health and safety.

Operationally relevant

The '*Breaking New Ground*' report demonstrated (to any who were still unconvinced) that sustainable development was operationally relevant for the mining sector.

Financially relevant

Furthermore, the increasingly active management of environmental and social issues by leaders in the sector have demonstrated to the sector as a whole that

'responsible' management can help companies to reduce costs, minimise risks, grow revenues and create new revenue-generating opportunities.

Investment relevant

Finally, as the profile of these issues grows and any discrepancy between company performance becomes apparent, we believe that these issues will become increasingly relevant to investors in the mining sector.

The aim of this report is to bring these sustainable development issues out of the political and economic arenas and into the investment world – to translate sustainable development issues into conclusions which have real investment implications. In particular, we identify those mining companies which are taking steps to mitigate the risks inherent in unsustainable practices.

Operational relevance

Given the broad scope of the sustainable development agenda and, indeed, the broad scope of the mining sector, to understand how the two relate at an operational level, we turn again to the categories outlined in the diagram above: economic impacts, social impacts and environmental impacts.

Economic impacts:

A company's economic contribution, in this context, typically refers to its contribution to international, national and local economic development. Companies are expected to develop their businesses in ways that promote economic growth, stability, productivity and competitiveness in the markets within which they operate. To assess this we need to consider such factors as:

- **Suppliers and customers** – to ensure that companies are not involved in anti-competitive practice
- **Employees** – to ensure that via training and development, the overall skills base of an economy grows
- **Government** – to ensure that companies fulfil their responsibilities in respect of tax and royalties paid to the appropriate local and national governments
- **Local communities / economies** – to ensure that companies make the most of any multiplier effect that comes from their presence by supporting and developing micro-economies around their own value chain. Also there will be interest in how companies leave self-sustaining economies behind them when they close mines

Notably, Black Economic Empowerment in South Africa, with its emphasis on beneficiation and employee ownership, has forced the mining sector to focus on many of these wider economic impacts. In particular, BEE requires companies to enhance their 'upstream impacts' by using BEE-accredited suppliers and their 'downstream impacts' by ensuring that S. Africa is able to capture a larger proportion of the production value chain that starts with each commodity.

Social impacts:

A company's social contribution typically arises from the stability and longevity (or not) of its relationships with a series of stakeholders including customers,

employees, local communities and wider society including the media and special interest groups.

Assessing companies' success in this dimension is more complex as these stakeholders may all have different priorities. Nevertheless, as a starting point, we seek to understand whether companies themselves have a clear communicable idea of who their key stakeholder groups are, what constitutes success and what constitutes failure for each group, where they currently stand and how they plan to progress.

- **Customers** – Companies that do not understand their customers' immediate needs are unlikely to remain in business. While it is easier to keep a closer eye on near-term product pipeline, longer-term changes in customers' expectations and how companies are preparing to meet these changes will ultimately dictate shareholder value.
- **Suppliers** – While price will clearly be the critical determinant of the relationship between a company and its suppliers, companies should also have regard for factors such as security of supply, reliability, quality, innovation, etc.
- **Employees** – Again, whilst wages and conditions are the principal determinants of the relationship between a company and its employees, attracting, motivating and retaining good employees will also require consideration of wider factors such as training and development, clear communication, aligning personal objectives with business ones, flexibility on work-life balance, etc.
- **Local communities** – While failure to manage relationships with local communities is manifested by demonstrations and campaigns, the best indicator of success may be silence. Transparency and engagement with local communities are tried and tested methods for building relationships with this stakeholder group.
- **Wider society** – While government tends to represent broad societal views, companies will also have to manage relationships with pressure groups and civil society organisations in respect of specific issues. Again transparency has proved to be an effective tool in identifying companies that are prepared to engage early with groups that may hold opposing views or be hostile to their interests.

In the mining sector, these issues typically manifest themselves through the health, safety and development of employees, the honesty and transparency of their dealings with national governments, their support for human rights and their relationships with local communities.

Mining companies are, however, also attaching increased importance to the marketing function, an understanding of their customers needs and relative economic value of their product.

Environmental impacts

A company's impact on the environment can be divided into its resource efficiency and its production of waste / pollution. Either of these effects can arise at various stages of a production process, as the table below outlines.

Figure 18. Environmental priorities

	Resource efficiency	Pollution / waste prevention
Supply chain	e.g. local sourcing of product reduces energy consumption in transport	e.g. organic farming reduces nitrification (caused by artificial fertiliser load)
Production processes	e.g. closed loop recycling processes to reduce raw material consumption within factories (e.g. reusing water, using waste offcuts etc.)	e.g. reducing SO_x and NO_x from electricity generation
Product in use	e.g. thinner-walled beverage cans use less metal	e.g. installing autocatalysts in cars to reduce emissions through the car's lifecycle
Product disposal	e.g. recycling of materials (paper, metals, plastics etc.) reduces overall resource consumption	e.g. removing heavy metals from products (e.g. batteries, electronic equipment) reduces their end-of-life impacts

Source: Citigroup Investment Research.

For the mining sector, the following aspects of performance are particularly relevant.

Figure 19. Environmental priorities of mining companies

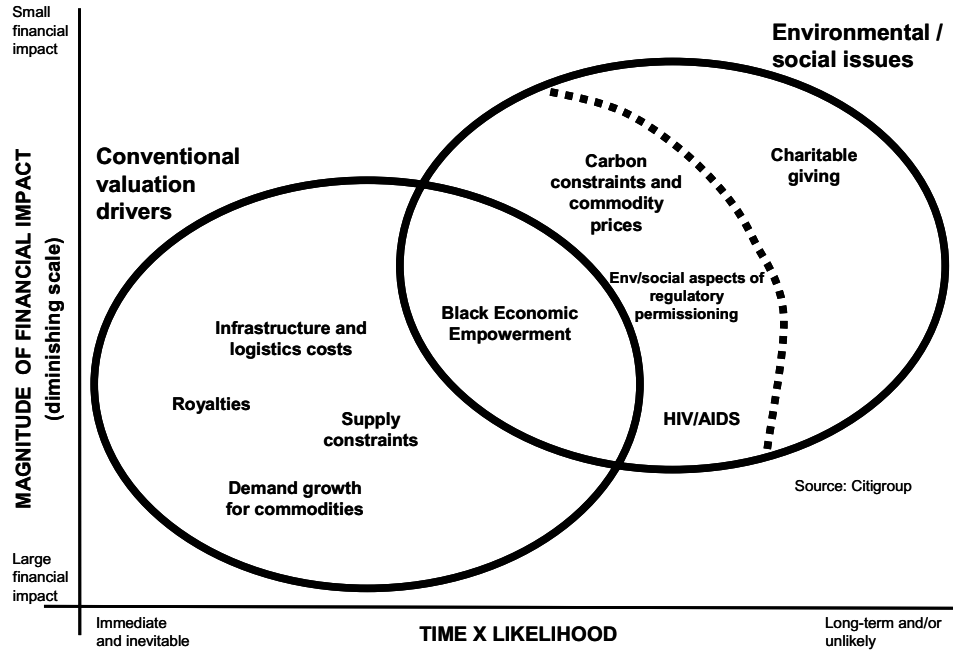
	Resource efficiency	Pollution / waste prevention
Supply chain	e.g. efficient sourcing of raw materials can reduce energy consumption in transport	e.g hydro power versus coal-fired power for smelting
Production processes	e.g. energy, water efficiency etc	e.g. managing tailings, toxic waste, avoiding pollution incidents etc.
Product in use	e.g. lightweight products reduce resource requirement and energy consumption	e.g. installing autocatalysts in cars to reduce emissions through the car's lifecycle
Product disposal	e.g. recycling of materials reduces overall resource consumption	e.g. again recyclability reduces waste disposal requirements

Source: Citigroup Investment Research

...but not all issues are equal

However, not all sustainable development issues are of equal importance to investors. As the following diagram demonstrates, some sustainability issues (e.g. Black Economic Empowerment, Royalty Payment, etc.) are already material, recognised and to some extent 'in the price' – although they remain live issues and could drive prices further in future. Other issues (e.g. carbon trading, environmental and social aspects of regulatory permissioning, HIV/AIDS, native title, etc) lie on the borderline of financial relevance and their potential to influence price is less well understood. Finally, some issues (e.g. charitable giving), whilst important to society and to a company's standing within it, will never realistically drive share prices.

Figure 20. Sustainable development of the mining industry



Source: Citigroup Investment Research

Financial relevance

As a starting point, we note that many of the environmental and social factors mentioned above have typically increased the costs of mining. While in many cases, the incremental costs may have been small, taken together they can be significant. Furthermore, the mining sector appears to be in transition from an 'externalising environment' (in which it is in companies' interests to lay as many costs as possible off onto the environment and society) towards an 'internalising environment' (in which environmental and social costs are internalised into the cost of doing business).

Downside risk

We see the key downside risks and costs which flow from unsustainable practices as being:

- Loss of mining licences or refusal of new mining licences.
- Fines and litigation following pollution incidents or accidents – or perhaps more seriously, the opportunity cost of any downtime caused by the accident.
- Labour disputes (including strikes).
- Risks to commodities that do not fit within a 'sustainable future'.
- The smaller players (that need access to capital) may find this constrained if they breach the Equator Principles.

Opportunity

On the other side of the coin, companies with strong practices should:

- Be favoured in mining rights permissioning.
- Benefit from the productivity gains of a motivated workforce.
- Stand to benefit from growth trends in favoured commodities.

Investment relevance

The extent to which a financially-relevant issue for a company becomes a material issue for investors depends on:

- The magnitude of the issue.
- The amount that the market knows vs the amount of new information to come into the market.

Becoming ever more important

Sustainable development issues are becoming more relevant for companies and investors in general because the problems are becoming more acute (e.g. climate change needs addressing now), because they are becoming better known (e.g. not least because the internet enables issues to be communicated rapidly around the world) and because consumers and governments are increasingly placing expectations directly on companies (e.g. through the developing expectations of 'Corporate Social Responsibility').

However, perhaps most importantly for the mining and metals sector, these issues are likely to intensify for two reasons:

- **Profitability restored:** The mining companies can no longer use low earnings and low commodity prices as arguments to mitigate the impact of non-financial issues in their dialogue with stakeholders. Historically, the metals and mining industry had suffered from a 20-year real decline in commodity prices, which led to a low profit environment. Arguably the industry used this to minimise expenditure on non-financial issues and to lobby for lower taxes and/or royalties and to press for workplace flexibility and less unionised workforces. However, this period has now passed and, in our view, the sector faces a sustainable higher commodity-price environment with better sector earnings expected. While broadly positive for the companies, this is also likely to result in stakeholder groups placing additional pressure on mining companies for a 'piece of the pie'.
- **Geographical expansion:** Increased challenges are likely to arise where companies seek out new mining opportunities in parts of the world where social and environmental issues are very stark. As mining companies move into developing countries with widespread inequality, with sensitive and bio-diverse environments, with competing land-ownership interests or with corruption and competing government interests, it becomes increasingly important that they have a clear idea of the economic, social and environmental value that they bring to a situation.

New information for the market

Although large amounts of information are in the public domain about the sustainability performance of mining companies, we would argue that this has not yet been presented in a way that is helpful to investors. This is principally because companies (and therefore analysts) have tended to focus primarily on the environmental and social impacts and only secondarily on how they impact upon the value creation process. Accordingly, we think very little of this information can be treated as "in the price".

By contrast, our starting point is that 'sustainable development' issues have potential to add or destroy value for companies, and thereby investors, at a number of different stages of the mining process.

Valuing sustainability impacts

We argue that the exposures of mining companies to sustainable development issues are a function of:

- Their current positioning.
- Their response to emerging trends.

Accordingly, we have set out to evaluate the sustainability performance of the various mining companies under our coverage on the five broad measures of sustainable development that we believe are most likely to drive value. With regard to their current positioning, we examine companies':

- **commodity exposure.**
- **country exposure.**

With regard to emerging trends we review their processes at different stages in the mining process, namely:

- **mine development** (incorporating mineral rights, land access and project implementation.
- **HSEE in operations** (incorporating health, safety, human resources and environmental performance).
- **sustainability governance.**

In each case we have developed sustainability indicators to measure the exposure and response of individual companies to each area.

Ultimately, the objective of this report is to identify whether the active management of sustainable development priorities is likely to create or destroy value. To do this, we take each aspect in turn; identify how sustainable development considerations are likely to play out and how companies are positioned according to appropriate performance indicators.

Riding with the cowboys, or hanging with the sheriff?

The sustainable development agenda presents companies with a number of choices:

- Seek out low-regulation, low-cost environments for their future development (riding with the cowboys).
- Develop a new business model that places a premium on environmental responsibility and social progress (hanging with the sheriff).
- Try to operate in the old way in the new world and go out of business (going to jail).

Clearly each approach presents its own risks and opportunities. 'Riding with the Cowboys' may be beneficial in the short run but depends on standards remaining forever low. To 'hang with the sheriff', companies will have to learn new disciplines as they accept that environmental and social costs will be inevitably be internalised and that it is therefore in their best interests to manage these costs as efficiently as possible, to maximise synergies between environmental/social performance and financial performance and to manage conflicts.

Commodity exposure

- **Sustainable development pressures are likely to impact the supply and demand for commodities.**
- **Demand for some commodities is likely to increase (e.g. through light weighting, recycling, pollution abatement) and for others, to reduce (health & safety, atmospheric pollution).**
- **In terms of supply, the sensitivity of each commodity to an increased emphasis on sustainable mining and smelting practice is likely to depend on the extraction technique, energy intensiveness, atmospheric emissions and rehabilitation.**
- **We have combined these supply and demand measures in an attempt to compare the impacts (positive & negative) of the sustainability issues on commodities.**
- **Commodities which benefit most from sustainability pressures are the platinum group metals (demand from pollution abatement catalysts), gold (long life cycle, high recyclability), and mineral sands (prolongs product life cycle, light weighting, low impacts from minerals processing).**
- **The major losers are thermal coal (green house gas emissions, environmental impacts of mining) and lead (health and safety, emissions).**
- **Sustainability considerations could have important impacts on the long term outlook for prices when full life cycle costing (cradle to grave) is included.**
- **Commodity exposure by company highlights the potential positive impact for the PGMs and gold producers (Norilsk, Lonmin, AngloGold Ashanti, Newcrest and Lihir) and a possible negative impact for the thermal coal producers (Xstrata).**

Sustainable development criteria

The implications of sustainable development in shaping the outlook of commodity markets are not commonly central issues in sustainability debates. However, there are numerous past examples of what are now considered as sustainability issues on

commodity markets, both positive (e.g. PGMs), and negative (e.g. lead, uranium). Here, we consider the implications of sustainability pressures on both demand and supply.

Demand

Sustainable development pressures may increase demand for some commodities (e.g. through light weighting, recycling, pollution abatement) and reduce demand for others (e.g. from health & safety or atmospheric pollution concerns).

These pressures are comparable to what ICMM (International Council on Mining and Metals) – the pre-eminent sponsor of recent debate on sustainability in mining) calls eco-efficiency – effective resource consumption and reduction of waste.

Production

The sensitivity of each commodity to an increased emphasis on sustainable mining and smelting practices also varies. These include waste disposal and clean up costs of mining and smelting.

Although both are important, we found that it was mostly demand side issues which tended to separate the outlook of commodities, one from another, partly because although sustainability pressures are likely to increase production costs of some materials, margins will be sustained.

Winners and Losers

There are some clear commodity winners:

Commodities which make the greatest contribution to life cycle costing and pollution abatement – zinc, nickel and platinum.

The most notable loser is coal – due to atmospheric pollution.

Demand

Will sustainability factors tend to drive trend demand growth higher or lower? The answer depends on the drivers of demand, and it depends on the commodity in question.

Recycling

Recycling is one of the most important components of sustainability and eco-efficiency. Metals are more readily recycled than many other materials, and therefore increased recycling pressures may favour metals over plastics.

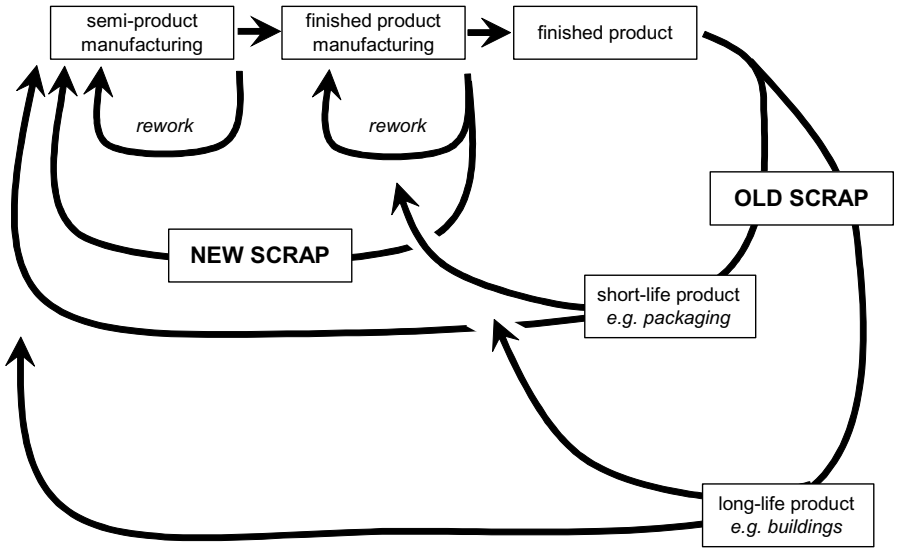
Recycling occurs through two routes:

- New or manufacturing scrap is generated during the production of finished goods. New scrap includes off cuts and swarf (turnings). It may be recycled within a factory, or returned to the refinery or smelter for reprocessing. New scrap has rapid cycle time (typically less than a year) and the amount of recycling is relatively price insensitive.

- Old scrap is generated from the recycling of finished goods at the end of their useful life. The cycle time for metal products is typically decades (e.g. materials in motor cars or buildings), but may be much shorter (e.g. packaging). The extent of recycling tends to be price sensitive. It is the potential for increased recycling of old scrap which offers the greatest sustainability benefits.

Scrap recycling networks vary …

Figure 21. Scrap metal flows



Source: Citigroup Investment Research

The level of recycling varies between metals due to:

- Intrinsic value – high value commodities can be recycled economically (e.g. aluminium cans are more frequently recycled than steel cans).
- Length of product lifecycle – copper wiring in buildings has a longer life cycle (40 years) than aluminium cans (a few months). Gold in the form of bullion or jewellery may have a life cycle of centuries.
- Collection difficulties – zinc in galvanized steel is only partially captured in furnace flue dust.
- Environmental issues – the toxicity of lead increases the frequency of used battery recycling.

… as do recycling rates

Figure 22. Recycling rates in metals (scrap as a % of total supply)

Aluminium *	64
Lead#	55
Steel	37
Nickel	37
Platinum	27
Gold	22
Copper	12
Zinc	7

Note: *31% excluding UBCs; # 66% in developed economies

Source: Citigroup Investment Research, WBME, ILZSG, INSG, CFMS IISI

Product life cycle

Extending product life cycles, and recycling, are the two main components of life cycle costing, which evaluates all the costs ("cradle-to-grave") of a product or installation.

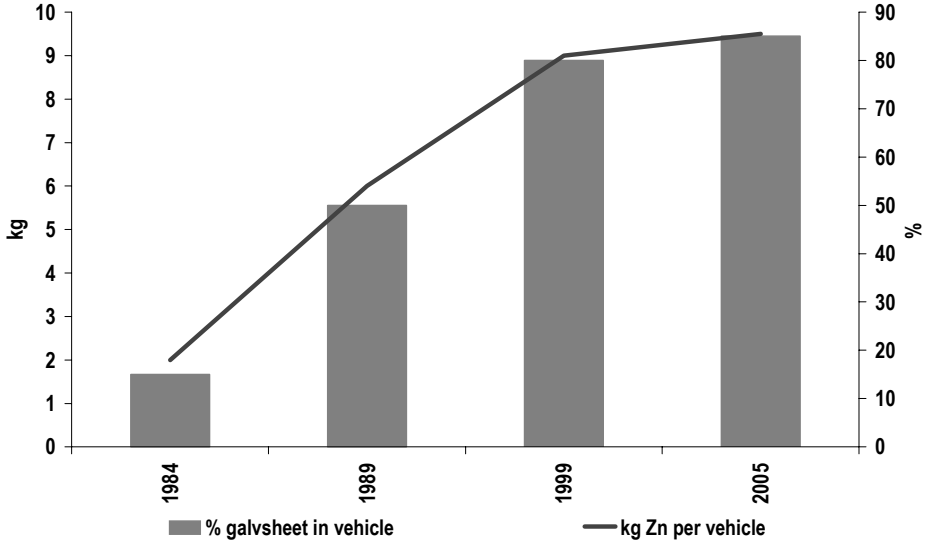
Metals which contribute to increased product life cycle include:

- Zinc in galvanized steel increases the life cycle of buildings and automobiles. Recently, galvanized reinforcing bar has been proposed as a means to combat concrete cancer in structures like buildings and bridges.
- Nickel in the form of stainless steel improves corrosion resistance. High nickel alloys offer greater corrosion resistance, but at greater expense.
- Titanium provides a yet higher level of corrosion resistance (and is also exceptionally light-weight), but at even greater cost than zinc or nickel.

Figure 23. Zinc consumption in auto bodies – USA

Growth in galvanized steel use & zinc demand, for corrosion resistance in vehicles, is flattening in developed economies

- but growth will remain strong in emerging markets



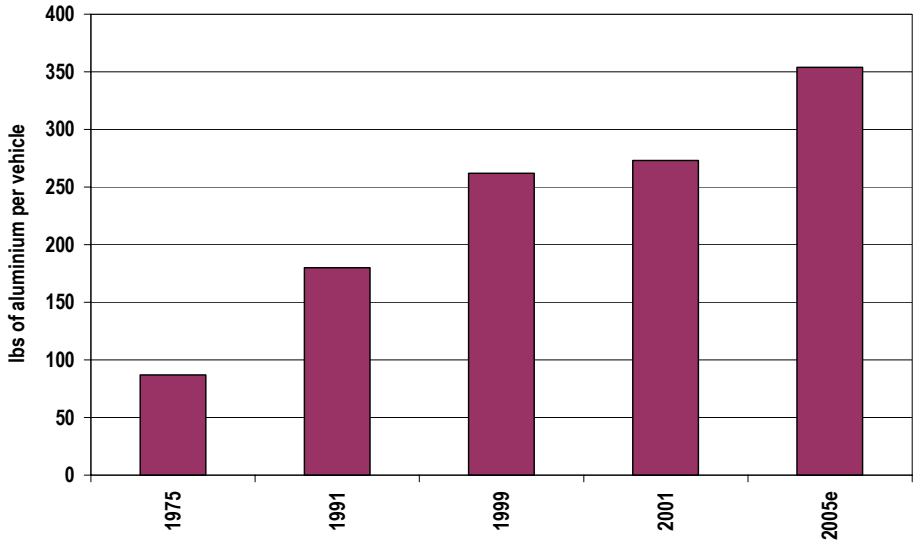
Source: International Lead Zinc Research Organisation

Light weighting

The increasing use of light weight metals in transport (principally aluminium, but also magnesium and titanium) is being driven by pressures to increase fuel economy and reduce emissions.

Figure 24. Aluminium Consumption in Automobiles (in USA)

Increasing use of aluminum in autos reduces fuel consumption and emissions



Source: Alcan

Atmospheric emissions

Restrictions and cost imposts on green house gas and other atmospheric emissions are now influencing demand and supply side of commodity markets. Here we discuss the impacts on demand for energy materials. Supply implications are discussed later.

Sulphur Dioxide

The EPA SO_2 trading programme, introduced in the USA in the early 1990s has dramatically altered the economics of coal fired electricity generation by boosting demand for and prices of low sulphur (compliance) coal.

Metals used in the construction of flue-gas desulphurisation systems (nickel alloys) have also benefitted.

Carbon Dioxide

The introduction of carbon trading in the EU and Australia is profoundly influencing economics of electricity generation from alternative sources. Developments are also occurring elsewhere which are likely to lead to CO_2 emissions restrictions.

In all 39 Kyoto protocol signatory countries ERU (emission reduction units) are generated which can be traded between countries.

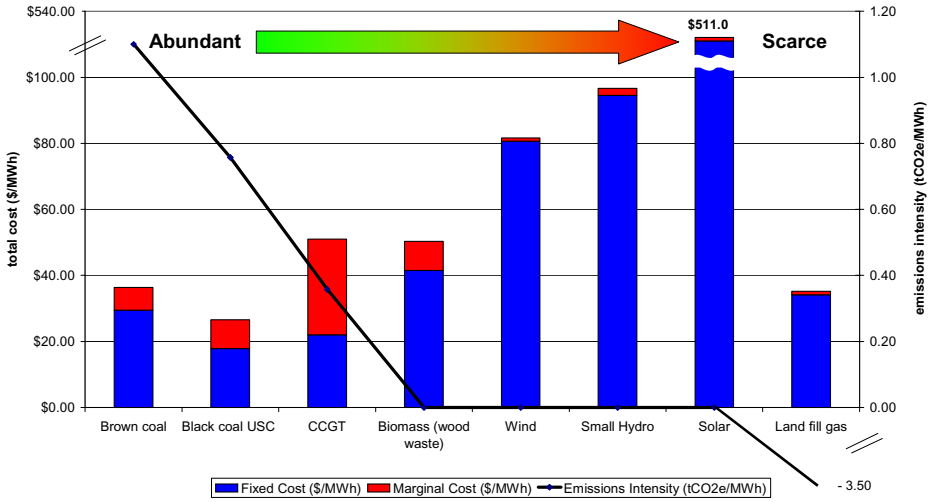
In China, India and Brazil, the CDM (clean development mechanism) generates Certified Emission Reduction permits.

In Japan, a voluntary emissions trading system will begin in April 2006, and a carbon tax of ¥2400/t CO_2 is proposed. The tax would be levied on energy generated by coal, gas and gasoline, and would have slightly different implications than an emissions trading system on the competitive position of alternative energy sources.

