




U.S. Mines to Market

Prepared for
The National Mining Association

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Report is published by

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Project Brief

SNL Metals & Mining has in excess of three decades of experience in the resource sector, providing strategic consulting services to mineral explorers, mine developers, commodity producers, equipment suppliers, the service sector, financiers, trade associations and governments.

The SNL mining database covers over 3,500 listed companies and 40,000 projects, and the consulting team augments this unrivalled source material with trend analysis, in-depth data assessment and industry surveys.

In early 2014, the National Mining Association commissioned SNL Metals & Mining to carry out a study to demonstrate the extent to which minerals produced in the U.S. contribute to the domestic manufacturing industries. The aim of this report is to provide a comprehensive, yet accessible and engaging report for wide readership, including the public and policy makers.

SNL Metals & Mining undertook the necessary research into domestic supply and demand chains for the U.S. mined commodities and their contribution to the manufacturing sector. Key minerals highlighted included copper, gold, iron ore, molybdenum, platinum group-metals, rare earths, silver and zinc. Information was gathered from SNL Metals & Mining's internal database and through interviews with key stakeholders in the U.S. mining industry.

Mark Fellows
Director, Consulting
SNL Metals & Mining
London
September 9, 2014

Executive Summary

In early 2014, the National Mining Association commissioned SNL Metals & Mining to carry out a study tracking the minerals mined and refined in the U.S. through to their end-use in finished products. The aim was to demonstrate the extent to which minerals produced in the U.S. feed domestic manufacturing industries.

This study has revealed numerous examples of domestic mine production supporting domestic manufacturing. The report also highlights several current trends that provide policymakers with a real opportunity to ensure that miners, manufacturers, consumers and the country as a whole derive more benefit from an optimized supply chain.

The consumption of metals and minerals is integral to the standard of living that Americans enjoy. The Mineral Information Institute estimates that the average American born in 2013 will depend on over their lifetime some 3 million pounds of minerals, metals and fuels. The 27,416 pounds of iron ore, 978 pounds of copper, 521 pounds of zinc and 1.8 ounces of gold, among other minerals and metals, will allow the average American to drive safer cars on better roads and bridges, live in sustainable buildings, use laptops and smart phones and generally enjoy a high quality of life.

A key finding of this report relates to a gross structural mismatch between domestic mineral supply and demand. Although the United States is a major mining country, it enjoys a much higher global ranking as a manufacturer than it does as a miner.

The United States is the world's largest manufacturing nation, followed closely by China and Germany. Value added to gross domestic product (GDP) by major American industries that consume processed mineral materials was $2.4 trillion, or 14 percent of total GDP in 2013. Given its world-class mineral resources and reserves, the United States has the potential to supply even more of the minerals needed to satisfy this domestic manufacturing demand.

Yet the United States is only the seventh largest global producer of metallic and industrial minerals, producing $74.3 billion worth of mineral raw materials (including industrial minerals) in 2013. The country is a top-ten producer for a number of metals (including copper, gold, silver, zinc and iron ore), but it is import-dependent on numerous key materials that are essential for manufacturing (most notably lithium, platinum, zinc, cobalt and rare earth elements).

Metals and minerals are required for both traditional manufacturing outputs, such as automobiles and consumer appliances, new frontier technologies and for both conventional and alternative energy generation. For example, more than 8,000 pounds of copper are needed to manufacture one wind turbine, 9 pounds of nickel are used in every hybrid vehicle and 9 pounds of lithium are required to produce a single battery for an electric vehicle.

A second key finding relates to developments in manufacturing, including its returning to American soil, a phenomenon referred to as re-shoring. This move is being driven by manufacturers' desire to reduce the risks in their supply chains, which are highly complex, fragmented and multi-layered, often extending to more than seven tiers of suppliers for any given product.

Furthermore, U.S. consumers and, in turn, manufacturers and their shareholders, are increasingly concerned with corporate accountability. Consumers want to see evidence of sustainable production processes, use of recycled materials, sound environmental practices and that raw materials are not sourced from conflict zones. The "Made in U.S.A." label is inherently reassuring to consumers in these regards.

A third key finding relates to the competitive advantages of the U.S. mining industry. Relative to their global peers, miners in the United States are highly efficient, often exemplifying best practices with regard to productivity, sustainability and safety. The United States remains highly prospective, from a geological point of view, with abundant, diverse mineral resources of high quality. While the country's mining sector is ideally positioned to support manufacturers' need for greater sustainability and shorter supply chains in the production process, an outdated, inefficient permitting system presents a barrier to American companies' access to the minerals they need and thus to economic competitiveness.

SNL notes that, despite the challenges, numerous manufacturers are already sourcing their raw material needs from the American mining sector. For example:

- Stillwater Mining, the only platinum-group metals (PGM) miner in the United States supplies catalytic convertors for the country's automobile sector through refiner and fabricator Johnson Matthey.
- Cliffs Natural Resources is an independent, owner-operator mining company supplying iron ore to the United States and global steel-making industries.
- Materion Corp has developed from humble beginnings as a miner of beryllium in 1931 to become a supplier of high technology products to the aerospace and defense sectors.

SNL concludes that the contribution of the mining sector in the United States, through a well-managed, sustainable supply chain, contribute significantly in further strengthening the country's manufacturers and economy.

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SECTION 1. INTRODUCTION

The first section of this report introduces the mining sector in the United States of America, and highlights its salient features. The second section takes a look at key minerals in the domestic mining industry, focusing on the cost competitiveness of the sector. The third section then shifts focus to the country's manufacturing sector, highlighting examples of the contribution of the mining sector to domestic manufacturing. The final section provides conclusions on the importance of the raw material supply chain to the U.S. manufacturing sector.

The history of the United States is intertwined with its mining heritage. The California Gold Rush of 1849, and the subsequent silver and gold strikes at Colorado's Pikes Peak and Leadville and Nevada's Comstock Lode, are part of a strong, and enduring, American tradition of exploration, resilience and the push to create better lives. The boom towns that sprang up across the "Wild West" not only supplied gold and silver, but also zinc, copper and lead, feeding the industrial revolution that would catapult the United States to become the world's largest economy in 1871.

The United States now accounts for one-fifth of global Gross Domestic Product (GDP). It leads the world in high technology (Silicon Valley), finance and business (Wall Street), higher education (17 of the top 20 universities in the world), and global foreign direct investment (17 percent of global net inflows - $236 billion in 2013).

The United States additionally is one of the world's oldest continuously functioning democracies, dating back to 1776. The country's stock markets reflect America's leadership of global financial markets, and it has a strong global trade profile thanks to massive exports of consumer and technology goods, and the import of natural resources. Many of the top global brands are American, including Apple, Google, IBM, Coca-Cola, AT&T, Microsoft and Visa.

Following the 2008 global recession, the United States economy's return to growth has been stronger and faster than its European counterparts, and the world continues to look to America to drive future growth. The International Monetary Fund's long-term outlook for the U.S. economy is for growth to accelerate to 2.8 percent in 2014 and to 3 percent in 2015.

The U.S. economy and society is founded on a stable political environment, the rule of law, technical expertise, skilled labor and the American entrepreneurial spirit. The United States remains at the frontier of new technologies and innovation across different sectors, from manufacturing and consumer products to the pharmaceutical industry. Fuelling this growth is the natural resources sector, comprising agricultural production, minerals and metals, and energy.

To ensure the continued sustained growth of the national economy, a stable, reliable and flexible supply of raw materials is essential. However, despite being the world's leading manufacturer, the United States is ranked only seventh in terms of global minerals and metals production. This is a significant fall from 1990 (see section 1.3), when it was the largest metallic and industrial minerals producing country in the world. The focus of this report is not on the reasons for this decline, but the importance of secure, reliable supply of materials to the domestic manufacturing sector, which may be best served by a strong domestic mining industry. The study also addresses obstacles to a strong mining industry and a reliable supply chain.

1.1 MINE TO MARKET CHAIN

The "production" of mined commodities (minerals and metals), such as copper and iron ore, have unique characteristics relative to the production of manufactured goods. Minerals and metals tend to have standard specifications and grades, and, because of the ease with which commodities can be compared and traded, there is often a global pricing mechanism. There is little or no after-sales service required.

For metals that are not traded on exchanges, such as tantalum or rare earths, there can be variations in grade and specifications. Products can be tailored to specific uses, and there can be competition in areas other than price (such as quality, delivery schedules and processing advice). Ultimately, the economics of the mineral industry (see table p8) are driven by the balance between supply and demand, with these factors influencing, and being influenced by, commodity prices and the level at which these metals and minerals re-enter the supply chain through the recycling of intermediate and final products.

The mine-to-market chain starts at the grassroots exploration stage, where prospectors and exploration companies seek indications of mineralization. Investigative drilling and reserve definition are used to ascertain whether a viable orebody has been identified. A feasibility study will then be prepared that charts the financial indicators for the mining project.

If sufficient investment funding is secured, and the required permits and licenses obtained, the project will be developed if it is economically viable to do so. Once the

TABLE 1 ECONOMICS OF THE MINERAL INDUSTRY

Factor	Indicator	Characteristics	Drivers
Demand	Commodity consumption	• Consumption is mainly for properties rather than intrinsic value • Substitution by another commodity is often possible • Inelastic to price in short term, but more responsive in longer term	• Population, geography, transport, availability, income levels, economic structure, technology, social trends, government regulations, prices
Supply	Availability costs	• Geological availability is fixed by nature • Most minerals are plentiful, but the cost of extraction determines whether they can be considered as readily-available "supply" • Cost of capital during permitting and licensing periods	• Ore grade, ore content, location, input prices, scale of operations, type of mining, technology, depletion, general economic factors, by-products and inventories
Pricing	Market forces	• Balance between supply and demand, and speculative elements • For major metals, determined on international exchanges	• Costs, nature of product, recycling, economic activity, inventory movements, exchange rates, confidence and speculation
Recycling	Reusage rates	• Metals are seldom consumed, and recycling contributes to differing degrees to supply	• End uses, technology, product life, regulation, recovery rates

Source: SNL Metals & Mining

mine is constructed, ore and concentrate production takes place.

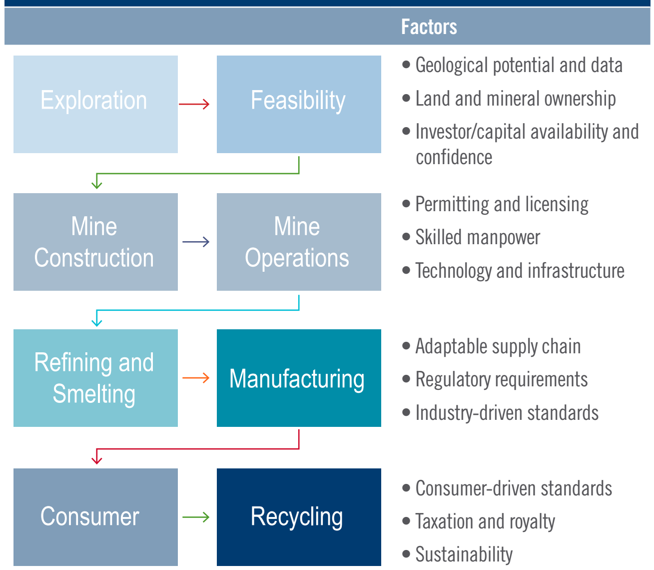
From discovery to first output, the development process for a mine can take in excess of 10 years, and cost several billion dollars. Factors that affect timelines and the mining chain are listed in Figure 1.

There are a number of factors that affect the length and timeline for this chain. For example, at the very start, prospecting activity will be affected by the land area available. Exploration may not be allowed on protected lands, even if they are rich in mineral deposits. For example, national parks and monuments, American-Indian reservations, military camps and scientific testing areas, and most wildlife-protection areas are not open for exploration or mining. The Bureau of Land Management administers more than 258 million acres of public land and 700 million acres of subsurface minerals across the country. The management of these lands, including permission for mineral exploration and mining, is guided by the principle of multiple use and sustainability.

Once a suitable orebody has been located and delineated, the time and difficulty associated with obtaining permits and licenses to construct and operate a mine can be significant barriers to development. For example in the United States just at the federal level, a mining operation commonly requires permits under each of the following:

- Federal Clean Water Act (Section 404)
- National Pollutant Discharge Elimination System
- Air Quality Act (Title V)
- Environmental Impact Statement

FIGURE 1 MINE-TO-MARKET CHAIN



Source: SNL Metals & Mining

Also, each individual state requires additional permits and licenses at the local level. These combined processes can take more than seven years to obtain.

The intermediate product from a mine (ore, concentrate or impure metal) is usually shipped to a smelter, and subsequently refined to a common quality specification that can be used as input into the manufacturing and construction sector. Once the product has come to the end of its useful life, the metal can usually be recycled.

Once ore has been mined and processed, there are various stages in the chain from producer of refined metal to manufacturer and consumer. At each stage, documentation is required that relates to the source of the

INDUSTRY STRUCTURE IS INFLUENCED BY:

- Number of producers
- Level of corporate diversification
- Primary versus by-product commodity
- State involvement
- Regulatory restrictions
- Barriers to entry
- Nature of end uses, and
- Concentration of production

original material (largely to prevent use of minerals from conflict zones). Often required are assessments of life-cycle impact and recycled-material content.

Consumers in mature economies are increasingly concerned with how products are produced, and from where. Consumer-driven standards related to environmentally friendly, fair wage and sustainably-sourced products are increasing. Examples include coffee that is "Fair Trade," to , wood products that are certified by the Forest Stewardship Council, renewable energy and materials that are conflict-free.

In the U.K., for example, the Eden Project, which is a sustainability-education center in Cornwall, became one of the first sites to utilize metal that could be traced from mine to construction site. The project assesses responsible-sourcing schemes, and seeks to influence policy at the U.K.'s Building Research Establishment and at the British Standards Institute.

The Eden Project specifically sourced its copper from Kennecott Copper's Bingham Canyon mine in Utah. This showcased the company's material stewardship program because of the high environmental and social standards maintained by Kennecott.

Initiatives in the metals and mining sector range from the Fair Trade Gold scheme (focusing on gold produced by artisanal miners) to the Coltan Fingerprint program by Germany's BGR (Federal Institute for Geosciences and Natural Resources). The latter initiative distinguishes the place of origin of tantalum ore as a measure against conflict minerals originating in the Democratic Republic of Congo. Other global standards include the e-sustainability Initiative Supply Chain and the Electronic Industry Citizenship Coalition. The latter is designed to improve the environmental and labor performance of mineral and metal suppliers to the electronics industry.

These initiatives apply to the entire mine-to-market chain; knowing the supplier is becoming as important as knowing the customer. Detailed oversight of overseas suppliers is inevitably more difficult to achieve than for local sources of supply. For this reason, U.S. manufacturers would benefit from a better understanding of the domestic mining industry.

Minerals play an important part in economic development, as highlighted in section 1.2, and the mining sector in the United States provided the raw materials for the country's industrialization at the start of the 19th century. While the country still ranks in the top 10 global metallic minerals producers, the expansion of this sector has become largely stagnant in the past two decades, as highlighted in section 1.3.

1.2 IMPORTANCE OF MINERALS

The 2003-2008 boom in commodity prices saw international prices for metals and other commodities nearly quadruple. This was largely fueled by demand from China, whose economy is at a resource-intensive stage; with each small incremental increase in GDP requiring a relatively large amount of raw materials. While this story has dominated headlines in the commodity markets, the demand for metals and minerals from mature economies remains critical.

A country's path of economic growth normally starts from an agricultural base, with manufacturing and the services sector making relatively small contributions to the economy. As surplus labor and capital are shifted from agriculture to the manufacturing sector, the latter becomes more important for economic growth. Urbanization inevitably follows, as does increased labor productivity.

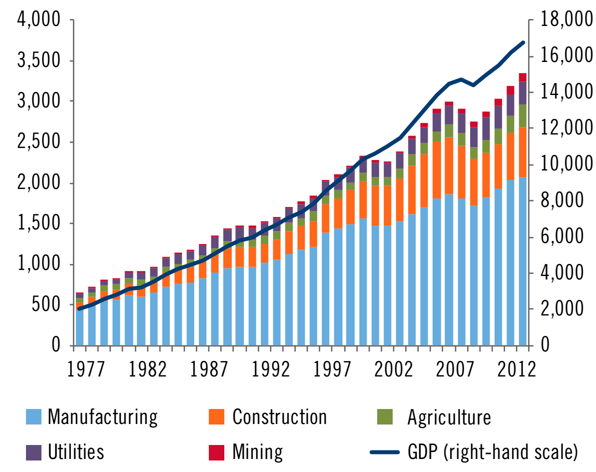
With further development, the mainstays of the economy become technology, innovation and a skilled work force. Eventually the service sector becomes the dominant contributor to the economy. An advanced or mature economy, such as the United States, relies heavily on its service sector to generate growth and employment, while manufacturing takes a lesser role.

In the late 1940s, manufacturing in the United States accounted for around 25 percent of U.S. GDP and about one third of all non-farm jobs. By 2013, it accounted for just 12 percent of U.S. GDP and about one in eleven of non-farm jobs. By way of comparison, agriculture's share of value added is now only around one percent while the services sector generates nearly 80 percent of the value added to U.S. GDP (U.S. Bureau of Economic Analysis).

Figure 2 shows the value added from different sectors to the U.S. economy over the past four decades. The manufacturing sector has been the dominant contributor to the economy; followed by construction, utilities, agriculture and mining (the services sector is excluded from this comparison).

The actual contribution of the mining sector to the economy is much deeper than reflected in the figure as its output fuels growth in the other four sectors. Refined-metal products, such as steel, are extensively used in the construction sector; copper wires are a basic component of electricity infrastructure in the utilities sector; and machinery and other metal products are used in manufacturing. The heavily mechanized nature of the American agricultural sector means that metals are a major component for the machines that are employed in the sector.

FIGURE 2 VALUE ADDED TO U.S. ECONOMY BY SECTOR ($ billion)



Source: U.S. Bureau of Economic Analysis

In the case of mature economies, such as the United States, the intensity of metals consumption tends to taper off when GDP reaches around $20,000 per capita. Since the economy is older, the use of recycled material becomes more prevalent as there is more material available to be recycled. The investment in infrastructure and buildings tends to move towards replacement and upkeep, while the housing market may continue to expand.

At the personal level, the consumption of metals and minerals is an essential ingredient to everyday life. The average American born in 2013 will consume three million pounds of minerals, metals and fuels over his lifetime. The 27,416 pounds of iron ore, 978 pounds of copper, 521 pounds of zinc and 1.77 ounces (troy) of gold, among other minerals and metals (see also Table 2), will enable Americans to drive safer cars on better roads and bridges, live in sustainable buildings, use laptops and mobile phones, and live in a more sustainable economy.

