TAILINGS RISKS: GOVERNANCE FAILURES AND CLIMATE CHANGE

Following the tailings dam collapse in Brazil at Vale's Corrego do Feijao mine in January, investors are seeking answers as to what caused it and which companies are most vulnerable to similar risks. This report explores the underlying factors of tailings dam collapse and where the risks are highest.

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EXECUTIVE SUMMARY

A tailings dam at Vale SA’s Corrego do Feijao mine east of Brumadinho, Minas Gerais, Brazil collapsed on January 25 unleashing an avalanche of mining waste that engulfed the surrounding areas. It was one of the deadliest tailings dam collapses in modern history, killing hundreds. Brazil is left wondering how in just three years two tailings dam collapsed — and to agonize about the safety of its other thousands of dams.\(^1\) Investors want to know how this may affect Vale’s valuation as well as where they may be vulnerable to more of these risks, especially as some factors that contribute to tailings dam collapses are becoming more common.\(^2\)

This paper examines the causes and repercussions of the recent tailings dam collapse at Vale, and examines which other companies and regions face similar risk factors.

KEY FINDINGS

- Risk factors for tailings dam failures are increasing. Mine grades (the amount of valuable commodity per ore) continue to decline leading to higher generation of mine wastes; extreme weather events also intensify risk of collapses and are projected to increase in frequency.
- Changing weather patterns may unwind the parameters used decades ago to design some tailings dam structures, before climate change was considered.
- Tailings dam collapses are preventable. Neglected maintenance, weak oversight and poor risk management often are the culprits for these major environmental disasters.
- Among metal mines owned by constituents of the MSCI ACWI Index, Brazil has the most metal mines in the world that are in high flood-risk areas, but China has an almost equal number. Neither country has a strong record in mining environmental performance.
- We identified eight companies, which compared to Vale, have a higher percentage of their global production value located in areas of high flood risks — all of which also have poor environmental management scores — such as other Brazilian companies Companhia Siderurgica Nacional and Gerdau and Chinese-listed companies Jiangxi Copper and Tongling NonFerrous.

\(^1\) https://www.reuters.com/article/us-vale-sa-disaster-dams/brazil-has-nearly-4000-dams-at-high-risk-minister-idUSKCN1PN1UG

BACKGROUND: FINANCIAL IMPLICATIONS OF TAILINGS DISASTERS

Tailings, the milled remains of earth separated from its economic commodities, present one of the most dangerous and costly long-term risks for mining companies.

On January 25, 2019 the dam near Brumadinho, Brazil, built for Vale’s Corrego do Feijao mine, collapsed—launching a tsunami-like flood of more than 12 million cubic meters of mine waste slurry. Company and community buildings were buried or washed away, along with the people inside. As of February 25, 179 people were confirmed dead and a further 131 were missing.

This disaster occurred before Vale had finalized its heavy liabilities and remediation costs from the last time it experienced a major tailings collapse, in November 2015 at the Samarco operation (a joint venture between Vale and BHP Billiton). The dam at Samarco spilled an estimated 60 million cubic meters of waste and killed 19 people as it decimated communities and fragile ecosystems flooded by a 400-mile-long deluge. Samarco has spent at least USD 3.5 billion in remediation and faces lawsuits seeking damages of over USD 40 billion. Having a second tailings dam failure compounds the costs to Vale in several ways:

- **Capital:** Within a week of the incident at the Corrego do Feijao mine, Vale announced a suspension of dividends and share buybacks, and the Brazilian government froze over USD 2.9 billion in Vale assets.  

- **Personnel:** The Samarco incident prompted a reevaluation of Vale’s governing board and management teams; the fallout from Corrego do Feijao may speed more turnover. Some Vale executives, employees and contractors may also face civil or even criminal charges.

- **Liabilities:** The second disaster could strengthen claims of negligence against Vale in pending lawsuits.

- **Social License to Operate:** Local opposition to Vale operations is likely to increase. Given the close proximity of Corrego do Feijao and Samarco, challenges to the mining company’s social (and legal) license to operate are likely to escalate in the region.