In the USA seven states in the north east are planning a CO_2 trading system to start in 2009.

In Canada, a national trading system is planned to begin in 2008.

Figure 25. Costs of electricity production & emissions – a comparison



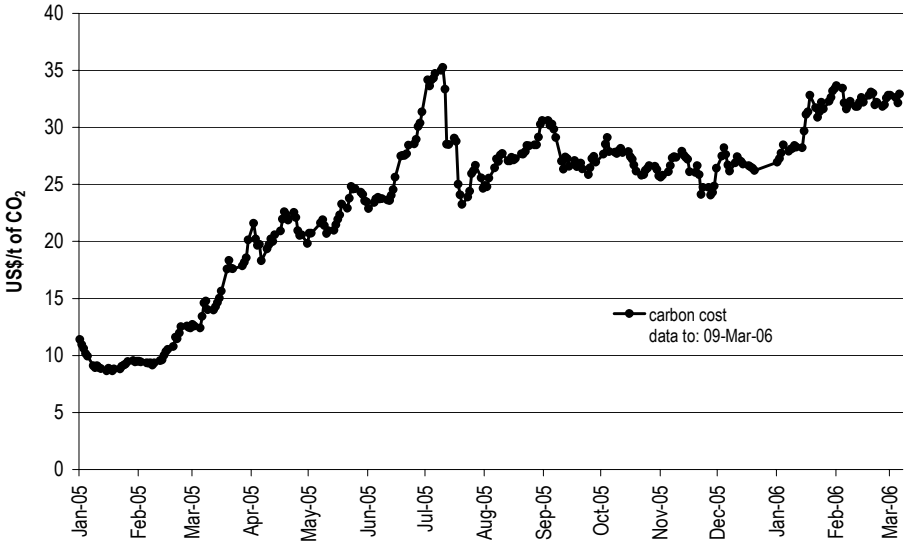
Source: Frontier Economics

Historically, costs relating to electricity production & emissions are inversely related – but carbon trading changes the merit order

Costs relating to electricity production and emissions have been typically inversely related. Emissions trading systems are designed to shift the traditional merit order, favouring low emission systems.

Coal-fired power stations generally emit more than twice as much CO_2 per MWe than do gas-fired stations. In Europe, cost of carbon credits (one credit equals one tonne of CO_2), has increased two and a half times since carbon trading began on 1 January 2005 (Figure 26).

Figure 26. Europe's cost of carbon



Source: Bloomberg, Citigroup Investment Research.

The new European carbon market

This has increased the cost of coal fired electricity generation by more than 200%, where carbon credits must be purchased, but only 50% for gas (Figure 27).

The cost of carbon credits has increased the cost of generating from coal vs. gas

Figure 27. Impacts of the cost of carbon on coal and gas energy costs

Category	Unit	Coal (US$54.3/t C&F ARA, Jan-06 average)	Gas (2005 average: US$25.2/MWh)	%diff, gas premia
Cost of energy	**US$/GJ**	**1.85**	**7.00**	**278%**
Cost of energy	US$/MWh	11.37	25.20	122%
CO_2 emissions	CO2 t/MWh	0.92	0.40	
Cost of carbon	US$/t CO2	34.00	34.00	
Cost of carbon	US$/MWh	31.28	13.60	
Cost of energy, incl. CO_2	US$/MWh	42.65	38.80	-9%
Cost incr. from CO_2	%	275%	54%	

Source: Citigroup Investment Research.

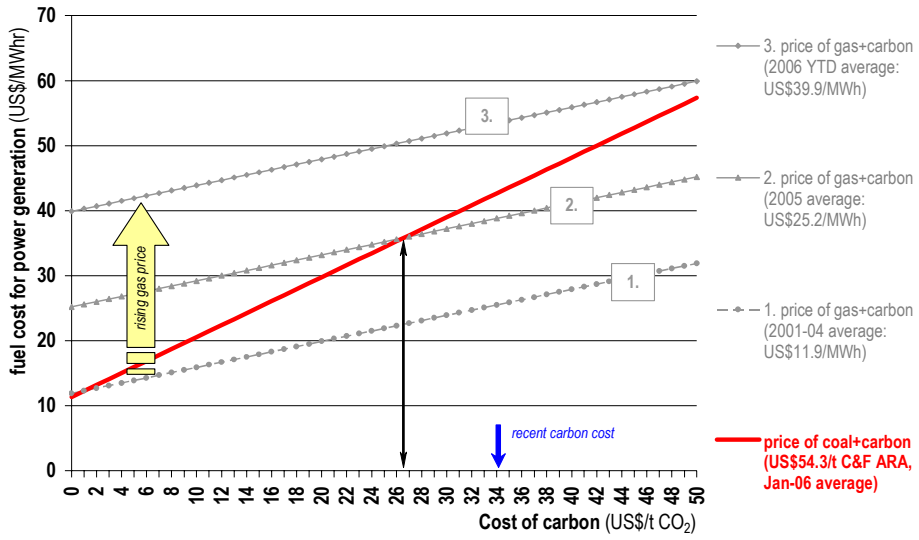
The competitive position of coal depends on the price of gas and the price of CO_2 (Figure 28).

Figure 28. Illustrating the impact of a rising cost of carbon

In Europe's power market, coal-fired electricity is not cost competitive if gas prices return to 2001-04 levels (US$12/MWh)

…but at 2005's much higher average gas price of US$25/MWh, coal is competitive for CO_2 costs of up to US$26/t

note:2005 equilibrium is at US$35/MWh



Source: Platt's ICR, Bloomberg, Citigroup Investment Research

The overall impact is reduced demand for coal, increased demand for gas, renewable energy sources, and nuclear power.

Clean coal technology

There are a number of new technologies which could provide relief to coal markets from these increasingly stringent environmental regulations.

Ultra super critical (USC) temperature boilers reduce CO_2 emissions from around 0.9t/MWh to 0.75; integrated coal gasification combined cycle (IGCC) boilers can reduce emissions by a further 20%. However, long term solutions are focusing on geosequestration or carbon dioxide capture and storage (CCS).

In a recent report by the United Nations Intergovernmental Panel on Climate Change, CCS costs are estimated at around US$50/t CO_2.

Typical CCS costs are around $50/t CO_2

Figure 29. Carbon dioxide capture and storage operating cost estimates

Coal power technology	CCS cost (US$/ tCO_2)
Conventional pulverized coal	30-70
IGCC	40-90
When combined with enhanced oil recovery	10-40

Source: United Nations Intergovernmental Panel on Climate Change

However, capital costs at the power station are 40%-60% higher, and fuel consumption is increased by 20%-40%.

In the long term it is projected that costs could decline by 20%-30%, and CCS could become economic at CO_2 prices of US$25-30/t CO_2.

Figure 30. A detailed breakdown of CCS cost estimates

CCS System Components	Cost Range	Remarks
Capture from coal or gas-fired power plant	15-75 US$/$tCO_2$ net captured	Net costs of captured CO_2 compared to the same plant without capture
Capture from hydrogen & ammonia production or gas processing	5-55 US$/$tCO_2$ net captured	Applies to hight-purity sources requiring simple drying & compression
Capture from other industrial sources	25-115 US$/$tCO_2$ net captured	Range reflects use of a number of different technologies & fuels
Transportation	1-8 US$/$tCO_2$ transported	Per 250 km pipeline or shipping for mass flow rates of 5 (high end) to 40 (low end) $MtCO_2$/yr
Geological storage*	0.5-8.0 US$/$tCO_2$ injected	Excluding potential revenues from EOR or ECBM
Geological storage: monitoring & verification	0.1-0.3 US$/$tCO_2$ injected	This covers pre-injection, injection and post-injection monitoring, and depends on the regulatory requirements.
Ocean Storage	5-30 US$/$tCO_2$ injected	Including offshore transportation of 100 - 500 km, excluding monitoring & verification
Mineral carbonation	50-100 US$/$tCO_2$ net mineralized	Range for the best case studied. Includes additional energy use for carbonation.

*over the long-term, there may be additional costs for remediation and liabilities.

Source: IPCC Special Report on Carbon dioxide capture and storage

Nuclear Power

Concerns over the implications of increasing green house gas emissions on the environment, as well as the increased cost of emissions, has rejuvenated interest in nuclear power.

Nuclear power is increasingly being seen as a sustainable alternative to other forms of power – coal and gas, as well as hydro and wind power. A UK study undertaken in 2000 (i.e. before carbon trading began) showed that nuclear power is 20% cheaper than coal fired and 36% cheaper than gas. When the cost of carbon is included, the differentials increase to 80% and 90% respectively. Onshore wind farm operating costs are some 20% cheaper than nuclear.

Plans for new reactors, especially in China, India and Japan, could add 85MW (23%) to nuclear generating capacity by 2105.

Figure 31. Nuclear power generating capacity & uranium demand

Growth Case

Country	Reactors under Construction		Reactors Planned		Reactors Proposed		Start-up Year										
	No.	MWe	No.	MWe	No.	MWe	2005e	2006e	2007e	2008e	2009e	2010e	2011e	2012e	2013e	2014e	2015e
Argentina			1	692						692							
Canada	1	515	2	1,030										*750*	*750*		
China	2	1,900	6	6,000	20	17,000	**950**	**950**		2,000	3,200	2,000	*2,000*	*2,000*	*2,000*	*2,000*	*2,000*
Finland			1	1,600							1,600						
France					1	1,600								1,600			
India	9	4,128			24	13,160		**490**	**1,799**	**1,107**		**470**	*1,000*	*1,500*	*2,000*	*2,100*	*2,100*
Iran	1	950	1	950	3	2,850		**950**									
Japan	3	3,294	13	14,682			**1,067**	**1,315**			**866**	2,760	1,375	2,768		1,385	*5,121*
North Korea	1	950	1	950								**950**					
South Korea	1	960	8	9,200			**950**			**950**	**1,900**	2,300	1,350			*1,350*	*1,350*
Pakistan			1	300								**300**					
Romania	1	655			3	1,995			**650**				*700*				
Russia	5	4,550	1	925	8	9,375				**950**		**2,650**	*2,175*	*2,450*	*1,250*	*950*	*2,450*
Slovakia					2	840											
Taiwan	2	2,600						**1,350**	**1,350**								
Ukraine			1	950									*950*	*950*	*950*		
USA	1	1,065							**1,065**					*750*	*750*	*1,500*	
World	**27**	**21,567**	**37**	**38,524**	**76**	**60,961**											
y-o-y change in MWe							2,967	5,055	4,864	5,699	7,566	11,430	9,550	12,768	7,700	9,285	13,021
Forecast total MWe							370,178	375,983	381,609	388,083	396,440	408,686	419,072	432,704	441,285	451,471	465,421
Estimated Uranium (t U) required							68,976	70,057	71,105	72,312	73,869	76,151	78,086	80,626	82,225	84,123	86,722

Source: World Nuclear Association, Citigroup Investment Research.

Pollution abatement

Increasingly stringent atmospheric pollution controls will necessitate the increased use of metals used in pollution abatement catalysts.

The most important application is the use of platinum and other PGMs in auto exhaust emission control catalysts. Prior to the introduction of emission standards and the use of PGM containing autocatalysts in the USA, cars emitted more then 100 grams per mile of hydro carbons, carbon monoxide, and oxides of nitrogen. Current legislation limits emissions to just over 2g/mile.

Exhaust emissions have declined from 100g/mile to 2g/mile

Figure 32. Auto exhaust emission standards in the USA (g/mile)

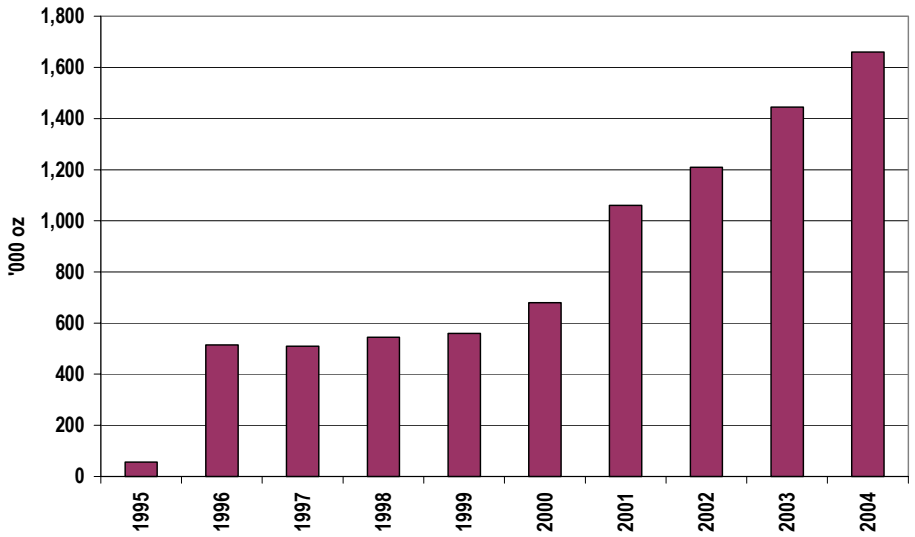
	HC	CO	NOx
Pre control	9	90	3.1
1975	1.5	15	3.1
1981	0.41	3.4	1
1993	0.25	3.4	0.4
1997	0.075	3.4	0.2
2003	0.04	1.7	0.5
2007	0.04	1.7	0.2

Source: Johnson Matthey

Autocatalysts, now account for more than half of global platinum demand.

Auto catalysts are now the largest source of demand for platinum

Figure 33. Platinum demand in auto catalysts



Source: Johnson Matthey

Platinum and palladium are also used in other pollution abatement systems such as emissions from slow combustion stoves.

Nickel is used as a catalyst and as a corrosion resistant alloy in pollution control systems.

Health & safety

Health and safety regulations have destroyed the market for certain metals (lead, mercury, chrome). We foresee nothing as severe for other major metals in the future.

However, the minor metal cadmium is under pressure – the EU has legislated for its removal from batteries after 2006. Batteries account for 70% of cadmium demand. The beneficiaries from the replacement of cadmium in batteries will be nickel metal hydride and lithium ion technologies.

Health and safety concerns exist for the use of other metals in certain applications: aluminium (Alzheimer's disease), nickel (dermatitis).

Conversely, long-standing health and safety concerns relating to the use of uranium in nuclear power generation are abating. The next generation of reactors are widely perceived to be safer than earlier ones.

Consumer awareness of sustainability – the industry's response

Consumer awareness of the environmental and social impacts is now influencing demand for goods and services. Until now, in the mining sector, public debate has focussed mainly on supply issues. However, some industries are now responding to new consumer expectations, although so far it is downstream industry participants who have been most pre-emptive.

- *Diamond industry*: certification of diamonds (the Kimberley process, sponsored by the UN) to prove that they are not from sources used to finance guerrilla warfare.
- *Gold industry*: collaboration between Tiffany & Co and Rio Tinto to ensure that gold is sourced from environmentally responsible suppliers.
- *Mineral sands industry*: DuPont has developed a practice with its suppliers that allow the promotion of its paint products as being derived from environmentally sustainable sources.
- *Energy industry*: consumers of some Australian utilities can elect to receive a portion of their power from renewable resources (at additional cost).

Changing materials technologies

New materials technologies will favour ceramics and composites over metals. Further, metals will continue to lose market share to plastics in automobiles, packaging and construction. However, plastics will have to more effectively address disposal and recycling challenges.

Battery technologies

Batteries are at present a minor source of demand for metals (except lead). However, if hybrid–electric vehicles were to become widespread, this could represent an important new source of demand for selected materials.

Batteries are a minor source of demand for the major metals

Figure 34. Metals used in batteries

	% of demand	battery technology
Lead	85	Lead acid
Zinc	2	zinc-carbon, alkaline, zinc air
Nickel	<5	nickel cadmium, nickel metal hydride
Cadmium	70	nickel cadmium
Lithium	2	lithium-ion
Cobalt	16	

Source: Citigroup Investment Research, ILZSG

Figure 35. Battery powered vehicles, battery technologies & metals consumption

But could increase in future

Battery technology	Consumption
lead acid(*)	>7kg/vehicle
nickel metal hydride	>10kg/vehicle
platinum fuel cell	10-15g/vehicle

(*) for SLI applications only

Source: Citigroup Investment Research

The most likely beneficiaries will be nickel and platinum. In addition, battery powered vehicles also consume more copper than conventional vehicles – around 20kg/car, five times more than in a conventionally powered vehicle.

Mining & processing

The supply side of commodity markets has received a higher profile and been subject to greater debate and political pressure than the demand side. There is no doubt that the challenges presented by sustainability are considerable.

Mining and concentration processes present degrees of sustainability challenge which vary with commodity.

Location of Reserves – country risk

Reserves and production of commodities are subject to differing degrees of country risk. Country risk takes the form of both investment risk and corruption risk (these issues are addressed elsewhere in the report).

Location of Reserves – ecosystems

A further sustainability challenge exists for proposed mining operations in particularly sensitive ecosystems such tropical rainforests, beaches, and arctic tundra. Certain commodities are more sensitive to these considerations:

- nickel mining in present (as opposed to ancient) lateritic zones,
- mineral sand mining on present (as opposed to fossil) beaches.

Itinerant (informal) versus formal mining

Itinerant mining tends to have more adverse environmental impacts, and features unsatisfactory health and safety standards when compared to corporate (formal) operations.

- Itinerant mining tends to be centred on high-value minerals – gold, diamonds and other precious stones and, occasionally base metals when market booms occur, such as tin in the late 1970-80s.
- In China, itinerant or informal mining is widespread.

Mining method – underground versus open pit

Whether mining is underground or open pit raises several conflicting environmental issues.

- Health and safety is typically worse underground.

Fatalities are lower in open pit mining

Figure 36. Fatalities in underground and open pit mining (fatalities per million hours worked)

	Underground	Open Pit	
Coal	0.24	0.10	USA
Coal	0.22	0.05	Australia
Coal	0.29	0.21	South Africa
Metals	0.35	0.15	USA
Metals	0.22	0.05	Australia
Metals	0.44	0.10	South Africa

Source: MMSD

- Land use is worse in open pit. Strip mining of coal in the eastern USA was a major catalyst behind the rise of environmental objections to mining.
- Open pit mining tends to result in increased waste rock production. Mining method is not the only cause of difference in metal: waste ratios and ore grade are further factors. But, for any given commodity, lower grade ores tend to be mined by open pit methods.

But waste rock production is greater

Figure 37. Waste produced per tonne of mineral

coal	1:1
copper	400:1
gold	4million:1

Source: Diamond 2005 (p463)

Tailings disposal

The methods of tailings disposal carry important environmental consequences.

- Tailings dams are a preferred form of disposal, but can be challenging in regions of high rainfall, seismically active or featuring steep geography.
- Tailings disposal into rivers destroys local fisheries. Deep ocean disposal is regarded as more environmentally acceptable.
- The scale of tailings disposal problems vary with production volume, and are therefore more onerous in copper and zinc mines than with nickel.

Rehabilitation

Rehabilitation of mine sites and tailings dams presents differing technical challenges depending on the nature of the ore and the associated mineral.

- Metal sulphide ore rock waste and tailings are more difficult to rehabilitate than coal mine waste.
- Acid drainage from sulphide ore mines was, along with strip mining of coal, were two of the earliest sources of environmental objection to mining.

Processing

Mineral processing (concentrating, smelting & hydrometallurgical processing) presents a number of environmental challenges which vary between metal: The key issues we have identified are: energy intensiveness and emissions.

Energy intensiveness

Metals smelting and refining are energy intensive processes. But aluminium smelting is more than 10 times more energy intensive than steel or other base metals.

Aluminum smelting is 10 times more energy intensive than other metals

Figure 38. Energy Consumption in Metals Smelting

Industry	Energy Consumption
	MBTU/t
Steel	14.3
Aluminium	120.1
Other Base Metals	10.2

Source: USA DOE, Citigroup Investment Research.

Atmospheric emissions

The most significant atmospheric smelter emissions are dust (perhaps containing toxic metals) sulphur dioxide and carbon dioxide.

The most problematic producers of this material are smelters of sulphide ores (copper, zinc, nickel) which produce around 1 tonne of SO_2 per tonne of metal (although much of this is captured in scrubbers).

Aluminium smelting generates 0.75t CO_2 per tonne of metal produced. Fluorine emissions are also an issue in some older smelters. Fluorine emissions are potent green house gases, some are thousands of times more potent than CO_2

Smelting producers greenhouse and other polluting gasses

Figure 39. Atmospheric emissions in smelting (emissions per tonne metal)

Aluminium	0.75t CO_2
Copper	1 t SO_2
Zinc	0.3 t SO_2
Nickel	1 t SO_2

Source: Citigroup Investment Research

Hydrometallurgical vs. Pyrometallurgical

Hydrometallurgical techniques do not have the same environmental challenges as smelting (emissions, slag disposal, energy intensiveness). But it does have its own critical shortcomings, including the difficult and costly management of various toxic chemicals (sulphuric acid, ammonia, cyanide, organic solvents).

The most important are:

- Copper – sulphuric acid from acid leach, and organic solvents from solvent extraction and electro winning.
- Nickel – ammonium from alkali leach.
- Gold – cyanide from leaching and mercury from artesianal mining and amalgamation of gold flakes.

Figure 40. Comparing processes for world metal production

Commodity	hydro	pyro
alumina	100%	0%
aluminium	0%	100%
copper	16%	84%
nickel	6%	94%
zinc	95%	5%
lead	95%	5%
gold	70%	30%

Source: Citigroup Investment Research

Combining demand & supply parameters

...a sustainability ranking

In an attempt to compare the impacts (positive & negative) of the sustainability issues discussed we have constructed a commodities league table.

The basis is the impacts of the major issues discussed above, each of which is assigned a weight; demand issues have been assigned an aggregate weight of 60%, supply issues 40%.

It is acknowledged that many of the issues are too complex to be adequately captured in such a ranking. For example, while all metals are amenable to

recycling, some have very high recycling rates because they are expensive (aluminium) or toxic (lead). Some sustainability issues have greater significance for some commodities than others (e.g. atmospheric pollution for coal).

Commodities which benefit most from sustainability pressures are:

- PGMs: demand from pollution abatement catalysts.
- Gold: long life cycle, high recyclability.
- Mineral sands: prolongs product life cycle, light weighting, low impacts from minerals processing.

The major losers are:

- Thermal coal: green house gas emissions, environmental impacts of mining.
- Lead: health and safety, emissions.

Figure 41. Sustainability ranking for commodities

	Weight	Commodity										
		Aluminium	Copper	Lead	Nickel	Zinc	Gold	PGMs	Coal	Iron Ore/Steel	Uranium	Mineral Sands
Demand factors	60%	2.3	1.8	1.9	2.5	2.2	2.6	2.7	1.3	1.8	2.0	2.2
recycling	15%	0.8	0.5	0.8	0.5	0.2	0.6	0.8	0.4	0.5	0.6	0.2
product life cycle	25%	1.0	0.8	0.8	1.3	1.3	1.3	1.0	0.6	0.8	0.6	1.3
light weighting	5%	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2
emissions (and abatement)	10%	0.1	0.3	0.1	0.4	0.4	0.3	0.5	0.1	0.3	0.5	0.4
technology advancements	2.5%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
health and safety	2.5%	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
Supply factors	40%	0.9	1.1	0.8	0.9	1.0	1.0	0.8	1.2	1.3	0.7	1.3
mining												
local environmental impacts	5%	0.2	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.1
rehabilitation	10%	0.2	0.2	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1
health and safety	5%	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.2
processing												
energy intensiveness	10%	0.1	0.4	0.4	0.2	0.2	0.4	0.2	0.4	0.4	0.1	0.4
atmospheric emissions	10%	0.2	0.3	0.1	0.3	0.3	0.3	0.2	0.3	0.3	0.2	0.5
Total	100%	**3.2**	**2.9**	**2.7**	**3.4**	**3.2**	**3.6**	**3.5**	**2.5**	**3.1**	**2.7**	**3.5**
Adjusted to score out of 30		**19.1**	**17.1**	**16.1**	**20.4**	**19.2**	**21.5**	**20.9**	**14.7**	**18.5**	**16.1**	**21.0**
Note												
Score out of 5, adjusted to out of 30												
High score indicates high sustainability rating												
Where criteria n/a assign		2.5										

Source: Citigroup Investment Research

Implications for long-term prices

Sustainability pressures may have implications for long-term prices, although we have not accounted for them at present. Demand for commodities such as platinum, aluminium and uranium is likely to increase in response to sustainability issues. Commodities where demand growth will be slower as a consequence of sustainability issues are lead and coal.

In the long-run, the price of commodities reflects the cost of their production which, in turn, will be affected by sustainability pressures such as rehabilitation costs, energy costs etc.

Additionally, and potentially of greatest importance in a more sustainable environment, the price should capture the full life-cycle costs, including recycling or disposal. This outcome will only occur once communities are willing to pay for such costs. Much additional work is required to quantify these issues.

Implications for the companies

In the following table we highlight each the percentage of earnings by commodity. In this analysis we have taken each companies expected earnings in 2008, to reflect the long-term balance of the companies portfolio and to exclude short-term cyclical distortions.

Figure 42. Company long-term earnings by commodity

	Aluminium	Copper	Lead	Nickel	Zinc	Gold	PGMs	Coal	Iron Ore/ Steel	Uranium	Mineral Sands
Anglo-American		11%	1%			19%	26%	23%	21%		
BHP Billiton	12%	16%		5%				10%	53%	3%	2%
Rio Tinto	10%	15%				2%		23%	39%	2%	8%
Alcoa	100%										
Alumina Limited	100%										
Lonmin							100%				
Impala Platinum							100%				
AngloGold Ashanti						100%					
Anglo Platinum							100%				
Xstrata		26%			12%			50%	12%		
Lihir Gold						100%					
Newcrest		10%				90%					
Vedanta	35%	18%			47%						
Norilsk Nickel				55%			45%				
Antofagasta		100%									
CVRD	5%	12%		4%					79%		
Kazakhmys		100%									

Source: Citigroup Investment Research.

By multiplying our commodity ranking by the companies earnings we are able to rank the companies out of a score or 30.