TABLE 2 SELECTED MINERALS CONSUMPTION IN THE UNITED STATES (PER CAPITA ANNUALLY)

348 pounds iron ore	Used to make steel for buildings, cars, trucks, planes, trains etc. Also used directly in other construction
12 pounds copper	Used in buildings, electrical and electronic parts, plumbing and transportation
11 pounds lead	Almost 90 percent used for batteries in transportation. Also used in electrical components and communications equipment
7 pounds zinc	Used to make metals rust resistant. Also used in various metals and alloys, paint, rubber, skin creams, health care, and in nutrition
0.25 pounds uranium	Nuclear-energy program

Source: The Society for Mining, Metallurgy and Exploration Foundation (2013)

U.S. consumption of metals and minerals is going to continue at, or around, current levels. This demand is driven by the items people depend on, ranging from health and transportation to communication, energy and even national defense. This includes products like cell phones, laptops and cars – but also buildings, infrastructure, lifesaving medical devices and body armor. The U.S. mining and manufacturing industries are mutually supportive – without access to minerals and metals, the technologies and every-day products we rely on would cease to exist.

However, with rising demand from China, domestic metals consumption in the United States will have to be fulfilled from an increasingly competitive global market; supply security will not only be an issue of geological availability but also of politics and economics. A strong domestic base of mineral producers will prove essential to supply security in the United States.

During the 1970s, issues around supply security focused more on price issues (following the sharp rise in oil prices) and less on limitations in physical supply. In the 1980s and 1990s, the supply issues moved towards environmental and social considerations, with a focus on minimizing damage to the environment and to local communities from mining operations. In the 2000s, the commodity price boom has shifted the debate towards the issue of access.

The increase in metal prices during the first decade of the new millennium was rooted in a fundamental gap between booming demand and a lagging supply. The current decade is about securing reliable long-term sources of minerals and metals.

The United States is a top five global producer of oil and agricultural products, and continues to be in the top 10 nations for a number of other important minerals, including copper, gold, silver, zinc and iron ore. Nevertheless, the United States suffers from a reliance on imports for many minerals.

This import dependence is of particular concern with regard to critical and strategic metals and minerals. These are defined as: "materials required for defense and national security needs" and "those materials for which the United States is largely import dependent, for which no viable economic substitute exists, or for which there is concern over the source (for geopolitical reasons) or the supply (for market reasons)."[2]

Domestic production can reduce the risk of supply disruptions, particularly for metals where foreign supply is subject to geo-political risk. China and its dominance of rare-earths production has brought into sharp focus the supply risk from trade restrictions. More recently, Indonesia's restriction on nickel concentrate exports has threatened nickel supply lines.

As a rising number of resource-rich developing countries look towards adding value to their mined products, for example by processing the raw ore into a more valuable product the incidence of such restrictive policies is likely to increase. Greater domestic metal production is a viable strategy to combat such international risk.

Unfortunately, the permitting process for new mineral and metal mines in the United States makes it harder to reduce the dependence on foreign-sourced raw materials. For a better, more sustainable and resilient U.S. economy, the responsible extraction of secure domestic mineral resources must be prioritized. The sector is examined in the next section.

1.3 DOMESTIC MINING SECTOR

The U.S. Geological Survey (USGS) estimates that $74.3 billion worth of mineral raw materials were produced in the United States during 2013, a slight decline from the $75.8 billion mined in 2012. This shortfall was attributable mainly to lower metals and minerals prices. Net exports of raw material and old-scrap generated $15.8 billion. Domestic raw materials and domestically-recycled materials were used to process mineral materials worth $665 billion. The consumers of these materials (including the net imports of $24 billion of processed materials) added an estimated $2,440 billion to the U.S. economy in 2013.

In 1990, the United States was the world's largest producer of metallic and industrial minerals. By 2013, the country had fallen to seventh place in the global ranking, with output accounting for less than 5 percent of the value of global mined output. China, Australia, Brazil, Russia, Chile and South Africa all ranked ahead of the United States.

TABLE 3 CHANGE IN MINED PRODUCTION VOLUME FOR TOP FIVE PRODUCERS (2000-2013)

Country	Copper	Country	Molybdenum	Country	Iron Ore
World	**36%**	**World**	**100%**	**World**	**101%**
Chile	24%	China	227%	Australia	245%
U.S.	-15%	U.S.	49%	Brazil	74%
Canada	-0.3%	Chile	15%	China	156%
Zambia	254%	Peru	152%	Russia	22%
Congo (Dem Rep)	2,497%	Mexico	70%	U.S.	-19%
Country	**Zinc**	**Country**	**Gold**	**Country**	**Silver**
World	**55%**	**World**	**10%**	**World**	**41%**
China	164%	China	170%	Mexico	78%
Peru	48%	Australia	-12%	Peru	51%
Australia	5%	U.S.	-36%	Australia	-13%
U.S.	-11%	South Africa	-61%	U.S.	-45%
Canada	-57%	Canada	-18%	Canada	-47%

Source: SNL Metals & Mining

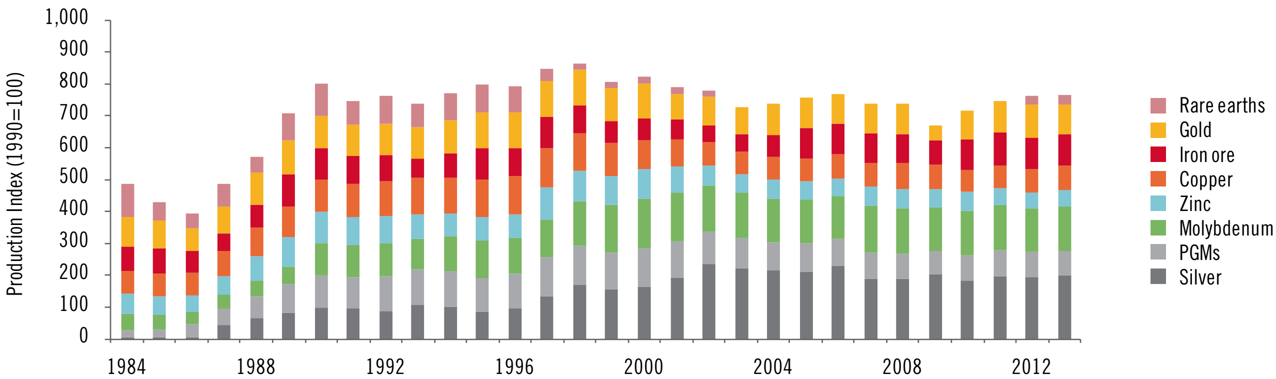
The decline in rank can be attributed largely to two factors: stagnating production in the United States, and increasing output elsewhere.

While the production for all major metals has increased globally during the past decade (Table 3), the output in the United States has not increased markedly, and other countries have outperformed the U.S. mining sector. For example, Chile, the largest global producer of copper, has increased its production by 24 percent during the past 13 years, while copper production in the United States has declined 15 percent. Australia managed a greater than three-fold increase in its iron-ore production, while output in the United States declined 19 percent. Similarly, global production for zinc, gold and silver increased by 55 percent, 10 percent and 41 percent, respectively, while production for these metals in the United States fell 11 percent, 36 percent and 45 percent, respectively.

Figure 3 reflects the level of mined production

[2] DOD, Reconfiguration of the National Defense Stockpile Report to Congress, pg1

FIGURE 3 PRODUCTION INDEX FOR MAJOR U.S. MINED OUTPUT (1990 = 100)



Source: SNL Metals & Mining

(as an index) for major metals in the United States This production index reflects tonnage, to strip out the effects of the commodity price boom of 2003-2008. The base year (1990) has been selected to better reflect the changes in production levels over the past two decades.

Production levels in the United States increased between 1986 and 1990 but, since then, mined output in the country has remained stagnant. While this report is not focused on the operating environment in the U.S. mining industry, the next section outlines the main impediments to growth. These impediments include delays in the granting of licenses and permits, rising capital and operating costs, and a recent reduction in exploration.

1.4 BARRIERS TO U.S. MINING GROWTH

Despite the relative decline, the United States remains home to some of the largest mines in the world. Examples include the Climax molybdenum mine in Colorado, the Red Dog zinc-lead mine in Alaska, the Newmont Nevada and Cortez gold mines in Nevada, the Morenci copper mine in Arizona and the Greens Creek multi-metallic mine in Alaska.

Canada's Fraser Institute produces a Policy Perception Index based on an annual survey of mining and exploration companies. These executives provide an assessment of a jurisdiction's mineral endowment and public policy factors. In 2013, Wyoming was ranked as the jurisdiction with the 5th highest international score; 93 out of a maximum possible score/rating of 100. Sweden received the highest score with 95, and other U.S. states included in the top 20 of the 112 regions were Nevada (ranked 8th), Minnesota (15th), Utah (16th) and Michigan (17th).

The mineral endowment of the United States cannot be disputed, and the individual states tend to score well for political stability, infrastructure and the skill of their labor force. However, regarding other factors, such as environmental regulations and uncertainty concerning the interpretation and enforcement of regulations, very few companies report the United States as a region that encourages domestic mining investment.

Respondent to the Fraser Institute's survey assess whether particular policy factors "encourage investment," are "not considered a deterrent to investment," are a "mild deterrent to investment," or are a "strong deterrent to investment."

Table 4 summarizes U.S. results for domestic mineral potential and the perceptions on enforcement of existing regulation and environmental regulations. Overall, the mineral potential of the United States is ranked as having the potential to encourage investment. For example, 73 percent of the respondents reported that, because of its mineral endowment, Alaska would be an "encouraging place to invest." However, the voting was conditional on the state adopting a world-class regulatory environment and highly competitive taxation.

When asked about existing regulations, the scores for the United States tended to deteriorate. The majority of respondents felt that, while not a deterrent to investment, the uncertainty concerning the administration and the interpretation/enforcement of existing regulations were not encouraging. With regard to environmental regulations, the positive responses fell further, with a majority of mining-sector stakeholders reporting that uncertainty over these regulations were a mild deterrent to investment.

TABLE 4 PERCEPTION OF THE U.S. MINING SECTOR*

	Mineral Potential (%)[a]	Uncertainty of Existing Regulations (%)[b]	Uncertainty Concerning Environmental Regulations (%)[c]
	Encourages Investment	Not a Deterrent	Mild Deterrent
Alaska	73	30	43
Arizona	51	50	43
California	41	10	32
Colorado	37	35	39
Idaho	45	52	42
Michigan	48	33	43
Minnesota	35	38	41
Montana	47	29	32
Nevada	68	41	26
Utah	56	55	26
Washington	21	23	41
Wyoming	43	50	17

** The Fraser Institute asked respondents whether the mineral potential, uncertainty over existing regulations and uncertainty over environmental regulations had the effect of "encouraging investment," were "not consider a deterrent to investment," are a "mild deterrent to investment," or are a "strong deterrent to investment." The table above indicates the percentage of respondents who agreed with the particular statements.*

a: Mineral potential, assuming policies based on best practices (i.e., world class regulatory environment, highly competitive taxation, no political risk or uncertainty and a fully stable mining regime)

b: Uncertainty concerning the administration, interpretation and enforcement of existing regulations

c: Uncertainty concerning environmental regulations

Source: Adapted from Fraser Institute's Survey of Mining Companies: 2013

1.4.1 Licensing and permitting delays

In the United States, the length of the permitting process has consistently eroded the country's attractiveness as a mining-investment destination. Earlier this year, in its annual report entitled "Where not to invest," consultancy company Behre Dolbear singled out permitting delays as the most significant risk to mining projects in the United States.

Prior to commencing construction or mining at an operation numerous permit approvals from federal, state and local agencies need to be obtained. The precise nature and number of permits required can be quite variable, and depend significantly on the project details, the land and mineral ownership i.e., federal, state or private) and the state in which the project is being developed. Multiple permits and multiple agency involvement is the norm, as is the involvement of other stakeholders including tribes, nongovernmental organizations and the public. As a result, mine permitting commonly involves overlapping requirements, redundant reviews and multiple bureaucracies.

Mines located on federal lands must obtain approval from the relevant federal land management agency (BLM or Forest Service), a major federal action that triggers preparation of the appropriate level of environmental analysis pursuant to the National Environmental Policy Act (NEPA). NEPA analyses, which in and of themselves generally involve multiple agencies and many stakeholders, are often the lengthiest step in the permitting process due to a lack of agency coordination and lack of timeframes. Additionally, even if a mine is located entirely on federal lands, it will be subject to state laws and regulations governing mining and environmental regulations and therefore, will need to obtain multiple state permits (i.e., air and water quality permits). Alternatively, a mine located entirely on state or private lands frequently will need to obtain federal permits that trigger NEPA environmental analyses (i.e., Clean Water Act 404 permit issued by the Army Corps of Engineers). Even a mine that requires no federal permits may not escape a lengthy NEPA process as several key mining states have adopted a state equivalent of NEPA.

As a consequence of its inefficient permitting system, it takes on average seven to ten years to secure the permits needed to commence operations. To put that into perspective, in Canada and Australia, countries with similarly stringent environmental regulations, the waiting period is two years.

The Rosemont Copper project, which potentially could be the third largest copper mine in the country, provides a real world example of the types of delays that plague the U.S. permitting process (see box below).

1.4.2 U.S. mining cost competitiveness

In general terms, mining in the United States is at a disadvantage, compared with many jurisdictions, because of the age of many of its operations, the country's high wage rates and demanding health, safety and environmental regulations. However, high productivity – including the benefit of large operations, which create significant economies of scale, and modern equipment – enables the country to compete competitively with many lower-cost economies.

Given that metal prices are generally priced in U.S. dollars, it should be noted that when the United States

ROSEMONT COPPER – STILL WAITING

Augusta Resources' Rosemont project near Tucson in Arizona is a large copper-molybdenum project, expected to produce 243 million pounds of copper once it goes into production, making it the third largest project in the United States.

The company is committed to setting high standards for environmental protection, creating an average of 2,900 jobs each year in Arizona and contributing $19 billion into the Arizona economy. Its commitments to sustainability include the use of solar and renewable energy for its administrative buildings, using less than half the water used by traditional miners, the use of new technologies to protect air quality and a reclamation process that starts from the first day of operations.

When in production, the Rosemont mine will provide more than 10 percent of U.S. copper demand, while requiring less than half the land area of other regional mines. However, as of July 2014, Rosemont is still awaiting final permits that will allow the mine to go into production.

The company has been embroiled in the permitting process for over seven years, and has conducted more than 450 technical studies. The table below outlines the timeline for the company's permitting processes. Rosemont's case is not an exception, but the rule when it comes to permitting delays in the United States.

ROSEMONT'S COPPER PERMITTING TIMELINE

2007	• Mine plan of operations filed
2008	• NEPA process launched, Environmental Impact Study initiated • Permit for mine water supply approved
2009	• Approval received for Reclamation Plan and Economic Impact Study • USFS delays DEIS issuance
2010	• USFS delayed DEIS released for additional study and modelling
2011	• USFS delivers preliminary DEIS to state and local agencies • Certificate of Environmental Compatibility issued
2012	• Public comment period for DEIS concluded • Aquifer Protection Permit approved • USFS delays the DEIS release for additional study
2013	• Air quality control permit obtained • USFS published Record of Decision and comments on final Environmental Impact Study
2014	• ACOE continues to evaluate Clean Water Act 404 Permit • USFS to take additional time to review comments on Record of Decision • July 2014: Awaiting Final Permit

DEIS: Draft Environmental Impact Statement

Source: Adapted from Rosemont Copper company presentations dollar is strong, low-cost mining countries can produce metals more cheaply, an effect that can be compounded when metal prices are low.

Figure 4 on p16 shows the average relative cash-cost competitiveness of mines in the United States over the past two years. The proportions of global production that have costs lower than for those in the United States are shown as a percentage of the global total.

The cost competitiveness of mining in the United States is heavily influenced by a range of technical and economic factors. These vary from commodity to commodity, and from mine to mine. Mining companies will seek to control costs, focusing on cost reduction as a primary means to improve their competiveness relative to the rest of the world, particularly when metal prices are low.

Technical factors include geological characteristics such as ore grades (metal content of mined ore) and by-product metals, but also the amount of waste rock that must be moved (the stripping ratio for surface mines, and the dilution factor for underground mines). The hardness of the ore, the complexity of the minerals and the size of the mine are also important. For example, low ore grades, hard ore, high strip ratios and complex minerals can lead to increased operating costs. Mining companies can influence these negative factors by using large mining equipment – especially where there are high strip ratios and/or low ore grades – to increase the economies of scale, or modern technology to extract metal from complex ores.

Ore grades can have one of the greatest impacts on the costs of mining and processing of metal-bearing ores. A ton of lean ore requires no more capital, energy, labor and supplies to mine than a ton of rich ore. However, because the rich ore contains more metal, it requires less of these inputs per ton of metal recovered.

The gross tonnage basis for costs is particularly important in the mining industry, because ore grades are very low (typically 0.3-2.0 percent metal in the case of copper ore). At these low levels, small differences in ore grade represent large variations in tonnages of ore that are mined for each ton of metal recovered, and in turn lead to large variations in mining and milling costs.

Typically, operations in the United States have low mined ore grades for iron ore and copper, necessitating greater energy requirements to extract the ore despite the relatively low cost of electricity in the United States.

Economic factors can be influenced by fluctuations in currency exchange rates, and by price and salary inflation. These can greatly affect a producer's comparative (or relative) cost position. Other economic factors can also influence mining costs such as energy prices, wage rates and financing terms.

In general, mining is characterized by the large initial capital expenditure required to build a mine. This is especially problematic in remote locations or where the weather is inclement, and where there are considerable infrastructural requirements. As a result, access to cheap financing can be a significant cost advantage. Typically, funding terms (e.g., interest rates on debt) for U.S. mining projects can be more favorable than for developing countries where investors must accept higher levels of risk.

These factors can influence onsite costs from mining, through the stages of metal extraction (crushing/grinding, concentration, metal separation) to offsite charges (transport/shipping, smelting/refining and marketing). The age of an operation, and its size where a mining company is unable to establish the advantages of economies of scale, can materially affect costs.

Over the past decade, the global mining industry has faced significant cost inflation at the mine level, over and above that expected from normal country inflation. In the future, such a high level of industry-specific cost inflation is unlikely to be repeated. Nevertheless, although more moderate, there is an expectation of a continued above-inflation rise in costs. This will be due to shortages and higher cost of raw materials, spare parts and equipment and, more significantly, a skilled labor shortage. The mining industry has yet to come to grips with this structural gap in experienced personnel, which will be most acute in the developed world, particularly Australia, Canada and the United States.

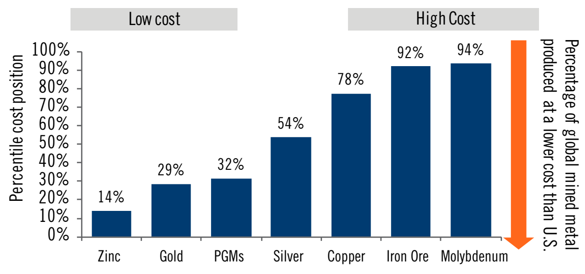
Labor is a significant component of onsite costs, for example accounting for approximately 25 percent of copper and zinc mining costs globally. Labor rates vary greatly with location, both internationally and within countries depending on proximity of desirable locations to live or the requirement for fly-in-fly-out practices. However, there is a clear difference between high and low wage economies (greater or less than $15/hour) with Australia, Europe, the United States and Canada having the highest labor rates, while the lowest can be found in China, Russia and Kazakhstan, followed by operations mainly in South America.