We estimate 33 percent of its production value is located within 100 miles of Corrego do Feijao. Already, Brazilian authorities have ordered Vale to close several of its operations.

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Figure 1: Vale mines within 100 miles of Corrego do Feijao represented approximately 33% of 2017 production

Source: MSCI ESG Research, SNL Metals and Mining, ALOS World 3D – 30m (AW3D30) Version 2.1

IDENTIFYING RISK FACTORS FOR TAILINGS DAM COLLAPSES

Stakeholders are searching for answers for how this could happen. Investors want to know where else it could.

While tailings dam collapses remain rare, they may be increasing in frequency. A study by UN Environment published in 2001 pointed out that high-consequence tailings failures have been increasing since 1990; more recent studies show further increases. Dams holding back tailings generally have a higher failure rate than other types of dams, in part because they are made of earthen materials, sourced from the mined land that generates the tailings. Earthen dams statistically have more structural failures than mines fortified with cement, a material often used in common hydroelectric dams.

Two primary causes account for about 80 percent of all dam failures: (1) “overtopping” i.e. insufficient flood or spillway capacity or (2) quality issues, usually problems with piping. To assess companies’ vulnerability to these issues, we have identified several factors that increase these risks. While we view overtopping as a result of both systemic trends in the industry and idiosyncratic risks related to the location of the assets, quality problems tend to result primarily from failures in governance and risk management.

Figure 2: Primary Causes of Dam Failures and Associated Risk Factors

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>RISK FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overtopping</td>
<td>• Pushing capacity limits</td>
</tr>
<tr>
<td></td>
<td>• Exposure to flood risks and extreme weather events</td>
</tr>
<tr>
<td>Quality Problems</td>
<td>• Lagging environmental management commitments</td>
</tr>
<tr>
<td></td>
<td>• Failures in governance, oversight and risk management</td>
</tr>
</tbody>
</table>


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1. SYSTEMIC RISKS: INCREASING VOLUME AND WASTE RATIOS

Rich ore deposits at the scale sufficient to satisfy project financing are becoming ever scarcer, yet the world's appetite for metals continues to grow. Consequently, mining companies have developed new technologies to economically process lower-grade ore that deliver higher waste ratios.\(^{11}\) Mine grades (the amount of valuable commodity per ore) for most metals have been on a declining trend for much of the past century.

**Figure 3: Declining Mine Grades Lead to More Waste**

![Graph showing declining copper grades and increasing waste ratios over time.](image)

Source: World Mine Tailings Failures Organization

2. CLIMATE CHANGE: INCREASING FLOODING AND EXTREME WEATHER EVENTS

Dams collapse when their systems are overwhelmed with pressure, often the result of deficient capacity or equipment to manage an influx of water. One of the most common causes of dam collapses is therefore from extreme weather events.\(^{12}\)\(^{13}\)

**Figure 4: Primary Causes of (All) Dam Failures in the U.S. 2010-2015**

![Bar chart showing the number of incidents by cause of dam failure.](image)

Source: US Association of State Dam Safety [https://damsafety.org/dam-failures](https://damsafety.org/dam-failures)

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\(^{12}\) US Association of State Dam Safety; [https://damsafety.org/dam-failures](https://damsafety.org/dam-failures)

Climate change presents a major escalation of this risk, as it may increase the frequency and severity of weather events. Hundred-year storms (i.e. storm of a size and strength not expected more than once every 100 years) are increasing in frequency while forests and other natural water-absorbing resources are being replaced with less permeable development in many parts of the world. Flood-control systems designed decades ago can be quickly overrun by the rise in water levels.

Inadequate drainage, which may be quickly overwhelmed by extreme weather events, can saturate embankments sapping its strength in a process known as liquefaction, a factor cited in the Samarco event. There were also reports that there were drainage problems at the dam that collapsed at the Cerrego do Feijao mine (WSJ, Kowsmann).

Looking back at 31 worldwide tailings failures recorded since 2012, 42 percent occurred in areas of high precipitation or high flood risk.

