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Summary

FOSTERING INTERNATIONAL COOPERATION IN THE FIELD OF RAW MATERIALS – THE INTRAW PROJECT AND THE EUROPEAN INTERNATIONAL OBSERVATORY FOR RAW MATERIALS

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FOSTERING INTERNATIONAL COOPERATION IN THE FIELD OF RAW MATERIALS – THE INTRAW PROJECT AND THE EUROPEAN INTERNATIONAL OBSERVATORY FOR RAW MATERIALS.

ABSTRACT

In the last decade, a structural change has taken place in the world's mineral markets and the global demand for raw materials stands at the bottom of a new growth curve. In this perspective, safeguarding the domestic minerals supply in a sustainable way will be challenging not only to Europe but also to other countries such as Australia, Brazil or the United States. As part of the European Commission's Horizon 2020, the International Cooperation on Raw Materials (INTRAW) project was launched in 2015 under the coordination of the European Federation of Geologists.

Since then and in line with the European Raw Materials Initiative and the Strategic Implementation Plan (SIP) of the European Innovation Partnership on Raw Materials (EIP-RM), the INTRAW project has been working on mapping national best practices, policies and strategies aiming to maintain a competitive and functioning economy and non-energy minerals industry (primary and secondary raw materials). INTRAW´s work has been focused in three domains: Research and Innovation, Education and Outreach, and Industry and Trade of five technologically advanced partner countries: Australia, Canada, Japan, South Africa, and the United States of America. Findings during the first year of our research show the leading role of Australia in long-term economic growth and of Western Australia in automation, of Japan in deep sea mining, substitution and raw materials diplomacy or of Canada in setting the pace of exploration.

The outcome of the ongoing mapping and knowledge transfer activities will be used as a baseline to set up and launch the European Union's International Observatory for Raw Materials as a definitive raw materials knowledge management infrastructure. The Observatory will be a permanent international body that will remain operational after the end of the project aiming at the establishment of strong long-term relationships with the world's key players in raw materials technology and scientific developments.

KEYWORDS

Raw materials management, best practices, international comparison, mineral policies, mineral strategies

INTRODUCTION

In the last decade a structural change has taken place in global mineral markets. The old rule of thumb – 20 percent of the world population in Europe, United States of America (hereinafter USA) and Japan consuming more than 80 percent of the total minerals production – is not valid any more. With the integration of India, the People's Republic of China and other populous emerging countries like Brazil and Russia into the world economy, today more than half of the world's population claims an increasing share in raw materials. Thus the global demand for raw materials stands at the bottom of a new growth curve. It is assumed that by 2030 the worldwide need for raw materials will have doubled. A doubling of raw materials demand for the important industrial metals is plausible in view of the relevant predictions, e.g. of the global motor vehicle stock. Some projects estimate that it will rise from approx. 800 million in 2002 to more than 2 billion light duty vehicles by 2030 (IEA, 2015), whereas in non-OECD countries an increase by 195 million to 1,172 million is expected, i.e. almost all growth is in developing countries. Estimates by the OECD Development Centre suggest that today's development and emerging economies are likely to account for nearly 60% of world GDP by 2030 (OECD, 2010). Raw materials technology developments are of increasing importance as a motor of growth in the emerging countries.

Access to raw materials on global markets is one of the European Commission's priorities. Over the last decade the European Union (hereinafter EU) has become much aware that securing a reliable, fair and sustainable supply of raw materials is important for sustaining its industrial base, an essential building block of the EU's growth and competitiveness. This was triggered by the increasing demand for unprocessed minerals and metals, volatility in the prices of certain raw materials, as well as market distortions and supply risks imposed by a number of countries involved in the trade of raw material commodities (e.g., resource nationalism in China for rare earths). Given the global nature of raw materials value chains and the afore-mentioned global challenges, finding solutions to ensure a level playing field and a fair and unrestricted access to raw materials for the EU and for non-EU countries requires international cooperation on raw materials.