The results of our analysis highlight the potential positive impact for:

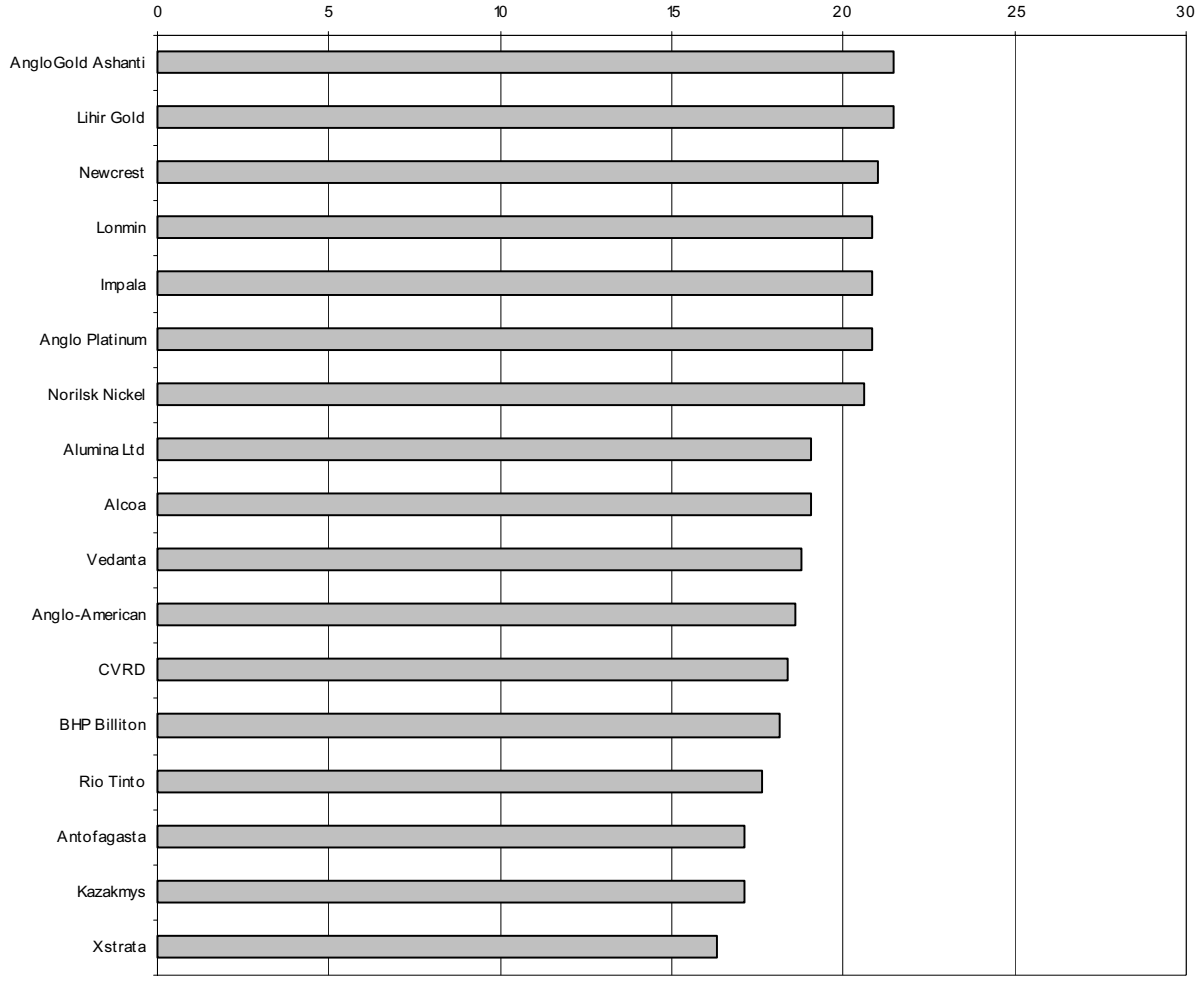
- The PGM producers (Norilsk and Lonmin)
- Gold producers (AngloGold Ashanti, Newcrest and Lihir)

Together with the negative impact for:

- The thermal coal producers (Xstrata).
- The pure copper producers (Antofagasta, Kazakhmys)

Interestingly, the large diversified miners of Anglo American, BHP Billiton, Rio Tinto and CVRD fare poorly on a commodity ranking.

Figure 43. Company ranking by commodity exposure



Source: Citigroup Investment Research.

Country exposure

- **The financial community has relied on bond markets as the key indicator of transparency and stability in assessing the risk rating on mining companies.**
- **In some developing countries, companies have been able to adopt weaker standards. However, all countries with a significant mining industry are moving towards more stringent regulatory frameworks.**
- **Instead of just relying on bond markets we have looked at insurance and corruption risk as more relevant indicator of risk for mining companies.**
- **On a ranking by company, it is the companies with a high proportion of their assets in Australia that are the leaders, namely Newcrest, Alumina Ltd and Rio Tinto. The laggards are Lihir, Kazakhmys and Norilsk.**

The consensus view is that mining is easiest in countries where the political systems are stable and transparent. In this respect, mining has been viewed in the same way as any other business or investment activity and the financial community has relied on bond markets to determine the risk-free rate in NPV analysis – the yardstick of mining analysts.

We, however, argue that metals and mining is more complex than this analysis suggests. Even where political systems are stable and transparent, such as the US, Canada and Australia, the development of mines is complex and challenging. Companies in these regions can be prevented from accessing land in environmentally sensitive and valuable areas, and are required to submit detailed environmental impact assessment and discharge applications.

Even once land has been acquired for mining purposes and the company has a viable ore body, project or expansion, this does not always guarantee that the project proceeds. Companies have to then negotiate with a host of stakeholder groups and can be subject to strikes and protesting. This is highlighted in a number of developments, for example;

- Inco's development of the Voisey Bay nickel project, in Canada
- Energy Resources of Australia development of the Jabiluka uranium mine in Australia.
- Alcoa's proposed expansion of the Wajerup alumina refinery in Australia

In some developing countries, companies have historically been able to adopt weaker standards due amongst other things to scarcity of enforcement resources or less stringent operating regulations. However, this can cause trouble for business competitiveness and damage company reputation; examples are already emerging of situations where mining companies operating in developing countries may lose

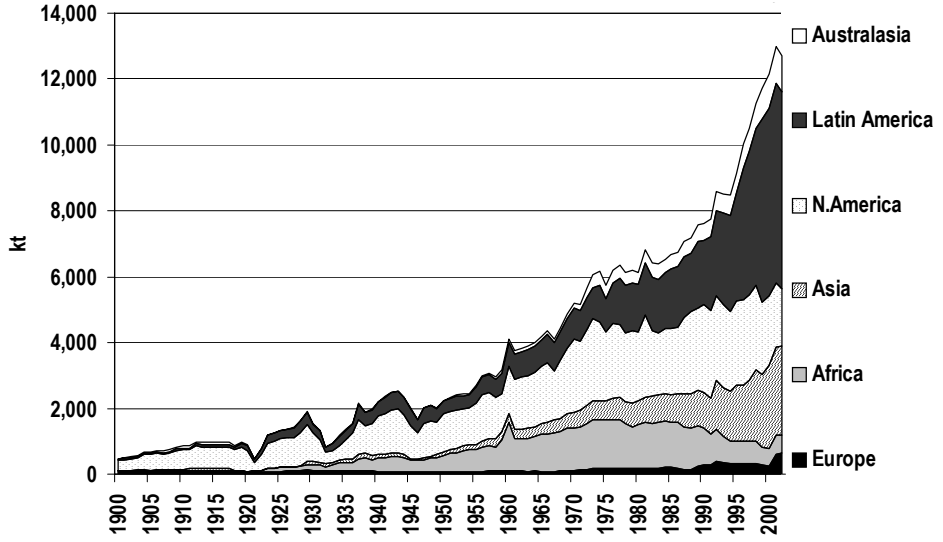
their operating license on account of the standards they apply. In general all countries with a significant mining industry are moving towards similar, stringent regulatory frameworks.

The type of environmental regulation varies depending on the location and type of mining operation. As the size and complexity of mining projects grow and increased competition for assets and consolidation drive companies towards developing projects in more politically-challenging countries, investors in the sector need to have a clear understanding of the levels of political and country risk that companies are running.

Access to reserves and potential to grow

One of the recent developments of the commodities boom is that countries are focussing more closely on their natural assets. For a long time countries were happy to provide tax breaks and other incentives allowing foreign miners into the region to spend capital, develop assets and deliver jobs. However with the lift in commodity prices and profitability of global mining companies, countries are looking at greater ways to prosper from the mining boom. Raising of royalties (South Africa, Chile and Peru), increased tax rates, nationalisation of assets (Russia, India) and selective selling of assets to domestic players (India/Russia) have all been measures used by governments to increase their cash inflow and participation in the commodities boom.

Figure 44. Copper mine production since 1900



Source: Metallstatistik; WBMS; Citigroup Investment Research.

Concurrently we are seeing a drying up of Greenfield asset development in developed mining regions (Australia, USA, Canada and South Africa) placing a greater importance of asset development in emerging markets. Inherently this will drive up the risk profile of major mining companies and may see a levelling of the rating gap between the miners

The increasing nationalisation of assets coupled with the lack of available projects in the 'developed mining world' would indicate that countries with operations in

regions that have a large proportion of the world's reserve base in a certain commodity have a greater likelihood of being able to tap those resources and grow. Countries such as Russia, Kazakhstan and India have a disproportionate amount of resources to production base indicating undeveloped assets and a greater ability to grow. Companies with exposure to these countries (Norilsk, Kazakhmys and Vedanta respectively) should have a greater ability to grow organically. Therefore whilst the mentioned companies get marked harshly for their higher level of political risk, the risk breeds higher levels of potential reward from production growth (note the growth in Vedanta's production and appreciation in the company's share price over the past 3 years).

Figure 45. Proportion of resources by region

	Bauxite/Alumina	Copper	Nickel	Zinc	Iron Ore	Coal
Australia	24%	5%	19%	17%	14%	8%
Nth America		9%	10%	27%	4%	23%
Brazil	8%		6%		22%	
Latam - Other	14%	48%	18%	9%	3%	
India	4%				3%	16%
EU	3%	5%	3%			
Kazakhstan	1%	2%		8%	4%	6%
Russia	1%	3%	6%		28%	9%
Africa	27%	4%	8%		2%	11%
China	7%	7%	5%	20%	8%	12%
Indonesia		4%	9%			

Source: Citigroup Investment Research and USGS

Figure 46. Proportion of production by region

	Alumina	Copper	Nickel	Zinc	Iron Ore*	Coal*
Australia	27%	8%	25%	12%	38%	25%
Nth America	11%	12%	14%	13%	3%	2%
Brazil	8%				35%	
Latam - Other	13%	47%	12%	19%		13%
India	5%				11%	
EU	10%	5%	2%	6%		
Kazakhstan	2%					
Russia	5%	14%	28%	34%		
Africa	1%	6%	6%	4%	4%	16%
China	11%	8%	12%	11%		16%
Indonesia						29%

* Seaborn trade

Source: Citigroup Investment Research and WBMS, CRU, UNCTAD, Barlow Junkers.

Bond market ranking

The following table ranks the credit ratings of countries by companies by S&P. We have then taken S&P credit rating and scored the country out of a score of 30.

Figure 47. Credit ratings by country

	Credit rating	Citigroup score out of 30
Australia	AAA	30
Papua New Guinea	B	10
Nth America	AAA	30
Brazil	BB-	13
Peru, Argentina	B+	11
Chile	A	22
India	BB+	15
EU	AAA	30
Russia/Kazakhstan	BBB-	17
South Africa, Namibia, Botswana	BBB+	19
Congo, Zambia	NR	6

Source: S&P

We have then multiplied a country risk rating by the % of a company's assets held in that country, as per the following table.

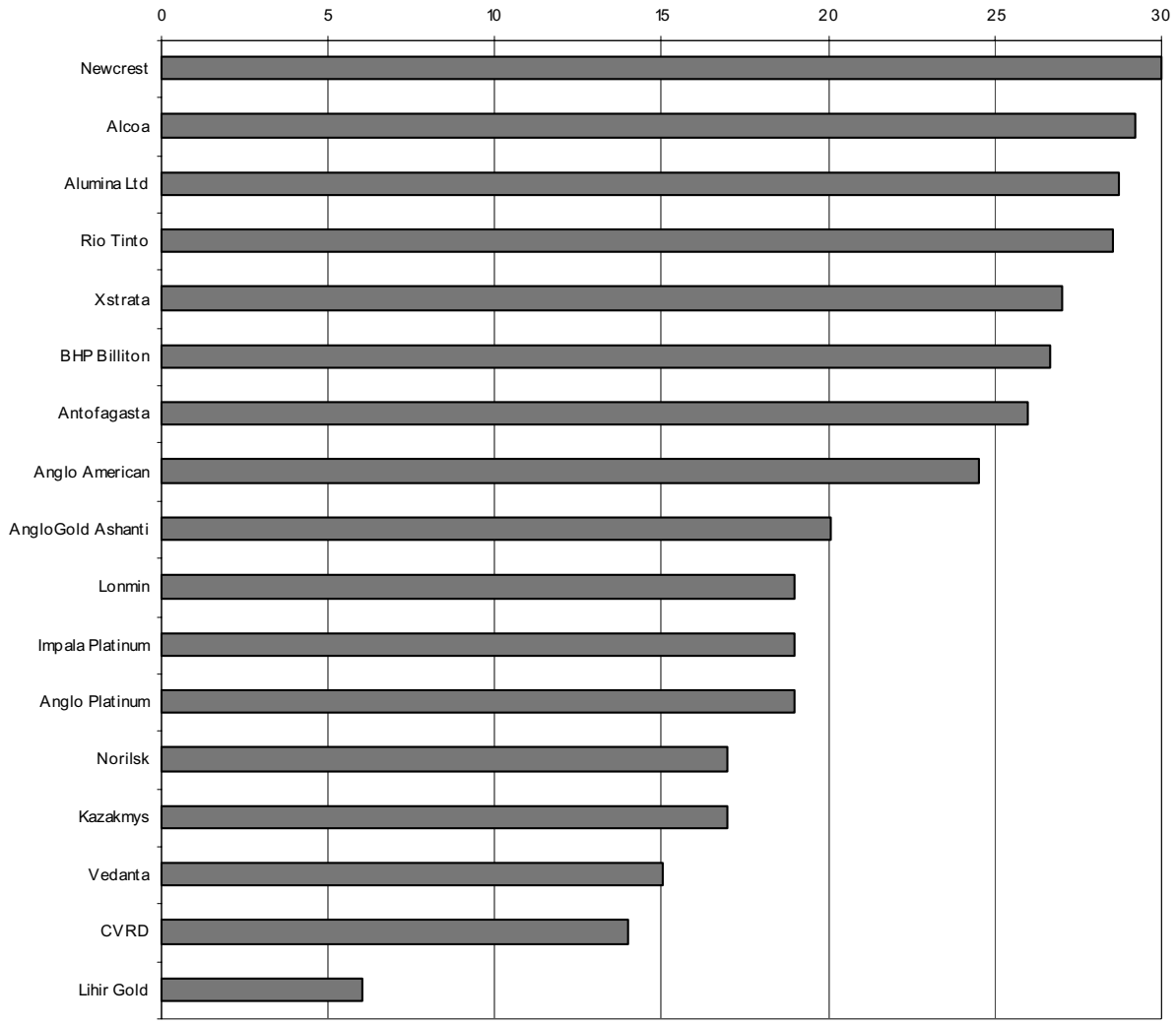
Figure 48. Companies commodity exposure by region

	Australia	PNG/ West Papua	North America	Brazil	Peru, Argentina	Chile	India	EU	Russia/ Kazakhstan	South Africa, Namibia, Botswana	Congo, Zambia Zimbabwe
Anglo American	6%		5%			11%		33%		46%	
Antofagasta						100%					
BHP Billiton	35%		6%	4%	2%	10%		26%		16%	
Lonmin										100%	
Rio Tinto	47%	2%	32%			8%	2%	5%		4%	
Xstrata	51%					12%		15%		23%	
Vedanta							90%				10%
Norilsk									100%		
Alcoa	25%		70%	5%							
Alumina Ltd	92%			8%							
Impala Platinum										80%	20%
AngloGold Ashanti			10%							90%	
Anglo Platinum										100%	
Lihir Gold		100%									
Newcrest	100%										
CVRD				100%							
Kazakhmys									100%		

Source: Citigroup Investment Research

On this bond rating analysis our ranking favours those companies that predominately have their assets in Australia or North America; namely Newcrest, Alcoa and Alumina Ltd. The laggards are those companies who have assets in PNG, India, Zambia and Brazil, namely Lihir, CVRD and Vedanta.

Figure 49. Ranking of companies based on bond markets by country exposure



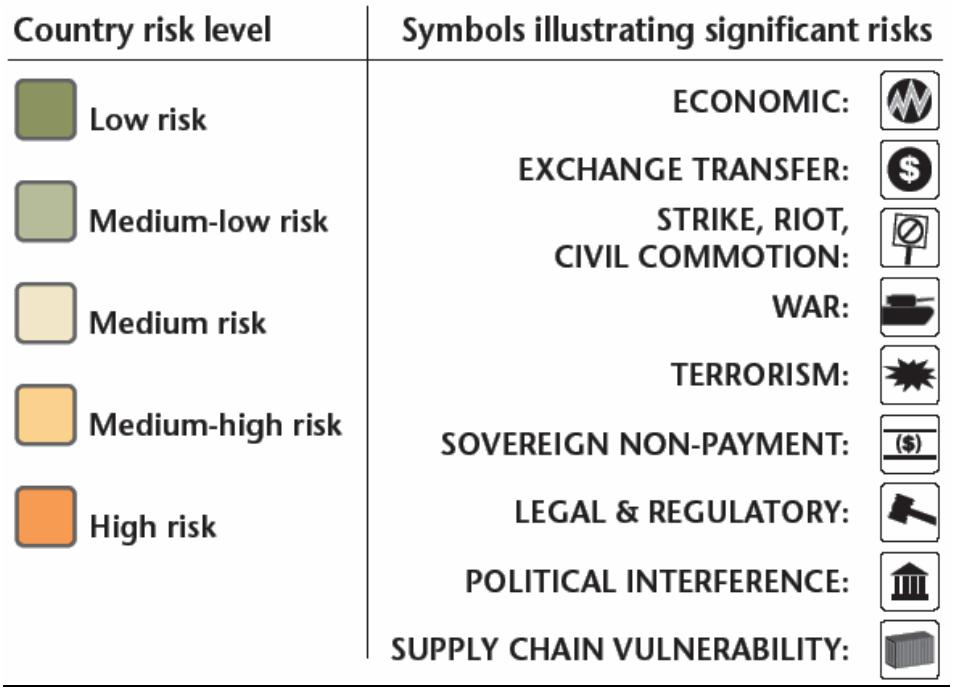
Source: Citigroup Investment Research

Political and economic risk

However, bond prices do not always tell the whole story – or more likely they are often driven by a range of different stories and therefore do not necessarily reflect those risks associated with a mining company.

Instead of relying on just the bond markets we have looked to the insurance market as a broad indicator of the political and economic risk that is more relevant for mining companies. Political risks arise from the actions or inaction of a foreign government and can result in the nationalisation of assets, political violence or embargoes. AON, the global insurance company ranks countries, from low risk to high risk based on significant risks.

Figure 50. Country risk level



Source: Oxford Analytica, AON

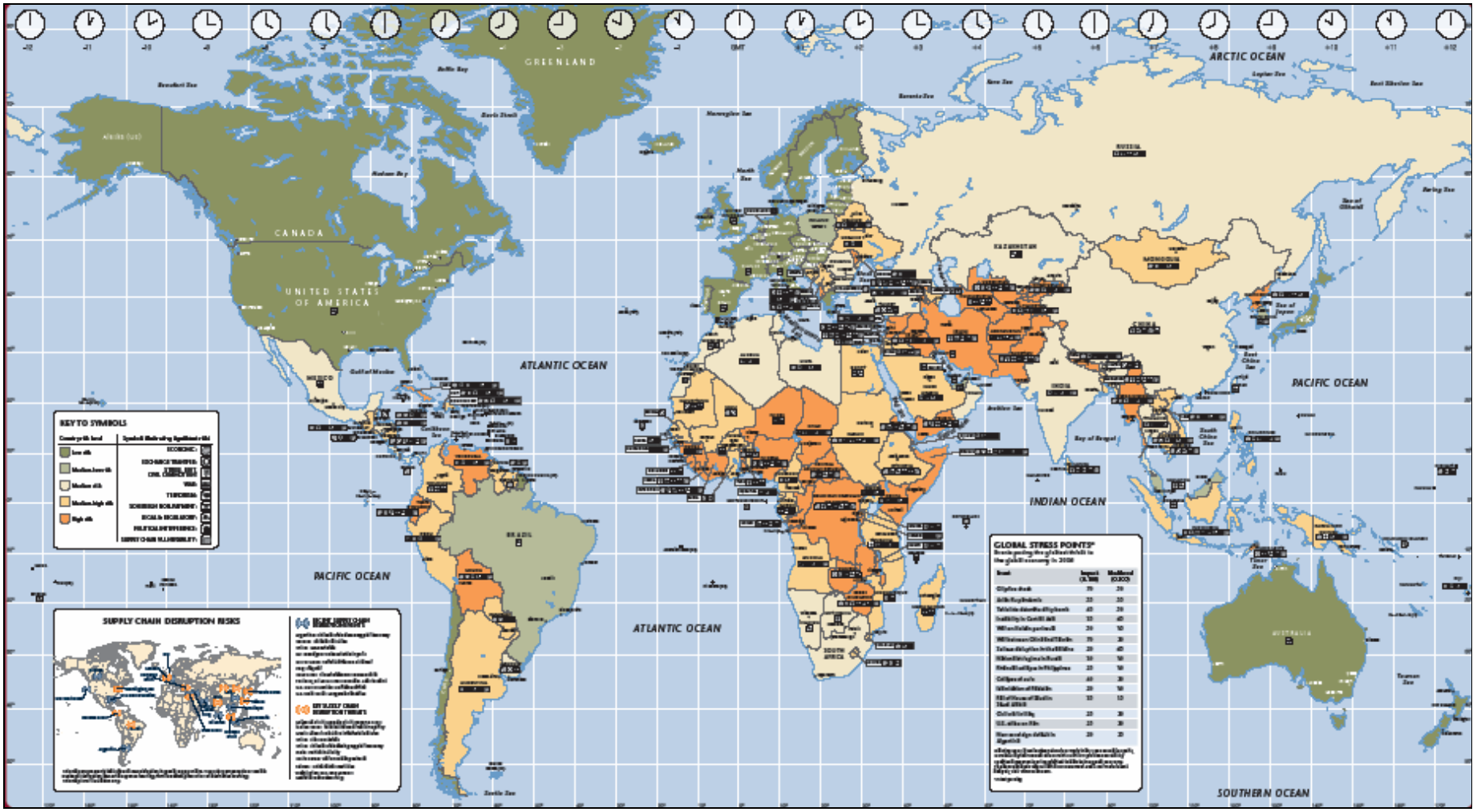
The following table ranks the risk ratings of countries by companies by AON. We have then taken AON risk rating and scored the country out of a score of 30

Figure 51. Country risk level

Country risk level	Country	Citigroup score
Low risk	Australia, Nth America, Chile	30
Medium-low	Brazil	24
Medium	South Africa, Namibia, Botswana, Russia, Kazakhstan	18
Medium-high	Mozambique, Angola, Papua New Guinea, Indonesia, Argentina, Peru	12
High	Zambia, Zimbabwe, Democratic Republic of Congo	6

Source: Oxford Analytica, AON, Citigroup Investment Research

Figure 52. Political and economic risk map



Source: Oxford Analytica

Perception of corruption index

To understand how a company's asset portfolio is exposed to potential corruption risk, we have cross-matched each company's portfolio with the 'Perception of Corruption Index' published by Transparency International.

Arguably this indicator excludes how a company manages the issue of corruption. There is a strong argument that companies with high governance standards can improve the environment within which they operate. We discuss this further in the forthcoming section on Mine Development.

In the table below, we have converted Transparency International's Perception of Corruption Index into a score out of 30

Figure 53. Corruption Index

	Corruption Index 2005, score out of ten	Citigroup score out of 30
Australia	8.8	26.4
Papua New Guinea	2.2	6.6
Nth America	8.0	24
Brazil	3.7	11.1
Peru, Argentina	3.2	9.45
Chile	7.3	21.9
India	2.9	8.7
EU	8.1	24.3
Russia	2.5	7.5
South Africa, Namibia, Botswana	4.9	14.7
Congo, Zambia	2.3	7

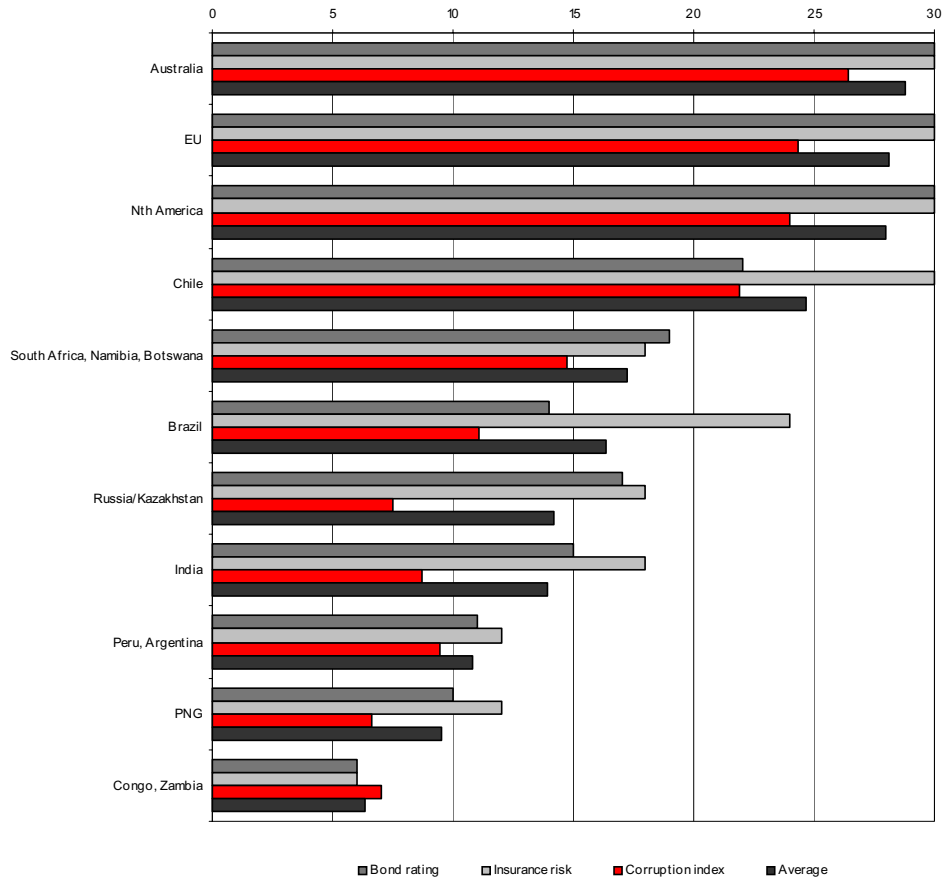
Source: Transparency International

Ranking of countries

The financial community has relied on bond markets as the key indicator of transparency and stability in assessing the risk rating on mining companies. The following table contrasts a country's bond rating against the country's Perception of Corruption index and Insurance risk rating.