Figure 5: Past Tailings Dam Collapse Incidents and Flood Risks

3. QUALITY PROBLEMS: FAILURES IN MANAGEMENT AND OVERSIGHT

At Brumadinho, although the dam collapsed late in its rainy season (when groundwater tables were elevated), there were no reports of massive flooding prior to the collapse. Instead, early reports suggest the primary cause was quality problems. Vale's allowing this to occur, especially a second time since November 2015, strongly point toward failings in management and governance.

While corporate governance at Vale had been under reform since the Samarco incident, neither internal nor external controls were strong enough to prevent the recurrence of a major tailings dam failure. We noted weaknesses for Vale at each of the following levels:

1. Operational Management
2. Board-Level Oversight
3. Regulatory Oversight

OPERATIONAL TAILINGS MANAGEMENT

In 2016, after the Samarco event, the International Council of Metals and Mining (ICMM) completed a review of tailings dam management. It concluded that "an increased emphasis on governance is needed to ensure that extensive existing technical and management guidance is more effectively applied."\(^{14}\)

Vale was not part of the ICMM when the Samarco event occurred because of a dispute with another member company but Vale rejoined in October 2017. Nonetheless, Vale failed to meet the standards set forth in the ICMM guidelines:

**Figure 6: ICMM's Six Key Elements of Tailings Storage Facility (TSF) Governance Framework**

<table>
<thead>
<tr>
<th>ICMM TSF Governance Key Elements</th>
<th>Weaknesses in approach by Vale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Accountability, Credibility, and Competency</td>
<td>Vale had an executive director in charge of tailings management, but the company's board lacked enough technical or operational experts to ensure safety and operational integrity.</td>
</tr>
<tr>
<td>2 Planning and Resourcing</td>
<td>The dam at Corrego do Feijao that collapsed was being decommissioned, but was designed as an “upstream” tailings dam. This design is common mostly because it is cheaper than other methods, albeit with a higher risk of failure. Past auditor reports also stated that there were major problems with the drainage system of</td>
</tr>
</tbody>
</table>

\(^{14}\) *International Council on Metals and Mining (ICMM). December 2016. icmm.com/tailings-report*
the dam; yet damage and mistakes during installations were not properly fixed.  

### 3 Risk Management

Contrary to risk management considerations, Corrego do Feijao's employee facilities and community buildings were built downstream from the tailings. Also it was reported in the media that the dam at the Corrego do Feijao did not have a seismic monitor. Official investigations indicated that a small quake played a role in the Samarco event (WSJ).

### 4 Change Management

The Corrego do Feijao mine, estimated to be 43 years old, was acquired by Vale in 2001, which later expanded production there. Dam inspectors indicated that they lacked necessary details of the construction and foundation of the dam that collapsed (WSJ). Further, changes in Vale management and board since the Samarco event may have increased risks in knowledge transfer.

### 5 Emergency Preparedness and Response

Vale admitted that warning sirens did not sound after the breach. The company stated that this occurred due to the speed at which the event unfolded.

### 6 Review and Assurance

Vale hired TUV SUD to act as its dam safety inspector, but the same firm was also hired as a consultant, which presents conflicts of interest (WSJ). Government safety and environmental regulatory enforcement may also have been compromised due to Vale's prominence and connection to the state.

Source: MSCI ESG Research, ICMM, WSJ, Vale

The enormous engineering challenge of managing tailings dams requires not only sufficient funding but also skilled management to prevent material mishaps. We have seen that this is another area where Vale has underperformed.

In and out of Brazil, Vale has been implicated in numerous environmental controversies and local opposition to its operations such as at its Brazilian Onca Puma operation. In 2017, the company reported it faced a total of about 70 land disputes. At the end of 2018, we estimated that more than 18 percent of its in-situ reserves value was at risk of community opposition over environmental damage or disturbance, despite strong conservation initiatives the company attempted.