Efforts to foster international cooperation are being made by the EU framed under the Strategic Implementation Plan (SIP) of the European Innovation Partnership on Raw Materials (EIP-RM) (https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/content/european-innovation-partnership-eip-raw-materials). The third pillar of the SIP refers to International Cooperation and promotes Global Raw Material Governance Dialogues and Raw Materials Diplomacy, e.g. the on-going dialogues between Europe and Latin America. The International Cooperation on Raw Materials (INTRAW) project, running during the period 2015-2018, has been formulated with the objective of mapping best practices and boosting cooperation opportunities on raw materials with technologically advanced non-EU reference countries (Australia, Canada, Japan, South Africa, and the United States) in response to similar global challenges. The ultimate goal of the project to set up and launch the European Union's International Observatory for Raw Materials as a definitive raw materials knowledge management infrastructure.

In this paper we present summarized results of the contextual analysis conducted for each of the reference countries and available in five Country Reports (Falck, Akhouri, & Murguía, 2015; Murguía, 2015a, 2015b, 2015c, 2015d). The information in the Country Reports was collected across three pillars: Research and Innovation (R&I), Education and Outreach, and Industry & Trade; in this paper we present insights of these three. The last pillar also encompasses an analysis of the key drivers of mining success across the reference countries (except Japan). The analysis is based partially on literature such as the Fraser Institute´s reports (Jackson & Green, 2015) or the annual ranking by the Behre Dolbear group (Wyatt & McCurdy, 2014). Results highlight for each of these pillars which good practices each country has conducted in order to be economically successful at a general level, and in relation to the management of minerals. Finally, a summary of the plans for the launch of the European International Observatory for Raw Materials are presented with the feedback on the country reviews received by a Panel of Experts.

Based on the comparison of results across countries, we aim to provide guidelines for the both EU and non-EU mineral-rich countries (such as Brazil) as to what are the historical and current key aspects that should be carefully looked into if a successful and sustainable mining industry is to be achieved.

METHODOLOGY

This technical paper arises from the research conducted for the INTRAW project on a country-level for 49 indicators with the aim of understanding the historical context and identifying the key drivers enabling the success of the mining industry, all of which are presented in detail in the "Country Reports" previously mentioned. These reports were created in an iterative way by the Consortium Partners, based on literature and local knowledge of the country by each expert and supporting teams. Preliminary results of the research were discussed with a Panel of International Experts during the Bled Workshop held in September 2015 in the city of Bled, Slovenia. This paper is built upon the afore-mentioned Country Reports, collects selected information, re-organizes it, and presents a comparison of main results.

RESULTS

Research and Innovation

Since the steel-based industrial revolution of the late 1890s, the USA has joined the ranks of world leaders in innovation. Government and industry-funded institutions have been developing throughout the 20th century which has given the country a solid R&D infrastructure, including government-funded labs, high-tech profile innovation clusters like Silicon Valley, and many others. Econometric studies strongly suggest that R&D spending has a positive influence on productivity, with a rate of return that is likely to exceed that on conventional investments. After the USA, Japan ranks 2^{nd} in the world in terms of total expenditure on R&D with a 3.3% of the GDP. The USA also leads the world rank in business expenditure on R&D, followed by Japan in 2^{nd} position. The USA features as a highly attractive destination for researchers and scientists, ranking 2^{nd} in the world after Switzerland. Japan ranks 2^{nd} position in the world after China with regards to the total amount of personnel working on R&D. All of the above show that the knowledge and resource base (infrastructure) in the USA and Japan has been of high importance in their transition towards a knowledge-based economy. Canada and Australia have a well-established science, technology and industry systems, even though they do not rank amongst the top ten countries in terms of R&D personnel, expenditure on R&D and attractiveness to researchers & scientists. South Africa also has a well-developed science system, which has been developed in relative isolation due to sanctions and since the end of apartheid has been reconnected to the world's developments.