In the 1990s, after several downturns and layoffs, skilled personnel were lost to more stable employers with many younger people moving away from the more remote mining areas to towns and cities. The consequence of this period of attrition of skilled people is that at many mines around 50 percent of the employees are due for retirement over the next 10 years. Mining companies are taking steps to try and rectify the situation, but with mines competing with mining contractors for the same skilled workforce, there may once again be wage inflation, which will impact costs.

For the global mining industry, the offsite cost drivers over the past decade have remained relatively stable compared with onsite costs of energy and labor. Onsite costs (including machinery, spares, explosives and tires) increased quite markedly until the credit crunch in 2008. Costs in terms of metal produced are more ambiguous because the effects of offsite smelting, refining and product shipping costs have to be taken into account, plus changes in metal prices and the effects of by-product credits. Changes in grades can push costs in either direction, even before considering changes in offsite costs.

The United States is generally regarded as a high-cost producer of copper (78th percentile), iron ore (92nd percentile) and molybdenum (94th percentile), the latter indicating that up to 94 percent of the global metal production is produced at a lower cost. The country is more competitive for the production of gold (29th percentile), PGMs (32th percentile) and silver (54th percentile). The United States is one of the most competitive countries for zinc mining (14th percentile), driven largely by attractive geology and high ore grades. However, within each commodity there lies a range of low to high cost mines. The cost competitiveness for each individual metal mined in the United States is discussed in the next section.

FIGURE 4 RELATIVE COST COMPETIVENESS OF U.S. MINING (2012-13)



Source: SNL Metals & Mining

1.4.3 U.S. exploration limitations

The long-term health of the mining industry in the United States (as elsewhere) rests in finding new ore reserves to replace production.

Domestic mining companies had maintained a strong rate of exploration for much of the past 15 years but, unfortunately, there has been a recent decline in overall ore reserves. This shortfall has been accompanied by a dearth of high-quality new projects entering the pipeline, significantly lower discovery rates and deep caution regarding acquisitions.

The United States has a land area of some 3.54 million square miles, which equates to 7.1 percent of the world total. Its neighbor to the north, Canada, has an almost identical land area, whereas Australia has 2.94 million square miles (5.9 percent of the total).

Cumulative expenditure in the United States from 1999 to end-2013 for the discovery of new minerals and metals has almost exactly equated to this "fair share" geographical amount, although the country has been generally outspent by both Canada and Australia.

In the 15 years to end-2013, global exploration expenditure for non-fuels metals and minerals amounted to $119 billion, with the U.S. taking 7.7 percent of the total. Of this American expenditure, the majority was devoted to the search for gold (35 percent) and copper (24 percent).

In 1999-2013, gold exploration in the United States represented 9 percent of the global spend of $35.4 billion, compared with a 19 percent share in Canada and 12 percent in Australia. Global discoveries during this period (total reserves, resources and production) amounted to 674 million ounces, of which deposits in the United States contributed 12 percent. Deposits in Canada and Australia contributed 16 percent and 4 percent, respectively.

Copper-exploration budgets in 1999-2013 amounted to $17.4 billion, with $1.3 billion (7.3 percent) of this being targeted on the search in the United States. Some 391 million tons were discovered globally, with a creditable 11.3 percent of these being uncovered in the United States.

Recent trends have been less favorable, however. The budget for U.S. copper exploration last year was only $333 million, compared with a global total of $3.47 billion. The search for gold last year in the United States cost $520 million, which equates to about half of the country's total metals and minerals exploration budget.

Minerals and metals mined in the United States contribute greatly to the country's diversified and successful economy, and are supporting the return of manufacturing to U.S. soil. While it remains true that the building blocks of the economy rest on large-scale consumption of copper, steel, molybdenum and zinc, the role played by minerals consumed in smaller amounts, such as gold, silver, rare earths and platinum, is also important.

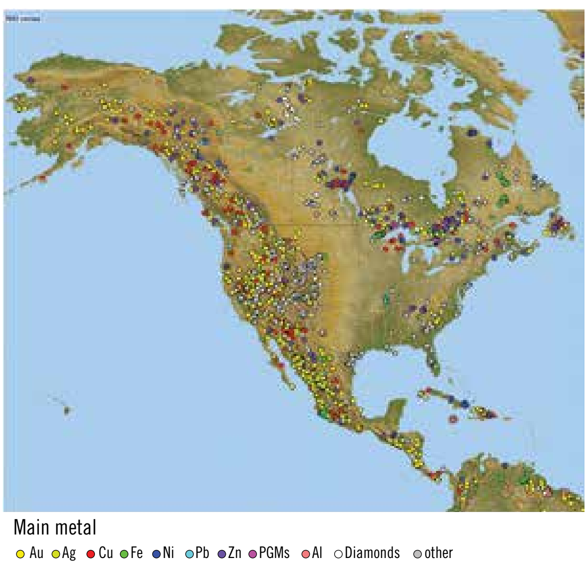
As the U.S. economy returns to historic growth rates, the need for minerals and metals grows too, and yet with declining relative production and growing demand, the country has become more import-reliant than a decade ago. The next section takes a more detailed look at select metals, their usage in the economy, supply and import dependency as well as cost competitiveness.

SECTION 2. MINING IN THE U.S.

The United States is the seventh largest global metallic and industrial mineral producer in the world; the USGS estimates the total value of U.S. metal mine production (excluding industrial minerals) in 2013 to be $32 billion, with gold (32 percent), copper (29 percent), iron ore (17 percent), molybdenum (10 percent) and zinc (5 percent) accounting for all but 7 percent of the total value.

More than half of U.S. copper production comes from Arizona; gold production is dominated by mines in Nevada; iron ore from Minnesota; molybdenum from Colorado and Arizona; PGMS from Montana; silver from Alaska and Nevada; and zinc from Alaska (see Figure 5).

FIGURE 5 NORTH AMERICAN MINES (2013)



Source: SNL Metals & Mining

According to the USGS, mined output in the United States includes barite, bentonite, beryl, boron minerals, cadmium, coal, copper, diamonds (although most U.S. output is from synthetic production), diatomite, feldspar, fuller's earth, gold, gypsum, iron ore (and steel), kaolin, lead, lime (quick and hydrated), mica, molybdenum, peat, perlite, platinum group metals, potash, pumice, rhenium, sand (and gravel), silver, soda ash, uranium, vermiculite and zinc; in addition to oil and gas production.

In its World Factbook 2014, the Central Intelligence Agency (CIA) lists the following resources as making a "significant" contribution to the U.S. economy, or as being likely to do so in the future: coal (the United States has the world's largest coal reserves, with over one-quarter of the world's total), copper, gas, gold, iron ore, lead, mercury, molybdenum, oil, phosphates, potash, rare earth elements, silver, tungsten, uranium and zinc.

This report focuses on eight metals in particular; copper, gold, iron ore, molybdenum, PGMs, Rare Earth Elements (REE), silver and zinc. The selected metals accounted for 93% of the value of U.S. mineral production in 2013. They are also widely used in the manufacturing and construction sector, contributing to both semi-finished products (such as metal fabrication) as well as consumer products (such as automobiles and computer equipment).

The remainder of this section draws an individual profile for each metal, highlighting its major uses, the consumption and supply patterns for the United States, and comments on foreign dependency and supply security for the country.

The data presented for each metal has been drawn from a number of sources, primarily the SNL Metals & Mining database, and complemented with information from the USGS. The sector usage for each metal refers to the consumption patterns in the U.S. economy. Domestic ore reserves and the global share have been calculated to reflect mineral concentration that can be economically extracted in the current or near future. Net import reliance, as a share of apparent consumption, is calculated as imports minus exports plus an adjustment for government and industry stock changes. The "main supplier nations" section refers to the source of ore and concentrate imports.

Cost competitiveness of mines in the United States is based on cash costs per ton of metal output, which allows comparison to the prevailing price of the commodity, and is a widely accepted measure of competitiveness. This value excludes other costs, such as capital expenditure and corporate costs.

2.1 COPPER

Share in Sector Usage	Building construction (44%) Electric and electronic products (20%) Transportation equipment (17%) Consumer and general products (12%) Industrial machinery and equipment (7%)	
U.S. Reserves	Known total	390 billion tons
	Share of global reserves	5.7%
U.S. Mine Production	Total	1.3 million tons
	Share of global production	6.8%
	Share of U.S. reserves	3.1%
	Share of global reserves	0.2%
	Value of production	$9 billion
U.S. Exploration Budget	Total	$333.5 million
	Share of U.S. total	32%
Government Stockpile		None
Net import reliance as share of apparent consumption		36%
Main Supplier Nations	Unmanufactured	Chile (54%), Canada (24%), Peru (11%)

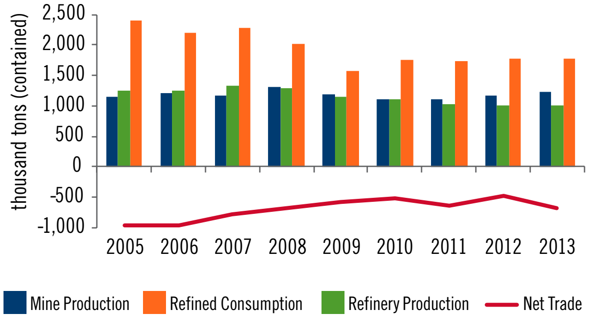
Source: SNL Metals & Mining

Copper is widely used in a number of semi-manufactured and manufactured products — especially electronic items — for wiring in construction as well as in roofing because of its water-proof nature. Copper wiring is also an essential component of all energy utility infrastructures. Other uses of copper can be found in medicine and nutritional supplements for both plants and animals.

Mined copper ore is concentrated by removing waste material, and these concentrates are then smelted into copper blister and refined into pure metal in a process whereby an electric current is passed through a metal-rich solution. The final product is consumed as copper metal or combined with other alloying metals such as zinc, tin, lead and nickel. Copper metal consumption has three major product lines; wire rod, brass mills and foundries/ powder plants.

Copper concentrate has traditional uses in brass and rod mills, foundries and chemical plants. Refined copper and its alloys are primarily used in building construction, electric and electronic products, transportation equipment, consumer and general products and in industrial machinery and equipment. The sector usage for copper in the United States is shown in Figure 7.

FIGURE 6 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – COPPER



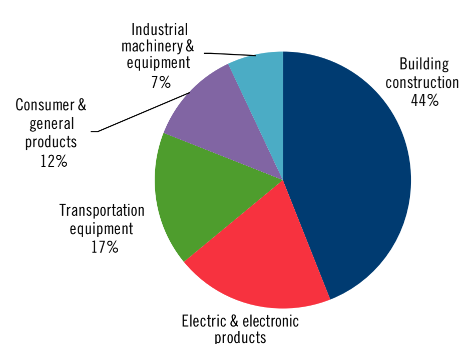
Source: USGS

The United States accounted for 7 percent of global production of copper in 2013. The U.S. copper mine production was 1.25 million tons last year, with domestic refined production of around 1.0 million tons. The total consumption of refined metal was 1.7 million tons, and so the country is a net importer of copper. Net trade was negative 0.68 million tons of refined metal in 2013 (Figure 6).

The top five copper producers accounted for 56 percent of U.S. production in 2013 and Freeport-McMoRan Inc.'s Morenci mine and Rio Tinto's Bingham Canyon mine, smelter and refinery in Utah are the largest producers in the country (Table 5).

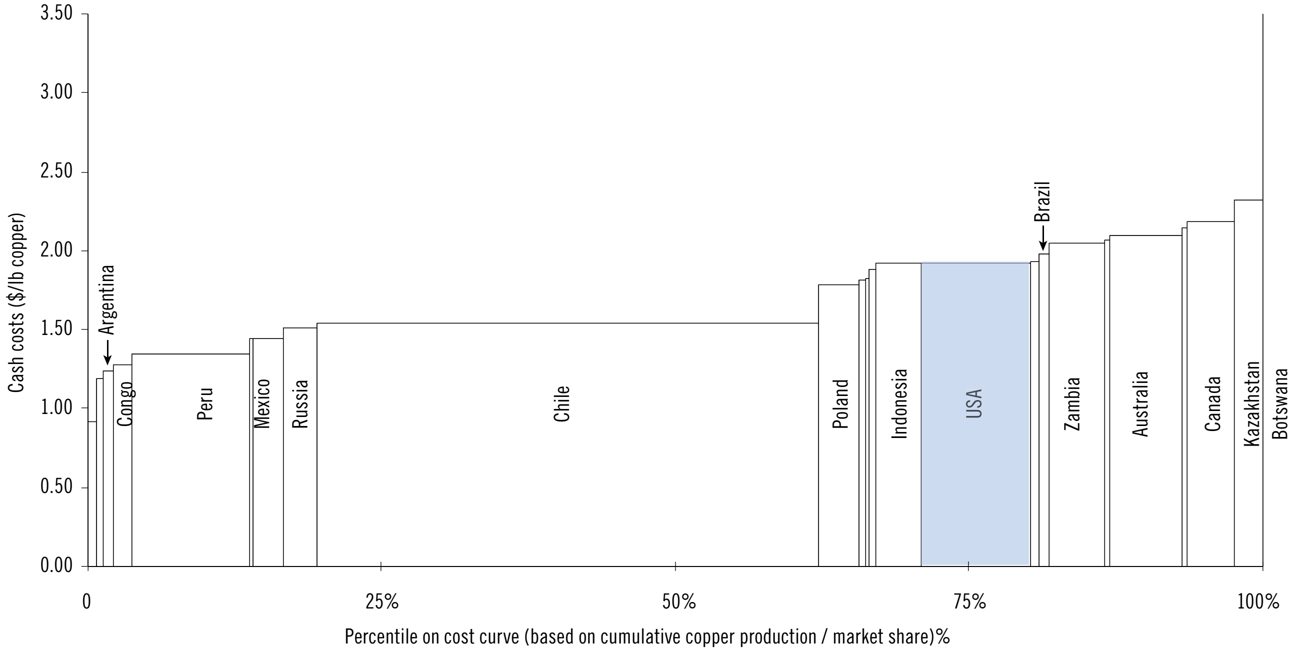
Copper mining also unlocks by-product metals commonly used in high technology products, including metals that raise the melting point of an alloy, increase its conductivity or act as a catalyst for chemical reactions. These metals include molybdenum, rhenium, selenium and tellurium.

FIGURE 7 COPPER USAGE IN U.S. (2013)



Source: USGS

FIGURE 8 RELATIVE CASH COST OF U.S. COPPER MINING (2013)



Source: SNL Metals & Mining, MineCost

TABLE 5 TOP U.S. MINES – COPPER (2013)

	State	Production (kt)	Share of U.S. Production (%)	Controlling company
World production		**17,900**		
U.S. Production (% of world)		**1,246**	**7.0**	
Morenci Copper (SX-EW)	Arizona	270	21.7	Freeport-McMoRan
Bingham Canyon	Utah	211	16.9	Rio Tinto Group
Bagdad	Arizona	85	6.8	Freeport-McMoRan
Ray	Arizona	70	5.6	Grupo México
Safford (SX-EW)	Arizona	66	5.3	Freeport-McMoRan

Source: SNL Metals & Mining

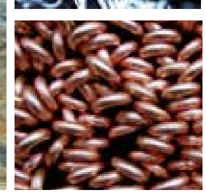
2.1.1 Copper mining cost competitiveness

There are currently 20 mines producing copper in the United States, with two mines — Bingham Canyon in Utah and Morenci in Arizona — accounting for 38 percent of the country's output. These are relatively high cost producers.

The average cost of mining copper in the United States in the past five years has increased by 30 percent, from $1.48/lb to $1.93/lb, which compares favorably against the rest of the global industry, where costs increased by 39 percent. Nevertheless, the United States has remained a high cost producer of copper (Figure 8).

Costs have generally increased due to mining lower grade ore, an increase in stripping ratios (waste relative to ore) along with higher input costs. Continued investment in modern mining equipment, adoption of innovative mining and extraction techniques, and recruitment and retention of experienced personnel will be essential if the copper mining industry is to continue operating profitably.





Bingham Canyon copper mine

2.2 GOLD

Share in Sector Usage	Electrical and electronics (38%)	
	Jewelry (36%)	
	Official coins (19%)	
	Dental (5%)	
	Other (2%)	
U.S. Reserves	Known total	3,000 tons
	Share of global reserves	5.6%
U.S. Mine Production	Total	229 tons (6.68 Moz)
	Share of global production	8.2%
	Share of U.S. reserves	7.6%
	Share of global reserves	0.4%
	Value of production	$10.2 billion
U.S. Exploration Budget	Total	$520 million
	Share of U.S. total	50%
Government Stockpile		Yes
Net import reliance as share of apparent consumption		Net Exporter
Main Supplier Nations		Mexico (57%), Canada (17%), Colombia (10%)

Source: SNL Metals & Mining

Gold, more than any other commodity, is strongly associated with the financial sector, from gold held by central banks, to its use as a financial asset by a large number of investors. It is also a vital constituent of jewelry. It is used in electronics, mobile phones, computer systems, and in a variety of high-performance and safety critical electronic systems. Gold's usage in the United States is shown in Figure 10.

Advances in gold-based nanotechnology are making contributions to diverse sectors from medicine to renewable energy. Research indicates gold nanotechnology to be an efficient and accurate method for delivering cancer treatments. Gold nanoparticles are also being used to improve the efficiency of solar cells. New research shows that gold can be used in catalytic convertors, with a more effective formulation when combined with palladium and platinum.

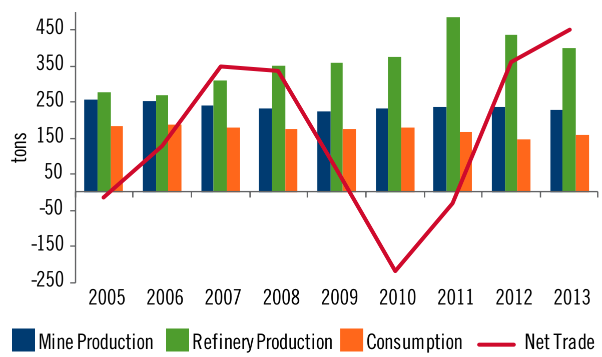
The pollution-prevention capacity of gold is being tested in Kentucky, with researchers using a gold and palladium catalyst to remove chlorinated compounds from water in the state. Gold could become an efficient and cost-effective tool to manage pollution resulting from industrial activities.

The United States is the fourth largest producer of gold in the world, accounting for 8.2 percent of global production in 2013. U.S. mined gold production in 2013 was estimated at 229 tons, with domestic refined production at 400 tons. Reported U.S. consumption (excluding stocks) was 160 tons, and the U.S. had a positive trade balance, with net trade reported at 450 tons (Figure 9).

The three largest operations in the United States are all in Nevada; Newmont Mining's integrated mines and Barrick Gold's Cortez and Betze Post mines. They accounted for just over half of the country's production last year (Table 6).

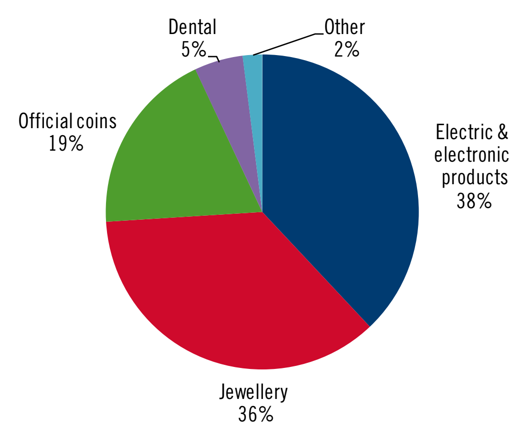
As a recent example of the use of U.S. precious metals, the gold, silver and bronze medals for the 2012 Olympic Games in London, were donated by Rio Tinto, with the metal sourced from the company's Kennecott mine in Utah. These were the largest and heaviest medals awarded in the history of the Olympics.