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15 Kowsmann, Patricia and Patterson, Scott. Wall Street Journal "Inspectors of Vale Dam in Brazil issued Warning Before Collapse." February 6, 2019
PRINCIPAL RISKS: LACK OF EXPERTISE AND INDEPENDENCE

The firm's connections to the state may also have resulted in lenient regulatory oversight. The Brazilian government has long had a stake in the company and holds "golden shares" that entitle it to extraordinary voting and veto powers. In 2017, Vale made changes to its ownership structure and management to lower government influence. As part of the shareholding structure changed, former Vale CEO Murilo Ferreira stepped down in 2017. He was viewed as a non-political appointee, but allegedly had political ties to the administration of former Brazilian President Dilma Rousseff, who faced charges of corruption. Ferreira was appointed as chairman of Petrobras, a powerful government-controlled oil and gas company, during the Rousseff administration. Rousseff was impeached in 2016 during the fallout of a corruption scandal the year prior.

Despite these changes and losing majority control, Vale's controlling shareholder, Valepar, which is largely controlled by state pension funds and the state development bank (BNDES), retained 38.7% ownership and over half of the director positions. None seemed to have the technical skills necessary to understand and prevent major engineering failures. We noted the company lacked an industry expert on its audit committee. In fact, we deemed only one member of its 12-person board as having industry expertise: Mr. Oscar Augusto de Camargo Filho, whose expertise comes from being a former executive in the industry. But his background is in law and business. Overall, the expertise of the directors on the board strongly tilted toward finance, rather than the operational side of management. Vale's new CEO seems to have understood this risk in hindsight. On February 1, after the dam burst, he was quoted as saying, "I'm not a technician. I followed the technicians' advice and you see what happened. It didn't work." 

It was not as if tailings risks were off the radar of Vale management, especially since Samarco. The company had announced steps to increase dry processing of ore to lower its need for dams and their risks from 40 percent (in 2016) to 70 percent by 2023. It also announced intent to acquire a company in December 2018 that is developing a dry process technology. But now it is forced to accelerate these plans to move away from unsafe dams, closing 10 facilities and 10 percent of its production at an estimated cost of USD 1.4 billion.

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17 According to Salim Mattar (current Secretary of Privatization and Debureaucratization of the Ministry of Economy) as of February 13, 2019, the government intends to lessen its participation in Vale through the reduction in the shares held by the state pension funds. https://economia.uol.com.br/noticias/reuters/2019/02/13/governo-quer-reprivatizar-a-vale-diz-secretario-de-desestatizacao.htm


IDENTIFYING VULNERABLE ASSETS

MINE-LEVEL EXPOSURE TO FLOOD RISKS

We identify 371 mining sites (out of 2,554), with primary ownership by constituents of the MSCI ACWI Index, situated within high flood-risk zones. Of these, 184 are hardrock metal mines, which generate more tailings waste than that of coal (although coal still has tailings in most cases).

Figure 7: Mines owned by companies listed in MSCI ACWI* and High Flood Risks

Source: MSCI ESG Research, World Resources Institute Aqueduct Global Maps 2.1, 2015, SNL Metals and Mining

Brazil is home to the highest number of these metal mines in flood zones, which raises the bar on the need for strong management. However, China has an almost equal number of mines (owned by MSCI ACWI constituents) that are in flood-prone areas. Brazil's mines are slightly older on average than China's (average startup date of 1982 vs 1992), but neither has a stellar record in preventing tailings dam incidents.

* MSCI ACWI constituents as of February 5, 2019
Figure 8: Countries With the Most Metal Mines in Flood-Zone Risk Areas

Metal mines in high-risk flood areas owned by MSCI ACWI constituent companies as February 5, 2019

![Bar chart showing the number of mines in high flood risk areas by country.]

Source: MSCI ESG Research, Global Flood Hazard Frequency and Distribution from Columbia University, and Center for International Earth Science Information Network, SNL Metals and Mining

Figure 9: Potential Damage of Tailings Dams in Brazil

![Map showing potential damage of tailings dams in Brazil.]

Source: MSCI ESG Research, WorldClim data for monthly precipitation in mm, ~1km, SNL Metals and Mining, Agência Nacional de Mineração: Brazil’s Tailings Dam Database
COMPANIES MOST AT RISK: HIGH FLOOD RISK AND POOR ESG MANAGEMENT

About 10 percent of mines located in high flood-risk areas face or have faced environmental controversies in the past 10 years. Strong commitments by mining companies in operational controls, quality and oversight of operations are important to prevent major accidents. We evaluate companies’ management capacity to prevent mishaps through their governance structures, policies, programs and track record in preventing environmental mishaps.

