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VIEWS

Sustainable Exploration—A Major's Perspective

INTRODUCTION

The theme of the recent AMIRA Exploration Managers Conference, *Smart Exploration: Insights, Technologies and Practices*, highlighted the key ingredients which must be integrated to develop a sustainable exploration program by specifically focusing on the role and interplay between innovative geological insight, improved technology, and more effective and efficient practices in successful exploration.

For Anglo American Exploration (AAE), sustainable exploration means delivering on safe discovery and maintaining continued access to land, resources, talent, and funding throughout the commodity cycles. This has involved the discovery of a pipeline of Tier1 deposits, achieved through exploring safely and responsibly to strengthen the Group's project portfolio. This result has ensured that AAE continues to be a key provider of both long-term growth and value addition for the Group.

Over the last decade, AAE discovered 15 base metal deposits and has been recognized by the Metals Economics Group (MEG) as one of the most successful base metal explorers. Our discovery odds and costs are in the lower quartile of industry benchmark whilst the resource tons and grade are in the top quartile.

Exploration success, best-in-class performance, and industry recognition as a leading exploration group ensure AAE's internal and external credibility. This is critical to ensuring the ongoing board support and a long-term commitment to funding. Key success factors to maintaining our competitive advantage include discovery track record, strong management support, maintaining social license to operate, and advancing exploration's geographic, scientific, and technical frontiers.

The role of exploration in major companies has been greatly debated in recent times; critically, it has been suggested

that junior companies are more successful and cost efficient. AAE's recent record has demonstrated that exploration can still provide a major company with growth opportunities and can distinguish it from its peers.

INDUSTRY CHALLENGES

The exploration and discovery business faces three key challenges: improving the declining rate of discovery, reversing the trend of increasing costs and lead time, and maintaining our license to operate. From my perspective as an explorer, our business ultimately is all about discovery, delivering value, and providing options for growth. Importantly, successful exploration and finding new ore deposits are people driven and team effort.

However, the challenge of maintaining our license to operate should not be underestimated. In particular, how do we as an industry attract and retain people? The current generation of graduates expects the employer to "do the right thing," to work safely and minimize the impact on both the communities and the environments in which they work. In addition to being at the forefront of exploration innovation and technology, we also need to advance our social frontiers if we wish to have continued access to land, resources, and talent.

In other words, we need to balance risk and reward when selecting the what, where, and how to explore. To build a competitive business for now and future generations and improve the industry's discovery track record, we need to continue to expand our geographic, scientific and technical frontiers. Partnerships at all levels are critical; this includes communities, industry, academia, and government coming together as necessary to help deliver on the commitment to advance scientific understanding and discovery for the benefit of society.

The singularly most important contribution geoscientists can make to society is the discovery of new deposits. In particular, given that the majority of the mining industry's wealth is captured in a few world-class mines, it is these rare

Tier1 deposits that provide the industry with the best opportunity to make a positive and lasting contribution to society.



GRAHAM BROWN
(SEG 1999 F)
Anglo American
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ANGLO AMERICAN EXPLORATION AT A GLANCE

The mining and exploration industry has three choices in providing options for growth: discover, acquire, or innovate! Discovery is creating value by finding new ore deposits; acquisition is recognizing value by quantifying the "blue-sky" potential to justify the premium paid; and innovation is unlocking value through technology developments. For example, there are many dormant deposits that have not been developed due to technological challenges, such as difficult mineralogy; recent advances in metallurgy are providing new processing options to bring these known deposits into production.

Anglo American's exploration business continues to be a major differentiator for the Group, with many of the discoveries contributing to the company's future growth and project pipeline, as well as adding substantial value to our existing assets and operations. In 2011, we spent \$121 million on exploration activities in 16 countries and we are active in all six Group operating regions; Africa, Asia, Australia, Europe, and North and South America.

Exploration and technology have both been identified as key enablers to deliver Anglo American's growth strategy. To be the explorer of choice, AAE is focused on four strategic pillars: safe discovery, leading explorers, global footprint, and targeting world-class assets in the most attractive commodities. AAE has successfully delivered value across three time horizons (1, 5, and 10 years) by adopting a distinctive frontiers approach (geographic, scientific, technical, and social) to exploration and discovery. This combination has maximized the financial return and optimized value for Anglo American.

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The key strategic drivers are resource replacement to extend the life-of-mine, asset upgrading to improve project pipeline quality, discovery track-record that provides options for business growth, and risk mitigation by both geographic and commodity diversification. In addition, the relative role of exploration and acquisition in business development varies by commodity, risk appetite, and the quality of both the internal project pipeline and growth opportunities available through merger and acquisition activity.

AAE focuses on the discovery of new mineral deposits and evaluation of existing resources. Activities include both greenfield and brownfield exploration. Our teams use a combination of traditional fieldwork and innovative technologies developed through industry partnerships, and both collaborative and one-on-one research programs. This has resulted in the development of leading-edge in-house discovery tools.

The team also balances geological prospectivity with country risk, focusing on the what and where rather than the how to explore. Years of operating around the world in key frontiers has provided the Group with strategic insights when identifying and assessing new areas of geography, commodities, business development opportunities, and the relative likelihood of securing and maintaining our licence to operate.