On a risk rating the countries of Australia, the EU and North America are the clear leaders on all measures. On the downside, PNG, Congo and Zambia are the laggards. Interestingly the insurance market places a lower risk rating on Chile and Brazil than the bond markets. Additionally, the Perception of Corruption index places a higher risk rating on Russia, Kazakhstan and India than the bond markets.

Figure 54. Ranking of countries

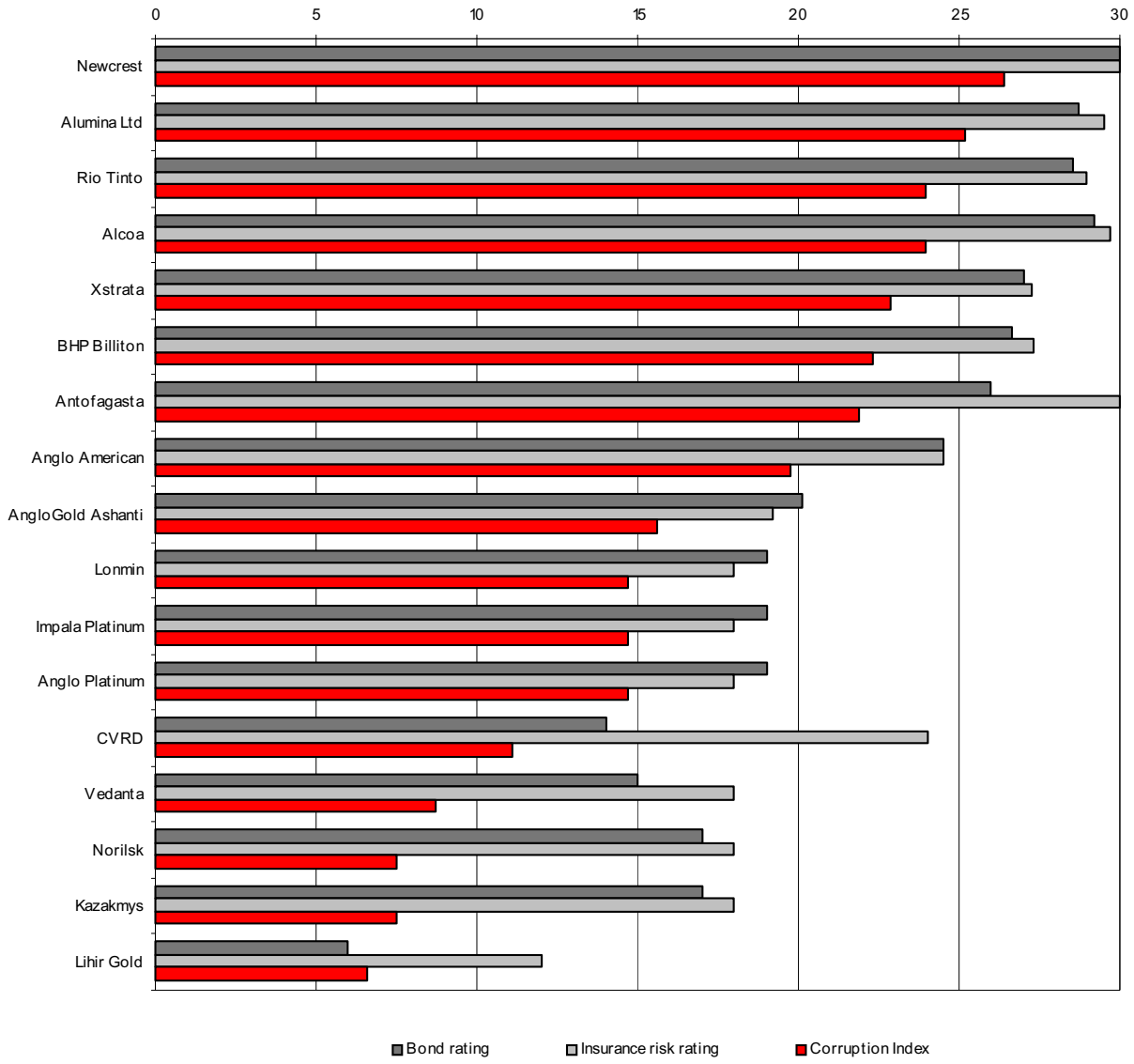


Source: Citigroup Investment Research.

Ranking of companies

On a ranking by company, it is the companies with a high proportion of their assets in Australia that are the leaders, namely Newcrest, Alumina Ltd and Rio Tinto. The laggards are Lihir, Kazakhmys and Norilsk.

Figure 55. Company ranking by country risk



Source: Citigroup Investment Research.

Mine development

- **Gaining mineral rights and ensuring access to land are key elements of the mine development process**
- **In addition to the technical, pricing and negotiation skills required, 'softer skills' around stakeholder consultation and environmental impact assessment can also be critical**
- **In this category, we rate Anglo-American as the top performer and note how the South African operators have the broadest understanding of their socio-economic impacts**

Sustainable development and mine development

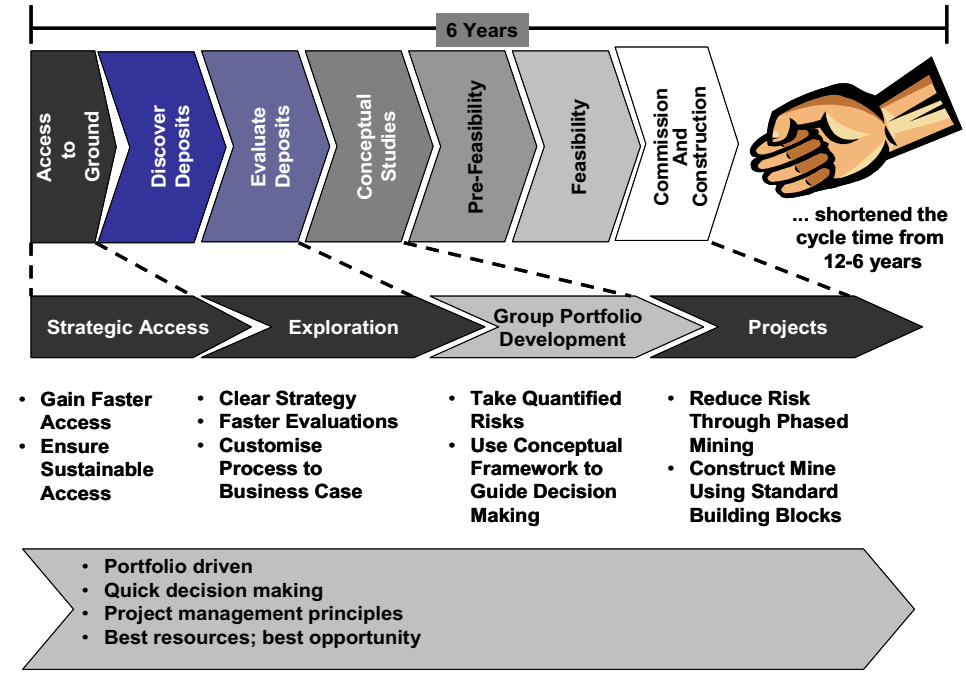
The project pipelines that secure mining companies' future growth prospects depend as much on the companies' ability to manage social and political risk as on their project management or technical expertise. These abilities are called on at a number of different stages in the project development process but all fundamentally contribute to mitigating against political risk and increasing the chances that projects are delivered on time and to budget.

- **Project selection**: At the earliest stages of considering a project, companies need robust procedures for understanding the governance systems of the host country and assessing what discount for political risk (if any) should be applied in considering the project's viability.
- **Tendering**: A track record for successful delivery of projects against complex social and environmental backgrounds can help a company in bids for future projects. It is interesting to note that two companies have recently highlighted that when bidding for access rights in China, while their technical and project management expertise was taken for granted, their ability to introduce best practice in areas such as HSE was of considerable interest.
- **Contracting**: While it is entirely in a company's interest to operate within a stable operating environment, their ability to influence the socio-economic stability of their host country is limited. They can, however, contribute to the development of a robust civil society by ensuring that information on royalty payments to host governments are published. Although this is clearly politically sensitive, a company's active participation in the Extractive Industries Transparency Initiative (particularly if it is an active participant in a pilot project) is a good indicator of companies' progress in this respect. Likewise, while the elimination of bribery and/or facilitation payments might impede a company in some initial contract negotiations, it will ensure that the company does not create a long-term liability for itself or for its employees (particularly now that UK and US law makes companies and individuals liable in their home countries for any corrupt practices undertaken overseas).

- **Capital raising**: The Equator Principles, which has been designed to guide international project finance banks in assessing sustainability risk, threatens to constrain bank involvement in a number of projects. This could constrain access to debt finance for projects that transgress against accepted global social and environmental norms, certainly for companies that do not have the capacity to manage the social and environmental complexities of such projects. Given that large companies typically do not need to revert to debt markets, this is likely to be of most relevance to smaller players.
- **Regulatory permission**: Further down the road, companies may require a range of specific national and local regulatory approvals (which will depend on robust environmental and social impact assessments and mitigation plans). Projects will also require the implicit approval of the local community who may be consulted as part of the regulatory process.
- **Closure**: While most projects will have clearly and contractually-defined environmental obligations on closure, obligations to leave functioning local economies and societies may not be specified. However, as discussed above, the ability to complete a mining project with reputation intact, will have implications for future involvement in the country concerned and in other similar projects. While closure provision has long been a condition of mining, there is an interesting question over whether ever-rising standards will force companies to make ever-higher provisions for closure costs or whether the ever-rising competence of companies in this respect (notably when companies plan ahead) will enable them to reduce provisions.

We argue that integrating these sustainable development issues in the company's capital allocation process can result in reducing lead times in mine developments. Both Rio Tinto and De Beers estimate that the normal lead times in mining development can be reduced from around 12 years to 6 years.

Figure 56. Reducing the lead times



Source: De Beers

Performance indicators for mine development

The mine development process not only tests companies' technical, valuation and negotiation skills but also a softer set of competencies ranging from commercially confidential tendering and contracting negotiations with government, through wider and more open discussions around regulatory clearance and on to the widespread community consultation that is needed to secure local community 'buy-in'. To measure such 'soft' competences we have selected the following somewhat more tangible indicators.

- **Stakeholder - government relations** – to gauge companies' ability to demonstrate to national governments how they deliver value beyond the payment of taxes and royalties
- **Stakeholder – local economic and community engagement** – to measure companies' level of engagement with local communities and to ascertain whether this goes beyond charitable giving, through stakeholder consultation and ultimately to economic development
- **Managing corruption** – to understand how companies minimise corruption within and outside the company (because, there is little point in shortening lead times through mechanisms which future scrutiny reveals to be corrupt and penalisable)
- **ESIAs (environmental and social impact assessments) and closure planning** – to gauge the quality of the process that mining companies use to assess and manage the environmental and social impacts of a mine throughout its life and beyond
- **Track record and reputation** – to understand whether past practices by the company has impacted reputation in a way which might constrain their future growth

Performance against these has been scored as below:

Figure 57. Stakeholder – government relations

Active strategy to enhance 'social capital'	5
Active and systematic measurement of indirect economic impacts (e.g. enterprise support, active support for supply chain etc.) BEE: Ahead	4
Full breakdown of direct economic contributions and reference to indirect contributions (e.g. training, education). BEE: In-line with targets	3
Reference to taxes / royalties paid, but no wider analysis of economic contribution. BEE: Lagging	2
All deals done on price alone - no consideration of wider economic benefits published	1

Source: Citigroup Investment Research

Figure 58. Stakeholder – local economic and community engagement

Sector leading and innovative	5
Pro-active, systematic and quantified engagement organised around an active communities policy (e.g. 1% of pre-tax profits to community activities) - with focus paid to local socio-economic development	4
Coherent community policy, details of stakeholder dialogue for specific projects - some ongoing community consultation	3
Coherent community policy - mainly related to charity / reference made to stakeholder consultation on a project basis	2
Some charitable contributions	1

Source: Citigroup Investment Research

Figure 59. Managing corruption

Sector leading and innovative	5
Internal: Actively monitored business ethics/corruption reporting procedure /External: Leadership of EITI process (via running pilot programme)	4
Internal: Policy, hotline but no reporting / External: Membership of EITI programme - but not a pilot	3
Internal: Business Ethics policy that forbids corruption / External: No involvement in EITI	2
No reference to corruption or policies to tackle it	1

Source: Citigroup Investment Research

Figure 60. ESIAs and closure planning

In addition to full ESIAs for developments, closure plans are pro-active and ensure socio-economic continuity (via community enterprise schemes), full environmental resitution (which will include full BAPs)	5
Full ESIAs (incorporating robust biodiversity criteria within land restitution) undertaken at outset; full closure plans incorporating environmental and social considerations	4
EIAs incorporate social considerations - some closure planning	3
Basic EIAs for project development phases only	2
No evidence of EIAs	1

Source: Citigroup Investment Research

Figure 61. Track record and reputation

The company's reputation is spotless	5
The company's reputation still suffers marginally from events in the past (even if they have been resolved to the satisfaction of direct stakeholders)	4
The company remains in dispute with some direct stakeholders over previous (but relatively minor) breaches of environmental or social norms	3
The company remains in dispute with some direct stakeholders over previous (major) breaches of environmental or social norms	2
The company has been found directly culpable for major breaches of environmental or human rights norms	1

Source: Citigroup Investment Research

Results

Against these indicators, the companies have scored as follows:

Figure 62. Results for mine development

Company Name	Stakeholder – government relations	Stakeholder – local economic and community engagement	Managing corruption	ESIAs and closure planning	Track record and reputation	Total out of 25	Weighting out of 20
ALCOA	2	4	2.5	2	2	12.5	10.0
Anglo Platinum	4	3	2.5	2	3	14.5	11.6
Anglo-American	5	5	3	2.5	3.5	19.0	15.2
AngloGold Ashanti	3	3	2.5	2.5	2	13.0	10.4
Antofagasta	1	2	1	2	3	9.0	7.2
BHP Billiton	3.5	4	3.5	3.5	3.5	18.0	14.4
Companhia Vale Do Rio Doce	1.5	1.5	1	1	3	8.0	6.4
Impala Platinum Holdings Ltd	5	3	3	3	3	17.0	13.6
Kazakmys	1	1	1	1	1	5.0	4.0
Lihir Gold	3	4	3	3	3	16.0	12.8
Lonmin	3	2	3	2	3	13.0	10.4
Newcrest Mining Limited	2	3	2	3	3	13.0	10.4
Norilsk Nickel	2	2.5	1.5	1	3	10.0	8.0
Rio Tinto	2	5	4	4	3	18.0	14.4
Vedanta	1	2	1	2	2	8.0	6.4
Xstrata	3	3	3	3	3	15.0	12.0

Source: Citigroup Investment Research

Conclusions

The global diversifieds stand out as the three leaders in this area with notable performance from:

- **Anglo-American** – whose Socio-Economic Assessment Toolbox (aimed at existing operations) is a structured way of ensuring that consultation with, and contributions towards, local communities are effectively delivered.
- **BHP Billiton** – where formal community relations plans are in place at 98% of operations and where 40% of operations have undertaken a Human Rights Self-Assessment.
- **Rio Tinto** – where all operations are required to have closure strategies (reviewed at least every five years) in accordance with a group-wide closure standard.

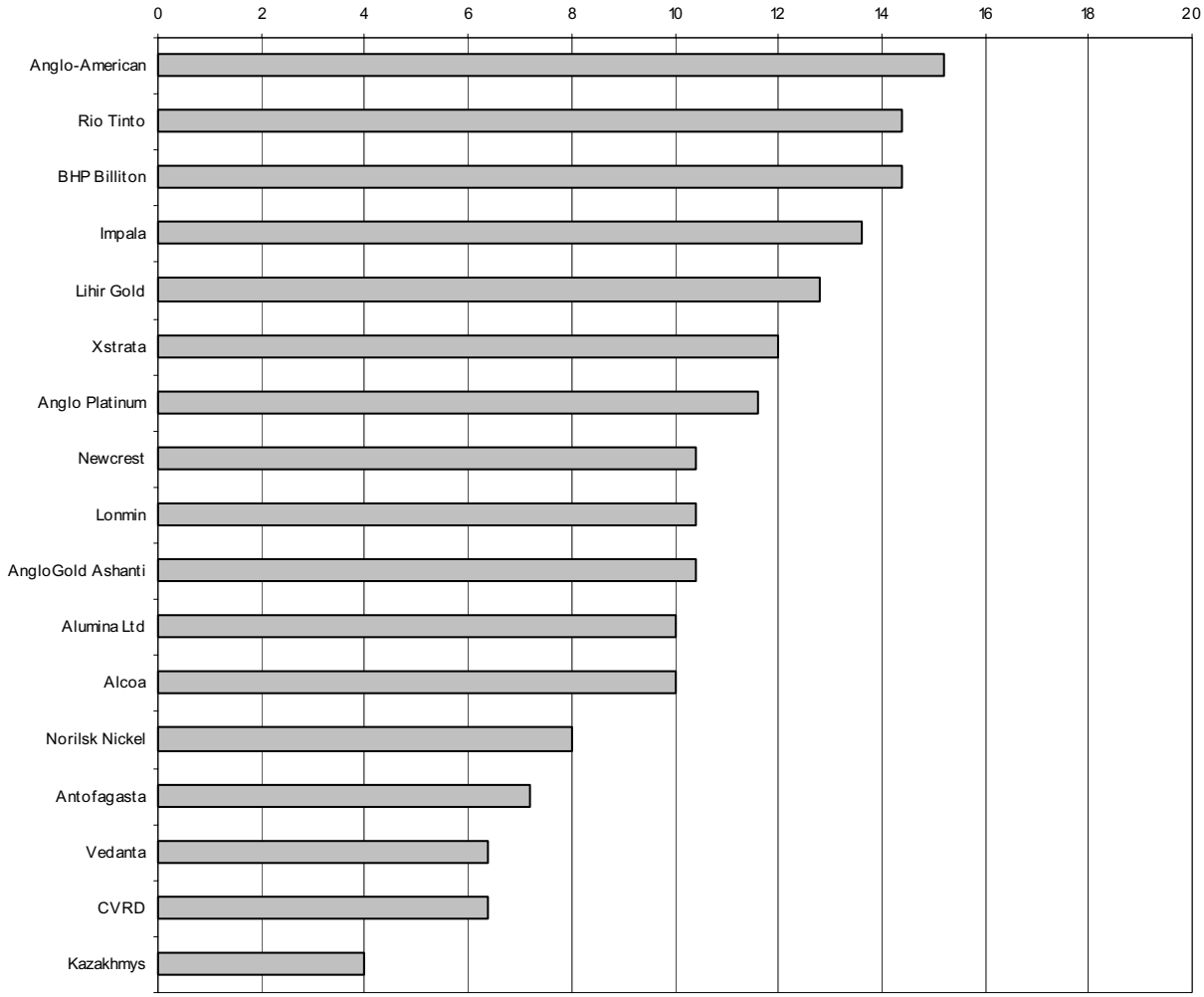
In this area, however, we also note that companies with operations in South Africa have the widest interpretation of their economic contributions – probably because the Black Economic Empowerment processes require them to think about their contribution to the whole value chain and all related participants. In this respect we highlight:

- **Lonmin** – who give a clear report of their direct and indirect economic impacts and the way that these affect different parts of the value chain.
- **Anglo-Platinum** – which details beneficiation opportunities in the downstream value chains of both jewellery and autocatalyts.
- **Impala Platinum** – which publishes a very visible breakdown of its response to the Mining Charter comprising FY'05 achievements, FY'06 targets and FY'09 targets.

In respect of the issue of managing corruption, we noted how most companies have an ethical code and how reporting 'hotlines' are now widely used. However, with some notable exceptions, the Extractive Industries Transparency Initiative does not appear to have received much support from the sector. In particular, we would highlight:

- **Rio Tinto**'s work with Transparency International to produce its 'Business Practices for Countering Bribery.

Figure 63. Company ranking by mine development risk



Source: Citigroup Investment Research

HSEE in operations

- **The wide range of sustainability issues that contribute to the overall operating efficiency of a mine can usefully be divided into cost management and risk reduction issues**
- **Cost management issues include levels of employee turnover and resource efficiency; risk reduction issues relate to any issues that could halt production and/or incur significant expenditure to maintain operations**
- **The issues covered in this section are typically immediate and investment in improvement initiatives should pay back quickly**
- **Accordingly, while we are disappointed that any company scores below 10/20 in our indicators, we expect to see rapid progress over the coming years**

HSEE stands for Health, Safety, Employment and Environment.

Sustainable development and operational efficiency

Operating an efficient mine requires companies to balance a wide range of social and environmental priorities including:

- Social: health and safety, training and development, workforce diversity, equal opportunities etc.
- Environmental: resource usage, pollutant/waste management, environmental management systems etc.

Below we explore how these various factors could affect the operating efficiency of a mine and select performance indicators for each.

Performance indicators

Health and Safety

Although standards have been improving for a number of years, companies are still incurring significant costs from accidents (from fines, compensation, downtime and increased insurance costs). Notably, in some cases, there are still disappointing levels of fatal accidents.

On the occupational health side, structured programmes will be needed to identify the impacts of noise, lung disease, vibration-related conditions etc. Identification can then lead to treatment/management of the condition and enable companies to contain potential future liabilities.

In this area we have also used a specific indicator on HIV/AIDS because of the impact of this disease on many workforces.

Figure 64. Safety

Zero fatalities	5
Very few fatalities, consistent improvement trend in CIFR, TRIF or LTIFR rates + moving towards focus on behavioural safety (e.g. behavioural. Audits)	4
Policy and objectives in place, performance measured and improvement trends visible (especially with regard to fatalities)	3
Policy and objectives in place - no improvement or deterioration trends visible	2
Not measured / reported	1

Source: Citigroup Investment Research

Figure 65. Occupational health – general systems

Sector leading and innovative	5
Pro-active screening and education process that incorporates widespread OHSAS1800 certification - comprehensive and pro-active programme for identifying and treating conditions	4
Pro-active attention to a wider range of conditions than are covered by legal responsibilities	3
Reactive to particular problems/issues that arise	2
Not mentioned	1

Source: Citigroup Investment Research

Figure 66. Occupational health – HIV/AIDS

Sector leading and innovative	5
Pro-active, measured programmes across all areas of employee development including improving diversity, training employees etc.	4
Active efforts to establish prevalence of HIV/AIDS among workforce	3
Consideration given to the matter - but little action taken	2
Not mentioned	1

Source: Citigroup Investment Research

Employee relations

The quality of employee relations (incorporating training, equal opportunities, diversity, union relations) feed into the operational efficiency of mines in a number of ways. A neglected workforce will ultimately express its dissatisfaction, often via unions, through wage negotiations and/or industrial action. By contrast a motivated workforce can improve productivity through constant attention to efficiency.

Finally, in special situations (such as S.Africa currently), the educational improvement and attainment of a workforce can smooth relationships with government and, again in this particular case, is critical for developing a new generation of management from within the HDSA pool.

Figure 67. Employee relations

Sector leading and innovative	5
Pro-active, measured programmes across all areas of employee development including improving diversity, training employees etc.	4
Active efforts to establish prevalence of HIV/AIDS among workforce	3
Consideration given to the matter - but little action taken	2
Not mentioned	1

Source: Citigroup Investment Research

Environmental indicators

Environmental management

Whilst not a perfect guide to the quality of environmental management, the existence of an ISO14001-certified environmental management system at a site is a useful proxy for investors as it indicates that processes are in place at the site to evaluate and address any environmental issues arising on a regular basis. The standard's in-built requirements for external audit and continuous improvement provide further comfort.

Figure 68. Environmental management

100% certification to ISO14001	5
>75% of major facilities certified with target date for full certification	4
Between 25% and 75% certified - with no target date for 100% certification	3
Some sites certified - no reference to rollout	2
Environmental management systems in place - but not certified	1

Source: Citigroup Investment Research

Pollution, waste control, incidents and liabilities

Clearly pollution and waste issues are the most visible environmental issues to affect the mining sector and are also the most likely to give rise to direct fines and liabilities.

Figure 69. Pollution, waste control, incidents and liabilities

Sector leading and innovative	5
All waste outputs actively managed and reduced (further reductions targeted), only minor incidents, no liabilities unaccounted for	4
Basic systems for waste reduction across the board / no significant liabilities outstanding	3
No significant incidents but work to do on other forms of waste and pollution control	2
Significant outstanding environmental liabilities or recent high level (Lvl4 or 5) incidents	1

Source: Citigroup Investment Research

Climate change

As energy intensive businesses, mines and smelters are affected by rising energy prices and, in Europe, by the rising cost of carbon. Accordingly, energy management remains a priority cost-control issue. Likewise the commodities that the company mines are likely to be affected by any changes in market conditions that aim to integrate climate change considerations into pricing. Although we have bundled all climate change related performance into this indicator, we recognise that these impacts may occur at a variety of stages from scoping the economics of a mine, through operations and on to end markets.