Companies with high exposure to flood risks and poor records in preventing environmental controversies are in the worst position relative to tailings risks. We identify four companies that, compared with Vale, have a higher proportion of global mine production value in high flood-risk areas and lag in environmental performance: Jiangxi Copper Company Limited, Tongling Nonferrous Metals Group, Companhia Siderurgica Nacional (CSN), and Gerdau. Note the latter two companies are Brazilian, but are integrated steel producers and therefore mining represents only a minority of their assets. The first two companies are based in China.

Other companies to note for this potentially dangerous exposure include the following:

- **Tahoe Resources.** Its Escobal mine in Guatemala faces high risks for both flood and seismic events. The mine has faced community opposition and regulatory suspensions.

- **Zijin Mining** had a tailings dam fail in 2010 that killed 22 people. It also partially owns the Porgera mine in Papua New Guinea (PNG) that uses a controversial riverine tailings disposal method.

- **Coal India** manages 81 coal mines in high flood-risk areas. One of its coal ash dams spilled in 2015 and allegedly polluted the Damodar River in Jharkhand state in India.
Figure 11: Companies with Mines in Flood Zones and Environmental Performance

Our Environmental pillar scores with a max score of 10 and min score of 0 are derived by assessing companies' exposure, management and performance on key environmental issues. For the diversified mining industry these key issues include Toxic Emissions & Waste, Biodiversity & Land Use, Carbon Emissions, and Water Stress. The graph below compares our assessment of companies' environmental performance and the proportion of their 2017 global mining production in areas with high flood risks. For details, see Appendix.

CONCLUSION

Major tailings dam failures are preventable. The technologies needed to manage tailings are available but not always used, and the frequency of these events is increasing. Given the high costs of failure, investors are searching for ways to identify potential investments at risk. Important considerations include commitments to operational excellence and oversight, characterized by independence, expertise and strong performance at preventing environmental and safety accidents. Strict regulatory enforcement is also an important component in stakeholder assurance. For state-owned companies, independence, and therefore assurance, could be compromised without third-party auditors. Investors may also want to consider characteristics at the asset level. Low-grade mines require a proportionally inverse degree of waste management, and this waste management may be getting more difficult for assets facing elevating flood risks from climate change-induced extreme weather.
APPENDIX:

COMPANIES WITH MINES IN FLOOD ZONES

The following table details the proportion of companies' global production in areas of high flood risks as well as corresponding details of our assessments of their ESG performance that can indicate a company's capacity to prevent major environmental or social accidents.

<table>
<thead>
<tr>
<th>Company</th>
<th>Volume</th>
<th>Exposure to Flood Risk</th>
<th>Environmental Management</th>
<th>Governance</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Tailings in 2017</td>
<td>% of 2017 global production in High-Risk Flood Areas</td>
<td>Mines in Flood Areas /Total Mines</td>
<td>Toxic Emissions and Waste Management Score (0-10 scale)</td>
</tr>
<tr>
<td>Companhia Siderurgica Nacional (CSN)</td>
<td>ND</td>
<td>100.0%</td>
<td>3/5</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Gerdau</td>
<td>ND</td>
<td>100.0%</td>
<td>1/1</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>Jiangxi Copper Company Limited</td>
<td>55,000,000</td>
<td>100.0%</td>
<td>8/9</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Tongling Nonferrous Metals Group</td>
<td>ND</td>
<td>100.0%</td>
<td>11/11</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Shenzhen Zhongjin Lingnan Nonfemet Company Limited</td>
<td>ND</td>
<td>100.0%</td>
<td>3/3</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>Tata Steel Limited</td>
<td>ND</td>
<td>85.9%</td>
<td>12/24</td>
<td></td>
<td>5.1</td>
</tr>
<tr>
<td>OceanaGold Corporation</td>
<td>**10,977,217</td>
<td>56.6%</td>
<td>4/14</td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td>Coal India Limited</td>
<td>ND</td>
<td>41.0%</td>
<td>81/136</td>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td>Vale S.A.</td>
<td>729,200,000</td>
<td>40.7%</td>
<td>33/63</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>Hudbay Minerals Inc.</td>
<td>30,545,163</td>
<td>35.8%</td>
<td>2/24</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>Tahoe Resources Inc.</td>
<td>ND</td>
<td>26.2%</td>
<td>1/16</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Anglo American Plc</td>
<td>479,119</td>
<td>25.8%</td>
<td>5/41</td>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>PT Aneka Tambang Tbk</td>
<td>ND</td>
<td>25.2%</td>
<td>6/31</td>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Zhongjin Gold Corporation Limited</td>
<td>ND</td>
<td>21.9%</td>
<td>4/27</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Zijin Mining Group Company Limited</td>
<td>**155,886,740</td>
<td>21.2%</td>
<td>12/69</td>
<td></td>
<td>3.5</td>
</tr>
</tbody>
</table>
## Volume