FIGURE 9 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – GOLD



Source: USGS

FIGURE 10 GOLD USAGE IN U.S. (2013)



Source: USGS

Although the medals themselves were stamped at the Royal Mint in Wales, Rio Tinto donated the 8 tons of metal required from its U.S. operation; 4.0 kg of gold, 5.5 tons of silver and 2.5 tons of copper. This is the second time that metal mined at Kennecott made it to the Olympics as Rio Tinto also supplied the metal for the medals at the Winter Olympics in Salt Lake City in 2002.

TABLE 6 TOP U.S. MINES – GOLD (2013)

	State	Production (t)	Share of U.S. Production (%)	Controlling company
World production		**3,022**		
U.S. Production (% of world)		**229**	**8.2**	
Newmont Nevada	Nevada	55	24.2	Newmont Mining Corp.
Cortez	Nevada	42	18.3	Barrick Gold Corp.
Betze Post	Nevada	28	12.2	Barrick Gold Corp.
Fort Knox	Alaska	13	5.8	Kinross Gold Corp.
Pogo (Stone Boy)	Alaska	10	4.5	Sumitomo Metal Mining Co.

Source: SNL Metals & Mining

2.2.1 Gold mining cost competitiveness

Since 2008, the average cash cost of gold production in the United States has increased 21 percent, compared with the global average increase of 69 percent to $752/oz.

As noted previously, the three largest operations in the U.S. are those of Newmont and Barrick in Nevada. Given the size of the output from these mines, their relatively low operating costs influence the overall weighted average cost of gold mined in the country.

In general, the relatively low cost at these mines in Nevada is largely due to economies of scale, high ore grades, and to high labor productivities and efficiencies. However, the remaining gold produced in the United States is from smaller scale, higher cost mining operations.

Overall the U.S. is cost competitive on a global basis, with only around 29 percent of global gold produced at a lower cost. However, in the long-term, more investment in both exploration and new mine construction will be required to maintain the country's output and competitiveness as resources at the existing low-cost operations decline.

Goldstrike gold mine in Eureka County in north-eastern Nevada

2.3 IRON ORE

Share in Sector Usage (for Iron and Steel)	Construction (40%)	
	Automotive (26%)	
	Machinery and equipment (10%)	
	Energy (10%)	
	Appliances (4%)	
	Containers (4%)	
	National defense and homeland security (3%)	
U.S. Reserves	Known total	6,900 million tons crude ore
	Share of global reserves	4%
U.S. Mine Production	Total	52 million tons usable ore
	Share of global production	2.7%
	Share of U.S. reserves	0.75% (of crude ore)
	Share of global reserves	0.03% (of crude ore)
	Value of production	$5 billion
U.S. Exploration Budget	Total	$24.4 million (estimate)
	Share of U.S. total	2.3%
Government Stockpile		None
Net import reliance as share of apparent consumption		Net Exporter

Source: SNL Metals & Mining

Nearly all iron ore is consumed by the steel industry, which has a broad range of applications, including renewable energy and general infrastructure, machinery and equipment, defense and the transportation industry. It is an essential ingredient of commercial and residential construction. Steel usage in the United States is shown in Figure 12.

The industry, directly and indirectly, supports more than one million U.S. jobs, with each of these indirect jobs in turn supporting seven more jobs in the domestic economy.

STEEL CONTAINED IN:	
Refrigerators	153 lbs
Gas stoves	149 lbs
Clothes dryers	107 lbs
Washing machines	95 lbs
Microwaves	29 lbs
Dishwashers	28 lbs
Kitchen sinks	9 lbs

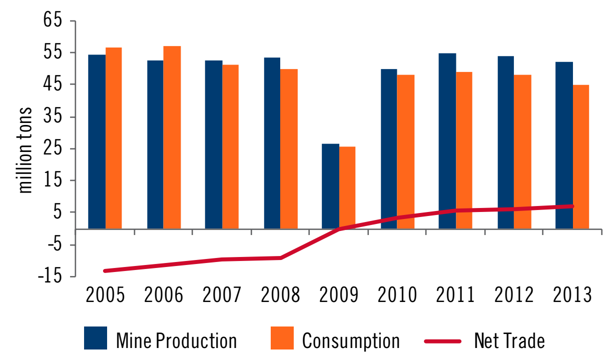
Source: American Iron and Steel Institute

The United States was the eighth largest national producer of iron ore in 2013, accounting for 2.7 percent of global production. The country produced 52 million tons of iron ore, with steel production at 87 million tons; In 2013 there were 100 facilities being operated by the U.S. steel industry.

Apparent consumption of iron ore last year was 45 million tons. The country has become a net exporter of iron ore since 2010, with a positive net trade of seven million tons (Figure 11). Although the United States is an exporter of iron ore, the country remains an importer of its finished product; steel.

The top three mines in the U.S. are Minntac, Hibbing and Tilden, which accounted for 58 percent of U.S. iron-ore production last year (Table 7).

FIGURE 11 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – IRON ORE



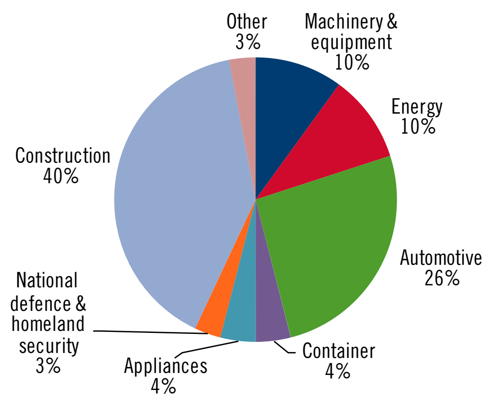
Source: USGS

TABLE 7 TOP U.S. MINES – IRON ORE (2013)

	State	Production (Mt)	Share of U.S. Production (%)	Controlling company
World Production		**1,930**		
U.S. Production (% of world)		**51.4**	**2.7**	
Minntac	Minnesota	14.6	28.4	U.S. Steel Corp.
Hibbing	Minnesota	7.7	15.0	ArcelorMittal, Cliffs Natural Resources Inc., U.S. Steel Corp.
Tilden	Michigan	7.5	14.6	Cliffs Natural Resources Inc.
United Taconite	Minnesota	5.2	10.1	Cliffs Natural Resources Inc.
Keewatin	Minnesota	5.1	9.9	U.S. Steel Corp.

Source: SNL Metals & Mining

FIGURE 12 STEEL USAGE IN U.S. (2013)



Source: American Iron and Steel Institute

2.3.1 Iron-ore mining cost competitiveness

There are 13 operating iron-ore mines in the United States, with eight mines accounting for virtually all of the production. Around 80 percent of the iron ore produced in the United States is sold to domestic steel mills with the rest sold to the export market.

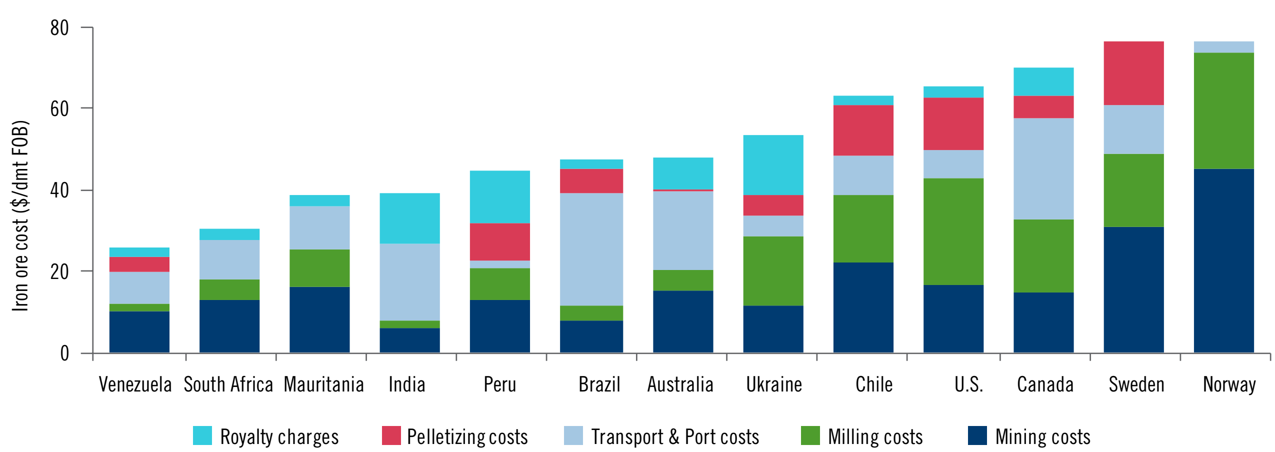
The cost of mining iron ore in the United States has increased over the past five years by around 14 percent compared with the global average increase of around 37 percent.

Despite this impressive cost control by U.S. iron-ore producers, the costs remain amongst the highest globally, with 90-94 percent of the global industry producing iron ore at a lower cost. There are a number of reasons for the high cost of production in the United States, ranging from aging operations where the cost of transporting ore from an ever-deepening pit bottom have increased, to high labor costs and deteriorating ore grades.

In recent years, mining in the United States has shifted to the extraction of taconite, a low grade magnetic iron ore which was previously considered as waste when high grade ore was plentiful. Many U.S. mining operations now produce taconite iron pellets by concentrating the low grade ore into an economically viable product. However the process is very energy- and water-intensive, requiring significant crushing and grinding, followed by magnetic separation to produce a powder or concentrate, which is then mixed with limestone and baked into pellets. The finished pellets contain more than 65 percent iron, the result of a costly and complex process which discards two-thirds of the rock originally mined.

Figure 13 above shows that while the United States is not the most expensive producer, the country's cost competitiveness is negatively impacted by the unavoidable milling costs (crushing and grinding, and magnetic separation) and pelletizing. This detriment will continue to impact iron-ore production in the future but it is to be hoped that technology advances and increased efficiencies will enable the industry to continue mining profitably.

FIGURE 13 IRON-ORE COSTS PER COUNTRY (DOLLARS PER DRY TONNE; 2013)



Source: SNL Metals & Mining

LOCAL COAL AND IRON

Cliffs Natural Resources Inc. (formerly Cleveland-Cliffs Inc.) is a major iron ore producer in the Great Lakes region, and a significant producer of metallurgical coal in the United States. Additionally, Cliffs operates iron ore mines in eastern Canada and an iron-mining complex in Western Australia.

The company is the largest supplier of iron ore pellets to U.S. blast furnaces, and believes that "if our customers succeed, we succeed." Cliffs also states that it recognizes "the role of logistics in unlocking value, as the development of premium mining districts further inland necessitate complex infrastructure networks."

The company is based in Cleveland, Ohio, and its primary operations are organized and managed according to product category and geographic location: U.S. iron ore, Eastern Canadian iron ore, Asia Pacific iron ore and North American coal.

Cliffs manages and operates five iron ore mines in Michigan and Minnesota, and the U.S.-based mines have an annual rated iron ore pellet capacity of 32.9 million tons, representing 59 percent of total U.S. pellet production capacity.

2.4 MOLYBDENUM

Share in Sector Usage	Machinery (35%) Electrical applications (15%) Transportation (15%) Chemicals (10%) Oil and gas industry (10%)	
U.S. Reserves	Known total	2.7 million tons
	Share of global reserves	25%
U.S. Mine Production	Total	61,000 tons
	Share of global production	19%
	Share of U.S. reserves	2.3%
	Share of global reserves	0.6%
	Value of production	$1.4 billion
U.S. Exploration Budget	Total	NA
	Share of U.S. total	NA
Government Stockpile		None
Net import reliance as share of apparent consumption		Net Exporter

Source: SNL Metals & Mining

Molybdenum has an important function in the manufacture of steel. A small amount of the metal goes a long way in improving the strength and hardness of alloys, corrosion resistance and weldability. High strength steel, containing molybdenum, increases vehicle strength in automobile manufacturing while reducing overall weight of the car body and chassis by 20-25 percent. These cars use less fuel and emit less CO_2, while at the same time improving passenger safety.

Molybdenum steels and super alloys enable supercritical and new ultra-supercritical coal-fired power plants to run at higher temperatures, increasing thermal efficiency and delivering significant reductions in CO_2 emissions.

Stainless steel, which contains molybdenum, increases corrosion resistance. The alloy is used for a wide range of specialty applications, including the construction of seawater desalination plants. In this way the metal contributes to the delivery of sustainable supplies of fresh water.

The metal's usage in the United States is shown in Figure 15.

The United States is the largest producer of mined molybdenum in the world, accounting for 19 percent of global production in 2013, when the country produced 61,000 tons of mined molybdenum. The United States consumed less than 40,000 tons in 2013, and is a net exporter of molybdenum, with a positive net trade balance estimated at 20,900 tons (Figure 14).

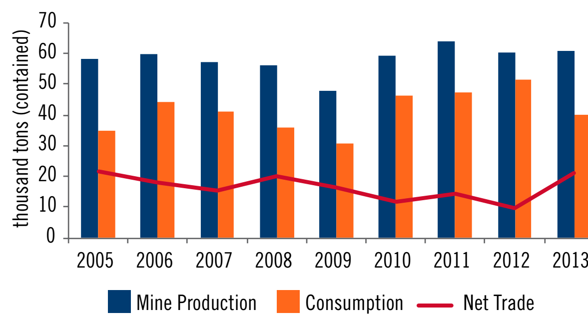
Two mines, Climax and Thompson Creek, account for 52 percent of U.S. production, and are the country's only primary producers of molybdenum. Other U.S. mines produce molybdenum as a by-product (Table 8).

TABLE 8 TOP U.S. MINES – MOLYBDENUM (2013)

	State	Production (kt)	Share of U.S. Production	Controlling company
World Production		**270**		
U.S. Production (% of world)		**59.9**	**22.2**	
Climax	Colorado	22.0	36.7	Freeport-McMoran Inc.
Thompson Creek	Idaho	9.5	15.8	Thompson Creek Metals Co.
Sierrita (Copper Mine)	Arizona	8.0	13.4	Freeport-McMoran Inc.
Bingham Canyon (Copper Mine)	Utah	5.7	9.5	Rio Tinto Group
Mineral Park (Copper Mine)	Arizona	5.2	8.7	Mercator Minerals Ltd.

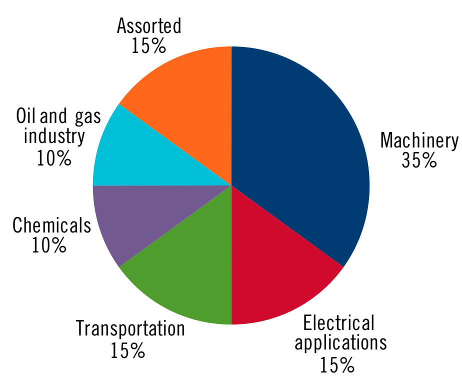
Source: SNL Metals & Mining

FIGURE 14 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – MOLYBDENUM



Source: USGS

FIGURE 15 MOLYBDENUM USAGE IN U.S. (2013)



Source: Minerals Education Coalition

2.4.1 Molybdenum mining cost competitiveness

In the United States, molybdenum ore is produced as a primary product by two mines, Climax in Colorado and Thompson Creek in Idaho (see Table 8), with other output coming as a by-product from operations in Arizona, Nevada and New Mexico. In the latter state, Chevron's Questa primary molybdenum mine was permanently shut down in 2014 as it was no longer economically feasible.

The primary operations account for around 52 percent of domestic output. The remaining molybdenum production is derived as a by-product of copper mining, notably due to its occurrence as the principal metal sulfide in large low-grade porphyry copper deposits.

About 70 percent of the world's molybdenum is produced as a by-product of copper and as a result is often mined irrespective of the price. Therefore, its supply is not dictated by the same supply-demand fundamentals that influence iron ore, copper or zinc. In other words, primary producers of a single metal like molybdenum can be at a disadvantage in terms of cost competitiveness compared with by-product producers.

Cash costs for mining molybdenum in the United States have fallen by around 23 percent since 2008 to \$6.4/lb, and globally by 34 percent to \$5.8/lb. The main reason for this relates to the relative strength of copper prices which have declined but not as sharply as molybdenum prices, benefitting the cost of by-product production. Nonetheless, 94 percent of global molybdenum is still mined at a lower cost than the U.S. output. This is a result of the associated high cost of copper mining within the country.

Thompson Creek molybdenum pit mine

2.5 PLATINUM GROUP METALS

Share in Sector Usage		Platinum	Palladium
	Auto catalyst:	34%	76%
	Jewelry:	19%	2%
	Electrical:	2%	6%
US Reserves	Known total (PGMs)	90,000 kg	
	As share of global reserves	1.4%	
		Platinum	Palladium
US Mine Production	Total	3,700 kg	12,500 kg
	Share of global production	1.9%	5.9%
	Share of U.S. reserves	0.4%	1.4%
	Share of global reserves	0.0%	0.2%
	Value of production		
US Exploration Budget	Total	$2.60 million	
	Share of U.S. total	0.2%	
Government Stockpile		None	None
Net import reliance as share of apparent consumption		79%	60%
Main Supplier Nations		Germany (18%)	Russia (33%)
		South Africa (18%)	South Africa (28%)
			UK (25%)

Source: SNL Metals & Mining

The platinum group-metals (PGMs) have diverse applications within the industrial sector, including catalytic convertors (fitted to cars and trucks to control pollution), fuel cells (platinum catalysts) and jewelry. PGM-based catalysts and compounds are used in the commercial manufacture of nitric acid, specialty silicon, computer hard disks and other electronic components, petroleum and glass for LCD and plasma screens. The usage of these metals within the United States is shown in Figure 17.

Platinum sensors are found in cars (exhaust gas sensors), homes (CO-based detectors) and in medical services (analysis of blood gasses). PGMs are also used in the treatment of cancer. One in four goods manufactured today either contains PGMs, or PGMs play a key role in their manufacture.

The volume of PGMs included in manufactured product is often small. For example, the automobile sector adds around $133 billion in value to the U.S. economy but the value of PGM-based catalytic convertors is only around $7 billion. Nevertheless, PGMs are essential, especially in reducing emissions.

The United States accounted for 1.9 percent and 5.9 percent of the global platinum and palladium production, respectively. There is only one PGM miner in the country; Stillwater Mining (see box p28 and Table 9).

The mined production for platinum and palladium in 2013 was 16,200 kg, with consumption of 186,200 kg. As a result, the U.S. relies heavily on imports for its PGM needs, and has a negative trade balance of 130,000 kg (Figure 16).