Figure 70. Climate change	
Sector leading and innovative	5
Researches and deploys innovative approaches such as sequestration - uses cost of carbon as a sensitivity on all projects at both operating cost and commodity level / Has identified impact of changing climate patterns on mining operations	4
Ongoing trend and forward-looking long-term energy consumption targets - absolute and relative	3
Energy use / GHG emissions monitored	2
Not measured / reported	1

Source: Citigroup Investment Research

Resource usage - water stress:

Most mining processes require significant and constant supplies of water to enable operations. In some cases, these are abstracted from finite groundwater sources; in other cases, there is a risk that companies will come into competition with a local population in water-stressed regions. On top of this, changing climatic patterns are likely to reduce the availability of water in some parts of the world. To mitigate against the risk of any increased costs in water supply, investors will be looking for companies that have undertaken comprehensive water availability audits at all of their sites.

Figure 71. Resource usage - water stress	
Water management plans specifically set in the context of climate change and/or water stress to local population	5
Water consumption measured, reductions targeted and water audits undertaken at all facilities - with reference to water needs of local population	4
Water consumption measured and, as-yet-incomplete plans to water audit	3
Minimal or no measurement of water consumption	2
Not mentioned	1

Source: Citigroup Investment Research

Results

Against these indicators, company scores were as follows:

Figure 72. Results for HSE and Operations

Company Name	Safety	Occupational Health	HIV/ AIDS	Employee Relations	Environmental management	Pollution & waste	Climate change	Water efficiency	Total out of 40	Weighting out of 20
ALCOA	3	3.5	2	3.5	5	3	3	3	26.0	13.0
Anglo Platinum	1.5	3.5	4	3	4	2	3	3	24.0	12.0
Anglo-American	3.5	4	4	4	4	3	4	3.5	30.0	15.0
AngloGold Ashanti	2	3.5	5	3	3	1	1.5	2.5	21.5	10.8
Antofagasta	2	2.5	1	3	2	1	1	2.5	15.0	7.5
BHP Billiton	4	3.5	3	2	5	3	4	3.5	28.0	14.0
Companhia Vale Do Rio Doce	2	1.5	1	2.5	3	1.5	1	2	14.5	7.3
Impala Platinum Holdings Ltd	3	3	4	4	3	2.5	2	3.5	25.0	12.5
Kazakmys	2	1	1	2	1	1	1	1	10.0	5.0
Lihir Gold	3.5	3	2.5	3	5	2	2	1	22.0	11.0
Lonmin	2	3	4.5	3	5	2	3	3	25.5	12.8
Newcrest Mining Limited	3	2	2	3.5	2.5	2	2	3	20.0	10.0
Norilsk Nickel	2	2	1	3	1	1	1	1.5	12.5	6.3
Rio Tinto	4	4	2.5	3	4	3	4	3.5	28.0	14.0
Vedanta	3	3	2.5	5	3	1	3	3.5	24.0	12.0
Xstrata	2.5	3	3	2	1	1.5	3	3.5	19.5	9.8

Source: Citigroup Investment Research

Conclusions

Again the global diversified players come out on top in this section largely on account of the breadth of issues they are actively managing. In particular indicator areas, we note:

Health and safety

In this area, there is a wide discrepancy between the leaders (low levels of LTIFR, continuing improvements and few fatalities) and the laggards (no reporting, high fatality rates and no improvement trend). Interestingly, this discrepancy crystallises most clearly in the different performance of **Anglo American** (four fatalities in 2004), **Anglo-Platinum** (24 fatalities in 2004) and **AngloGold Ashanti** (32 fatalities in 2004).

On Occupational Health, we have found it harder to distinguish between laggards and leaders (possibly due to a lack of clear reporting) and only **Rio Tinto** and **Anglo American** score '4's.

On HIV/AIDS, we note the considerable effort devoted to the issue by operators in S.Africa and note with disappointment the apparent lack of focus in India and Latin America. Although the scale of the issue in Africa is extreme and financially material for the companies, it would probably be wise for companies to extend their programmes beyond this known problem area. For pro-active engagement, we commend:

- **Anglo-Gold Ashanti**'s well-structured 5-part programme incorporating: education and training; voluntary counselling and testing (VCT); a wellness programme (including ART); ill-health retirement for employees who become AIDS-ill; and home-based and community-based programmes.
- **Lonmin**'s quantitative target for numbers of employees under treatment.

Employees

Although most scores clustered around '3' we highlight **Vedanta** on account of a recent site visit from which our analyst reported "a higher level of engagement by skilled and semi-skilled employees than anywhere else in the industry".

Environment

In the environmental dimension, we were surprised by the laggards. As pollution and waste control are such obvious and critical environmental issues, we were surprised by how little reporting there was in this area (and therefore how many companies scored '1').

With respect to water consumption, we were underwhelmed by the companies' responses, with the exception of the long-term targets of **BHP Billiton** and **Rio Tinto's** 'Water Position Statement'.

On climate change, again we were surprised (given that energy is a direct cost issue) that there was so little reporting from some companies. However, on the positive side we highlight the following innovations:

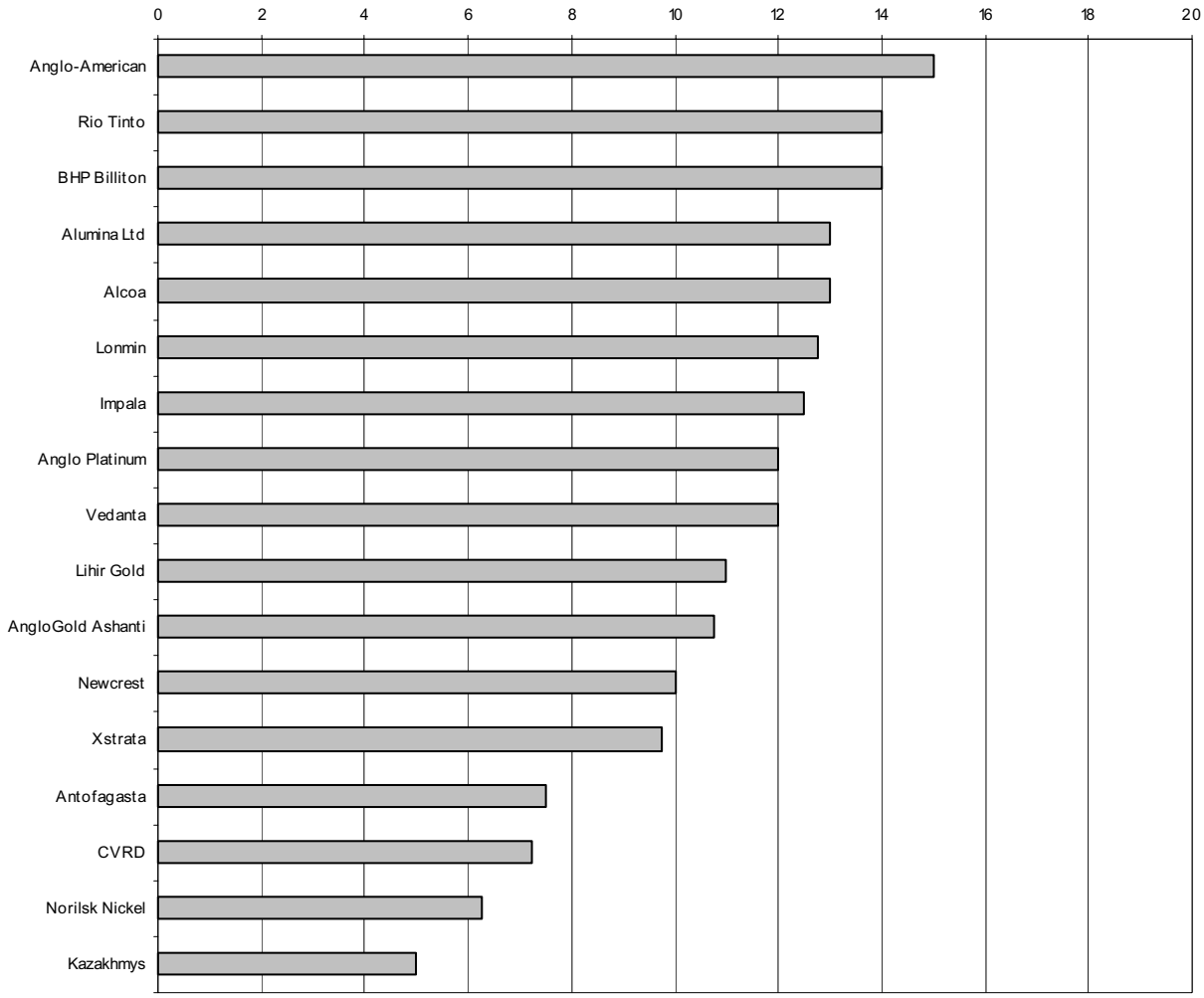
- **Anglo-American:** Long-term energy intensity reduction target and investments in projects (including a coal-to-liquids project with Monash Energy).
- **BHP Billiton:** Experimental purchasing of carbon permits (6 purchases to date) with ideas over how carbon permits could be stapled to coal sales – shadow price of CO_2 used for all carbon-intensive projects.
- **Lihir Gold:** Which intends to apply for certified emissions reductions (CERs) from its geothermal power station – these can then be sold into the European Union emissions trading scheme at the prevailing 'cost of carbon'.

Finally on this theme, we would draw attention to the subtle but important difference between the policy statements of coal miners:

- **Rio Tinto:** "Rio Tinto believes that emissions of greenhouse gases resulting from human activities are contributing to climate change. Avoiding human caused changes to the climate is an important international goal. In order to achieve this goal the world needs reductions in emissions of greenhouse gases" (Rio Tinto CSR Seminar April 2005).
- **Xstrata:** "…Given the increasing global demand for energy, and the current limited potential for fuel switching and renewables, coal will continue to be an important energy asset in the future. Xstrata recognises that coal is also a carbon liability and that climate change is a real international and community issue…" (See p45 of Xstrata Sustainability Report for full statement).

The issues covered in this section should be clearly visible to management, solutions should be actionable and investment in remediation measures should pay back quickly. Accordingly, while we are disappointed that any company scores below 10/20 in our indicators (of which there were 5), we expect to see rapid progress over the coming years.

Figure 73. Company ranking HSEE in operations



Source: Citigroup Investment Research

Sustainability governance

- **'Sustainability governance' ensures that good practice lessons from projects can be replicated around a company's portfolio**
- **We use Citigroup's 7-point 'sustainability governance' model – adapted somewhat for the mining sector…**
- **As might be expected, there is a good correlation between the companies that score well on 'sustainability governance' and those that score well on 'Mine Development' and 'HSEE in Operations'**
- **This reinforces our thesis that such centralised governance systems are actively of use in driving performance improvements at the sharp end of the mining business**

Sustainable development and governance

It is also important that companies make a convincing response to sustainable development at a corporate level – as it is the corporate response that ensures that lessons from projects can be learned and replicated to advantage in further projects. To determine the level of companies' sustainability governance, we use Citigroup's 7-point measure and, in each company look for:

…senior management commitment to,…

…and a strategic vision of, sustainable development that…

…is integrated into business processes via functioning management systems…

…that can identify and manage environmental and social risks…

…and promote potential 'sustainable opportunities'…

…in line with good financial disciplines…

…and that is reported transparently to investors

(For further details on these indicators and their have been selected see 'Crossing the River' 1 July 2005 Mike Tyrrell)

Sustainability governance and the mining sector

To calibrate these indicators and tailor them to the mining sector we have adopted the expected outputs as follows:

Figure 74. Measures of sustainability governance

Category	Sector leading	Good	Average	Poor	V. poor
Senior management commitment	Sector leading and innovative	Commitment by all layers of management with remuneration linked to safety performance	Commitment by all tiers of senior management	Board / CEO committed but no evidence of commitment by divisional heads / middle management	No evidence of senior management commitment
Strategic vision	Sector leading	Engagement with and leadership of thought leading organisations - (ICMM) or other business/sustainability orgs	Company is comfortable with the term 'sustainable development'; are members of ICMM (or similar orgs) but do not appear to be taking responsibility for driving forward projects	Company displays a broad understanding of HSE, employees and community - does not display a wider vision of sustainable development	v. basic policy statement or no statement on corporate responsibility
Functioning management systems	Sector leading and innovative	Full management information and reporting systems that stretch from site level to boardroom - chains of responsibility flow through main management line (e.g. MD of each site / business division is resp - rather than just HSE professional)	Internal reporting systems which involves hands-on activity by management – responsibility probably lies with HSE professionals	Sense that HSE report is compiled by HSE professionals only	Disconnected
Downside risk management	Sector leading and innovative	Engagement with thought leaders (ICMM) and potentially hostile interest groups (e.g. NGOs)	Widespread engagement on sustainability issues with supportive interest groups (e.g. industry associations)	Active engagement with industry associations	Limited (reluctant) engagement on sustainability issues
Innovation for growth	Sector leading and innovative	Full lifecycle assessments of product range and active involvement in innovations such as mine certification, Kimberley process, carbon capture / trading etc.	Takes the lead on a number of interesting projects / innovations but not widespread	Is involved (usually as secondary partner) in industry projects or initiatives	No information
Financial disciplines	Quantified financial data on strategic or business case	Specific understanding of a number of facets of the business case for sustainable development	Specific understanding of the business case for sustainable development	General understanding of the business case for of a number of aspects of sustainable development (e.g. sust dev is about the sustainability of our business / industry)	No reference
Transparency	Active attempts to engage 'mainstream' financial analysts in sustainability challenges	Annual sustainability report + annual presentation to SRI investors / corporate stakeholders	Annual sustainability report	Ad hoc sustainability reporting - or regular detailed chapter in annual report	No sustainability reporting beyond basic statement on website or in Annual Report

Source: Citigroup Investment Research

Results

Against these indicators, companies have performed as follows:

Figure 75. Sustainability governance - company performance

Company Name	Senior mgmt commitment	Strategic vision	M'gmt systems	Risk m'gmt	Innovation	Financial discipline	Transparency	Total out of 35	Weighting out of 20
ALCOA	3	5	3	4	3	3	3.5	24.5	14.0
Anglo Platinum	2	3	2	1	2	2	3	15.0	8.6
Anglo-American	4	4	4	4	4	3	4	27.0	15.4
AngloGold Ashanti	3	3	2.5	3	2	3	3	19.5	11.1
Antofagasta	1	1	1	2	1	1	2	9.0	5.1
BHP Billiton	4	4	4	5	5	4	4	30.0	17.1
Companhia Vale Do Rio Doce	1	1	2	2	1	1	1.5	9.5	5.4
Impala Platinum Holdings Ltd	2	2.5	2	3	1	2	3	15.5	8.9
Kazakmys	1	1	1	2	1	1	1	8.0	4.6
Lihir Gold	2	2	2	1	3	2	2	14.0	8.0
Lonmin	5	3	4	2	4	1	4	23.0	13.1
Newcrest Mining Limited	3	2	2	1.5	1	1	3	13.5	7.7
Norilsk Nickel	2	2	3	1.5	1	2	2.5	14.0	8.0
Rio Tinto	4	5	4	4	4	3	4	28.0	16.0
Vedanta	3	2	3	2	1	1	2	14.0	8.0
Xstrata	3	3	3	2	3	1	3.5	18.5	10.6

Source: Citigroup Investment Research

Conclusions

From these scores we conclude that the global diversified players tend to have more comprehensive and robust sustainability governance systems than their smaller counterparts. They are also more likely to be actively engaged in innovation to drive sustainability forward within the sector. In particular, we noted:

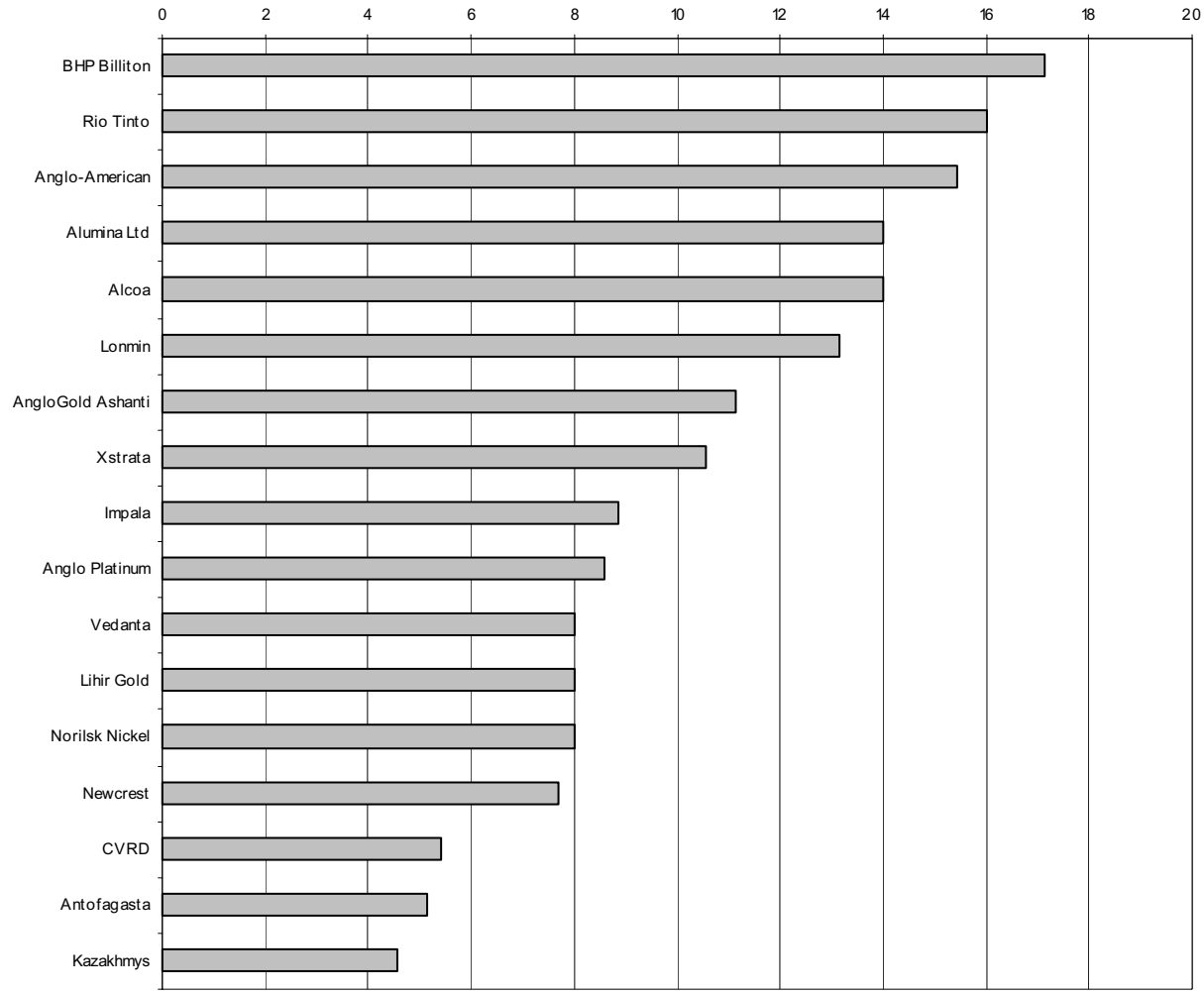
Alcoa/Alumina: Which scores a '5' for its long term '2020 Strategic Framework' and its full and active engagement with the ICMM. We were also impressed by the active, direct and ongoing communication between Alcoa's Public Issues Committee and a number of NGOs

Lonmin and Xstrata: Which have made considerable strides over recent years (in Xstrata's case since admission to the London Stock Market) particularly in respect of communication with investors

BHP Billiton: Which has completed lifecycle assessments for all of its major mineral products and is also actively engaged in pilot projects to develop miner certification processes

Rio Tinto: Which has lead the sector from the start in the development and adoption of industry standards including ICMM and the GRI (Global Reporting Initiative)

Figure 76. Sustainable Governance - company performance



Source: Citigroup Investment Research.

On the all important question of whether the company has identified a 'financial case for sustainable development', we recorded an interesting range of ideas

- Some companies do not address the issue at all
- To others, the argument is a basic cost argument as they have identified that HSEE improvements can save them resources and therefore money
- For companies that look further than the mine perimeters, the question is principally an issue of the sustainability of the industry and its attractiveness to the best graduates, to regulators and to the public at large
- The more advanced have started to think about how such value can be actively demonstrated both internally (to company management) and externally (to investors). However, there are few conclusions to show yet.

As we have suggested throughout this report, to demonstrate the investment value from sustainability companies will have to look beyond the potential productivity gains (from HSEE in Operations) and even beyond the full socio-economic analysis (of mine development and closure) to the investment decision-making

processes that incorporate country exposure and commodity exposure (as we have done in this report.)

To conclude therefore we bring all five indicators together in an evaluation of how sustainability, can create value for investors.

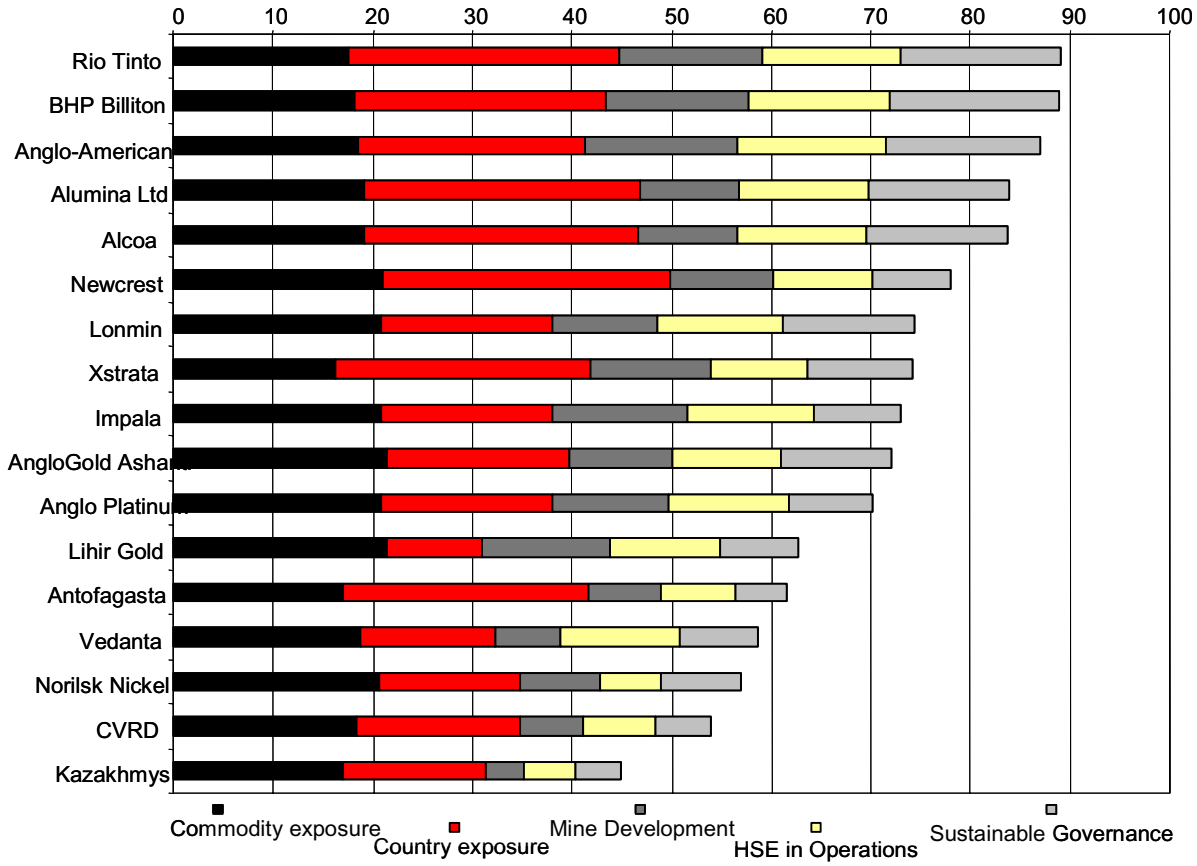
Citigroup Sustainable Mining Index

We have combined the five indicators to create the Citigroup Sustainable Mining Index (CSMI). Our mining index is based out of 120 and is split 50% between commodity and country exposure (i.e. 'what do you do') and 50% towards mine development, HSEE in Operations and sustainable governance (i.e. 'how do you do it').

We have weighted our 5 Sustainable Factors as follows;

- Commodity exposure out of 30
- Country exposure out of 30
- Mine development out of 20
- HSEE in operations out of 20
- Sustainability governance out of 20

Figure 77. Citigroup Sustainable Mining Index



Source: Citigroup Investment Research.

The results of our analysis suggest that on average the mining companies generally perform well on commodity exposure and country exposure. Where the mining sector is divided on Mine Development, HSEE in Operations and Sustainability Governance.

The major stands out in the sector are; BHP Billiton, Rio Tinto and Anglo American. The laggards are Kazakhmys, CVRD and Norilsk Nickel.