<table>
<thead>
<tr>
<th>Company</th>
<th>Total Tailings in 2017</th>
<th>% of 2017 Global Production in High-Risk Flood Areas</th>
<th>Mines in Flood Areas / Total Mines</th>
<th>Toxic Emissions and Waste Management Score (0-10 scale)</th>
<th>Environment Pillar Score (0-10 scale)</th>
<th>Corporate Governance Global Percentile Ranking</th>
<th>ESG Rating Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>South32 Limited</td>
<td><strong>16,649,000</strong></td>
<td>13.1%</td>
<td>1/25</td>
<td>2.9</td>
<td>2.1</td>
<td>100%</td>
<td>A</td>
</tr>
<tr>
<td>Yamana Gold Inc.</td>
<td><strong>25,973,389</strong></td>
<td>12.4%</td>
<td>1/21</td>
<td>4.2</td>
<td>3.4</td>
<td>65%</td>
<td>BBB</td>
</tr>
<tr>
<td>AngloGold Ashanti Limited</td>
<td>ND</td>
<td>11.8%</td>
<td>9/37</td>
<td>4.9</td>
<td>3.5</td>
<td>85%</td>
<td>B</td>
</tr>
<tr>
<td>Silvercorp Metals Inc.</td>
<td>ND</td>
<td>11.8%</td>
<td>2/8</td>
<td>3.1</td>
<td>2.2</td>
<td>68%</td>
<td>B</td>
</tr>
<tr>
<td>Peabody Energy Corporation</td>
<td>29,584</td>
<td>11.4%</td>
<td>31/74</td>
<td>2.7</td>
<td>2.9</td>
<td>73%</td>
<td>BBB</td>
</tr>
<tr>
<td>Barrick Gold Corporation</td>
<td>52,184,268</td>
<td>9.6%</td>
<td>4/88</td>
<td>4.3</td>
<td>1.8</td>
<td>82%</td>
<td>BB</td>
</tr>
<tr>
<td>ArcelorMittal</td>
<td>ND</td>
<td>8.5%</td>
<td>18/41</td>
<td>4</td>
<td>2.5</td>
<td>40%</td>
<td>B</td>
</tr>
<tr>
<td>Glencore Plc</td>
<td>2.129 *10^9</td>
<td>7.5%</td>
<td>9/154</td>
<td>2.7</td>
<td>3.0</td>
<td>88%</td>
<td>BB</td>
</tr>
<tr>
<td>Compania de Minas Buenaventura</td>
<td>ND</td>
<td>2.8%</td>
<td>1/27</td>
<td>3.1</td>
<td>1.8</td>
<td>71%</td>
<td>B</td>
</tr>
<tr>
<td>Shandong Gold Mining Co., Ltd.</td>
<td>ND</td>
<td>2.6%</td>
<td>2/15</td>
<td>1</td>
<td>0.8</td>
<td>39%</td>
<td>CCC</td>
</tr>
</tbody>
</table>

*Source: As of February 19, 2019 MSCI ESG Research, SNL Metals and Mining*

**2016; ND = Not disclosed; Lagging performance (bottom third of total scoring) is highlighted in red**
# Mines in High Flood-Risk Areas

This sample of mines includes mines found in areas of high flood risk that either have faced environmental controversies and/or are owned and operated by poorly rated companies.