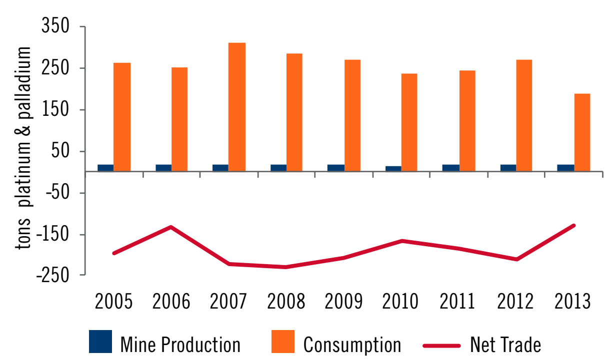
This import reliance is extremely problematic for U.S. manufacturing because of the geopolitical risk associated with the two main sources of PGMs: Russia (the supply risk being highlighted by the recent unrest in eastern Ukraine) and South Africa (the industry there having been significantly impacted by strikes over the past year).

South Africa's year-long strike affected global supplies of platinum and palladium by idling nearly 60 percent of the country's supply. This comes at a time where car manufacturers are increasingly using PGMs in emissions catalysts for automobiles.

Car sales are expected to surge in North America as well as in China. Analysts expect a 5 percent increase in global sales of cars and light commercial vehicles this year to a record 88.4 million units, and this total is expected to grow a further 5.4 percent in 2015. More than 90 percent of the new vehicles will have catalytic convertors, palladium being used for gasoline-fuelled engines and platinum for diesel engines. This will result in an estimated global demand for 7.19 million ounces of palladium in 2014.

This exposes U.S. car manufacturers to greater international competition (from increased car manufacturing in other countries) at a time when PGM supply is under severe pressure from the production cut backs in South Africa and narrowing of supply due to the political situation with Russia. This year's shortfall is expected to be twice as large as in 2013.

FIGURE 16 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – PGMS



Source: USGS

STILLWATER AND JOHNSON MATTHEY

Based in Billings, Montana, Stillwater Mining Co. is the only U.S. producer of platinum group metals (PGMs), and the largest primary producer of these metals outside of South Africa and the Russian Federation. The company is listed on the New York Stock Exchange (ticker: SWC).

Stillwater Mining operates the Johns-Manville (J-M) reef in southern Montana (the only known source of PGMs in the United States, and the highest grade resource in the world), and recovers PGMs from spent catalytic converters. The company also owns the Marathon PGMs-copper deposit in Ontario, Canada, and the non-core copper-gold exploration project at the Altar deposit in Argentina's San Juan province.

Although the U.S. uses less than 10 percent of the world's PGMs, Stillwater has an important role as the only producer in the country. A secure supply is required for the metals, which are used in a wide variety of applications.

In May 2014, Stillwater Mining announced a five-year refining and sales contract (effective July 1, 2014) with Johnson Matthey, a leading manufacturer of auto catalysts and a precious-metals refiner. Under the agreement, Johnson Matthey will purchase all of Stillwater Mining's mined palladium and a "significant" share of the company's mined platinum (both on an annual pricing mechanism linked to various industry benchmarks).

Stillwater Mining will utilize Johnson Matthey's refining services for all its mined production and recycled material on "competitive" terms. The two companies will also work together to secure material for Stillwater's recycling business, and will collaborate technically to improve the PGMs smelting and refining process.

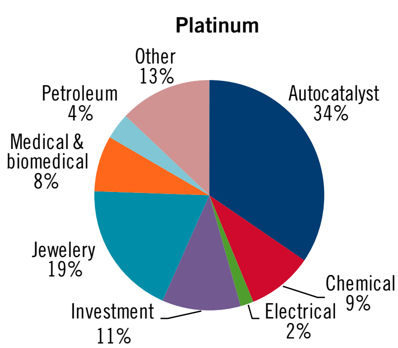
The ultimate client base for Stillwater Mining's projects is huge, and very diverse, but the recent agreement with Johnson Matthey means that most of the smelted production will be processed at Johnson Matthey's east coast refineries in New Jersey and Pennsylvania, and then manufactured by Johnson Matthey into auto-catalysts. Much of this will be for (but not restricted to) the U.S. market.

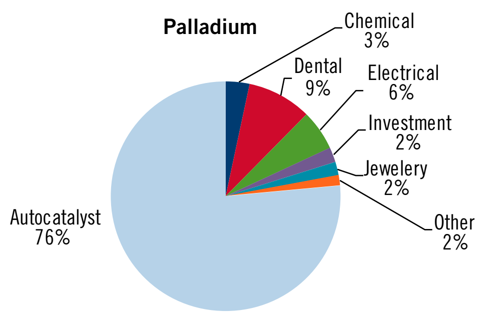
Almost all of Stillwater Mining's production will now be processed domestically, and most will be used in manufacturing within the United States. Some platinum will be supplied to Tiffany, and recycled material will continue to be offered to BASF.

As a U.S.-based producer, the crucial advantage that Stillwater enjoys is its secure-supplier status (in terms of both operational and political risk), especially with the strikes affecting South African mines, and political uncertainty in the Russian Federation.

An important advantage for domestic producers is the quick turnaround when processing precious metals, such as PGMs. Clients also appreciate the high safety and environmental standards of American mining operations, and U.S. laws are also trusted, of course, which provides reassurance that purchase transactions are secure.

FIGURE 17 PLATINUM AND PALLADIUM USAGE IN U.S. (2013)





Source: Johnson Matthey

TABLE 9 TOP U.S. MINES – PLATINUM AND PALLADIUM (2013)

	State	Production (t)	Share of U.S. Production (%)	Controlling company
World Production		**445**		
U.S. Production (% of world)		**16.3**	**3.7**	
Stillwater	Montana	11.4	69.9	Stillwater Mining Co.
East Boulder	Montana	4.9	30.1	Stillwater Mining Co.

Source: SNL Metals & Mining

2.5.1 PGMs mining cost competitiveness

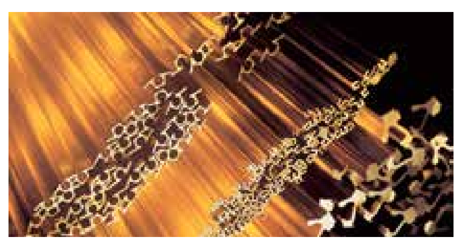
The overwhelming majority of PGMs mined in the United States come from Stillwater Mining Co.'s mines at East Boulder and Stillwater in Montana. The company produces over three-times as much palladium as platinum (it is the world's fourth largest palladium miner) and, as a result, its mines are regarded as primary palladium operations.

Consequently, platinum is generally produced as by-product in the United States, in contrast to the majority of the mines in South Africa, which produce a greater amount of platinum than palladium. Stillwater also recovers a significant amount of PGMs from spent catalytic converters through its recycling business.

Stillwater Mining operates amongst the world's highest grade PGM deposits and has 35-40 years of mineable reserves. As a result, the cost of mining PGMs in the United States is relatively competitive compared with operations in Canada, South Africa and Zimbabwe. Nevertheless, around 32 percent of the global industry operates at a lower cost than U.S. operations.

Stillwater Mining has faced a number of cost increases since 2011, largely driven by increased labor costs and technical issues, including grade control and mining dilution (i.e., the removal of too much waste rock). The company is addressing labor costs through operations and employee restructuring, along with productivity improvements, and Stillwater Mining aims to position itself in the lower portion of the cost curve.

In addition to the existing Stillwater and East Boulder mines, Stillwater Mining is currently developing shafts into new reserve areas on its existing leases; these may have the scope to add to its production profile in the medium term, as existing operations mature. At East Boulder, the company is developing the Graham Creek project, which could begin production by early 2015. At the Stillwater mine, development of the larger Blitz project will take six years to complete, which underscores the long lead times and high capital costs that are typical in the mining industry.

Stillwater mine

2.6 RARE EARTH ELEMENTS

Share in Sector Usage	Catalysts (65%)	
	Metallurgical applications and alloys (19%)	
	Permanent magnets (9%)	
	Glass polishing (6%)	
U.S. Reserves	Known total	13 million tons of REO content
	Share of global reserves	9%
U.S. Mine Production	Total	4,000 tons
	Share of global production	4%
	Share of U.S. reserves	0.03%
	Share of global reserves	0.003%
	Value of production	$160 million
U.S. Exploration Budget	Total	Not Available
	Share of U.S. total	Not Available
Government Stockpile		None
Net import reliance as share of apparent consumption		70%
Main Supplier Nations		China (79%)

Source: SNL Metals & Mining

The U.S. Department of Energy calls rare earth elements (REE) the "technology metals," while the Japanese describe REEs as the "seeds of technology." Small quantities of these extremely important elements are used in a large variety of manufactured products.

REEs are consumed in, for example, automotive catalytic convertors, fluid cracking catalysts in petroleum refining, phosphors in color television and flat panel displays (cell phones, portable DVDs and laptops), permanent magnets and rechargeable batteries for hybrid and electric vehicles, generators for wind turbines and numerous medical devices. There are also important defense applications: jet fighter engines, missile guidance systems, anti-missile defense, space-based satellites and communication systems.

There are 17 REEs (15 lanthanides plus scandium and yttrium) and while these elements are more abundant than copper and gold in the earth's crust, they are considered rare due to their low concentration.

The only current REE mine in the United States is Molycorp Inc.'s Mountain Pass mine in California (see case study on p31). This world-class REE deposit was closed in 2008 because of low prices (although processing continued of already mined ore) but the mine commenced start-up operations (code-named Phoenix) in 2012, yielding more than 4,000 tons in 2013. The mine produced 1,000 tons in Q4 2013 but sold 3,200 tons (at $39/kg) from accumulated stocks. The mine is ramping up production in 2014, with an eventual annual capacity of 20,000 tons.

Rare Element Resources Ltd.'s Bear Lodge project is positioned to be the next North American source of REEs. Bear Lodge is in a world-class mining district and described as a "dependable, long-term source for rare earths."

Another REE developer in the United States is Ucore Rare Metals Inc., which has multiple projects across the country. Ucore's primary focus is the 100 percent-owned Bokan-Dotson Ridge property in Alaska. The deposit is particularly rich with heavy rare earth elements, including the critical elements dysprosium, terbium and yttrium.

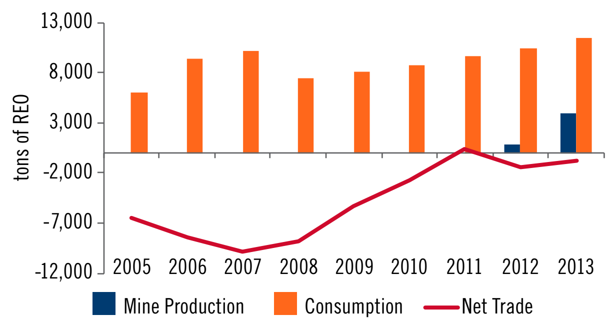
Elsewhere, Texas Rare Earth Resources Corp. (TRER) is developing the Round Top deposit in Hudspeth County, Texas. In November 2013, Gustavson Associates completed a preliminary economic assessment on the project, and the company expects to complete a full feasibility study by the end of this year.

U.S. consumption of REEs was 11,500 tons in 2013, leading to a negative trade balance of 1,940 tons. This net trade position is expected to improve as mine production picks up (Figure 18). Note that the net trade data includes cerium compounds, and REE oxide and compounds, but does not include REE alloys.

The use of REEs by application in the United States is shown in Figure 19, which illustrates the forecast change in usage over a five-year period. While the share of demand in catalysts is expected to decline, the application of REEs in magnets and polishing (glass) is expected to rise.

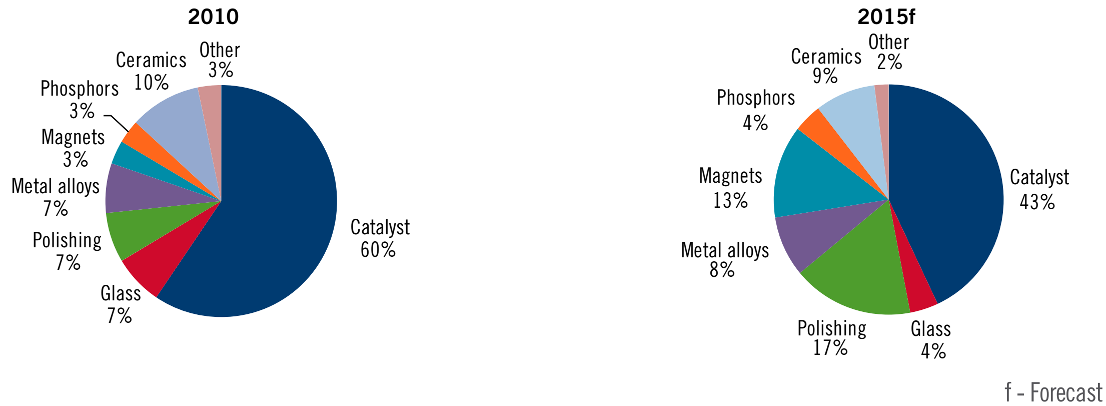
Note that the conversion from rare earths in their elemental form (REE) to the oxide form (REO) depends upon the individual element, but varies from 1.137 (for lutetium) to 1.269 (yttrium).

FIGURE 18 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – RARE EARTH OXIDES



Source: USGS

FIGURE 19 RARE EARTH DEMAND BY APPLICATION IN THE UNITED STATES



Source: Rare Earth Elements: The Global Supply Chain (2012); Congressional Research Service, Dec. 16. 2013

MOLYCORP, MAGNEQUENCH AND MUNITIONS

In 1982, General Motors (GM) isolated neodymium powder and invented a process for its production. The company pioneered the construction of neodymium magnets, which are used in air-bags and mechanical sensors. The latter, being essential for high-speed, high-capacity computer data storage, are used in precision-guided munition supplied to the U.S. Department of Defense.

In 1986, GM created the Magnequench division to commercialize Neo powder and the bonded magnets. In 1995, Magnequench was sold to a consortium controlled by Chinese state-owned enterprises.

The major supplier of rare-earth oxides to Magnequench was Molycorp Inc., which was (and still is) the only rare-earth producer in the United States. However, Magnequench's operations in the United States were shut down in 2001 and all production was moved to China. In 2005, Senator James Inhofe summed up the situation; "over 12 years, the company has…moved piecemeal to China, leaving the United States with no domestic supplier of neodymium, a critical component of the rare earth magnet."

Control of Magnequench returned to the United States in 2012 with the company's acquisition by Molycorp. Perhaps even more importantly, domestic output of REOs was restored following the resumption of commercial production at Mountain Pass in 2013. Meanwhile, the trade dispute, filed by the United States, Japan and the EU against China's rare earth export restrictions, and its control over 90 percent of global production, has gone to the World Trade Organization.

Concern remains over the ease by which national safety had been compromised by losing control over crucial technology and components of U.S. munitions, and the continued scarcity of alternative domestic supplies of REOs. The latter has been attributed to the difficulty of obtaining permits for exploration, and the volatile price of REOs because of China's price-setting ability.

2.7 SILVER

Share in Sector Usage	Electrical and electronics (35%)	
	Coins and medals (25%)	
	Photography (10%)	
	Jewelry and silverware (6%)	
	Other (24%)	
U.S. Reserves	Known total	25,000 tons
	Share of global reserves	4.8%
U.S. Mine Production	Total	1,090 tons (31.79 Moz)
	Share of global production	4.2%
	Share of U.S. reserves	4.4%
	Share of global reserves	0.2%
	Value of production	$840 million
U.S. Exploration Budget	Total	NA
	Share of U.S. total	NA
Government Stockpile		None
Net import reliance as share of apparent consumption		58%
Main Supplier Nations		Mexico (51%)
		Canada (25%)

Source: SNL Metals & Mining

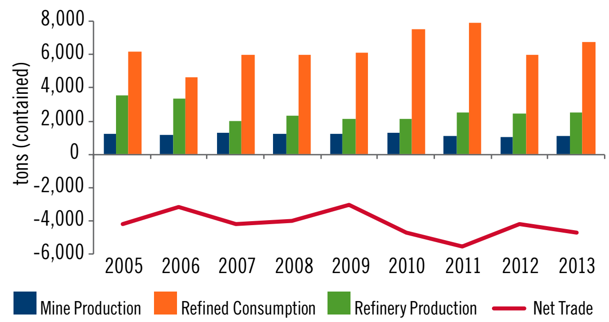
Rather like gold, but not to the same degree, the demand for silver comes from both the financial markets as well as from direct consumption. Silver is used in photovoltaic cells, ethylene oxide catalysts, batteries, bearings, electronics, brazing and soldering, automotive industry and jewelry (the United States was the largest importer of silver jewelry in 2013).

Silver oxide batteries have begun to replace lithium batteries as, although the former are more expensive, they have a higher power to weight ratio. In industry, silver bearings are an essential component of engines and machinery that require higher temperatures and continuous function.

Other usages include power switches for electronics that require high electrical conductivity, printed circuit boards and TV screens. Within cars, electrical functions (such as starting the engine, opening power windows and adjusting power seats) use silver-coated contacts. Some 36 million ounces of silver are used annually in automobiles. The usage of silver in the United States is shown in Figure 21.

The United States is the seventh largest silver miner in the world, accounting for 4.2 percent of global production in 2013. The domestic mined production of U.S. silver was estimated at 1,090 tons last year, with refinery production of 2,500 tons. Apparent consumption of refined silver was reported at 6,710 tons, and the U.S. had a negative trade balance of 4,660 tons of refined silver in 2013 (Figure 20).

FIGURE 20 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – SILVER

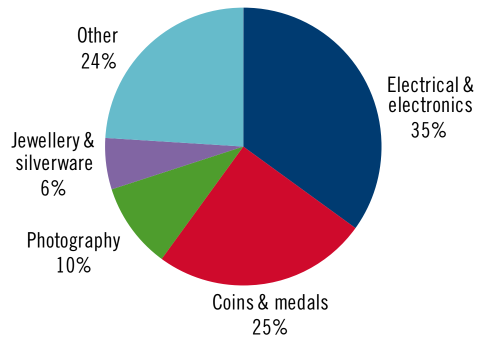


Source: USGS

The top three operations, the mines at Greens Creek and Red Dog, and Newmont's operation in Nevada, account for just less than half of this production (Table 10). The table reflects production levels for silver as both primary and by-product output.

Hecla Mining is one of the oldest producers of precious metals in the U.S., and in 2013 the company's Lucky Friday mine in Idaho produced 1.5 million ounces of silver, and lead and zinc concentrate. The production, valued at $100 million, was purchased by Teck Resources and shipped to Canada for refining at the Trail smelter in British Columbia. Part of the refined material is then sold back to the United States, with 13 percent of Teck's revenue originating from the country in 2013.

FIGURE 21 SILVER USAGE IN UNITED STATES



Source: USGS

Hecla's wholly-owned Greens Creek mine in Alaska is an important primary silver producer (and also the third-largest zinc producer in the United States). Gold production from the mine has customers in the United States and Canada, while the mine's lead-silver concentrate is shipped to South Korea, China and Canada. Zinc concentrate is destined for customers in Japan, South Korea and Canada. Bulk concentrate (zinc, lead and silver) is shipped to Japan.

TABLE 10 TOP U.S. MINES – SILVER (2013)

	State	Production (t)	Share of U.S. Production (%)	Controlling company
World Production		25,800		
U.S. Production (% of world)		1,106	4.3	
Greens Creek (Polymetallic Mine)	Alaska	232	20.9	Hecla Mining Co.
Red Dog (Zinc/Lead Mine)	Alaska	200	18.1	Teck Resources Ltd.
Newmont Nevada (Gold Mines)	Nevada	90	8.1	Newmont Mining Corp.
Bingham Canyon (Copper Mine)	Utah	89	8.1	Rio Tinto Group
Rochester (Primary Silver Mine)	Nevada	87	7.9	Coeur Mining Inc.