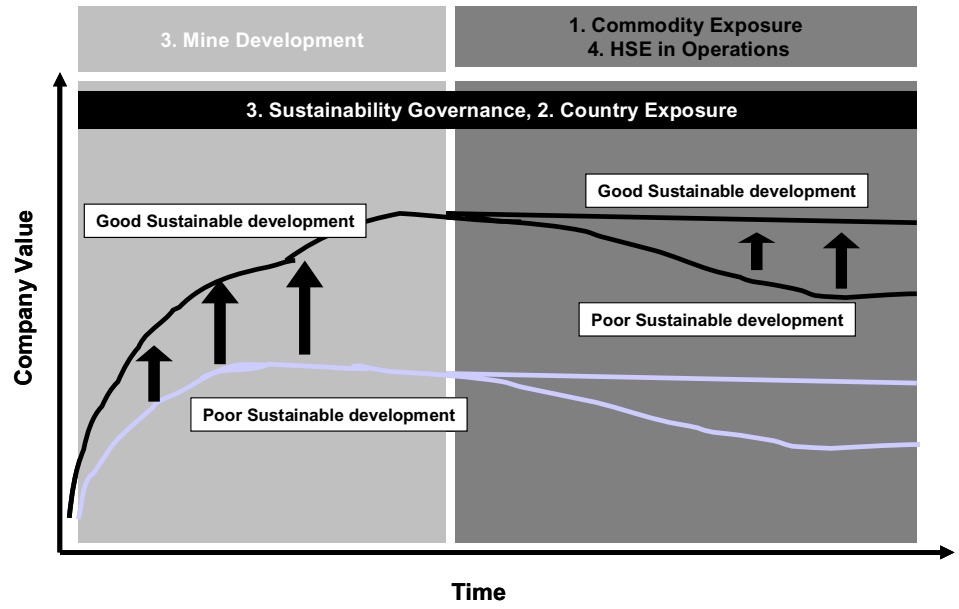
Creating value

- **Creating shareholder value within the context of the sustainable development agenda will require companies to balance their economic, environmental and social responsibilities, each of which can be broken down into specific areas of performance.**
- **Our analysis suggests that the largest upside to valuation could occur for the large diversified mining companies such as Anglo American, BHP Billiton and Rio Tinto. Valuation upside is in the range of 23% to 29%.**
- **Interestingly, the South African platinum producers such as Lonmin, Impala and Anglo Platinum could also see valuation upside based on commodity exposure and managing risks.**

The impact of sustainability issues

The cost of failing to meet the challenges of sustainable development will be high. The reputation of companies, projects (and indirectly financiers and owners) will be likely to suffer when environmental, social and ethical impacts, either actual or perceived, of mining and metals developments are not managed appropriately. As such, it is crucial that operational, risk management and decision-making procedures are introduced to identify, mitigate, manage and monitor environmental and social impacts effectively.

Figure 78. Valuation impact of sustainable development



Source: Citigroup Investment Research.

Unless a company can demonstrate high standards with respect to sustainable development, its position in the marketplace, its profitability and even its legal licence to operate may be compromised with corresponding impact on valuation.

Within a given project or site this can occur at the 'mineral rights and land access' stage, during project implementation or during mining operations. Beyond the individual project, companies need to be aware of the impact that sustainable development may have on commodity prices, of the impact of operating within politically-unstable environments and of the broad advantages that an overall sustainability governance system can bring.

In our opinion, non-financial sustainable development issues represent a material risk to companies and are likely to affect long-term shareholder value through; access to capital, access to land, company reputation, security of supply, royalties/taxes, relations with regulators, liabilities, access to markets, lead times, and costs. However, the critical question for mining analysts is one of financial impact.

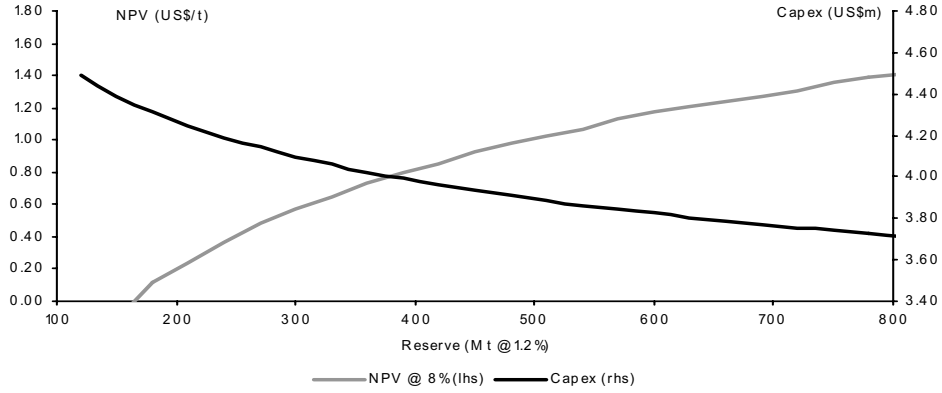
Financial analysis

We have created a 'generic' copper mine to determine what financial impact on mining valuations arises from various sustainable development criteria.

We have built our copper mine based on a number of data points from recent and proposed greenfield copper developments.

- The results of our analysis are represented in a graphical format in the following chart. This chart compares capex requirements and NPV valuations for given copper reserves. Our analysis highlights that for a copper development such as Spence or Las Bamabas at a reserve of 370Mt would imply an NPV of $0.76/t or around US$280m at a capex of around $1.4bn.
- In comparison a large-scale development such as Oyu Tolgoi or Olympic Dam, in the order of 700 to 800Mt of reserves would imply an NPV of between $1.31/t and $1.41/t or between US$0.9bn and US$1.1bn.

Figure 79. Greenfield Copper Development Capex and NPV per Reserve Tonne



Source: Citigroup Investment Research.

Our assumptions in building our generic model are detailed in the following table.

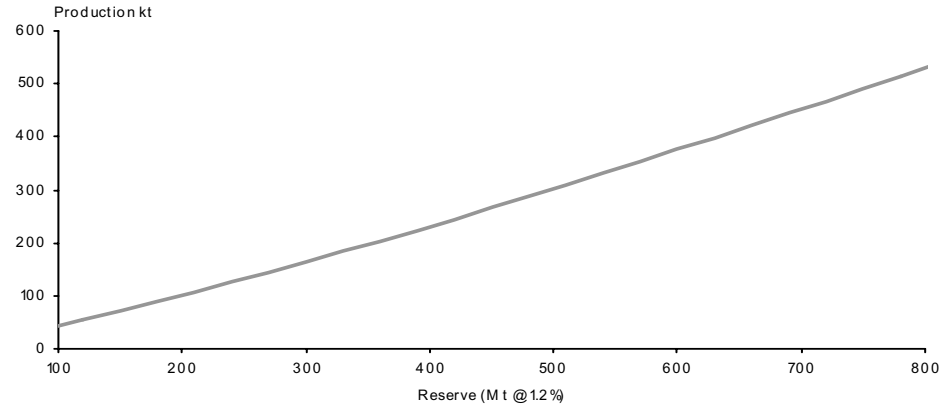
Figure 80. Assumptions – Greenfield Development

Discount rate	8%
Reserve Mt	370
WACC	8%
Gross development capex US$m	1485
capex/tonne	4.01
Resource grade %	1.20%
Long-term copper price c/lb	95.00
Cash costs inc by product c/lb	40.00

Source: Citigroup Investment Research analysis.

We have assumed that the overall production of the mine will be dependent on the reserve position. The following chart plots production against reserve position.

Figure 81. Production versus Reserve



Source: Citigroup Investment Research.

Financial impact

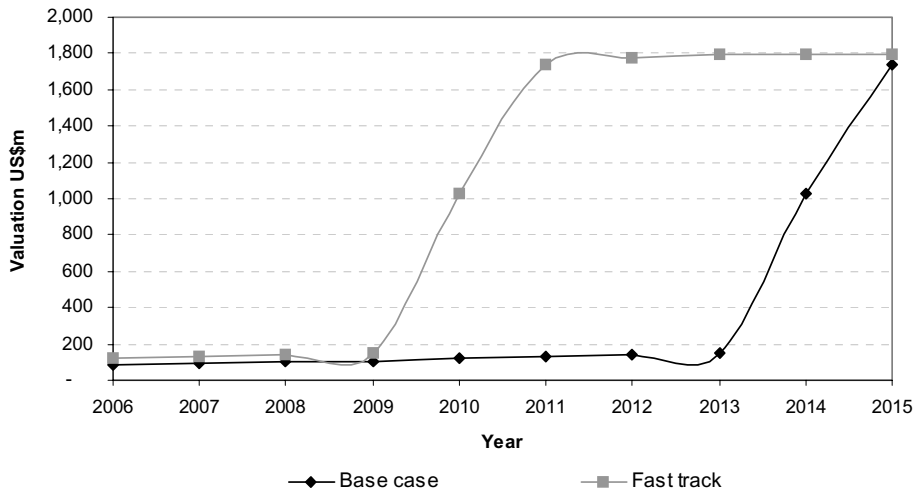
Our base case 'generic' copper mine can give a range of sensitivities to changes in input assumptions. In the following charts we present a number of different scenarios run for our key input assumptions, namely:

- Bringing forward capacity
- Discount rate
- Cash costs
- Changes to taxation payments

Bring forward of capacity

As discussed previously in the Mine Development section the ability to shorten lead times in the mining industry is a key driver to increased valuation. On our calculations shortening the lead time of a mining project would add around $6.8bn in bringing forward value for a mining company, as evidenced in the following chart.

Figure 82. Bring forward of capacity

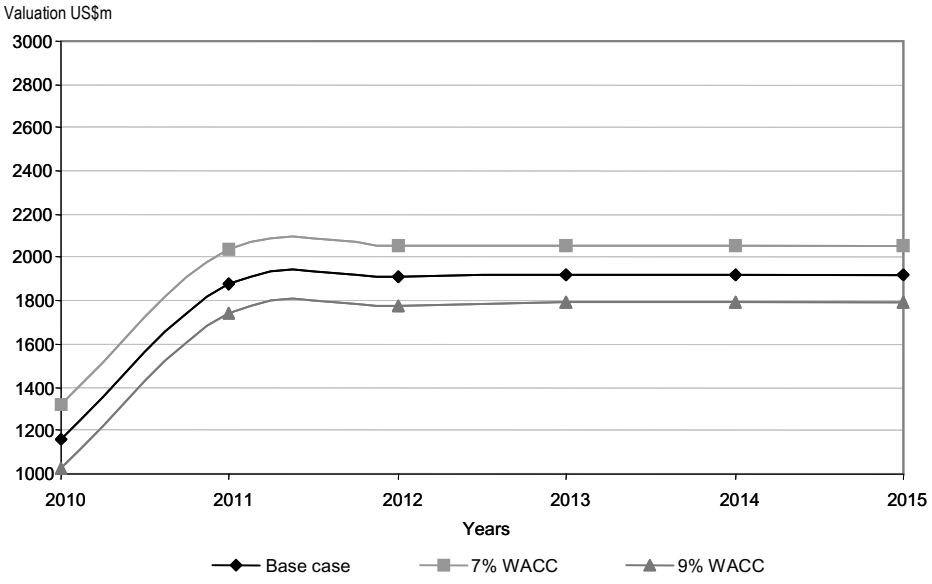


Source: Citigroup Investment Research

Discount rate

Under a fast track expansion and using a discount rate of 8% we calculate that our copper mine would generate a DCF valuation of around US$1.9bn by 2012. For every 1% change in the discount rate our valuation would change by $147m or by around 8%.

Figure 83. Discount Rate Sensitivity (+/- 1%)



Source: Citigroup Investment Research

Operating costs

In our generic model we have assumed an average operating cash cost, including by-product, of 40c/lb. This is in line with industry cash costs. The following tables show our expected cash costs for the major copper producers, including and excluding by-product credits.

Figure 84. Cash Cost (ex by-product) – US$/lb

Cash Cost (ex by-product)	2002a	2003a	2004a	2005e	2006e	2007e	2008e
Anglo	0.53	0.55	0.64	0.66	0.63	0.64	0.65
Antofagasta	0.46	0.48	0.60	0.75	0.61	0.53	0.52
BHP Billiton	0.00	0.45	0.53	0.64	0.51	0.59	0.54
Freeport	0.60	0.73	1.02	0.93	0.85	0.90	0.00
Groupo Mexico	0.00	0.46	0.21	0.20	0.97	0.87	1.01
KGHM	0.84	0.89	1.02	1.25	1.25	1.25	1.24
Phelps Dodge	0.69	0.68	0.67	0.60	0.63	0.66	0.80
Rio Tinto	0.48	0.50	0.58	0.55	0.57	0.59	0.60
Southern Peru	0.58	0.58	0.68	1.01	0.97	0.87	1.01
Xstrata	0.00	0.76	0.97	0.96	0.98	0.93	0.90
Average	0.42	0.61	0.69	0.75	0.80	0.78	0.72

Source: Datastream and Citigroup Investment Research analysis.

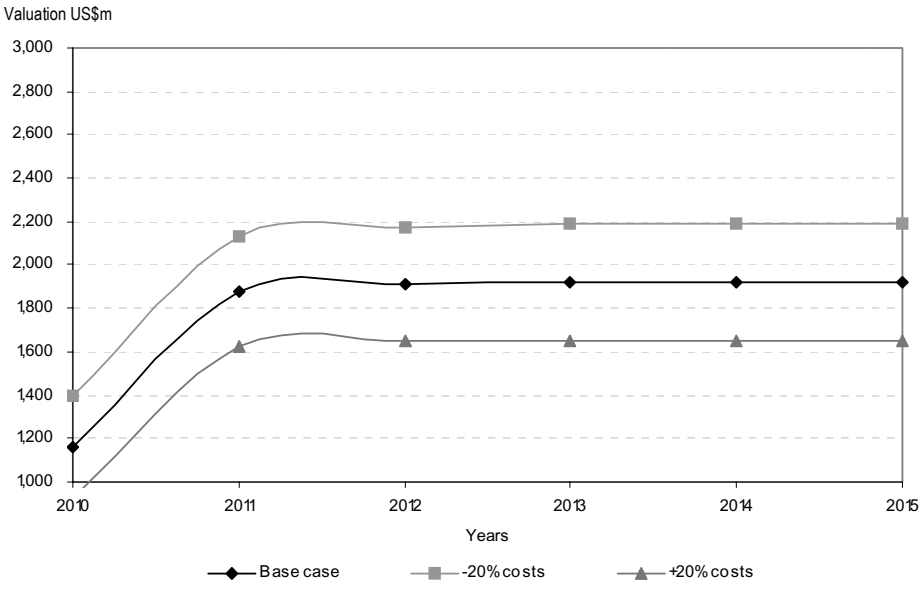
Figure 85. Cash Cost (incl. by-product) US$/lb

Cash Cost (in by-product)	2002a	2003a	2004a	2005e	2006e	2007e	2008e
Anglo	0.43	0.48	0.49	0.59	0.48	0.49	0.50
Antofagasta	0.39	0.36	0.24	0.07	0.09	0.25	0.43
BHP Billiton	0.46	0.43	0.47	0.53	0.42	0.43	0.40
Freeport	0.12	-0.02	0.40	0.07	0.02	0.07	0.00
Groupo Mexico	0.00	0.46	0.21	0.20	0.12	0.34	0.73
KGHM	0.65	0.65	0.73	0.93	0.92	0.91	0.95
Phelps Dodge	0.62	0.60	0.23	0.43	0.32	0.19	0.20
Rio Tinto	0.30	0.31	0.44	0.23	0.36	0.42	0.45
Southern Peru	0.46	0.40	0.05	-0.02	0.12	0.34	0.73
Xstrata	0.00	0.42	0.61	0.61	0.55	0.54	0.57
Average	0.34	0.41	0.39	0.37	0.34	0.40	0.50

Source: Datastream and Citigroup Investment Research.

For every -/+20% change in costs our valuation would change by $261m or by around 13%.

Figure 86. Cost Rate Sensitivity (-/+ 20% costs)

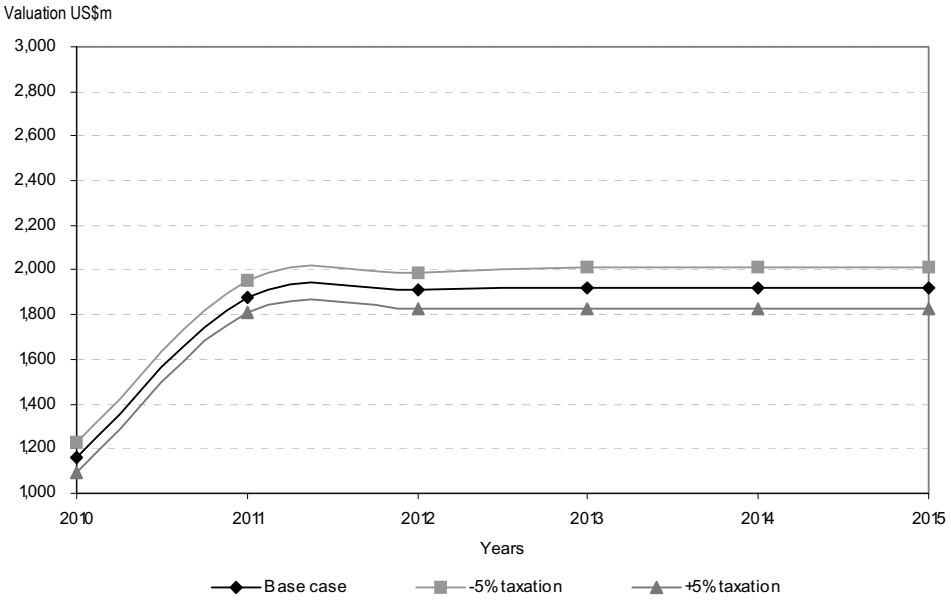


Source: Citigroup Investment Research

Operating costs

For every -/+5% change in the taxation rate would change our valuation by $80m or by around 5%.

Figure 87. Cost Rate Sensitivity (-/+ 5% change in taxation)



Source: Citigroup Investment Research

Valuation impacts

The financial community has relied on bond markets as the key indicator of risk, and valuations have been derived using a Net Present Value (NPV) technique, which discounts a company's cash flow based on the company's Weighted Average Cost of Capital. As a scenario analysis, we have used a risk adjusted discount rate based on our Citigroup Sustainability Mining index for our WACC calculations.

As an example, we have used our calculation of WACC for Anglo American. We derive a valuation (NPV) of £14.33 or US$25.08 per share for Anglo American based upon a WACC pf 10.3% nominal. Our WACC is derived using discount rates appropriate to the South African and non-South African business and based on these countries bond rates. We have assumed an equity risk premium of 6%, beta of 1.1 and a nominal risk-free rate of 5.23%. We model in US dollars and then convert to £/share using the current GBP/USD spot exchange rate.

Figure 88. Nominal WACC calculation

WACC	
CoE (post tax)	11.8%
CoD (pre tax)	7.2%
Gearing	22%
Eff. Tax	30%
WACC	10.34%
CAPM	
beta	1.10
rf -risk free rate (10yr)	5.23%
Equity Risk Premium	6.00%
CAPM discount rate	11.8%

Source: Citigroup Investment Research.

However, we have developed a risk adjusted discount rate based on sustainable development indicators. In this analysis we have used the US risk free rate of 4.5% and equity risk premium of 3.2%, thereby assuming that the mining companies can finance on the US interest rates, we have then applied a sustainable development risk premium over the risk free rate dependent on how the company ranked on our index. The calculation is broken down in the following table.

Figure 89. Risk adjusted discount rate based on sustainable development indicators

WACC	
CoE (post tax)	8.6%
CoD (pre tax)	6.5%
Gearing	22%
Eff. Tax	30%
WACC	7.7%
CAPM	
beta	1.10
rf -risk free rate (10yr)	4.5%
Equity Risk Premium	3.2%
Sustainable development risk premium	0.5%
CAPM discount rate	8.6%

Source: Citigroup Investment Research.

Running our risk adjusted discount rate through our financial models, as a scenario analysis raises some interesting results. Our analysis suggests that the largest upside to valuation could occur for the large diversified mining companies such as Anglo American, BHP Billiton and Rio Tinto, which suggest valuation upside in the range of 23% to 29%.

Interestingly, the South African Platinum producers such as Lonmin, Impala and Anglo Platinum also suggest valuation upside based on commodity exposure and managing risks.

Figure 90. Valuation impacts

Maximum	Current WACC	Risk adjusted discount rate	Current NPV	NPV on Risk	% Change
Rio Tinto	10.7%	7.5%	$36.70	$47.27	29%
BHP Billiton	10.7%	7.5%	$12.70	$16.34	29%
Anglo-American	10.3%	7.7%	$25.08	$30.86	23%
Alumina Ltd	10.7%	8.1%	A$7.20	A$8.89	23%
Alcoa	8.1%	8.1%	$35.00	$34.96	0%
Newcrest	8.1%	8.8%	A$5.40	A$4.94	-9%
Lonmin	9.8%	9.2%	£13.55	£14.33	6%
Xstrata	10.4%	9.2%	$23.72	$26.31	11%
AngloGold Ashanti	9.9%	9.4%	R144.00	R149.31	4%
Impala Platinum	13.0%	9.6%	R722.00	R945.52	31%
Anglo Platinum	13.5%	9.6%	R384.00	R517.80	35%
Lihir Gold	9.6%	10.5%	A$1.44	A$1.35	-6%
Antofagasta	10.9%	10.6%	$31.41	$32.23	3%
Vedanta	11.1%	10.9%	$12.10	$12.29	2%
Norilsk Nickel	11.1%	11.1%	$67.41	$67.26	0%
CVRD	10.9%	11.5%	$47.70	$45.20	-5%
Kazakhmys	12.7%	13.2%	$10.55	$10.74	-10%

Source: Citigroup Investment Research

Transparency & Access – the future

- **We have based our scores on published reports, so companies that don't report well don't score well**
- **However, many of these companies also have access to the resource-rich (but underproduced) resource bases of the world**
- **If these companies can embed sustainability improvements and disclosure as part of broad-based improvement in their communications to capital markets…**
- **…the sustainability valuation upside that we have highlighted to the global majors may also be accorded to the emerging players**

Transparency is key

Considering the final indicator of our 'sustainability governance' with 'Transparency" and comparing this to companies overall scores for management, we see that there is a strong correlation between companies that don't report and companies that score poorly in our Index.

Figure 91. Strong sustainability disclosure

	Transparency score	Transparency rank	Overall management score	Management rank
Xstrata	4	1st =	53.5	7th =
Anglo American	4	1st =	76	1st =
BHP Billiton	4	1st =	76	1st =
Lonmin	4	1st =	61.5	5th
Rio Tinto	4	1st =	74	3rd

Source: Citigroup Investment Research

Figure 92. Weak sustainability disclosure

	Transparency score	Transparency rank	Overall management score	Management rank
Antofagasta	2	12=	33	14
Companhia Vale Do Rio Doce	1.5	15	32	15
Kazakmys	1	16	23	16
Lihir Gold	2	12=	52	10=
Vedanta	2	12=	46	12

Source: Citigroup Investment Research

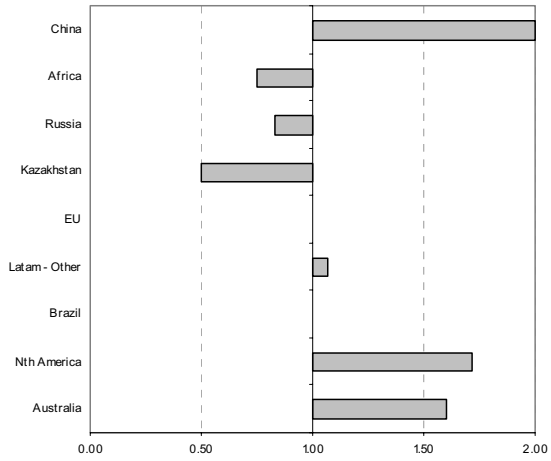
Some of our indicators are fully objective and not affected by reporting (e.g. fatalities, application of environmental management systems, membership of external bodies etc.). Other indicators, however, are affected by how much companies choose to disclose (e.g. senior management commitment, stakeholder engagement, etc.)

We make no apologies for this; if companies choose not to disclose, they should not expect to be accorded a premium. Further, although companies will often protest to the contrary, corporate disclosure on sustainability issues is almost always a good indicator of underlying corporate performance on these issues.

Resource availability

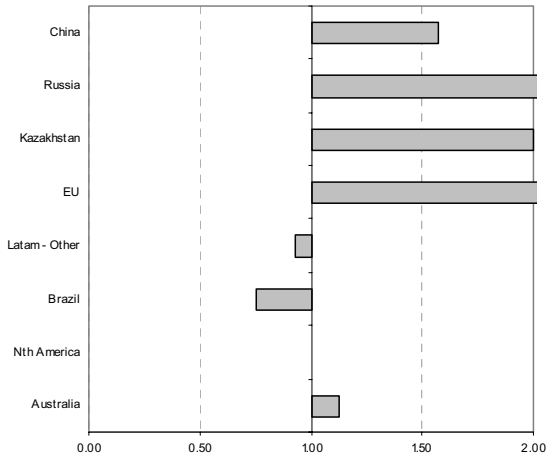
However, we also note that some of the companies with poor disclosure are particularly exposed to resource-rich but as yet unexploited areas of the world and accordingly have an enviable opportunity-set. In the following charts we take the ratio of production over known resources, i.e. a number greater than one means that the company is producing at a faster rate than known resource. The chart highlights the production upside in copper in regions such as Africa, Russia and Kazakhstan and for bauxite/alumina in Brazil.

Figure 93. Copper production over resources



Sources: USGS.

Figure 94. Alumina/Bauxit production over resources



Source: USGS.

The challenge facing these companies is, of course, to capitalise on this opportunity set and to ensure that capital markets incorporate this within their valuations.