R&D Advancing Science and Discovery

Advancing R&D (research and development) frontiers and the discovery of new Tier1 deposits is key to future exploration success, value-creation, and delivering a commercial competitive advantage. Recent examples of innovative and cutting-edge technologies that have advanced science and discovery in both exploration frontiers and near mine environments include the following examples:

- The Sakatti polymetallic deposit is a greenfield discovery, located 150 km north of the Arctic Circle in the Lapland tundra of Finland. For this project, a closed-system drilling mud technique, involving complete recycling of muds and removal of drill cuttings, was developed in partnership with a local drill contractor. This discovery tool significantly reduced costs and the environmental impact, affirming our license to operate.

- The Gergarub polymetallic deposit is a brownfield discovery, located 8 km from the Skorpion mine, in the Sperrgebiet desert, Namibia. The Low Temperature Superconducting Quantum Interference Device (LT SQUID) is a new generation ground electromagnetic geophysical system for enhanced detection of orebodies that was developed in a one-on-one collaboration with the Europe-based Institute for Photogenic Technologies (IPHT). Advantages are greater sensitivity and depth penetration plus improved signal to noise ratio, which when combined with enhanced data interpretation techniques provides an additional targeting vector. This high-resolution instrument contributed to the discovery of Gergarub and also played a role in the discovery of two further massive sulfide deposits undercover in Africa and Europe.
- The Los Sulfatos base metals deposit is another brownfield discovery, located 8 km from the Los Bronces mine, above 4,000 m in the high Andes, Chile. A competitive tender process awarded a contract to an international engineering consortium to develop an 8 km exploration tunnel using a Tunnel Boring Machine (TBM). This was the first time TBM technology has been used in a near-mine exploration-stage project. This evaluation technology is safer, faster, and lower cost than the traditional drill and blast method and provides year-round access and drilling platforms.

Industry Recognition and Awards

In 2011, the industry recognized our discovery track record, expertise, and leadership in base metals exploration with two major awards and a number one ranking. AEE was presented with the PDAC (Prospectors and Developers Association of Canada) and FEM (Fennoscandia Exploration and Mining) discovery awards for the Los Sulfatos and Sakatti discoveries, respectively, and the Group was ranked by the MEG as the most successful major base metals exploration team during the period 1999–2010.

Over the last decade, AAE delivered 15 base metal discoveries and nearly 50 Mt of contained metal, including eight greenfield and seven brownfield successes in both exploration frontiers and

near mine districts, respectively. During this period the geosciences and exploration management team provided the broad leadership experience and practical insights required to build and maintain a competitive global exploration and discovery business.

Interestingly, 10 of these discoveries crop out and relied on traditional geological fieldwork as an important discovery method. In addition, seven are located in Chile, an established exploration environment that some have thought of as mature. This is contrary to current perceived wisdom throughout much of the exploration community, that all the major outcropping orebodies are found, technology will provide the silver bullet to improve the discovery rate, and only high-risk countries are underexplored and prospective.

Key success factors include a safe discovery culture, high-quality exploration teams (so-called hunting packs) innovative geologic thinking, appropriate discovery tools and evaluation technologies, continuous senior management support, consistent funding through the commodity cycles, and time to build local knowledge and operating capabilities.

Industry Benchmarking and Metrics

MEG recently announced that the 2011 nonferrous exploration spend was at a new all-time high (more than \$18 billion). However, the relative amount spent on grassroots exploration is at a historical low (33%), which is the net effect of industry consolidation, focus on low-risk brownfield exploration, and the fact that the majority of juniors, which account for up to 50% of the worldwide exploration budget, only recycle known properties.

According to some estimates, less than 20% of the exploration budget is spent on high-risk grassroots regional programs. If this trend continues, the question for the industry is who will make the next generation of Tier1 deposit discoveries.

Recent Australia Mining and Exploration Council (AMEC) industry reviews on discovery rates and costs indicate that on average only one to two Tier1 discoveries are made each year, and the unit cost per discovery is \$2.6 billion, an increase of two to three times over the last decade. For comparison, AAE net exploration and evaluation expenditures per Tier1 deposit discovery was

\$125 million. The clear message is that Tier1 deposits are rare and being an average explorer is not sustainable; this will ultimately result in gamblers' ruin and value destruction.

The MEG benchmark of base metal discovery and acquisition metrics over the last decade highlights AAE as being in the lower quartile discovery cost (c/lb) and upper quartile in quality (tons and grade). Persistence and a focus on quality have resulted in AAE's discovery odds of less than 100 to 1, much better than the industry rule of thumb of greater than 1,000 to 1.

In addition, nearly \$600 million was returned to the Group from asset sales of both noncore commodities and deposits that failed to meet minimum investment criteria. This combination of a venture capital funding model and focused portfolio management resulted in low net exploration expenditures, averaging \$25 million per annum during the period 1999–2010.