Source: SNL Metals & Mining

2.7.1 Silver mining cost competitiveness

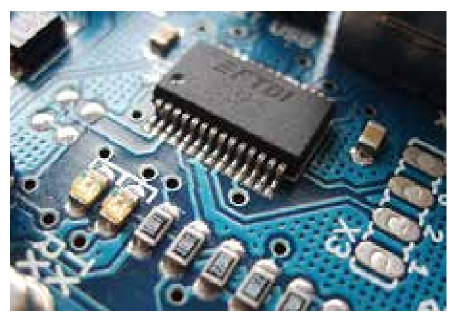
Silver is produced in the United States at three primary silver mines and from 39 domestic base- and precious-metal mines as a by-product. Globally, silver is predominantly mined as a by-product metal with around 20 percent from primary silver mines, 75 percent from multi-metallic mines (including copper and zinc) and around 5 percent arising as a by-product of gold mines.

Because it is generally produced as a by-product at mines that derive most of their revenue from other metals (mainly lead, zinc, copper and gold), the mined supply of silver, both globally and domestically, is largely determined by the price of other metals. One consequence of this is that the economics of silver production are affected less by the silver price than they are by the prices of the primary metals mined. Therefore, when prices of by- and co-products metals are high, unit costs of mining silver can appear low.

Average cash costs of mining silver in the United States are estimated at $11.9/oz in 2013, compared with a global average of $12.0/oz. Globally, costs since 2008 have increased 81 percent compared with a 63 percent increase in costs at U.S. operations.

Over the past couple of years, silver production in the United States was moderately cost competitive, with around 54 percent of the industry producing the precious metal at a lower cost. Longer term, cost competiveness will remain a challenge, and will be largely dependent upon the strength of copper and zinc prices which will influence the profitability of silver mine production.

Hecla's 100%-owned and operated Greens Creek mine in southeast Alaska



2.8 ZINC

Share in Sector Usage	Galvanizing (80%) Brass and bronze (6%) Zinc-base alloys (5%) Others (9%)	
U.S. Reserves	Known total	10 million tons
	Share of global reserves	4%
U.S. Mine Production	Total	0.76 million tons
	Share of global production	5.6%
	Share of U.S. reserves	7.6%
	Share of global reserves	0.3%
	Value of production	$1,600 million
U.S. Exploration Budget	Total	$36.6 million
	Share of U.S. total	4%
Government Stockpile		Yes
Net import reliance as share of apparent consumption		74% (refined metal) Net exporter of ores and concentrate
Main Supplier Nations	Ore and concentrate	Peru (76%)

Source: SNL Metals & Mining

Nearly 80 percent of zinc is used in galvanizing to protect steel from corrosion. Zinc is also used in the production of alloys for the die casting industry, and to produce brass and bronze. Other applications include the use of rolled zinc in roofing, gutters and drainage pipes. Zinc oxide and sulfate are used to produce zinc-based chemicals. These applications are found in a wide variety of products in the construction, transport, consumer goods, electrical appliances and general engineering sectors.

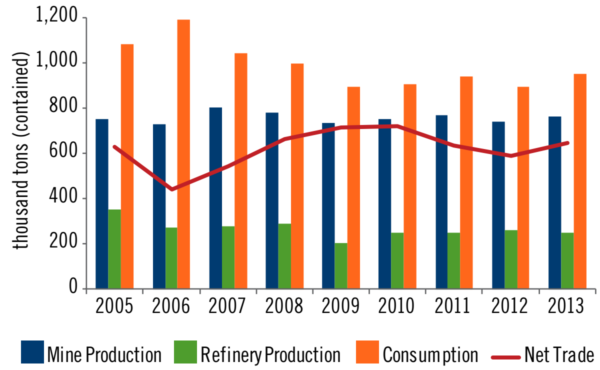
The most important role for zinc in the galvanizing industry is to produce superior corrosion protection for steel elements. In the United States some $121 billion is spent annually on corrosion protection systems. Most original equipment manufacturers (OEMs) utilize hot-dip galvanized steel because of its durability and maintenance-free qualities. Fire engines, tow trucks and salt spreaders are increasingly turning to galvanized steel.

In the chemical industry, zinc is used in the manufacturing of bleaches for the textile and paper industries. Zinc dust is used as a precipitant for copper, cadmium, gold and silver processing, and as a catalyst in the production of benzene and gasoline. Zinc dust also improves high-temperature performance and is used in brake linings in the automotive sector. Other diverse applications include explosives, fireworks, match heads, smoke compounds and soot removal agents. Zinc usage in the United States is shown in Figure 23.

The United States is the fifth largest producer of mined zinc, accounting for almost 6 percent of global production in 2013. Some 760,000 tons of zinc (contained) was mined in the U.S. during 2013, with refinery production at 250,000 tons. The country consumed 950,000 tons of refined metal with a negative trade balance of 685,000 tons of refined zinc metal. While the United States is a net exporter of zinc ore and concentrates, it is a net importer of refined zinc metal, which is reflected in Figure 22.

The Red Dog zinc-lead mine in Alaska accounted for 72 percent of U.S. production (Table 11).

FIGURE 22 U.S. PRODUCTION, CONSUMPTION AND NET TRADE – ZINC



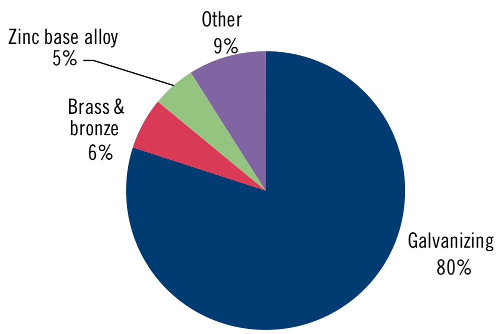
Source: USGS

TABLE 11 TOP U.S. MINES – ZINC (2013)

	State	Production (kt)	Share of U.S. Production (%)	Controlling company
World Production		**13,600**		
U.S. Production (% of world)		**765**	**5.6**	
Red Dog	Alaska	551	72.1	Teck Resources Ltd.
East Tennessee	Tennessee	71	9.3	Nyrstar NV
Greens Creek (Polymetallic Mine)	Alaska	58	7.5	Hecla Mining Co.
Mid Tennessee Complex	Tennessee	50	6.5	Nyrstar NV
Doe Run (Viburnum)	Missouri	30	3.9	the Doe Run Co.

Source: SNL Meals & Mining

FIGURE 23 ZINC USAGE IN UNITED STATES



Source: USGS

2.8.1 Zinc mining cost competitiveness

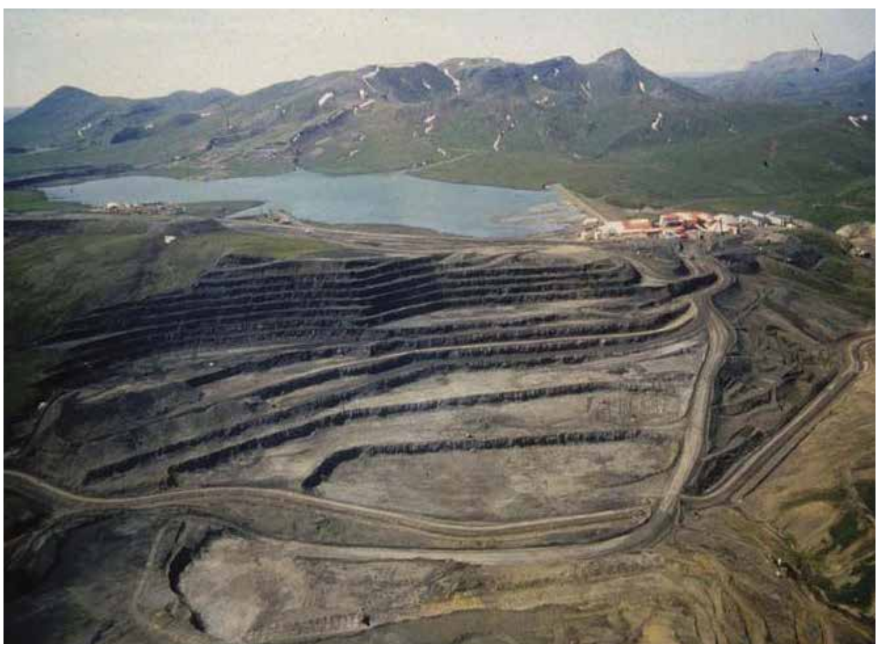
There are five operations in the United States producing zinc: Doe Run, Greens Creek, Red Dog and the two Tennessee operations belonging to Nyrstar. The latter company consolidated six underground mines in 2009 into two divisions: the 'Middle Tennessee' mines at Gordonsville, Elmwood and Cumberland; and the 'East Tennessee' mines at Young, Coy and Immel.

The largest zinc operation by far is the Red Dog mine in Alaska, one of the world's largest zinc mines, that produces over 550,000 tons of zinc annually, accounting for over 70 percent of the country's mined zinc output and more than 4 percent of global production. By virtue of its size, high grade ore (17-20 percent zinc) and open-pit mining method, Red Dog is able to operate at relatively low cash costs.

The other zinc mines in the United States produce significant amounts of by-product metals, such as lead (Doe Run) or gold (Green's Creek), which help lower costs when netted-off against zinc costs. However, costs at the underground mines in Tennessee are high.

Average cash costs for zinc mining in the United States have declined over the past five years in the United States from \$0.69/lb to \$0.52/lb, while the global average has remained fairly stable. Zinc mines have enjoyed success at remaining below the global industry's 25 percent cost quartile but, longer term, the zinc mining industry will face increased cost pressure. This is because the aging operations, declining ore grades and falling production (notably at Red Dog) will lead, inevitably, to higher costs.

It is worth noting that the Red Dog mine is reliant on expensive diesel fuel for power generation, but longer term the operators have the potential to develop a natural gas field neighboring the mine that may provide a cheaper alternative electric power source. However, there are a number of challenges facing this long term reliable supply. These include the costs of developing the field along with technical and environmental issues.



Red Dog mine in Alaska

2.9 SUMMARY

The discussion in this chapter has focused on the nature of consumption, supply and net trade for each individual metal. In addition, the concentration of domestic production, reserve potential and the cost competitiveness for each metal were also discussed. Table 12 summarizes these findings: import dependence reflects the net import reliance as a share of apparent consumption; concentration of domestic production shows the value of output attributable to just the top five mines; current production as a percentage of U.S. reserves; and cost competitiveness lists the cost percentile in which the average U.S. mines operate.

TABLE 12 DEPENDENCY, CONCENTRATION AND POTENTIAL FOR MAJOR METALS

Metal	Import dependence (%)	Concentration of domestic production in top five mines (%)	Production as share of reserves (%)	Cost Competitiveness (percentile)
Copper	36	56	3.1	78
Gold	Net exporter	65	7.6	29
Iron ore	Net exporter	78	0.8	94
Molybdenum	Net exporter	84	2.3	94
Platinum	79	100	0.4	32
Palladium	60	100	1.4	32
Silver	58	63	4.4	54
Zinc	Net exporter	99	7.6	14

The United States is a net exporter of four major metallic minerals (gold, iron ore, molybdenum and zinc) and a net importer of four others (copper, platinum, palladium and silver). The concentration of production in the top five mines is particularly pronounced for PGMs, where a single company accounts for all of U.S. production. For zinc, one mine (Red Dog) accounts for nearly 70 percent of the country's production.

While these assets can be considered excellent in their own right, the heavy dependence on a handful of mines does expose the domestic markets to risk of disruption. For example, a landslide at Bingham Canyon mine (which is a major producer of copper, molybdenum and silver) on April 10, 2013, resulted in a substantial reduction in output in the immediate months that followed. While some operations were resumed at the mine within 48 hours, "normal operations" are only expected to start in 2016.

Increasing the number of operating mines in the country is recommended as a mitigation strategy for such risks, and the United States has the domestic resources available. The fourth column in Table 12 highlights production potential in the United States by indicating the levels of current production as a share of identified U.S. reserves for each metal. It is clear that current exploitation levels can be substantially increased.

The last column indicates the cost competitiveness of each metal. As discussed in section 1.4.2, high cost operations are often associated with low-grade mines. Expansion of mining projects into greenfield operations (such as the Rosemount Copper project highlighted on p14) could well improve the cost competitiveness of mining operations in the country.

This section focused on mineral and metals, in the next section the report focuses on the role these metallic minerals play in contributing to the manufacturing sector, and on why supply security and reliability is so critically important for the United States.

SECTION 3. U.S. MINERALS AND THE DOMESTIC ECONOMY

As noted in the CIA's World Factbook, the United States has "the largest and most technologically powerful economy in the world, with a per capita GDP of $49,800. In this market-oriented economy, private individuals and business firms make most of the decisions, and the federal and state governments predominantly buy goods and services in the private sector. U.S. businesses enjoy greater flexibility than their counterparts in Western Europe and Japan in decisions to expand, lay off workers and develop new products. At the same time, they face higher barriers to enter their rivals' home markets than foreign firms face entering U.S. markets."

U.S. GDP in 2013 is estimated at $17,000 billion, with the U.S. manufacturing sector contributing more than $2 trillion to the domestic economy's added value, accounting for 13 percent of GDP. Manufacturing supports an estimated 17.4 million jobs in the country, with 9 percent of the workforce directly employed by the manufacturing sector. The manufacturing sector is also responsible for two-thirds of the expenditure on research and development by the private sector, and is a major driver of innovation.

Manufacturing is an important constituent of the national economy, and American firms are at, or near, the forefront in global technological advances. In order to maintain their lead, a reliable supply of raw materials is crucial to the sector's continued growth. In this section, the report looks at the mineral and metal needs of the manufacturing sector, and the importance of reliable, traceable supply chains for the raw materials that support manufacturing.

3.1 MINING AND MANUFACTURING

In 2013, mining activity (including the extraction of ferrous and nonferrous minerals, and quarrying) added $96 billion to U.S. GDP (Figure 24). The Bureau of Labor Statistics reported direct employment in the mining sector to be around 212,000 in May 2014.

Minerals and metals contribute to the economy directly through income and employment generation, and by providing jobs in supporting supplier services in other sectors. Within the mining and metals specific industries, the contribution from the manufacturing of primary metals was estimated at $66 billion, fabricated metals products $137 billion and a further $67 billion from activities that provide support for mining.

FIGURE 24 VALUE ADDED AND EMPLOYMENT FROM U.S. MINING TO MANUFACTURING (2013)

Mining	• Value Added: $96 billion • Direct employment: 212,000
Support Activities for Mining	• Value Added: $67 billion • Direct employment: 436,000
Primary Metals	• Value Added: $66 billion • Direct employment: 401,000
Fabricated Metals	• Value added: $137 billion • Direct employment: 1,456,000
Manufacturing	• Value added: $2,100 billion • Direct employment: 12,1610,000

Source: U.S. Bureau of Economic Analysis

These supporting activities include firms providing ancillary services, such as traditional prospecting methods and making geological observations at prospective site. The sub-sector generates around 436,000 jobs in the United States.

Metal ores, including pig iron, from the mining sector, coupled with scrap, provide the raw materials for the primary metals sector. This includes iron and steel mills, ferroalloy manufacturers, steel and aluminum producers, as well as nonferrous metal producers (including copper, lead, magnesium, molybdenum, nickel, gold, silver and platinum).

The output from the primary metals sector provides the raw materials for the metals fabricating sector (within the United States and overseas). Fabricated metals incorporates a number of industries, including forging and stamping, architectural and structural metals manufacturing, wire products, shipping containers, machine products and metal coatings.

In 2013, the fabricated metals sector contributed $137 billion to U.S. GDP. These fabricated metal products go into a large number of manufactured products, from household goods (microwaves and refrigerators) to semi manufactured products (copper wires and bus bars used in electricity generators and power transmission systems, and electricity cables).

All manufactured goods will have some mineral and metal component, in some cases they may account for a large proportion of the finished product (steel accounts for near two-thirds of an automobile's weight). In other cases the proportion might be small (0.3 grams of gold in a 2.3 kg laptop). Throughout the manufacturing spectrum, minerals and metals are an essential component; as direct inputs into the product themselves, and as constituents of the machines that make these products.

According to the U.S. Bureau of Economic Analysis, in order to deliver one dollar of output to the final user, electrical equipment and appliances require an input valued at an equivalent 0.45 cents from mining and primary and fabricated metal. Machinery requires an equivalent 0.42 cents, motor vehicles (and parts) 0.34 cents and other transportation equipment 0.26 cents. These numbers reflect only the share of metallic minerals, and do not include energy and non-metallic minerals (Table 13).

TABLE 13 METALS INPUT TO DELIVER $1 OF OUTPUT TO FINAL USERS (2012)

	Mining	Primary metals	Fabricated metal products	Total
Electrical equipment, appliances and components	0.03	0.31	0.11	**0.45**
Machinery	0.03	0.26	0.14	**0.42**
Motor vehicles, bodies and trailers and parts	0.02	0.20	0.12	**0.34**
Other transportation equipment	0.02	0.15	0.09	**0.26**
Construction	0.02	0.05	0.07	**0.14**
Computer and electronic products	0.01	0.07	0.05	**0.12**
Utilities	0.02	0.01	0.01	**0.04**

Source: Calculated from U.S. Bureau of Economic Analysis Data

3.2 U.S. AS GLOBAL LEADER IN MANUFACTURING

As noted previously, the United States is the world's largest manufacturing nation, followed closely by China and then Germany. Manufacturing activity, relative to the rest of the economy (measured by GDP contribution), is more significant in the United States than in the UK and France, but is less significant than in Germany, Japan, South Korea and China. Despite this lower share of manufacturing in GDP, the absolute value added by manufacturing grew 33 percent in the United States between 2000 and 2013.

While the product profiles for most manufactured goods (whether automobiles, computers or machinery) is similar, U.S. manufacturing can be distinguished from other advanced economies by the leadership role of American firms in their respective fields.

U.S.-based companies often rank in the top ten global companies for major manufacturing sectors (Table 14), being leaders in aerospace and defense, general industrial goods, industrial engineering, industrial transportation, technology and hardware.

Product and manufacturing-process innovation is important in maintaining a global lead in these manufacturing sectors. Domestic producers of metals and minerals can play a key role by contributing to the use of new, or innovative, materials in the manufacturing process. For example, when General Electric removed the hard-to-source rhenium from the super alloys it uses to produce gas turbine blades, domestic mineral producers could be useful to identify suitable substitutes from domestic resources.