Most cowboys are farmers

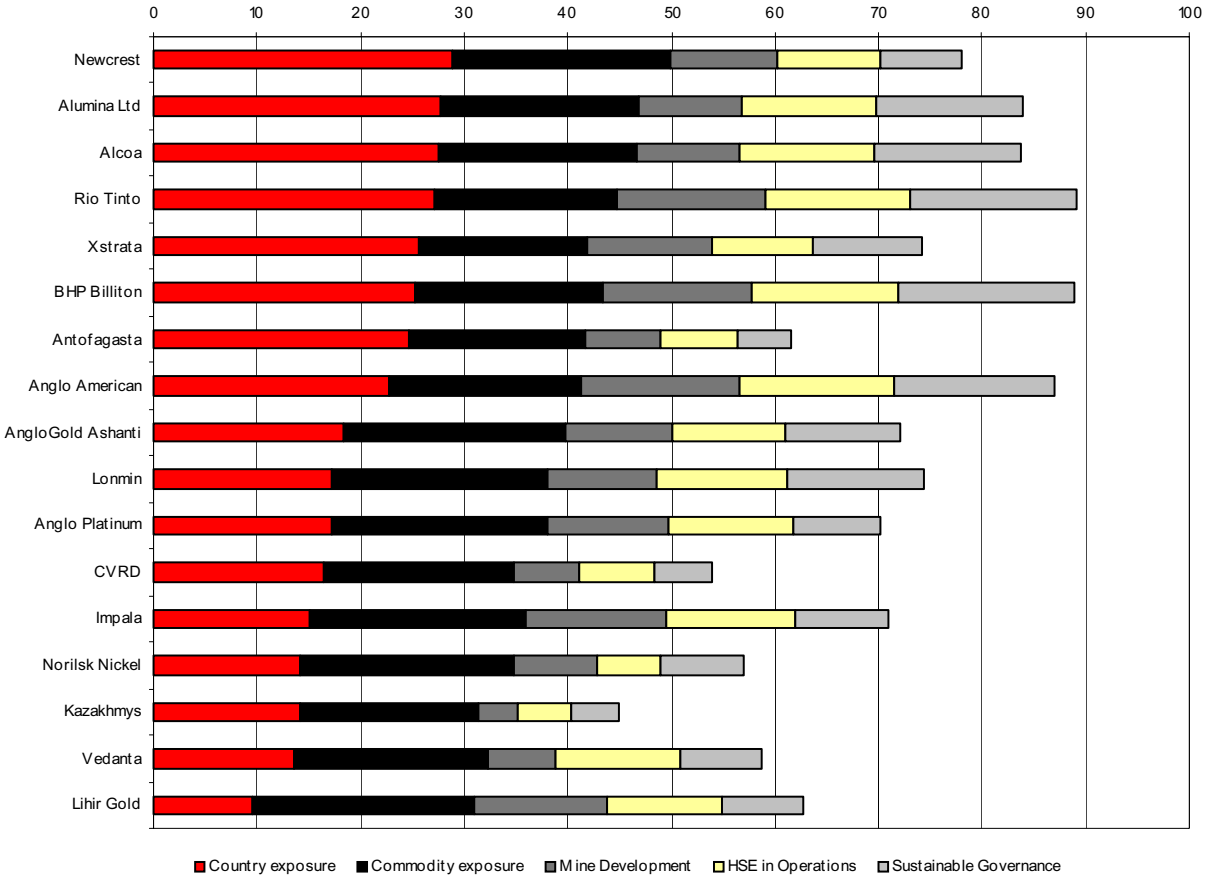
While we have already covered in detail the arguments about how strong sustainability performance enables companies to convert opportunity-sets to revenues, this section highlights how these companies will need to embed sustainability disclosure as part of their broader efforts to communicate with capital markets. If they can do this, the sustainability valuation upside that we have highlighted to the global majors may also be accorded to these emerging players.

The following chart orders the companies firstly on country risk rating and then on our other risk measures. From this we discern that:

- A number of companies rate strongly across each category, e.g. Alcoa, BHP Billiton and Rio Tinto.

- Anglo American, Impala and Lonmin have low country ratings but offset these with strong risk control measure.
- Companies with strong commodity and country positions that stand to benefit most from improving their sustainability management practices are Antofogasta, CVRD and Xstrata.
- Finally, some companies need to improve their sustainability risk management to enable them to manage comparatively weak country positions – although of these, we note that Lihir Gold, Norilsk Nickel and Vedanta have relatively strong commodity positions to support this effort

Figure 95. Companies ranked by country risk versus our overall sustainable development risk



Source: Citigroup Investment Research.

In this respect, we remind investors that, in reality, cowboys are farmers who tend cattle and, it is only in the movies that they ride wild, shooting people.

Appendix 1: SRI and sustainable development

- **'Socially Responsible Investment' has now fully emerged from its niche and proved its worth as an investment strategy**
- **A variety of 'SRI' investment styles present investors with a wide range of funds each with different risk/reward characteristics**
- **Sustainable development + financial markets = SRI**

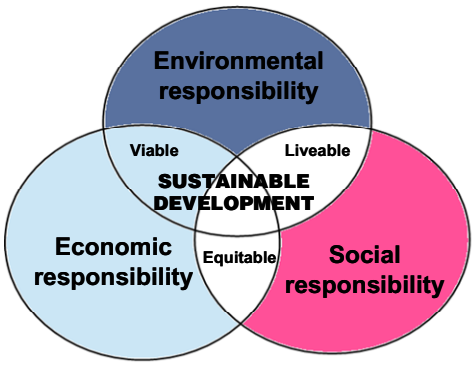
Over the last fifteen years, Socially Responsible Investment (SRI) in Europe has developed from a niche activity practiced by a few specialist fund managers and tolerated by the mainstream investment community and by companies into a sizeable investment style that involves most large European investment institutions and has considerable influence over corporate practice on environmental and social issues.

What is SRI?

SRI defined

As defined by the UK Social Investment Forum, SRI is investment which "combines investors' financial objectives with their commitment to social concerns such as social justice, economic development, peace or a healthy environment." Alternatively it can be defined simply as "investment that takes 'sustainable development' considerations into account". As such SRI takes as its basis the objective of balancing social, environmental and economic factors, as below:

Figure 96. Sustainable development



Source: Citigroup Investment Research.

Who and Where?

5 years of growth...

The last five years have seen a considerable growth in interest in SRI. In Europe, most major institutional fund managers either have developed or are in the process of developing some form of SRI capability. In the USA SRI tends to be

undertaken by specialist fund managers and future development driven by current trustees and treasurers of the state pension funds, rather than the large asset managers.

...across Europe and all groups

Although there are slight differences in emphasis, as regards client groups served, SRI funds are broadly available in all European markets across all client groups: retail, institutional, high net worth and charitable organisations.

The Dow Jones Sustainability Index remains a prominent feature of the international SRI market, with a steadily increasing number of licences and a research process that is well-respected by companies. Likewise, FTSE4Good has established a position as have a number of local country indices.

How large is SRI?

While global assets under SRI management have now reached US$2.5 trillion, it should be noted that the penetration of SRI varies significantly from market to market and from investment style to investment style. Although market data in this segment of the investment industry has been poor, it is gradually improving. The table below includes the most recent data for funds under management, as well as some notes on growth trends in key markets.

Figure 97. Assets under SRI management (Globally)

Country	SRI assets under management	Trends
US	US$2.16 trillion overall, (2003) of which… US$1.7 trillion is in screening-only funds US$7bn is in shareholder advocacy funds US$441bn is in combined screening & shareholder advocacy funds US$14bn is in community investing fund	Assets under management in screened portfolios rose 7% 2001-2003 (The broader universe of all professionally managed portfolios fell by 4% over the same period). Shareholder resolutions rose 15% between 2001-03
Canada:	US$38.2bn, (2004)	31% increase since 2000.
Asia	US$2.5bn, (2002)	Although the first SRI-related fund was launched in Japan less than three years ago, SRI assets have reached almost US$1 billion. SRI funds are also becoming available in Hong Kong
Australasia	US$16.8bn, (2004)	SRI has grown more than twice as fast as the overall Australian retail and wholesale investment market 2003-04 (which grew 18% over that period).
Europe	EUR 34bn in core SRI funds, (2003) EUR 218bn with simple exclusions EUR 336bn covered by engagement overlays	A wide variety of factors (including retail, institutional and high-net worth clients) are driving growth around Europe

Source: Citigroup Investment Research, US Social Investment Forum Trends Report Canadian Social Investment Review 2004, ASrIA, Australian Ethical Investment Association, Benchmarking Study 2004

Figure 98. Assets under SRI management (Europe)

Country	SRI assets under management	Trends
France	EUR2.08bn, (2003)	The focus in this market is on sustainability over screening, with trade unions playing a key role in driving growth.
Germany, Austria & Switzerland	Over EUR3bn in Germany & Switzerland, with up to Euros1bn in Austria, (2003)	The institutional market in these countries relies mainly on screening, and to a lesser extent, on engagement.
Italy	EUR240m institutional investment, (2003)	The retail SRI market in Italy is approximately EUR1.2bn and uses a screening approach.
Netherlands	EUR3.1bn	In addition to this, almost all Dutch pension funds use basic negative screening criteria.
Spain	EUR0.08bn	SRI is still very small in Spain but NGOs are raising its profile.
UK	Over £80bn occupational pension funds are subject to engagement in line with the pension fund's SRI policies. £17bn of charity funds is subject to screening. £4.2bn in screened retail funds, (2003)	Almost £200bn of UK equity holdings are now subject to SRI engagement activities as part of the fund manager's own SRI policy.

Source: Citigroup Investment Research, EIRIS, Eurosif (The first benchmark of the European market was undertaken by Eurosif in 2003; as yet there are no reliable figures indicating growth rates, although these should be available by end 2005)

But does it perform financially?

The evidence collected to date (and there has been a considerable amount of research undertaken) is inconclusive; some SRI funds outperform, others underperform. Much of this is summarised in a study ('Sustainability Pays') conducted by UK-based NGO, Forum for the Future, for CIS.

Sustainable development + financial markets = SRI

Economic, social and environmental challenges

Sustainable development was first defined by Gro Harlem Bruntland, Chair of the World Commission of Environment and Development, in 1987 as "development which meets the needs of the current generation without compromising the ability of future generations to meet their own needs". As such it encapsulates the varied challenges of climate change, social justice, sustainable resource usage, poverty alleviation etc and has become the benchmark standard by which government, civil society and increasingly companies and investors measure their success in balancing economic development, social progress and environmental protection.

Appendix 2: Investment Thesis, Valuation and Risks

Alcoa Inc

Investment Thesis

We rate the shares of Alcoa Inc Buy/ Medium Risk (1M) with a target price of US$36.00. We believe Alcoa presents a solid financial profile heading into a period of cyclical acceleration, and view Alcoa as a defining name in metals and a core cyclical, particularly given our view that the aluminum market will continue to tighten in 2006. This repeats, perhaps in more muted form, the pattern seen in alumina, iron ore, nickel, and what has been taking shape in copper. Our positive view is predicated on an aluminum price forecast of $0.95 per pound in 2006 compared to $0.85 in 2005; EPS sensitivity of roughly $0.09 for every $0.01 annual change to the aluminum price, or $1.35 per share at a 15x mid-cycle multiple; additional cyclical leverage implied by 525,000 T of mothballed capacity; new growth initiatives in Brazil, Australia, Iceland, and elsewhere, which should improve portfolio quality; progress on costs savings achieved against the three-year $1.2 billion challenge; and improving return on capital employed (ROCE) toward a first-quintile S&P Industrials benchmark, although at 9.2% in 2006E it is far from the targeted 14% to 15%.

Valuation

Our $36 target price remains unchanged and is based on three valuation methods; 1) price to forward earnings, 2) price to operating cash flows, 3) and DCF with respective weightings of 40/40/20. We apply mid-cycle type earnings multiples based on the view that our 2007 earnings estimates, driven partly by a forecasted $0.81/lb aluminum price (compared to $1.01/lb in 2006), reflect mid-cycle levels.

We view the cycle of aluminum company P/E multiples since 1990 to be 24 – 14 – 8x. Historically, Alcoa has traded at a median P/E of 15x within a range of 23 – 8x EPS. We apply a 14.0x multiple to our 2007E EPS estimate to arrive at a price target of $35 per share.

We view the cycle of aluminum company Operating Cash Flow (OCF) multiples to be 17 – 9 – 6x (trough–mid–peak). Historically, Alcoa has traded at a median OCF multiple of 9x within a range of 6 – 17x. We apply a 8.5x mid-cycle multiple to our 2007E OCF estimate to arrive at a target price of $38 per share.

Our DCF model incorporates our detailed estimates through 2008, and assumes cyclical dip in 2009 followed by 3.0% growth in unlevered free cash flows (uFCF) through 2013 and 1% terminal growth. The discount rate of 8.2% is derived from the CAPM model assuming a beta of 0.92, Citi equity risk premium standard of 3.7%, risk free rate of 4.5% (10-year Treasury), long-term tax rate of 29%, and business risk premium of 1%. DCF modelling yields a value of $35 per share.

Risks

We rate Alcoa Medium Risk because of its large size, steady growth in dividends, and high interest coverage, partially mitigated by the cyclical nature of its businesses and high beta. As an industrial cyclical company, the greatest single risk facing Alcoa is the scope and pace of synchronous economic recovery. Should the major industrial economies lapse back into recession, Alcoa's revenues and earnings would suffer in tandem with likely low aluminum prices and soft demand for engineered products.

Aluminum in its various forms accounts for roughly two-thirds of revenue and we estimate that every one cent change to the annual aluminum price impacts EPS by $0.09. Availability of predictable, inexpensive electricity is critical to the aluminum smelting business as it accounts for roughly 25% of the cost structure. Despite its terminal-commodity attributes, the aluminum industry is very competitive in terms of securing critical inputs, accessing Asian growth markets, and winning bids for fabricated and engineered products. Substitution threats from steel and composites are pervasive. The metals industry is highly regulated, and Alcoa is subject to environmental scrutiny of its mining, waste disposal, and air emissions, particularly fluorides from the smelting process which are classified as potent Greenhouse Gases. Operating in 43 countries, representing 39% of revenues in 2003, Alcoa is subject to foreign political and currency risks that could impact asset tenure, environmental or operating permits, intellectual property, and the enforceability of commercial agreements. The company also faces a major labor negotiation in North America ahead of May, 2006 contract expiry.

Alcoa has set ambitious operating and profitability targets, which may be difficult to attain. These include delivering on targets such as the $1.2 billion 2004-2006 cost reduction challenge, and development projects in Jamaica, Brazil, Australia, Iceland, and China. Its much-touted strategic foray into downstream and engineered products, and re-positioning as a manufacturing company, remains a work in progress. These segments have not yet delivered enhanced margins, and confront considerable investor skepticism.

If the impact on the company from any of these factors proves to be greater than we anticipate, the stock will likely have difficulty achieving our target price. If the impact on the company from any of these factors proves to be less than we anticipate, the stock could move further above our target price. Specifically, the stock is unlikely to reach our target price if aluminum fails to reach our forecasted levels.

Anglo American

Investment Thesis

We rate Anglo American Buy, Medium Risk (1M) with a target price of £25.00. Anglo is levered to the economic cycle yet also displays defensive characteristics, helped by the group's exposure to precious metals. Anglo's defining characteristic from its major diversified mining peers is a different asset mix, with greater leverage to precious metals (platinum, gold and diamonds) as well as exposure to non-mining natural resources such as pulp & paper and industrial minerals

(aggregates). The diversification into 'non-core mining activities' sees Anglo's group margin fall below that of its peers, due to the inherently low-margin nature of the non-mining assets. However, these industries do provide Anglo with significant levels of growth opportunities not presented to its peers.

The other differentiating point for Anglo is the large level of South African exposure, which encounters political risk and the imposition of future royalties. The level of earnings from South Africa has dropped significantly over the past six months mainly due to the strengthening of the rand. However, we believe that political risk and royalties should impact future earnings and thus have a cautious view on the South African earnings stream.

Risks

We rate Anglo American Medium Risk. The risk rating on the stock is derived after consideration of a number of factors. These factors include an assessment of industry-specific risks, financial risk and management risk. In addition, we consider historical share price volatility, based upon the input of the Citigroup quantitative research team, as a possible indicator of future stock-specific risk.

With regard to Anglo, we would highlight in particular that Anglo is a diversified metals and mining company with a large number of operations producing a range of commodities across several continents. Operating risk is therefore lower than in smaller metals and mining companies with fewer operations.

Key risks to our projected earnings, cash flows and target price relate to weaker-than-expected commodity prices/economic growth and currency appreciation in South Africa. In particular, appreciation of the rand/US dollar rate above R6.00 would adversely affect financial forecasts and valuation. With about 35% by NPV of assets in Africa, country risk is an important consideration, especially in relation to recent proposed changes in the South Africa mining legislation. If the impact on the company from any of these factors proves to be greater than we anticipate, we believe the stock will likely have difficulty achieving our target price. If the impact on the company from any of these factors proves to be less than we anticipate, the stock could materially outperform our target price.

Valuation

Our revised Anglo American valuation (NPV) of £14.33 per share is based upon a DCF analysis using discount rates appropriate to the South African and non-South African business units to accommodate for political risk. The businesses are analysed under a 10.3% nominal, after-tax, unlevered discount rate. This assumes a market risk premium of 6%, beta of 1.1 and a nominal risk-free rate of 5.23%.

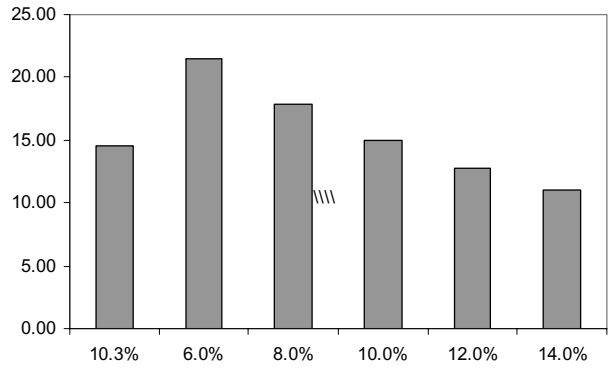
Figure 99. Anglo American Valuation

NPV Valuation Summary	US$m	US$ps	£ps	Rand ps
Gold	5796	4.01	2.29	24.83
Platinum	6433	4.45	2.54	27.56
Diamonds	3991	2.76	1.58	17.10
Coal	6702	4.63	2.65	28.71
Base Metals	4803	3.32	1.90	20.58
Ind Minerals	3746	2.59	1.48	16.05
Ferrous Metals	4381	3.03	1.73	18.77
Paper & Packaging	7418	5.13	2.93	31.79
Corporate	-2610	-1.80	-1.03	-11.18
Total Operations (US$)	42350	29.27	16.72	181.46
Net Debt	-6055	-4.18	-2.39	-25.94
TOTAL VALUATION	**36295**	**25.08**	**14.33**	**155.51**

Source: Citigroup Investment Research

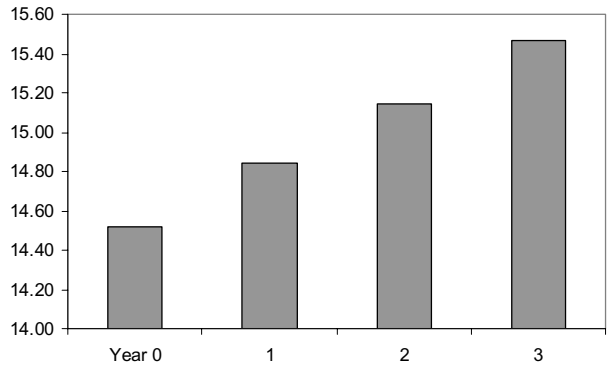
The following tables highlight the sensitivity of Anglo's NPV to changes in discount rates and time (years).

Figure 100. DCF sensitivity at different WACC



Source: Company reports and Citigroup Investment Research

Figure 101. DCF sensitivity with time (Years



Source: Company reports and Citigroup Investment Research

Our NPV derived price target of £21.50 per share is set at a 50% premium to our NPV of £14.33. We assume a peak P/NPV multiple of 50% based on historical trading for a diversified miner. This is a reflection of the company's portfolio mix. A 50% premium to NPV is in line other major peers such as Rio Tinto, which has traded at this premium to NPV at peak cycle multiples.

P/E

Our P/E derived fair value of £27.21 per share is based on a 15x 2006E EPS of 318 cents per share. A P/E of 12x represents a top of the cycle multiple for the sector, where a P/E of 18 represents a bottom of the cycle multiple. On average Anglo American has traded on a 15x earnings throughout the cycle.

Target price

We calculate a one-year target price of £25.00 per share, rounding up our average price/NPV valuation of £21.50 per share and checking against our traditional multiple P/E analysis £27.21 per share.

BHP Billiton

Investment Thesis

We rate BHP Billiton Buy/Medium Risk (1M) with a 12-month target price of A$27/share or £11.50/share.

BHP has evolved from a company earning below cost of capital returns to substantial excess returns (our 'Evolving Excess Returns' thesis), a process that has driven strong share price performance.

BHP is also one of a handful of positive plays on the Chinese growth story. Whilst China accounts for only a few percent of global GDP, it accounts for >10% of IP, and 15-25% of commodity demand—about the same as the US.

Valuation

Our target price is £11.50/share. Our BHP valuation (NPV) of £7.40/share is based on DCF analysis using an 8% real, after tax, unlevered discount rate and using a beta of 1.1. Our long-term equilibrium commodity prices and other key assumptions are available in our Metals & Mining Strategy reports.

We calculate a 1-year target price using a combination of Price/NPV and traditional multiples assuming 1) a target price of £10.40/share based on a 40% premium to NPV; 2) a multiple based target price of £12.20/share and 3) a 50% weighting for each method.

Risks

We rate BHP Medium Risk, referencing a number of quantitative and fundamental screens. Key risks to our projected earnings, cash flows and valuation relate to weaker than expected commodity prices/economic growth and US$. Adverse movements in these risk factors may impede BHP's share price reaching our target price.

Country risk is a significant consideration with about 40% by NPV of operations in Africa, South America and Asia. Operating risk is lower than in smaller metals and mining companies with fewer operations.

BHP is a Medium Risk company utilizing an Australian quantitative risk model utilizing, amongst other criteria, earnings and dividend stability measured in A$ and ranked against an Australian universe. But, BHP is managed in US$ (e.g., progressive US$ dividends) and there is a natural US$ hedge in its earnings stream which would work to make its earnings stream more stable in an international context. If a US$ perspective were taken on these issues a lower risk rating could be warranted.

Impala Platinum Holdings

Investment Thesis

We rate Impala Platinum Buy, Medium Risk (1M) with a target price of R1141.63. In our view, Impala is the best-placed company in the PGM sector to weather the

ravages of the strong rand. It is partially shielded via Impala Refining Services (contributing 12%-15% to profits), which has US$-denominated costs, and Zimbabwe operations (10% contribution to profits) that have a relatively small exposure to rand costs. Near term, however, political and economic problems in Zimbabwe have been of concern.

The group is increasing the amount of platinum ounces under its control and we believe that this should position the company well to benefit from a growing PGM market. Current plans are for a CAGR of 10% over the coming years, taking overall output to over 2.0moz Pt by 2006.

The group's focus is on its Zimbabwean operations (Zimplats and Mimosa) where organic growth from these two operations remains on track despite near-term political uncertainty. Production at its flagship Rustenburg operation is being increased to record highs of 1.16moz Pt and we expect output to remain at over 1.1moz Pt in the future.

The group has good operating practices that allow for higher productivity and lower unit costs. Mechanisation is also much more advanced at Impala's Rustenburg compared with AngloPlat's operations. In addition, the company is not experiencing the same severity of capex intensity and debt problems as AngloPlat.

Other advantages include a strong balance sheet that should facilitate future funding requirements.

Valuation

Our target price of R1141.63/share is generated by giving a 70% weighting to NPV and 30% weighting to P/E, cash flow and EV/EBITDA. Impala's share has traded at up to a 50% premium to NPV at the peak of the cycle. The solid results for F2005, a weaker rand, good cost controls and a strong PGM basket have underpinned the share price. Indeed, the share is trading at a premium of nearly c20% above our estimate of its NPV. The share was re-rated strongly in the past few months on the back of stronger PGM prices and a mildly weaker rand. Should the rand continue to weaken (with PGM prices holding up), it is possible that the stock could trade at even higher premiums to NPV

Risks

We rate Impala Platinum as Medium Risk. Although it is essentially a single commodity company with almost all its assets in southern Africa and has displayed more earnings volatility compared with diversified miners, we believe it is one of the best-run companies in South Africa. Other factors that we take into consideration include an assessment of financial risk as well as management risk. In addition, we consider historical share price volatility, based upon input from the Citigroup quantitative research team as a possible indicator of future stock-specific risk. Key risks to Impala failing to achieve our projected earnings, cash flows and target price relate to the following:

- Rand strength. A stronger-than-expected rand would continue to depress rand-denominated cash flows. It should be noted, however, that because of Impala's IRS business, the sensitivity of the company's HEPS to the rand is

not as extensive as other South African PGM groups. We estimate that around 30% of IRS's cost base is US-dollar denominated.

- Cost pressures will likely continue to be a feature in the current year with the lag in wage increases exacerbating the impact of a strong rand.
- Impala has made a significant investment in Zimbabwe. Any further deterioration in the political situation there or the inability to expand the production assets could be a big problem for the company.
- Although investors may be worried about appropriation of assets in Zimbabwe, we do not believe that mines will be taken away or nationalised because they are a key source of much-needed foreign currency for the country.
- HIV/AIDS is a big problem for the mining sector in South Africa. Impala Platinum is one of the few companies that has been proactive in tackling the scourge. Since the early 1990s, the company has had an active HIV/AIDS education programme at its mines, which is helping to reduce new infections.
- If the impact on the company from any of these factors proves to be greater than we expect, the stock will likely have difficulty in achieving our financial and price targets. Likewise, if any of these factors proves to have less of an effect than we expect, the stock could materially outperform our target.

Lonmin

Investment Thesis

Our target price on Lonmin is £21.50, reflecting the strong PGM market and our earnings upgrades. We maintain a Buy/ Medium Risk (1M) recommendation on the stock. Costs are under control after four years of inflation. The company also appears more committed to developing their PGM business rather than looking to diversify. We view both aspects as positive movements for the company.

Lonmin is the third-largest platinum producer, with 100% of its revenues generated from South Africa. Unlike gold and metals, PGMs have limited cyclicality and thus the stock is judged versus future growth and cash flow potential.

Lonmin is in the process of capital expansion programme, which should see production volumes exceed 1moz of platinum by 2008. However, beyond the current expansion plans there is limited scope for significant growth without significant capital expenditure. There are also very few corporate transactions available to the company.

Therefore, cash flow and dividend yield play an important part in the investment story for Lonmin. The company has historically had a dividend yield at a 50% premium to the market, reflecting the group's long-term cash generation potential. Cash flow and consequently dividends are under pressure from low palladium prices and a strong rand.

Valuation

Our target price on Lonmin is £21.50 reflecting Lonmin's improved earnings profile, which has been driven by:

- Increased near-term PGM prices (in particular Rhodium);
- Weaker rand assumptions lifting underlying earnings as well as deferred tax benefit; and
- Change in our cost assumptions.