SUSTAINABLE EXPLORATION

Successful Exploration and Discovery is a major differentiator in terms of leadership, expertise and value creation. In the

past the priority was focused on finding and building mines, whereas today the focus has changed to include building partnerships on all levels of society.

Future success and sustainable exploration requires delivery on advancing exploration of frontiers, maintaining access to land, mineral resources and talent, and providing options for growth through discovery, acquisition, and innovation. For AAE, this means a pipeline of Tier1 deposit discoveries achieved by safe discovery, enabling both continued long-term growth and the addition of value for the Group. 

Erratum: SEG Lima Proceedings

An incorrect Abstract appears in the Proceedings for the XVI Congreso Peruano de Geología and SEG 2012 Conference, published on a USB flash drive for attendees at the meeting.

The correct Abstract for poster no. 40, submitted by Ignacio González-Álvarez et al. for the SEG Posters section, appears below. It will also appear in the online SEG bookstore (www.segweb.org/store), as a publication in the SEG Conference Series, 2012.

Poster 40 (Ext. Abstract)

Hydrothermal Ni: Doriri Creek, Papua New Guinea

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The Doriri Creek (DC) Ni-Pd-Pt prospect was discovered in 1966 in the Papuan Ultramafic Belt (PUB) in Papua New Guinea (PNG). Lindley and Kirakar interpreted the DC as a hydrothermal Ni accumulation in 2007. The DC is located in the southern area of Mt Suckling (~180 km SE of Port Moresby), where local intrusive rocks associated with the Suckling area are intermediate to acid dikes and small stocks. The DC prospect is located within the tectonized Australian and Woodlark plate contact. The active volcanoes of Mount Victory and Waiowa indicate thermal activity in the area.

The PUB has been interpreted as a Jurassic-Cretaceous SW Pacific ophiolitic nappe obducted onto the Owen-Stanley Metamorphic Complex during the Eocene, forming a ~400-km-long, 25- to 40-km-wide belt of peridotites overlain by a suite of gabbros and basalts, with a total thickness ranging from 14 to >20 km.

The Doriri Creek prospect is the result of episodic hydrothermal fluids flowing through the major Doriri fault that resulted in Ni concentration (grades up to 1.55 wt % nickel, up to ~15 m width and <500 m long) during the alteration of an ultramafic unit of peridotites/pyroxenites within an Mg-rich gabbro-norite envelope. Ni is concentrated in chlorite and serpentine group minerals and in Fe oxides, with a minor amount in pentlandite in locally sulfidic samples. The ore mineralogy is also associated with a high concentration of phosphorus in

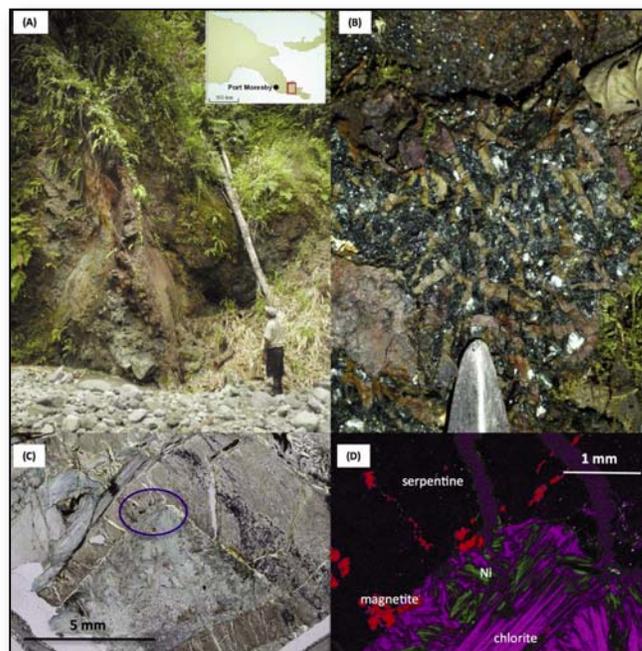


FIGURE 1. (A) Overview of the Doriri Creek outcrop. (B) Mineralized sample zone, displaying coarse flakes of chlorite, bands of serpentine, and oxidized magnetite containing 1.26 wt % Ni. (C) Transmitted-light image of sample D18PNG11; (D) element map of the selected area in (C). Element map display Ni (green), Al (purple) and Fe (red) distributions. Ni is located here within chlorite.

the form of apatite that concentrates LREE (Light rare earth elements). Palladium concentrations correlate with Te-Se and Ni content in the ore samples analyzed for this study, which are enriched in Pd up to 0.37 ppm. Platinum is present in concentrations up to 0.06 ppm. PPM reports costean sample grades with 14 m width at 1.25 wt % Ni and 0.65 g/t Pd + Pt.

The Doriri Creek alteration halo is narrow, ~100 m in width, and more pronounced to the west than to the east, and is characterized by enrichments of U, K, and W over background values, as well as a local magnetite concentration of up to ~35% whole rock, which is very pronounced in the sulphide-rich area of the system that is part of a fine stockwork that occurs throughout the magnetite at depth. The top part of the DC system is overprinted by tropical weathering, which displays REE fractionation, characterized by LREE enrichment and positive Ce anomalies. 