TABLE 14 U.S. COMPANIES IN TOP 500 COMPANIES (2013)

Sector rank	Global rank	U.S. companies	Market value $m	Turnover $m	Employees
MATURE MANUFACTURING					
Aerospace and defense					
1	62	United Technologies	107,100	62,600	212,000
2	81	Boeing	92,500	86,600	168,400
Automobiles and parts					
6	148	Ford Motor	60,600	146,900	181,000
8	173	General Motors	54,700	155,400	219,000
12	337	Johnson Controls	31,400	42,700	170,000
General industrials					
1	8	General Electric	259,500	146,000	307,000
3	87	3M	89,200	30,900	88,700
4	113	Honeywell International	72,500	39,100	131,000
Industrial engineering					
1	137	Caterpillar	63,400	55,700	118,500
5	302	Illinois Tool Works	34,100	14,100	51,000
Industrial transportation					
1	94	Union Pacific	85,400	22,000	46,400
2	126	United Parcel Service	69,100	55,400	395,000
NEW MANUFACTURING					
Electricity					
4	240	Nextera Energy	41,600	15,100	8,900
5	244	Dominion Resources	41,300	13,100	14,500
6	261	Southern	39,000	17,100	26,300
Electronic and electrical equipment					
2	209	Emerson Electric	47,000	24,700	131,600
6	448	TE Connectivity	24,700	13,300	84,000
Technology hardware and equipment					
1	1	Apple	478,800	170,900	80,300
2	41	Qualcomm	133,400	24,900	31,000
3	46	Intel	128,300	52,700	107,600
4	56	Cisco Systems	115,500	48,600	75,000

Source: The Financial Times

An example of a close relationship between a metals supplier and fabricator is that between Essar Steel Minnesota and the U.S. subsidiary of ArcelorMittal. In March 2014, Essar Steel entered into a decade long off-take agreement to supply 3.5 million tons of standard and fluxed iron ore pellets per year to ArcelorMittal.

Essar Steel is the only producer in the United States capable of producing the full range of iron pellets, and ArcelorMittal sees this agreement as fulfilling its strategy of securing a long-term supply of crucial raw material within the United States that also meets its stringent blast-furnace quality requirements.

For the development of new technologies, the collaboration between manufacturers and the mining community is essential. Manufactured products that have only recently been brought to market will have relatively few manufacturers, and may require specialized suppliers. In contrast, "mature" technologies tend to have many manufacturers, with the technology being easily accessible and sourcing of minerals is dependent on finding large quantities where supply reliability is guaranteed.

Whether new or mature, the United States will lose its strong manufacturing base without a stable supply of metals and minerals. In the remainder of this section, the report divides manufacturing into mature and new manufacturing sectors, and discusses their specific mineral and metal requirements.

3.3 MATURE MANUFACTURING

The major mature manufacturing sectors where minerals and metals are an essential ingredient include transportation (automotive and airplanes), construction (residential and commercial), infrastructure, consumer products (such as washing machines, refrigerators and cell phones) and the industrial machinery used to produce these goods.

In 2013, the United States was the second largest producer of cars and commercial vehicles (behind China), producing 22 million vehicles (13 percent of the world's total). At the dawn of the automotive industry, car manufactures used only five major raw materials; wood, rubber, steel, glass and brass. Today, there are 40-60 mineral-based components.

The average automobile contains more than a ton of iron and steel, 240 pounds of aluminum, 42 pounds of copper, 41 pounds of silicon, 22 pounds of zinc, and more than 30 other minerals, including titanium, platinum and gold. The use of metals in cars also differs, with hybrid versions containing near 75 pounds of copper wiring, compared with the 50 pounds found in a traditional automobile. As mentioned above, PGMs, used in the manufacturing of catalytic convertors, are also an essential component.

Around three-quarters of the weight of an average vehicle comes from metal, primarily steel and iron. Increasingly, efforts are being made to increase the use of aluminum, magnesium and titanium to reduce the weight of vehicles and thus improve fuel economy. The steel alloys used in the construction of vehicles themselves are a combination of other minerals and metals, such as molybdenum, nickel, chromium, manganese and vanadium. PGMs (see case study below) are important for the production of one small but essential component of an automobile, the catalytic convertor, without which production of cars would not be possible.

PGMS AND AUTO-CATALYSTS

More than 95 percent of all cars have a catalytic convertor. This auto-catalyst is a small device fitted to cars and trucks (mostly with gasoline engines) that are responsible for converting over 90 percent of the carbon monoxide and oxides of nitrogen into less harmful exhaust gases. Outside of the United States, catalytic convertors are now required on construction and agricultural equipment in many markets (including the European Union). A basic catalytic convertor has a honeycomb structure, which is painted with platinum, rhodium and/or palladium. A single convertor will contain 3 to 9 grams of these precious metals.

Nearly 34 percent of platinum, 76 percent of palladium and 79 percent of rhodium demand in North America is for converting noxious diesel and petroleum fumes from vehicles into safe emissions.

While the convertors themselves are a small component, both in value and volume, in the average car, without them the automobile sector could not function. As national governments move towards enforcing increasingly stringent emissions standards, the use of platinum, palladium and rhodium will increase.

The U.S. Department of Commerce estimates that between 1997 and 2012, the share of domestic commodity output by the motor vehicle industry has declined substantially for primary metals (from 15 percent to less than 10 percent) and for fabricated metal products (falling from 12 percent to below 10 percent)[2].

The materials developed in the automotive sector will often filter through to other industrial sectors. The U.S. automotive sector, apart from producing cars, incorporates a substantial supply chain that includes the producers of specialized equipment for automotive production. For example, General Motors sources $130 billion worth of commodities and services from chassis to logistical services. The company's supply chain is reported to be over seven tiers deep, with some 18,500 suppliers around the world.

Automobile manufacturers are the lead firms of their supply chain, acting as final consumers of the various mineral and metallic inputs that are sourced from their suppliers. The major automobile makers have dedicated in-firm units that calculate their exposure to supply risks in raw materials, in the short, medium and long term and will design appropriate strategies to mitigate such risks.

Within most mature manufacturing products, firms will source their mineral and metal inputs, on occasion the reverse will also happen with mining companies expanding into manufacturing. For example, Alcoa Inc. is the world's leading producer of alumina, primary and fabricated aluminum, and is active in all major aspects of the industry from technology through mining, refining, smelting and fabricating to recycling. Related businesses include precision castings, vinyl siding, closures, packaging machinery and electrical distribution systems for cars and trucks.

Alcoa also delivers value-add products made of titanium and nickel. It is a global leader in lightweight metals engineering and manufacturing, and the company's technologies enhance transportation, and improve industrial and consumer electronics products. Alcoa enables "smart" buildings, sustainable food and beverage packaging, high-performance defense vehicles, deeper oil and gas drilling and more efficient power generation. In June 2014, the company expanded its aerospace product manufacturing capabilities, using its expertise as a mining company to enhance its manufacturing skills (see case study on p41).

[2] http://www.esa.doc.gov/sites/default/files/reports/documents/up-dthesystemicallyimportantautosupplychainmay2014final_0.pdf

ALUMINUM: ALCOA AND THE AEROSPACE SECTOR

Perhaps the best corporate example of adding value to a mined product comes from Alcoa Inc., which last year celebrated its 125th anniversary. The stated mission of the U.S. company is "creating value and differentiating our business through advanced technology."

Alcoa's revenue in 2013 was $23 billion, with 60,000 employees at more than 200 locations in 30 countries. Of this revenue, only $3.3 billion came from the mining of bauxite and the refining of alumina. A further $6.6 billion came from other "upstream" activities (including aluminium, casting and energy), with the balance of corporate revenue being attributable to added-value products.

A good example of the company's drive to add value to the mined product came in June 2014 when Alcoa boosted its aerospace capabilities in Virginia. The company announced plans to invest $25 million at its Alcoa Power and Propulsion facility in Hampton to scale-up a breakthrough process technology that cuts the weight of its highest-volume jet engine blades by 20 percent and significantly improves aerodynamic performance.

The acquisition further strengthens Alcoa's robust aerospace business, and positions the company to capture additional aerospace growth with a broader range of high-growth, value-add jet engine components. The acquisition is strategically aligned with the company's objective to continue to build its value-add businesses.

There are 20 refineries and smelters in the United States producing alumina and aluminum. The feedstock, however, is all from imported bauxite as the only bauxite mines in the United States are small operations in Alabama and Arkansas producing bauxite for non-smelting purposes, and North American Potash's alunite property in Arizona.

However, the country does have large reserves of bauxite, and in 1967 the ore was designated the official State rock of Arkansas, which has the largest bauxite deposits in the United States. Other domestic raw materials, such as alunite, anorthosite, coal wastes and oil shales, offer additional potential sources for alumina, although it would require new plants using different technology.

3.4 HIGH-TECHNOLOGY MANUFACTURING

The U.S. manufacturing sector employs nearly 50 percent of the country's workers in research and development (R&D). This emphasis on innovation is particularly important in high-technology manufacturing, and metals and minerals have a crucial role in the development of new products. For example, Intel estimates that while 11 mineral-derived elements were used to create a computer chip in the 1980s, the content increased to 15 in the 1990s and rose to 60 elements by the 2000s. General Electric is known to use 70 of the first 83 elements in the periodic table in its manufacturing processes and products.

Although steel and plastics (a derivative of a mined product; petroleum) are the dominant components (by weight) of most electronic products, more than 60 minerals are typically required in their manufacture.

Most consumers are unaware of the minerals contained in high-technology products. For example, computer circuitry will include gold, aluminum, lithium, chromium, silver, nickel, gallium, lead, zinc, copper, steel, tungsten, titanium, cobalt, germanium, tin and tantalum. Tantalum is used in the anodes for electric capacitors, rhenium as a strengthener in the turbine blades for jet engines, and neodymium is used in alloys for permanent magnets (utilized in navigations systems, household goods and audio equipment).

The evolution in more complex materials in manufacturing (e.g. the creation of more reactive catalysts) is often based on the addition of new metals, in effect creating super alloys. For example, the alloy used to manufacture aircraft turbine blades saw the addition of titanium, aluminum, copper and molybdenum in the 1940s; tungsten, niobium and tantalum in the 1960s; and rhenium in the 1990s.

The resultant super alloy is now able to operate at higher temperatures, sustaining an increase in the engine operating temperature, increased engine efficiency and reduced greenhouse gas emissions. Unfortunately, the U.S. has no mined production of tungsten, niobium or tantalum, and less than 5 percent of the global production of mined titanium. Also, although the mined output of copper is still significant in the United States, it now represents less than 7 percent of global production. For manufacturing security, the supply of these important feedstocks needs to be secured, or alternative metals sourced.

The development of super alloys and the advancement in materials technology is strongly affected by the availability of raw materials. As the world income levels rise and consumption increases in the emerging economies of China and India, the competition for raw materials will also increase.

Researchers and product designers in the United States are increasingly being hampered by potential constraints in the resource available, while designing new and better materials.

Substitution can only go so far, with research showing that 12 of the 62 metals and metalloids in the periodic table have either no substitutes or inadequate substitutes (including magnesium, manganese and REEs). Security of supply for raw materials could be effectively enhanced, by increasing the production of these materials within the United States.

Innovation is not restricted to product development, and R&D can be directed at any stage of the supply chain. Certainly, process-driven innovation is a key contributor to cost effectiveness, and so close proximity of the manufacturers and the mining companies that supply and develop raw materials is an added advantage. This clustering of production and manufacturing functions can benefit overall efficiency by mutual understanding of processes and delivery schedules. Subtle variations in delivery specifications can also be investigated more easily if the supplier is located nearby. For example, from Materion's humble beginnings as a beryllium miner in 1931, it has now become a provider of high technology components to a number of manufacturers, based on its ability to interact closely with its clients (see case study below).

Most of the minor metals and minerals used in the high technology electronic sector are not mined individually, and are produced as a by-product of base metals during the recovery/refining process. Minor metals individually have less than 150,000 tons of annual production, a small amount compared with the 20 million tons of copper produced annually.

For example, rhenium is a by-product of copper/molybdenum mining that is used in high-temperature super alloys for turbine blades. In combination with tungsten and molybdenum, it is a component in electrical contact points, heating elements and x-ray tubes. Freeport-McMoRan Inc.'s Sierrita mine, located south of Tucson, is currently the only producer in the United States, accounting for 15 percent of U.S. consumption, with the rest being imported from Chile, Germany and the Netherlands. Rhenium production is closely linked to the production of copper, and with a price increase in the latter, more production of the former is a possibility.

Table 15 highlights a number of metals that are considered critical for the U.S. economy, and for national security, that are "un-locked" by the production of base metals. These minerals are small by weight and value in most electronic products, and yet without them the production of the items would be impossible.

SPECIALITY METALS: MATERION AND TECHNOLOGY COMPANIES

Materion Corp. offers a number of precious and non-precious speciality metals to the high-technology sector in the United States and abroad. The company produces a number of components for the automotive and consumer electronics, defense, energy, and commercial aerospace and telecommunications sectors.

Materion is the only mine-to-mill producer of beryllium; its Brush Wellman mine and plant are located in the Sevier Desert of western Utah. The company has been mining beryllium since 1931, gradually moving up the value chain to incorporate refining and then technology products including beryllium alloys and oxides.

Defense and science is the largest market for beryllium and composite materials, while other applications include acoustics, optical scanning and performance automotive applications. For example, NASA's space telescope uses beryllium mirrors.

Materion's beryllium-production facilities are located in Ohio, California and Arizona, and the company supplies a domestic and international market. In 2008, Materion entered into an agreement with the U.S. Department of Defense to set up a new beryllium plant in Elmore, Ohio. Construction was completed in 2012 and the plant is ramping up production.

TABLE 15 UNLOCKING CRITICAL TECHNOLOGY MATERIALS

Metal	Usage	By-Product of
Cadium	Alloys, coatings, nickel-cadmium batteries, pigments and plastic stabilizers	Zinc
Germanium	Fiber-optic systems, infrared optics, electronics and solar electric applications, phosphors and infrared devices	Zinc
Indium	Electrically conductive purposes (flat-panel devices) solders and alloys, electrical components and semiconductors	Zinc - Tin
Rhenium	Three-quarters of all rhenium consumed in the U.S. is used in the manufacture of super-alloys of iron, cobalt, or nickel	Copper
Selenium	Catalyst, plating solutions, metallurgical additive to improve machinability of copper lead and steel alloys	Copper
Tellurium	Alloying additive in steel and others metals, production of solar cells, photoreceptor and thermoelectric devices	Copper

Source: American Resources Critical Metals Report (2013)

Within high-technology manufacturing, the protection of intellectual property (IP) rights is becoming of greater concern, particularly with the advent of manufacturing in Asia. IP can apply to the nature of the technology, the process of manufacturing and the very product itself. With the exploration of new technologies, and particularly the innovative uses of new materials (minerals and new combination alloys), there is a need to protect the necessary investment in research and development.

Unfortunately the ability to protect IP rights has frequently been compromised, and litigation can be difficult. As a result, it is important to use trustworthy suppliers and partners. U.S. suppliers are more likely to be aware of these IP issues, and can be successfully litigated against if they are in negative breach.

3.5 ADVANCED ENERGY SECTOR

Emerging sustainable technologies are a significant step towards diversifying the supply of U.S. energy. As the performance of these technologies improves, especially the efficiency of energy supply, the United States will become less dependent on foreign supplies of energy. While improving material use efficiencies contributes towards lower dependence on foreign suppliers, on its own this would not be enough to make the United States self-sufficient in its raw material requirements. Ensuring an increase in domestic supply of minerals and metals on the other hand, would make a larger contribution to supply security.

While the benefits of sustainable technology are widely understood in terms of "renewable resources," such as sunlight, wind and water, the metal and mineral component of these technologies is often not appreciated (see Table 16). The rare earth metals, neodymium and tellurium, for example, are essential to harness the power from renewable sources. While the United States has suitable reserves to provide these resources in-country, its import dependency remains high, given the low mined production of these minerals at this time.

Indeed, old and new materials alike are required for sustainable technologies. For example, the average wind turbine contains 2 tons of copper for every megawatt (MW) of power generation, compared with around 1.3 tons per MW for a coal power station. Even higher copper intensities are seen in nuclear plants (2.5 tons per MW) and for solar facilities (6.8 tons per MW).

Initiatives such as California's resolution to obtain 33 percent of its energy from renewable sources by 2020 will be followed by others in the United States, as well as abroad, putting immense pressure on supply. According to PricewaterhouseCoopers (2011), almost 90 percent of businesses in the renewable energy sector consider mineral and metal scarcity as having a detrimental impact on their industry.

According to the American Physical Society and the Materials Research Society, "A shortage of energy-critical [minerals] could significantly inhibit the adoption of otherwise game-changing energy technologies. This, in turn, would limit the competitiveness of the U.S. industries and the domestic scientific enterprises and, eventually, diminish the quality of life in the United States."

While sustainable technologies can contribute to American energy security, true security will only result when supply of domestic minerals and metals into this sector is also dependable.

Full benefits of renewable energy and related technologies are dependent on the ability to scale up production and reach wider markets. At the moment, the contribution of solar, wind and other renewable energy to total U.S. energy generation is only 11 percent.

TABLE 16 METAL AND MINERALS USED IN SOLAR PANELS AND WIND TURBINES

Mineral/Metals	Component	Mined in the U.S.	Import Dependency (%)	U.S. Reserves as a share of global reserves (%)
Arsenic	Semiconductor chips	No	100	By-product
Bauxite	Aluminum	No	100	0.1
Boron Minerals	Semiconductor chips	Yes	Net exporter	19.0
Cadmium	Thin film solar cells	Yes	<25	6.4
Cobalt	Magnets	No	76	0.5
Copper	Thin film solar cells	Yes	36	5.6
Gallium	Solar cells	No	99	By-product
Indium	Solar cells	No	100	By-product
Iron Ore	Steel	Yes	Net exporter	4.0
Lead	Batteries	Yes	25	5.6
Molybdenum	Photovoltaic cells Alloy in steel	Yes	Net exporter	25.0
Phosphate rock	Phosphorous	Yes	3%	1.6
Rare earth oxides	Magnets Batteries	Yes	<70%	9.0
Selenium	Solar cells	Yes	Net exporter	8.3
Silica	Solar cells	Yes	Net exporter	NA
Tellurium	Solar cells	Yes	Withheld	14.5
Titanium oxide	Solar panels	Yes	Net exporter	3.5
Zinc	Galvanizing	Yes	74%	4.0

NA: Not applicable

Source: USGS and Minerals Education Coalition

Nevertheless, the cost of wind and solar energy has fallen 85% over the past 20 years (with the fall in prices for the latter being particularly steep in the past five years), and the production of both solar panels and wind turbines is increasing across the United States (as it is in other countries).

With the wide deployment of renewable energy systems, the need for significant quantities of new minerals and metals could be affected by supply shortages that would delay the implementation of and increase costs for these technologies. The domestic mining sector needs to work with U.S. manufacturers to ensure that America can meet its renewable energy goals.

3.6 RETURN OF DOMESTIC MANUFACTURING

The U.S. economy contracted at an average annual rate of 3.5 percent between Q4-2007 and Q2-2009, with a cumulative decline over the six quarters estimated at 5.1 percent. Since then, there has been a significant recovery in United States economic activity, and manufacturing activity is returning to pre-crisis levels. Domestic manufacturing is also benefitting from the re-shoring phenomenon as U.S. companies bring production facilities back from overseas. Re-shoring occurs in two ways; first when a firm moves its manufacturing operations back to the U.S. from an overseas territory, and second when a firm switches its supplier from an overseas firm to a domestic one.