The USA, Japan and South Africa have strong R&D cultures. Compared to many nations, the USA has a highly developed and successful industry-research institute collaboration system. USA companies are highly sophisticated and innovative, supported by an excellent university system that collaborates admirably with the business sector in R&D. Japan´s R&D culture developed during the 20^{th} century and was led by technology transfer process from the West to Japan during the catch-up period and afterwards when Japan took the lead in innovation. R&D in Japan is mostly (70%) financed by the private sector. Knowledge transfer between companies and universities is low in Japan, and start-ups are still low in comparison to other peer countries. Japan´s national innovation system is now in a transition towards science-based industries and the R&D culture is still maintained as a key to resume economic growth. Despite South Africa's strong R&D tradition, it's Gross Expenditure on Research and Development (GERD) of 0.8% is below that of other emerging economies with much of the research being business-driven. Australia and Canada rank poorly internationally in innovation and do not have strong R&D cultures. Canadian companies are thus rarely at the leading edge of new technology and too often find themselves a generation or more behind the productivity growth achieved by global industry leaders. University-industry collaborations are not well-developed. However, unlike the general trend, the Canadian mining industry is a global leader in capital investment, financing and innovation. Australia has a moderate to low performance on innovation due to a poor business innovation culture. Yet its innovations in the mining sector have been and remain of significant importance (as driver of productivity increase).

The USA has an excellent track record at continuously investing in geoscientific data and related research as they are considered critical factors enabling the development and growth of the mining industry. The U.S. Geological Survey was established in 1879 to determine the natural wealth of the country, and has continued to serve that role. Likewise, the U.S. Geological Survey and the U.S. Census Bureau closely monitor production and consumption of an extensive range of commodities, which provides critical economic intelligence regarding the viability of operations. The information acquired and published by the USGS is internationally considered reliable and their data and publications are freely available and are amongst the most widely used around the world for mineral statistics. The availability of excellent geoscientific data enables small and medium sized mining companies to compete with larger enterprises, who tend to create and maintain their own knowledge bases in addition to the publicly available data.

Raw materials-related R&D is conducted in South Africa by public and private partners. Mintek is one of the world's leading technology organisations specialised in mineral processing, extractive metallurgy and related areas. The Council for Geoscience (CGS) and the Council for Scientific and Industrial Research (CSIR) are two of the National Science Councils of South Africa. One of the mandates of the CGS is to develop and publish world-class geoscience knowledge products and to render geoscience-related services to the South African public and industry. The CSIR mining research is focused on mineral extraction, particularly underground mining of gold and platinum: breaking and moving rock (drill and blast) safely and efficiently, and in increasing the safety of operations for workers to a maximum. Besides public agencies, much R&D is conducted in South Africa in the mining field via private sector involvement. For instance South Africa's gold and platinum mining industry works at greater depths and under more difficult conditions than any other mining industry in the world.

Canada is also heavily invested in geoscientific data but unlike the USGS (central body), the data acquisition and related research is done by provincial geological surveys, with the data made publicly available. The mining industry has continuously invested in R&I, even during bust times and high risk, like in the 1990s when the sector invested in new, automated technologies that enhanced the economic viability of projects by lowering production costs. The sector has undergone a profound change to a high-tech industry, and it has become a driving force in Canada´s new knowledge-based economy. New technologies in mining have created a circle of growth and innovation that circulates through two-way linkages between mining and the rest of the economy. A large part of innovations in the mining industry takes place in the exploration sector. Vancouver is the global centre of expertise for mineral exploration, with some 1,200 exploration companies located in the British Columbia, most of which are in the greater Vancouver area. Also in exploitation, innovation plays a central role. For instance in the 1960s R&I in reliable transport infrastructure (e.g. development of the ice roads technology) granted access for exploration first, and development later, of diamond orebodies in the Northern Territories. A more recent example is given nowadays by much of Canada’s remaining base metals, which are likely located two kilometres or more beneath the surface. This situation presents cost and operational challenges. In response, the industry is investing in remote-operated equipment, automated loading and transportation systems, robotics and seismic mapping. Many of these innovations have been funded by the industry, whereas government-funded research mechanisms are not aligned and it is claimed that they do not provide support commensurate with the industry’s innovation needs, priorities and contributions (Marshall, 2014).

Australia has traditionally maintained a high level of investment in R&I in the mining sector. One of the most significant Australian innovations was the development of flotation (the most effective method of separating minerals from the gangue) in Broken Hill in 1903, and is a method widely used in the international metal mining industry. Similarly influential was the development of heap leaching of low grade ore bearing gold in Western Australia. Nowadays Australia keeps pioneering R&I to increase productivity and cost control and the Pilbara region acts as the main focus for innovation activity in mining. In this region several companies, including some from the mining equipment, technology and services sector, are testing and running automation technologies such as driverless haul trucks, automated wheel changers for haul trucks, remote train and ship loading, remotely operated drill and smart blast activities, as well as the development of a new class of tunnelling machines for underground mines. All such innovations will continue to provide Australia with a competitive advantage in the field of mining.