The target price is primarily based on an NPV methodology, using conservative long-term commodity and currency assumptions. The valuation matrix combines NPV, P/E and price to cash flow multiples to provide a target price that encounters both long- and short-term trends. We have generated a target price of £21.50 by having a 50% weighting to NPV, 25% weighting to P/E and a 25% weighting to price to cash flow. We feel that the analysis provides a better insight into valuation for a single commodity play than the 'through the cycle' approach that we have used on the diversified mining companies.

Risks

We rate Lonmin Medium Risk, reflecting the improved operating environment in South Africa regarding Black Economic Empowerment. The risk rating also reflects our perception of Lonmin's intentions to diversify. We feel that diversification would destroy value in the company.

The risk rating on the stock is derived after consideration of a number of factors. These factors include an assessment of industry-specific risks, financial risk and management risk. In addition, we consider historical share price volatility, based upon the input of the Citigroup quantitative research team, as a possible indicator of future stock-specific risk.

With regard to Lonmin, we would highlight in particular that the company is a single commodity company and therefore displays greater earnings risk than a diversified metals and mining company. Key risks to our projected earnings, cash flow and target price relate to weaker-than-expected commodity prices/economic growth and currency appreciation in the South African rand. Lonmin derives 100% of its earnings from Africa. Therefore the stock has a heightened risk profile as it is exposed to southern African political risk and the increasing impact of AIDS and HIV. The imposition of future royalty payments and Black Economic Empowerment levels also provide risk to achieving our target price/forecasts on Lonmin and ultimately its share price.

Kazakhmys

Investment Thesis

We rate Kazakhmys as Sell/ High Risk (3H) with a target price of £7.00. KAZ is a single commodity stock and as such is highly levered to the economic cycle, and more importantly the copper price. We believe that the copper price has peaked as

supply is currently outstripping demand growth. Consequently earnings and cash flow should be in decline,

Vedanta is also a unique play on the Kazakh economy. Kazakhstan continues to grow rapidly and significant investment and construction is underway in the region. Metals demand is on the increase and growth is roughly double what we see in the west. The company also has the potential to exploit the undeveloped natural resources in Kazakhstan and grow via acquisition.

Valuation

Our KAZ valuation (NPV) is £5.64 per share, and is based upon a DCF valuation using a market risk premium of 6%, beta of 1, nominal risk free rate. Our long-term equilibrium commodity prices and other key assumptions are available in our regular *Metals & Mining Strategy* and *Handbook* reports.

We calculate a one-year target price of £7.00/share. Our target price and recommendation are based upon three primary valuation techniques:

- DCF-derived NPV analysis.
- Earnings multiples (primarily P/E).
- Industry benchmark analysis (primarily market capitalisation to tonne of production).

We take a blended approach to the above methods to derive our target.

Risks

We rate Kazakhmys as High Risk. The risk rating on the stock is derived after consideration of a number of factors. These factors include an assessment of industry-specific risks, financial risk and management risk. In addition, we consider historical share price volatility, based upon the input of the Citigroup quantitative research team, as a possible indicator of future stock-specific risk. With regard to KAZ, we would highlight in particular that it is a single commodity play with the bulk of its earnings being derived from copper. Consequently, its operating risk is higher than in the major diversified mining houses. Adverse movement in the copper price away from our forecasts could see a significant delta in our forecasts from actual profits, both positively and negatively. KAZ's desire to grow via acquisition also brings acquisition risk. Finally the company conducts the bulk of its business in Kazakhstan. Consequently the company suffers from a higher level of political/sovereign risk than the likes of BHP, RIO or Xstrata, which have more than of their assets located in the OECD. These risks could prevent the shares from reaching our target price.

Appendix 3: Glossary

Agitation: metallurgy, the act or state of being stirred or shaken mechanically, sometimes accomplished by the introduction of compressed air.

alloy: compound of two or more metals.

alluvial: transported and spread by water.

anode: rectangular metal plate with a positive charge, cast in a shape suitable for refining by the electrolytic process.

anomaly: relatively unusual geochemical or geophysical response from a geographical or geological surface – generally positive exploration result.

ash: the residue remaining after a pulverized sample of the coal is incinerated under standard laboratory conditions.

assay: chemical test by wet or fire methods performed on a rock sample to determine the amount of valuable metal contained.

autogenous grinding: process of grinding ore with the ore itself, in a rotating cylindrical mill. The grinding ore medium is typically large pieces of ore.

ball mill: steel cylinder containing about 40% volume of steel balls, used to grind ore. The balls in the rotating mill tend to cascade, grinding the ore.

base metal: non-precious metal, such as copper, lead or zinc. Base metals are commonly used in industry alone rather than in alloys.

Beneficiation: concentrating or enriching of the valuable minerals in ore.

bio-leaching: metal extraction method that uses bacteria to oxidize refractory sulfide ore, making it amenable to normal oxide ore processing techniques.

block caving: method of underground mining whereby large blocks or ore are delineated and undercut by drilling, causing the ore to break or cave under its own weight, then extracted through a system of draw points and conduits.

borehole: a hole drilled through the strata to obtain geological specimens or to provide access for geophysical devices.

bullion: metal formed into bars or ingots.

calcine: concentrate type used in smelting; the sulfur has been driven off by oxidation.

carbon: fine-sized granules of activated carbon, typically derive from ground coconut shell used because of its hardness.

Carbon-in-Column (CIC): method of recovering gold and silver from pregnant solution, using a heap leaching process. The precious metals, suspended by up-flow of solution through a tank, is adsorbed onto fine carbon.

Carbon-in-Leach (CIL): method of recovering gold and silver from fine ground ore by simultaneous dissolution and adsorption of the precious metals onto fine carbon in an agitated tank of ore solids/solution slurry. The carbon flows counter currently to the head of the leaching circuit.

Carbon-in-Pulp (CIP): method of recovering gold and silver from fine ground ore by adsorption of the precious metals onto fine carbon in an agitated tank of ore solids/solution slurry. This recovery step in the process follows the leaching process which is done in similarly agitated tanks, but without carbon.

cash operating cost: cost per unit that is equivalent to direct operating expense, including mining and processing, waste stripping and mine-site administration, less production royalties, mining taxes and by-product credits for payable metals recovered.

cathode: rectangular metal plate with a negative charge used in electrolytic refining. The deposited metal recovered onto this plate is called cathode metal and is melted into commercial shapes such as bars or ingots.

clarifier filter: pressure filter containing cloth leaves which support a porous filter medium and filter out all fine solids from relatively clear feed solution. The sludge collected is periodically flushed from the filter on a regular cycle.

classifier: mineral processing machine which separates mineral particles according to size and density.

coking coal: coal which is suitable for making coke, used in steel production.

complex ore: ore containing a number of minerals of economic value.

concentrate: fine-textured product separated in the milling process that contains a high percentage of valuable metal.

concentrator: milling plant that produces a concentrate of the valuable minerals or metals. Further treatment is required to recover the pure metal.

cone crusher: machine which crushes ore between a gyrating cone or crushing head and an inverted, truncated cone known as a bowl.

core: cylindrical rock sample generally produced by diamond drilling.

cut-and-fill: method of underground mining whereby the ore is removed in slices, or lifts, and then the excavation is filled with rock or other waste material (backfill), before the subsequent slice is extracted.

cut-off grade: minimum grade level below which the mineralized geology is not regarded as economic ore. The minimum grade of ore used to establish reserves.

cyanidation: method of extracting exposed gold or silver grains from crushed or ground ore by dissolving it in a weak cyanide solution, usually in agitation tanks in a mill or on ore heaps.

de-aeration tower: closed tank from which air is evacuated by a vacuum pump on the closed system. As solution flows through a contained media of large surface area, oxygen is removed (boils) from the solution.

dewatering: process of separating solids from solution by sedimentation in tanks called thickeners, or by filtering the solution through filter cloth in filters.

diamond drilling: drilling method using a diamond bit to cut a cylindrical hole for taking core samples.

dilution: mixing of ore grade material with non-ore grade waste material in the mining process.

disseminated: ore deposit consisting of fine particles of ore mineral dispersed through the enclosing rock.

Dore: unrefined gold bullion containing various impurities such as silver, copper and mercury, which will be further refined to near pure gold.

dragline: large earthmoving machine with a bucket suspended from a crane like boom.

electrolysis: process of passing current through a solution containing dissolved metals directing the metals to be deposited onto the negatively charged cathode.

electrolytic refining: process of purifying metal plates that are suspended as anodes in an electrolytic bath. The targeted metal is progressively plated onto refined starter sheets called cathodes.

electrowinning: the removal of precious metals from solution by the passage of current through an electrowinning cell. A direct current supply is connected to the anode and cathode. As current passes through the cell, metal is progressively deposited on the cathode. When sufficient metal has been deposited onto the cathode, it is removed from the cell and the sludge rinsed off the plate and dried for further refinement.

filter press: pressure filter containing cloth leaves which are supported within a closed container to remove solids from a fine-feed slurry. The solid sludge collected is periodically removed from the filter by opening the filter plates, scraping off the solids and replacing the plates with new and clean filter cloth or filter paper for continued filtering.

flotation: concentrating process in which valuable mineral particles are activated to become attached to bubbles and float above the waste particles, then isolated in a solid-solution pulp.

flux: mix of chemical substances that react with gangue minerals to form slag, which are liquid at smelting furnace temperature and sufficiently low in density to float on the molten bath of metal.

fold: any bending or wrinkling of a rock strata.

free milling: ores of gold or silver from which the precious metals can be recovered by concentrating methods without resorting to pressure leaching or other chemical treatment.

gangue: collective term for worthless minerals in an ore deposit.

geophysics: scientific method of prospecting, utilizing magnetics, specific gravity, electrical conductivity and radio-activity to detect minerals.

gold precipitate: fine sludge of gold, silver and zinc. The precious metals are precipitated out of solution by the addition of fine zinc dust.

grade: ratio measuring the quantity of targeted metal in a given quantity of ore. Head grade is the average grade of ore fed into a mill or heap leach metal recovery operation.

grizzly: grating, usually constructed of steel rails, placed over the top of a chute or ore pass for the purpose of stopping large pieces of rock or ore that may hang up in the pass.

gyratory crusher: machine that crushes ore between an eccentrically mounted crushing cone and a fixed crushing throat. Typically, it has a higher capacity than a jaw crusher.

heap leach: mineral processing method involving the crushing and stacking of ore on an impermeable liner upon which leach solutions are sprayed to dissolve metals such as gold and copper. The metal, in the collected solution flowing from the leach pad is subsequently treated to recover the metals.

high volatile coal: coal with more than 17% volatile matter.

hydrometallurgical: pertaining to metallurgical processes in which the principal medium is water; can be at temperatures and pressure substantially above ambient conditions when autoclaves are used, generally involves chemical reactions.

Indicated Mineral Resource: that part of a Mineral Resource for which quantity, grade or quality, densities, shape and physical characteristics, can be estimated with a level of confidence sufficient to allow the appropriate application of technical and economic parameters, to support mine planning and evaluation of the economic viability of the deposit. The estimate is based on detailed and reliable exploration and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes that are spaced closely enough for geological and grade continuity to be reasonably assumed.

Inferred Mineral Resource: that part of a Mineral Resource for which quantity and grade or quality can be estimated on the basis of geological evidence and limited sampling and reasonably assumed, but not verified, geological and grade continuity. The estimate is based on limited information and sampling gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes.

jaw crusher: a machine in which rock is broken by the action of swinging steel plates.

jig: milling equipment used to concentrate high density minerals by gravity on a screen submerged in water, either by the reciprocating motion of the screen or by the pulsation of water through it.

leaching: chemical process used in the extraction of valuable minerals from ore.

lode: mineral deposit in solid rock usually with well defined boundaries.

longwall mining: a high capacity underground mining method which utilizes a mechanical shearer to cut the coal.

magnetic survey: survey of a geological target's magnetic field, either from the ground or from the air.

Measured Mineral Resource: that part of a Mineral Resource for which quantity, grade or quality, densities, shape, physical characteristics are so well established that they can be estimated with confidence sufficient to allow the

appropriate application of technical and economic parameters, to support production planning and evaluation of the economic viability of the deposit. The estimate is based on detailed and reliable exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes that are spaced closely enough to confirm both geological and grade continuity.

metallurgical coal: coal used in the production of steel.

metallurgy: study of extracting metals from their ores.

mill: processing plant which treats ore for the purpose of upgrading the mineral content into a higher grade product called a concentrate, which is further treated, and disposing of the waste minerals to an impoundment area.

mineral: naturally occurring substance having distinctive physical properties and chemical composition.

Mineral Reserve: the economically mineable part of a Measured or Indicated Mineral Resource demonstrated by at least a preliminary feasibility study. This study must include adequate information on mining, processing, metallurgical, economic and other relevant factors that demonstrate, at the time of reporting, that economic extraction can be justified. A Mineral Reserve includes diluting materials and allowances for losses that may occur when the material is mined.

Mineral Resource: a concentration or occurrence of natural, solid, inorganic or fossilized organic material in or on the Earth's crust in such form and quantity and of such a grade or quality that it has reasonable prospects for economic extraction. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge.

native metal: metal occurring in nature in pure form, separate from other elements or minerals.

non-refractory: ore containing gold or other metal that can be satisfactorily recovered using gravity concentration or cyanidation methods.

ore: mixture of valuable minerals and gangue minerals from which at least one of the minerals can be extracted economically. An ore body is a natural concentration of valuable material amenable to economic extraction.

outcrop: part of rock formation that can be seen naturally at the earth's surface.

overburden: material which overlies a deposit of useful material.

PCI: pulverized coal injection.

pig iron: raw iron produced from blast furnaces.

placer: deposit of sand and gravel containing valuable metals such as gold, tin or diamonds.

platinum group metals (PGMs): collective term for ruthenium, rhodium, palladium and osmium, iridium and platinum. Platinum metals are occur as native metals, invariably associated with each other and gold, silver, copper, nickel and iron.

Probable Mineral Reserve: the economically mineable part of an Indicated, and in some circumstances a Measured Mineral Resource demonstrated by at lease a preliminary feasibility study. This study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate, at the time of reporting, that economic extraction can be justified.

Prospect: mining property with demonstrable potential for ore discovery.

Proven Mineral Reserve: the economically mineable part of a Measured Mineral Resource demonstrated by at least a preliminary feasibility study. This study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate, at the time of reporting, that economic extraction is justified.

pyrometallurgical: pertaining to ore-refining process, such as smelting, dependent on the action of very high levels of heat. Examples include fluid-bed roasting of zinc concentrates, matte smelting of copper concentrates, fire refining of blister copper.

reclamation: process of converting mined land for alternative uses.

recoverable: portion of metal contained in ore that can be extracted by processing.

refining: process of transforming material into its purest state ready for its intended end-use. Precious metal bullion is fire-refined to high purity gold and silver.

refractory: mineralization normally requiring more sophisticated processing technology for extraction, such as roasting or autoclaving under pressure.

reverberatory furnace: long, flat furnace used to slag gangue minerals and produce a matte of sulfide minerals.

rod mill: rotating steel cylinder that uses steel rods as a means of grinding ore.

royalties: government charge for the mining of coal.

run-of-mine (ROM): mined ore of a size that can be processed without further crushing.

semi-coking coal: coal which is suitable for making strong coke in its own right but suitable as a component in coke oven blends.

slag: vitreous mass of glass material separated from the fused metals, product of the smelting process.

smelting furnace: furnace, usually cylindrical, employed to melt concentrated valuable metals and minerals; impurities are isolated and removed in the slag that floats on top of the melt.

sodium cyanide: chemical used in the milling and heap leaching of gold ores to dissolve gold and silver.

solutions: includes water solutions in the leaching circuit; fresh make-up water; pregnant solution containing significant amounts of precious metals and leaching reagents (chemicals); barren solution which contains small quantities of valuable metals; leaching reagents.

solvent extraction-electrowinning: Also, (SX-EW). Metallurgical technique, applied only to copper, in which metal is dissolved from the rock by organic solvents, then recovered from solution by electrolysis.

strata: beds or layers of sedimentary rock.

strike length: length of a deposit able to be accessed for mining.

strip ratio: ratio of quantity of overburden waste material that needs to be removed, to tons of ore being accessed, in an open pit mining operation.

strip vessel: closed container in which loaded carbon is placed in order to remove precious metals from the surface of the activated carbon.

stripped carbon: activated (coconut shell) carbon, which has had the precious metal values removed by chemical processing, prior to preparation for reactivation and recycling back to the stripping circuit.

tailings: crushed or finely ground waste rock from which valuable minerals or metals have been extracted.

tenement: mining lease, exploration permit, or mineral development license.

thermal coal: coal which is combusted to provide heat for steam generation and subsequent power generation.

total cash cost: cash operating cost plus production royalties and mining taxes.

total production cost: total cash cost plus depreciation and amortization.

Troy ounce: measure of weight in which precious metals are sold. One Troy ounce contains 31.1 grams.

waste: barren rock or mineralized material that is too low in grade to be economically processed.

zinc dust: finely ground or formed zinc metal used to precipitate gold and silver from solution. The precious metal values precipitate into a fine sludge and the zinc metal replaces these values in solution.

Glossary - SRI

Basel Convention: the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal' was drafted and adopted in 1989 and came into effect in 1992. The convention works to reduce the movement of hazardous wastes to ensure that wastes are disposed of as closely as possible to where they were produced and to minimize the generation of hazardous wastes in terms of quantity and level of hazard.

BREEAM: used to assess the environmental performance of both new and existing buildings. It is regarded by the UK's construction and property sectors as the measure of best practice in environmental design and management.

brownfield land: land that has previously been used for development.

carbon management: tool for reducing an organization's impact on climate change through the management of its carbon emissions.

CO_2: carbon dioxide.

CDM: Clean Development Mechanism generates Certified Emission Reduction permits for China, India and Brazil.

CSR: Corporate Social Responsibility – a concept that considers many aspects of a company's performance and risks associated with issues such as employment, environment, human rights, communities and business relationships and is a corporate response to the sustainable development agenda.

CSI: Corporate Social Investment.

CSMI: Citigroup Sustainable Mining Index – used to rank mining companies in terms of commodity and country exposures, degree of mine development, HSE in operations & sustainable governance.

effluent to surface water: total volume of excess water discharged to surface water (e.g. rivers, dams, pans) during the reporting period.

EIA: environmental impact assessment.

EITI: the Extractive Industries Transparency Initiative launched in September 2003 by Mr. Tony Blair, British Prime Minister.

EMP: environmental management program.

EMS: environmental management system.

EPA: Environmental Protection Agency.

Equator principle: set of UN guidelines covering international project finance & sustainability risk.

ERU: emission reduction units – securities that can be traded between signatories of the Kyoto agreement.

ESIA: Environmental & social impact assessment.

FIFR: fatal injury frequency rate; the number of fatal injuries per 200,000 hours worked.

ICMM: International Council of Metals & Mining.

ILO: international labour standards covered in the Declaration on Fundamental Principles and Rights at Work (adopted by the International Labour Conference at its 86th session, Geneva 1998): Convention No. 29: Forced Labour, 1930; Convention No. 87: Freedom of Association and Protection of the Right to Organize, 1948; Convention No. 98: Right to Organize and Collective Bargaining, 1949; Convention No. 100: Equal Remuneration, 1951; Convention No. 105: Abolition of Forced Labour, 1957; Convention No. 111: Discrimination (Employment and Occupation), 1958; Convention No. 138: Minimum Age, 1973; Convention No. 182: Worst Forms of Child Labour, 2000.

GHG: greenhouse gas.

governance: management processes and systems that determine how decisions are made and a company is managed.

Green Roof: term for covering the tops of buildings with plants, trees and grasses. A Green Roof has a range of environmental benefits, such as minimizing rainwater run-off.

greenhouse gas emissions: for CO_2-equivalent: quantity of CO_2 from electricity purchased and internally generated. Conversion factors used are as recommended by the Intergovernmental Panel on Climate Change (IPCC). Gases include CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and other CO_2 equivalents.

GRI: the Global Reporting Initiative was established in 1997, with the mission of designing globally applicable guidelines for preparing enterprise-level sustainable development reports.

ground water quality deterioration: monitoring results indicate deterioration of ground water quality because of the operation's activities.

ground water quality monitoring: monitoring program to monitor water quality. Required sites are those identified for monitoring by legal permit requirements or by the site EMS.

ground water used: water abstracted/collected by the operation itself from ground water sources, e.g. from boreholes and mine de-watering, which is used by the operation.

hazardous waste to incineration: this could include heavy metal contaminated sludge; contaminated containers (reagent containers, oil/grease containers, anti-freeze drums); medical waste, vehicle batteries, and oil-contaminated material (gaskets, filters, soaking agents, rags). Incineration refers to incineration in a facility designed and operated in a manner compliant with legislation or internationally accepted practice (this does not include burning of waste in a pit or open area).

hazardous waste to landfill: this could include: heavy metal contaminated sludge; contaminated containers (reagent containers, oil/grease containers, anti-freeze drums); contaminated soil; and oil-contaminated material (gaskets, filters, soaking agents, rags).

HMO: health maintenance organization.

ICMM: International Council on Mining and Metals.

IIED: International Institute for Environment and Development.

ILO: International Labour Organization – the specialized UN agency that seeks the promotion of social justice and internationally recognized human and labour rights. It was founded in 1919.

IPA: International Platinum Association, which provides a communication forum for producers and fabricators and facilitates market development.

ISO 14001: an international standard on Environmental Management intended to assist organizations to achieve environmental and economic goals.

ISO: an EMS standard published by the ISO.

IUCN: the World Conservation Union (IUCN) defines a protected area as 'an area of land and/or sea especially dedicated to the protection and maintenance of

biological diversity, and of the natural and associated cultural resources, and managed through legal or other effective means'. IUCN categorizes protected areas by management objective and has identified six distinct categories of protected areas.

light weighting: increase in the use of light-weight metals in transport, driven by pressures to increase fuel economy and reduce emissions.

LTIFR: the number of lost-time injuries per 200,000 hours worked.

MMSD: Mining, Minerals & Sustainable Development – project begun in 2000 to develop an understanding of how to maximize the contribution of the mining and minerals sector to sustainable development at a global level.

Montreal Protocol: initiative that covers substances that deplete the ozone layer. It is a landmark international agreement designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere (chlorofluorocarbons, halons, carbon tetrachloride, and methyl chloroform) were to be phased out by 2000 (2005 for methyl chloroform).

Morley Sustainable Investment: global fund management company and a leader in Socially Responsible Investment and Corporate Social Responsibility.

NGO: non-governmental organization.

NIHL: noise-induced hearing loss.

non-hazardous waste incineration: incineration refers to incineration in a facility designed and operated in a manner compliant with legislation or internationally accepted practice (this does not include burning of waste in a pit or open area).

non-hazardous waste to landfill: domestic-type waste to on-mine and off-mine landfill sites.

non-potable water: water obtained from an external source that is untreated or only partially treated and is not of a standard suitable for drinking. This does not include waste water/second-class water, which is effluent from sewage works. It also does not include untreated surface water and ground water, extracted by the operation itself.

ozone-depleting compounds: quantity of ozone-depleting compounds (ODCs) released/vented to atmosphere during the reporting period, expressed as CFC-11 equivalent. ODCs include the following compounds: chlorofluorocarbons (CFC) (CFC-11, CFC-12, CFC-113, CFC-114, CFC-115); hydro-chlorofluorocarbons (HCFCs); halons (Halon 1211, halon 1301, halon 2402); carbon tetrachloride; trichloroethane; methyl bromide; and hydrobromofluorocarbons.

Park and Ride schemes: provide a means of traveling in and out of a town or city centre. Visitors park their car at a designated car park outside the town or city centre and travel in by a designated bus.

particulates: mass of particulates released to atmosphere from point sources during the reporting period.

PCBs: polychlorinated biphenyls are mixtures of chlorinated compounds.

POPs: persistent organic pollutants are chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of living organisms, and are toxic to humans and wildlife. POPs circulate globally and can cause damage wherever they travel.

RIDDOR: Reporting of Injuries, Diseases and Dangerous Occurrences from the 1995 Regulations. These Regulations require an employer to report certain dangerous events to the appropriate enforcement body. Such events include fatalities, major injuries, injuries where employees are away from work over three days and a wide range of occupational diseases as well as an extensive list of other defined dangerous events.

SRI: investment decisions based on environmental and social factors, as well as financial returns. SRI balances the need for financial returns with the investment's potential impact upon the environment and society. Most major investors operate SRI funds, which will only invest in companies meeting predetermined environmental and social criteria.

surface water quality deterioration: monitoring results indicate a deterioration of surface water quality off-site because of the operation's activities, during the reporting period.

surface water quality monitored: a surface water quality monitoring program to monitor water quality at all the required surface water quality monitoring sites. Required sites are those identified for monitoring by legal permit requirements or by the site EMS.

surface water used: water abstracted/collected by the operation itself from surface water sources, e.g. from rivers, dams, and pans, and which is used by the operation, but excludes water recycled internally from storm-water and tailings return-water dams.

sustainable development: integrating economic, social and environmental policies to ensure a better quality of life for everyone, now and for generations to come.

Sword of Honour: one of the top awards in safety. The Sword of Honour recognizes organizations that implement safety systems that protect people, plant, equipment and the environment and increase productivity and profitability.

The Carbon Trust: launched in April 2001, this Government body works with businesses and the public sector to meet the UK's ongoing targets for carbon dioxide emissions; to improve the competitiveness of UK business through resource efficiency; and support the development of a UK industry sector that capitalizes on low carbon technologies. Climate Change Levy is a tax on industrial and commercial use of energy. The levy is designed to stimulate increased energy efficiency across business thereby reducing the UK's emissions of greenhouse gases.

Travel Plan: package of measures used by an employer to encourage staff to use alternatives to single-occupancy car-use.

UNEP-WCMC: United Nations Environment Program – World Conservation Monitoring Centre.

WBCSD: World Business Council for Sustainable Development.

WHO: World Health Organization.

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ANALYST CERTIFICATION Appendix A-1

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