Examples of re-shoring during the past two years include Apple's decision to relocate some of its production of Mac computers back to the United States, in Austin, Texas. Elsewhere, Walmart has committed to increase spending by $50 billion in the next decade on U.S.-made products, and General Electric moved its appliance manufacturing from China to its own plant in the United States to deliver specifically for the domestic market. Morey Corp, a producer of circuit board

FIGURE 25 RE-SHORING OF ELECTRONIC AND ELECTRICAL PRODUCTS

Company	Product	Re-shored from	Re-shored to
Apple	Computers	China	U.S.
Digital Innovations	Electronic devices	China	Illinois, Midwest
Electrolux	Appliances	Canada	Tennessee
Farouk Systems	Appliances	China	Texas
Foxconn	LCD TVs	China, Taiwan	California, Michigan
GE	Appliances	China	Kentucky
Google	Phones	China	California
Lenovo	Pcs	Asia	California
Light saver technologies	Safety lights	China	California
Morey Corp	Circuit boards	China	Illinois
NCR	ATMs	China, India, Brazil	Georgia
Neutex	Lighting	China	Texas
NV3	Charging kiosks	Asia	Maryland
Seesmart	Lighting	China	California
Suarez Corp (SCI)	Appliances, electrical	China	Ohio
Whirlpool	Appliances	China	Ohio
Zentech	Electronics	China	Maryland

Source: http://www.todaysengineer.org/2013/Mar/reshoring.asp components, reduced its inventory by 94 percent and had a better quality product once it moved production facilities back to the United States from China. Figure 25 lists other major re-shoring announcements made in recent years.

ADVANTAGES OF RE-SHORING

- Freeman Schwabe Machinery (Ohio) moved its hydraulic die-cutting presses from Taiwan back to the U.S.; the warranty claims for its products fell by 90% and the speed to market was cut by 30 days.
- Master Lock (Wisconsin) a producer of combination locks, re-shored its production from China and found its U.S. productivity to be six times higher, producing a lower total cost for its output.
- Bailey Hydropower (Tennessee) re-shored its hydraulic cylinder production from India to find it could deliver faster than the previous five week average of the company. The company experienced fewer supply chain problems and was able to eliminate shipments of poor-quality units.

The "Made in the U.S.A." brand now appears to be back in vogue and consumer preference for domestically-manufactured products is increasing. Re-shoring is not a short-term trend and is expected to gain traction in the coming years. The fall in energy prices, linked to the increased production from shale gas, will encourage domestic manufacturing. In addition, the advantages of shortening supply chains (discussed below) in the manufacturing sector are becoming more evident, which will boost the domestic manufacturing sector further.

3.7 COST ADVANTAGES OF DOMESTIC SOURCING

The supply chain from mine to manufacturer is often complex and multi-tiered, with a number of primary and fabricated metal producers, and component manufacturers, between the mine selling its output and a final goods manufacturer receiving a metal-based input. Domestically-sourcing minerals and metals, leading to a shorter supply chain, has a number of cost advantages for the manufacturing sector:

- **Logistic costs:** The transportation costs for inputs and raw materials can carry heavy costs, while domestic sourcing can reduce this expenditure. For example, when U.S. steel manufacturers repatriated operations from China, the largest benefit was shorter supply chains. In 2010, the average transportation costs for U.S. manufacturers to ship from China to sell product in the United States was equal to 8.1 percent of revenues, compared with 3.2 percent in 2006[3]. The energy costs associated with the transportation sector are expected to remain high, and shortening supply chains, particularly with increased use of domestic suppliers can reduce the total cost for manufacturers.
- **Carrying costs:** Domestic and foreign suppliers are paid under different schedules, with the latter often leading to tying-up of cash resources of firms. For example, Chinese suppliers are generally paid prior to shipment, typically three to six weeks before receipt of goods, while U.S. suppliers are typically paid two to three months after shipment date, which essentially is the same as the receipt date.
- **Cost of Compliance:** The cost of complying with U.S. legislation on strict social and environmental requirements following the Dodd-Frank regulations is likely to be higher for overseas suppliers. For example, Hewlett-Packard extensively uses gold, tantalum, tin and tungsten in its products, and a typical laptop, weighing 2.0 kg, contains about 10 gm of tin, 0.6 gm of tantalum and 0.3 gm of gold. These metals are also classified as conflict-minerals, and the company estimated that about 1,000 suppliers in its chain ultimately provide a product that may contain minerals from a conflict zone. Monitoring and evaluating suppliers for sustainable metals sourcing requires resources, both human and financial, and the U.S. Securities and Exchange Commission estimates that compliance will cost affected companies $3-4 billion in the first year and at least $200 million each year thereafter.
- **Lower landed costs:** Domestically-sourced minerals and metals can lead to lower landed costs. These costs include packaging, duty, freight (such as surface transportation), fees and insurance.
- **Travel costs:** The costs of travel associated with the startup of the sourcing relationship, as well as for ongoing auditing and problem solving, is often overlooked when companies calculate sourcing costs. Most customers visit a supplier several times a year. For a local supplier, this may require anything from a few hours to a day or two, at most. For an Asian

[3] http://www.pwc.com/us/en/10minutes/assets/pwc-la-13-0048-us-reshoring-v9.pdf

supplier, each trip can take a week or two, and might cost $10,000 including time and travel expenses.

- **Inventory carrying costs:** With the possibility of supply-chain disruptions becoming more common, manufacturers are under increasing pressure to increase on-site inventory levels. As opposed to a just-in-time production approach, the former adds to the costs for the firms. Sourcing from domestic suppliers is not only likely to result in less inventory costs but also decrease, shipping time for deliveries.
- **Currency costs:** These costs occur when payments for suppliers and those for saleable products are in different currencies. Any movement in the U.S. dollar can have an impact on the balance sheets of a company, particularly when payments are being made in controlled currencies such as the Chinese Yuan. With domestic suppliers of raw materials, currency movements do not have the same impact on the cost of manufactures.

3.8 DOMESTIC SUPPLIER ASSURANCE

Sustainable credentials have become increasingly important in the past decade, with regulatory and consumer pressure to ensure sustainability across the entire value chain. Consumer trends are increasingly moving beyond the final product, and require information on the input materials and the supply processes involved in the production of goods. The campaign against conflict minerals from the Democratic Republic of Congo (DRC) is well known, other awareness campaigns have focused on “death metal” or tin that is mined from the alluvial tin belt running from Burma down to Indonesia.

The need for detailed information from first, second and third-tier suppliers is encouraging companies to bring their assets, and suppliers, closer to “home.” These extra tiers in the supply chains can extend to three or more levels, and stretches the ability of the lead firms to maintain extensive knowledge of their supplier base. The advantage of having metals and mineral suppliers in the United States eases the cost of compliance and the effort required to map the supply chain. U.S.-based suppliers carry a higher assurance that they comply with U.S. regulations on environment, sustainability and on labor laws.

With the wave of new regulations (not least in the United States and European Union) that focus on pursuing better business practices, using domestic mineral sources would be advantageous for manufacturing companies.

On the environmental front, manufacturing companies are being required to document their entire supply chain; electricity consumption, the carbon footprint of the production process as well as the logistics/shipping operations. Life-cycle impact assessments are becoming increasingly common.

Collecting data on the financial stability, labor relations, tax payment history, environmental standards and business practices of U.S.-based suppliers is likely to be less costly, quicker and more accurate, than it would be for overseas suppliers. The case of Stillwater (presented above) highlights the advantages of domestic sourcing.

RELIABLE SUPPLIER

An example of a reliable supplier is Valcambi Green Gold. In 2013, the company produced 20,000 ounces at its Swiss refinery using gold from Newmont’s Nevada mines, which have been in production for nearly 50 years. Valcambi’s “green gold” is certified, and assures customers that it is sourced from mines meeting high environment, safety and human rights standards. As a result, Wal-Mart is a major customer of Valcambi gold for its jewelry products.

ASSURED PGM SUPPLY: STILLWATER MINING

Stillwater Mining enjoys a crucial advantage as a secure supplier (in terms of both operational and political risk) of platinum group metals. This advantage has been emphasised recently by the strikes affecting South African mines and political uncertainty between Russia and the Ukraine. The company also has an important advantage in terms of its quick turnaround when processing precious metals.

Clients appreciate the high safety and emissions standards of American mining operations. U.S. laws are also trusted, which makes any corporate deals more secure. Other advantages for domestic clients include lower costs for national delivery, although this is of less concern for PGMs given the high value of the mined product.

Environmental requirements for PGM production in the United States are extremely stringent, compared with South Africa (which captures less than 70 percent of its toxic products) and Russia (which vents everything). U.S. miners can turn this to their advantage by ensuring that there is a focus on the supply of PGMs that are mined using environmentally-sound methods.

3.9 QUALITY RISK MITIGATION FROM DOMESTIC SUPPLIERS

Supply chain vulnerabilities, particularly the fragility of extended supply chains, have become evident in recent years, whether they were related to natural disasters, such as the flight disruptions caused by volcanic ash across Europe, and Japanese earthquake and tsunami, or damages to reputation, such as labor rights issues at Foxxcon and Apple.

Quality risks arise when a component is of sub-standard quality or does not meet the specifications demanded by the customer, such as tolerances and strength. The entire lot may require to be returned, or products already in the market may need to be recalled. The recent cases where General Motors had to recall nearly 8.5 million vehicles in North America were linked to faulty components. Mazda, Honda and Nissan also recalled 2.8 million vehicles due to faulty airbags in the past year.

The cost of such incidents goes beyond the immediate financial damage; they lead to a negative impact on the company's share price, and on the brand and corporate image. The quality risk can be further damaging to national security as well, as was the recent case of counterfeit and scrap electronic components (mostly from China) having made their way into U.S. military and other systems.

Investigations by the Pentagon in 2012 and 2013 revealed the presence of Chinese parts and raw materials in U.S. aircraft and weaponry, although this is prohibited by law. Lockheed Martin's F-35 fighter was found to have Chinese magnets in its new radar systems, with the B-1-Bomber and F-16 fighter jets also containing Chinese raw material. Chinese sourced titanium may have been used in SM-3 IIA missiles. Retrofitting and replacing the magnets in the F-35s could have cost as much as $10 million; the original magnets cost just $2 million. While the Defense Department insists that no sensitive information was revealed to the Chinese during the procurement of such magnets, it does highlight the exposure of U.S. national defense to issues of security when it has to rely on raw materials from outside the country.

Quality risks are spread across the entire supply chain, from the procurement of materials to the producers of the components of the manufactured products, as the above example shows. The magnets were a relatively small part of the aircraft as well as the costs of production. Local procurement, from domestic raw material suppliers could have avoided this issue.

The advantage of U.S. sourcing lies in the business ecosystem in which domestic firms exist: their ability to test and certify materials before they are delivered, the capacity of these firms to meet stringent standards because of the regulatory environment in which they operate, and finally the knowledge of the standards of the manufacturing sector they service.

3.10 SUMMARY

The U.S. manufacturing sector plays host to leading firms, both in mature and new technologies. These companies are market leaders and at the frontier of growth in the business world. Manufacturing activity has become fragmented over the years, with a lead firm using inputs from a large number of first tier suppliers to assemble their products. The first tier suppliers in turn have their own input providers, with the list going as deep as seven tiers.

U.S.-based manufacturers are re-examining their production chains, which have become stretched across the globe, from the United States to East Asia and South America. Re-shoring; the process of moving production and supplier inputs back to American soil is increasing.

This re-shoring is being driven by the need to reduce the risks inherent in long supply chains. Furthermore, U.S. consumers and, in turn, manufacturers and their shareholders, are increasingly concerned with corporate accountability. Consumers want to see evidence of sustainable production processes, use of recycled materials, sound environmental and human rights practices.

As technology becomes more complex, fewer suppliers are able to deliver the full range of services required of the product. As a result, the manufacturing process is becoming segmented, and the producer of the final product is often a system integrator, rather than a company that owns the entire process. Consequently, production risks have increased, and there is a trend to at least geographically shorten the chain.

As the U.S. manufacturing sector returns to growth, the importance of a secure, stable, reliable and sustainable raw material supply is increasing.

The major metals are employed both in mature and new technologies. Other metals, often produced as a by-product of mining activities, are also important for manufacturing processes. In an increasingly competitive world, where the demand for raw materials will come from emerging and mature economies, the ability to secure supply for U.S. manufacturers is of great importance. Domestic minerals can contribute to the material needs of the economy, but also do it in a sustainable way, while reducing supply chain risks for manufacturers.

SECTION 4. CONCLUSIONS

Minerals and metals are a components of almost every manufactured product. Regardless of new technologies that might be developed, particularly in the renewable energy sector, the demand for major metals as well as their by-products is increasing.

The United States is a leading manufacturing economy, with U.S.-based firms being leaders in their subsectors. The co-operation between mining and manufacturing firms in the United States produces synergies that are beneficial to both. Stillwater mining, the only PGM producer in the United States, works in close co-operation with Johnson Matthey to provide the raw materials for catalytic convertors. Materion, a beryllium miner and processor, develops specialty metals for use in the high-technology sector as well as for the U.S. Department of Defense.

Freeport-McMoRan's Sierrita mine is the only producer of rhenium that is used for super alloys for turbine blades of jet aircrafts. Thomson Creek, the major primary molybdenum miner in the country, provides raw materials for strengthening steel that is used in construction and manufacturing sectors. Essar Steel is the only producer in the U.S. capable of producing the full range of iron pellets that ArcelorMittal uses to meet its stringent blast-furnace quality requirements.

Manufacturing companies are increasingly adopting a "sustainable business" strategy, developing sustainable sourcing policies, ensuring their suppliers respect environmental laws, human rights and have sound business practices. This is being driven not only by the firms themselves, but also the government and the consumers that they serve. Fair Trade Gold, conflict-free minerals and the Global e-Sustainability Initiative are just some of the examples of product stewardship in metals sourcing for major manufacturers.

U.S. mining companies lead the way: Newmont's Nevada gold mines exclusively provide the raw material for Valcambi "Green Gold," for its certified assurance of being sourced from mines meeting high environmental, safety and human rights standards.

This compliance, both to internal and regulatory standards, has a cost. The Securities Exchange Commission estimates that for conflict-free minerals compliance alone, affected companies will face costs of $3-4 billion in the first year and at least $200 million each year thereafter. Compliance costs do not end there, the resources required to document and monitor suppliers can be high. The cost of not monitoring is more damaging, as experienced by the automobile sector, with General Motors having to recall nearly 8.5 million vehicles in North America due to faulty components.

American-made products are increasingly popular with consumers. As re-shoring of manufacturing activity has gathered pace for the past five years, manufacturers are looking to shorten their supply chains. Apart from mitigating supply chain disruption risks, locating suppliers within the country brings numerous cost advantages (lower logistic and carrying costs) and also increases the ease of doing business, as firms operate in the same regulatory environment as manufacturers.

The continued growth of the manufacturing sector is linked to raw material supply security. This can be defined by a number of factors, including the availability of raw materials, the reliability of delivery, price security and compliance risk.

Availability of raw materials, particularly in relation to minor metals, is the geological presence of materials. The 2003-2008 commodity price boom was triggered by an increase in demand for metals across the board, but especially from China. With supply unable to meet demand, prices increased sharply. While the 2008-2009 global financial crises reduced price pressure in the short run, prices have returned to their pre-2008 levels. More importantly, they are not expected to recede to their pre-2003 levels. The world's demand for minerals and metals is now greater than ever before, and the United States will need to participate in an increasingly competitive global market for these metals.

As a result of the substantial increase in commodity prices, new supplies have emerged in a number of developing regions, often operating under risky political, economic and social environments. Geo-politics have become as important a determinant of mineral supply as geology. Disruptions to supply, whether linked to natural disasters or to government interventions, have become more common.

Indonesia's attempt to limit exports of unprocessed nickel ore impacted global nickel supply, the strikes in South Africa have affected PGMs and the ongoing political turmoil in Ukraine impacts Russian supplies. Even if minerals and metals are being produced, geopolitics can have a negative impact on delivery schedules for manufacturers. Since advanced manufacturing business models rely on just-in-time delivery, these delays carry risk for these businesses.

Another supply risk facing manufacturers, particularly for minor metals, comes from price disruptions. The often quoted example of the impact on price of China's move to limit its REE exports is well known. Other metals, such as tantalum, have experienced similar short-term price increases. These minerals are either produced as by-products, or by a handful of producers; either way, they can have a disproportionate impact on price levels. While the major metals are traded on large exchanges, price movements linked to investment traders and financial institutions have brought some level of volatility to international metal prices.

Metals are a homogenous product, in their refined stage, with a clear standard based on purity. However, other standards are beginning to be applied to differentiate metals; based on the sustainability of the mining processes that produced them. Again, the standards for conflict-free minerals have been well publicised over the past few years. Other standards, such as those for respect for human rights, non-corrupt business practices, transparency in mining company revenue flows (such as the Extractive Industries Transparency Initiative) are becoming more common, driven by the public, companies and governments. Assurance of supplier practices are becoming more important for manufacturers, with knowing your supplier becoming as important as knowing your customer.

For all the factors listed above, sourcing from the U.S. domestic mining sector carries advantages; the "Made in the U.S.A." label is inherently reassuring to consumers in all these regards.

A key finding of this report relates to a gross structural mismatch between mineral supply and demand. Although the United States is a major mining country, it enjoys a much higher global ranking as a manufacturer than it does as a miner.

In 1990, the United States was the largest mining country in the world; by 2013 it had fallen to seventh, having been overtaken by China, Australia, Brazil, Russia and South Africa. Two factors contributed to this fall in rank; countries elsewhere expanded their mined production while output stagnated, or dropped, at U.S. mines.

In terms of geological potential, the U.S. is considered well-endowed, and so the global mining community looks favorably at the region as a place to invest. Non-geological factors are less favorable. One of the largest obstacles to expansion in the mining sector has been delays in receipt of environmental permits and mining licenses. These in turn contribute to the poor cost competitiveness of mining operations in the country, which are often beset by aging operations, high wage rates and environmental costs.

High levels of productivity, helped by the large scale of many U.S. operations and modern equipment, have enabled the country to compete competitively with lower-cost economies. The U.S. mining sector could well address its high costs if newer projects were encouraged and brought online.

With respect to individual metals, the U.S. is a net exporter of gold, iron ore, molybdenum and zinc and a net importer of copper, PGMs, rare earths and silver. Concentration of production for these metals tends to be heavily skewed towards the top five mines operating in the country. This only furthers the supply risk for manufacturers who are seeking stable supply.

In summary, the United States remains highly prospective, from a geological point of view, with abundant, diverse mineral resources of high quality. While the U.S. mining sector is ideally positioned to support manufacturers' need for greater sustainability and shorter supply chains in the production process, an outdated, inefficient permitting system presents a barrier to American companies' access to the minerals they need and thus to the economic competitiveness of the U.S. mining industry.

Relative to their global peers, U.S. miners are highly efficient, often exemplifying best practices with regard to productivity, sustainability and safety. The examples of Stillwater, Thomson Creek, Materion Corp., Cliffs Natural Resources and Kennecott Utah show that it can be done. Molycorp's restart of its Mountain Pass REE mine should not be an exception when it comes to encouraging mining operations in the country. The Rosemont Copper project should be an example of sustainable-mining best practices for the world, and not a story of delayed permits and uncertainty.

Given the regulatory support to achieve its full potential, the U.S. mining sector can become not only highly regarded for its geological potential but also for its mining operations.