Education and Outreach

The INTRAW project undertook an analysis of mining & raw material supply education provision and skills availability in Canada, USA, South Africa, Australia and Japan, their national workforce demands, perceptions of skill levels/qualities, and funding. These technologically advanced non-EU reference countries were chosen for mapping best practices and boosting cooperation opportunities between the EU and other technologically advanced countries. During the last decade, skills shortages have been arguably the mining industry’s most significant problem. The analysis examined formal programmes of adult education leading to diploma, certificate, degrees, further and higher education qualifications, or vocational education programmes including apprenticeships, all of which lead to a formal award. Outreach consisted of a range of initiatives, courses, organisations and schemes specifically aimed at certain sections of society, especially those from historically disadvantaged, ethnic, or native populations who wish to learn more about mining and gain access to jobs in the mining industry.

Reviews were performed for each target country to provide data on courses, student numbers, centres of excellence, delivery mechanisms and, where possible, staff numbers. The internationalization of education and barriers to access were also analysed. Important educational and human resource issues that the analysis identified included gender imbalances, minority groups, local community skills development support, university recruitment and company strategy. The analysis revealed a number of key elements that characterise mining education across these advanced raw material producing countries.

Mining is undertaken in over 100 countries and it is estimated that on a global basis the formal mining sector employs more than 3.7 million workers. Although every mine is different, the organisational structure of a mining company generally includes senior corporate staff, managers, university-educated specialists, supervisors, and operational staff and skilled and semi-skilled staff and associated contractors.

Today's mining industry relies on highly skilled workers with a diverse skill set, the ability to use sophisticated technology and operate in challenging environments. It typically seeks skilled operators, graduates and technical specialists with not just mining knowledge but also digital literacy, problem solving ability and good interpersonal skills, who can work safely in both a team and individual capacity. Staff require initial training and must also continuously upskill as technology advances. Benefits to staff include operating in an environment where safety is paramount and enjoying pay and conditions that are highly attractive.

Mining education encompasses a wide range of education and training options that can be accessed by students seeking to enter the industry, mature entrants reskilling, in-work employees' upskilling and even those taking courses purely for interest. Universities offer a range of mining focused undergraduate degree options around applied geology, mining engineering, mineral processing and metallurgy, as well as a raft of generic but relevant subjects in engineering, business, environment, etc. At postgraduate level, more vocational Masters courses are offered, focused on mineral exploration, mining geology, geotechnical engineering, geometallurgy, construction, minerals engineering, minerals processing, metallurgy, and environmental impact. Advanced study through research Masters and PhDs are an important provision in many universities and are typically based on industry-related scientific questions, undertaken in collaboration with or sponsored by individual companies, or as part of larger collaborative research programmes. Universities may also have a range of continuing professional development (CPD) short courses, professional programmes and some distance learning provision accessed by those in the industry to address specific skill needs or for professional development.

Training for technician and administrator levels in mining related areas are usually delivered by technical colleges and training centres. These usually involve a combination of conventional teaching with placements and work-based learning, and include technical, commercial and clerical provision. Vocational training courses including artisan and trade skills (e.g., welders, drillers, maintenance mechanics, electricians, loader operators etc.) usually have many more training routes through both mining and other sector training organisations and are typically delivered by apprenticeships involving block or day release, combined with workplace skill development. Mining investment in efficiency, mechanisation and automation will push up the required skills levels and reduce the opportunities for low skill jobs.

Volatility in the industry and increased resource nationalism, as well as demand of producer countries for local staff to take over the more senior roles, is leading to a need for rapid upskilling and loss of experienced international staff. The cyclical nature of the industry has caused endemic skills shortages followed by oversupply, which lags the industry cycles and results in elevated costs and loss of experience from the industry. Employers need to consider funding, retaining and upskilling staff through the downturns and this may require new models of employment.