<table>
<thead>
<tr>
<th>Owner Name</th>
<th>Property Name</th>
<th>Primary Commodity</th>
<th>Country</th>
<th>Actual Start-Up Year</th>
<th>Mill Capacity (tonnes/yr)</th>
<th>% of 2017 Global production</th>
<th>Controversies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglo American Plc</td>
<td>Los Bronces</td>
<td>Copper</td>
<td>Chile</td>
<td>1925</td>
<td>48,840,000</td>
<td>23%</td>
<td>Archived - Minor</td>
</tr>
<tr>
<td>Hudbay Minerals Inc.</td>
<td>Constancia</td>
<td>Copper</td>
<td>Peru</td>
<td>2015</td>
<td>31,000,000</td>
<td>36%</td>
<td>Minor</td>
</tr>
<tr>
<td>Glencore Plc</td>
<td>Antapaccay</td>
<td>Copper</td>
<td>Peru</td>
<td>2012</td>
<td>23,100,000</td>
<td>4%</td>
<td>Archived</td>
</tr>
<tr>
<td>Barrick Plc</td>
<td>Pueblo Viejo</td>
<td>Gold</td>
<td>Dominican Republic</td>
<td>2013</td>
<td>7,920,000</td>
<td>10%</td>
<td>Severe</td>
</tr>
<tr>
<td>Tongling Nonferrous Metals Group</td>
<td>Dongguashan</td>
<td>Copper</td>
<td>China</td>
<td>2004</td>
<td>4,300,000</td>
<td>77%</td>
<td>Archive - Minor</td>
</tr>
<tr>
<td>OceanaGold Corporation</td>
<td>Didipio</td>
<td>Gold</td>
<td>Philippines</td>
<td>2013</td>
<td>3,500,000</td>
<td>39%</td>
<td>Moderate</td>
</tr>
<tr>
<td>South32 Limited</td>
<td>Cerro Matoso</td>
<td>Nickel</td>
<td>Colombia</td>
<td>1982</td>
<td>3,000,000</td>
<td>13%</td>
<td>Very Severe</td>
</tr>
<tr>
<td>OceanaGold Corporation</td>
<td>Waihi</td>
<td>Gold</td>
<td>New Zealand</td>
<td>1988</td>
<td>2,050,000</td>
<td>18%</td>
<td>Minor</td>
</tr>
<tr>
<td>Tahoe Resources Inc.</td>
<td>Escobal</td>
<td>Silver</td>
<td>Guatemala</td>
<td>2014</td>
<td>1,640,000</td>
<td>26%</td>
<td>Severe</td>
</tr>
<tr>
<td>Yamana Gold Inc.</td>
<td>Minera Florida</td>
<td>Gold</td>
<td>Chile</td>
<td>1986</td>
<td>830,000</td>
<td>12%</td>
<td>Archived</td>
</tr>
<tr>
<td>Gerdau S.A.</td>
<td>Miguel Burnier</td>
<td>Iron Ore</td>
<td>Brazil</td>
<td>ND</td>
<td>ND</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Companhia Siderurgica Nacional (CSN)</td>
<td>Casa de Pedra</td>
<td>Iron Ore</td>
<td>Brazil</td>
<td>1913</td>
<td>ND</td>
<td>96%</td>
<td></td>
</tr>
<tr>
<td>Coal India Limited</td>
<td>Eastern Coalfields</td>
<td>Coal</td>
<td>India</td>
<td>2007</td>
<td>ND</td>
<td>7%</td>
<td>Moderate</td>
</tr>
<tr>
<td>Coal India Limited</td>
<td>Bharat</td>
<td>Coal</td>
<td>India</td>
<td>2007</td>
<td>ND</td>
<td>6%</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

*Source: MSCI ESG Research, SNL Metals & Mining*
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