Real-time skills and employment data are not easily accessible and new methods are needed if prediction through the cycle is to be realistic. There appear to be few absolute skills shortages, perhaps in mining engineering and mineral processing but not critically so. Criticality is caused by timing of availability as the training duration lag time reinforces the skills shortage as the upturn develops and compounds the oversupply at the next downturn. Training needs to be more aligned with industry cycles –good practice evidence is available but there is a need for more creative solutions to in-work education and industry-education partnership arrangements.

In aiming to address educational issues in the mining industry, in addition to the key findings outlined above, the analysis has produced a list of possible metrics to benchmark and compare EU countries against and form the basis for action plans:

- Number of universities teaching mining/minerals geoscience
- Length of programs and quality of curriculum (including staff: student ratio)
- Number of students and demographics
- Amount of mining/minerals geoscience in secondary school curriculum
- Number of mining education organizations and membership
- Training data and workforce shortages
- Qualification requirements

- Others metrics identified in reports by the Mining Industry Human Resources Council - Canada (MiHR), Society of Mining Professors (SOMP) and national workforce planning exercises

Industry and Trade

Trade inter-dependencies

During the second half of the 20th century the international trade of raw materials, importantly of metals and minerals, expanded remarkably and it consolidated as a principal driver behind the economic growth of industrial economies such as the USA or Japan. Dramatic decreases in transport and communication costs coupled with reductions in trade barriers have been the driving forces behind today's global trading system. Nowadays, by weight, coal and iron ore are by far the most extensively traded minerals. The USA and Japan were key players shaping the international trade in mineral raw materials and their economic success was and is closely interrelated with those supply partners such as Canada, Australia and South Africa, amongst others. Special mineral trade bilateral partnerships during the 20th century and which still today remain very important were those of USA-Canada and Japan-Australia.

- ***USA-Canada partnership***: due to geographic proximity and similar historical cultural characteristics, the USA and Canada share a history of economic development based on the domestic use and bilateral trade of mineral resources. Actually, for many years, the USA-Canada border has been the longest in the world and both countries have been sharing the world's most comprehensive bilateral trade relationship. In 2013 U.S. exports to Canada accounted for 19% of overall U.S. exports, in turn, Canada's exports to the U.S. accounted for a 75% of all exports (2014). In 2013 and concerning mineral commodities (ores, concentrates, and semi- and final-fabricated mineral products), 50.2% of mineral Canadian exports were sent to the USA and 50.8% of mineral imports came from the USA.

- ***Japan-Australia partnership***: main enablers of strong raw material trade relationships between both countries was the creation of bulk transport vessels lowering transportation costs, the adaptation of port facilities, and the bilateral agreements on commerce and business, with the Commerce Agreement signed between both countries in 1957 (the first trade agreement of Japan after WWII). More recently it has been boosted with the Japan-Australia Economic Partnership Agreement (JAEPA) entering into force in January 2015. The main historical drivers of the boom were coal and iron ore exports enabled by discoveries in the Pilbara region in Western Australia and by other metals. Long-term contracts were here key enablers, e.g., by guaranteeing Japanese demand and providing a secure base for investment by the Australian partners. Notably since the 1960s (Siddique, 2011), Japan has traditionally imported strategic resources (iron ore, coal, manganese) and exported vehicles and machinery to Australia. Australia´s mining sector has heavily relied on foreign investments, and Japan has been injecting capital in investments for over half a century. Nowadays Japan depends on Australia for around 60% of its imports of coal and iron (Australia´s first and second most valuable exports), and Australia is Japan´s main supplier of natural gas and uranium. Australia's economy has grown strongly in tandem with trade with Japan and its mineral demand is synchronized to the business cycle of Japan, China and India (Liew, 2012). Japan buys more than any other country of five of Australia's most valuable merchandise exports: coal, aluminium, natural gas, bovine meat and copper ores (Australian Government Department of Foreign Affairs and Trade, 2008).

In a globalized market economy, all of the partner countries have based their minerals supply and demand on other multiple partners with smaller but significant shares. The USA is a good example of changing and multiple sources for supply combining domestic extraction and imports. The domestic endowment of natural and mineral resources (e.g., coal, wood) was highly important in the early phases of the industrialization, but then the economy began a transformation process towards a knowledge and services-based economy in which the availability of domestic resources became less important, i.e. supply could be covered to a large extent by mineral imports. Around 1950 the USA became a net importer of minerals (Lindert, 2000), rubber and forest products (Palo, Uusivuori, & Mery, 2012) and in 1958 the USA turned from a net exporter of fossil energy carriers to a net importer, and by 1973 already 20% of all fossil energy carriers and one-quarter of all petroleum and natural gas was imported. Net imports of ores and metals began to increase in the late 1940s with imports of non-metallic minerals rapidly rising in the 1970s. Currently the USA, which is inhabited by 5% of the world´s population, is the world´s largest economy and consumer of natural resources using roughly 20% of the global primary energy supply and 15% of all extracted materials (Gierlinger & Krausmann, 2012).

In Japan, the government and the mining industry have been historically closely interrelated. Japan's post-WWII high growth era and its sustained economic and industrial development was enabled by a dynamic mineral resources policy which ensured that the Japanese industry secured a stable supply of raw materials to overcome its extreme import dependency of minerals (Japan's import dependency in 2012 was 99.6% for oil, 97% for natural gas, 100% for copper ore, and 99.3% for coal). The latter encompassed not only securing the supply of primary raw materials via agreements with countries and direct investments by private capitals in overseas mines and in exploration in Japanese offshore resources. Private Japanese capitals have invested in over 40 iron, nickel, copper, zinc and gold mines in Southeast Asia, Australia, North and South America, and Africa. For instance, in Brazil, owner of 80% of the world´s niobium reserves, JOGMEC, Japanese steel companies and Korean companies have invested USD 1.95 billion to acquire 15% of Cia. Brasileira de Metalurgia e Mineração, the world's dominant producer of niobium.

Nowadays the government administrative agency Japanese Oil, Gas and Metals National Cooperation (JOGMEC) is a key actor in the Japanese resources policy. With a worldwide network of 13 offices, JOGMEC leads a multi-faceted strategy and permanently supports the domestic and overseas development of the minerals industry, both primary and secondary, fostering innovation and cooperation. Such a strategy encompasses joint operations, training for experts, providing equity capital and loans and liability guarantees for metal exploration and development by Japanese companies, conducts overseas geological surveys to help Japanese companies secure mineral interests and to support their exploration projects, among others. Also, Japan is investing much in offshore exploration for energy and minerals; for instance in 2014 JOGMEC pioneered the signing of the world's first cobalt-rich ferromanganese crust exploration area contract with the International Seabed Authority and secured exclusive interests for Japan.

South Africa has also been closely related in minerals trade with Japan as supplier of essential minerals such as chromium, manganese, cobalt, vanadium, and PGMs of which South Africa hosts 95% of world reserves (USGS, 2016). Japan is, in fact, South Africa's third largest trading partner and over 100 Japanese companies have a presence there. Japanese private investments have been led towards the metals sector, and recently JOGMEC has invested in a number of exploration joint ventures in South Africa particularly in nickel and the PGMs (including a joint venture with Platinum Group Metals Ltd in Waterberg and the joint venture in the Stellex North Project) and a rare-earth joint venture in Malawi.

Selected key drivers of mining success

Another aim of the contextual INTRAW Country Reports was the analysis of *key drivers* behind the success of the domestic non-energy extractive industry in all mineral resource-rich countries, with the exception of Japan which is often considered a mineral resources-poor country (excluding in-use stocks) and does not host a domestic mining industry. Even though the historical circumstances of each country differ and the mining industry evolved adapting to internal and external situations, the INTRAW project identified a series of common drivers. The most important are summarized below.

Exploration phase:

It is widely recognized that mineral endowments are one necessary but not sufficient condition for the extractive industry to flourish. The mineral endowment is closely related to prospecting and exploration activities and investments which render mineral occurrences into discovered deposits. During exploratory phases, key drivers (not exclusive of the exploration phase) are:

- ***Availability of public and reliable geoscience data***: Canada´s federal government (and the provinces too) have traditionally provided funding for public geoscience information on the premise that good economic government policy requires a sound knowledge of Canada's mineral potential. The public availability of up to date bedrock geological maps, regional geochemical, geophysical and geospatial data (in a repository) and reports, reduce the cost and risk of exploration by allowing companies to identify areas of high mineral potential, reducing the need to spend time and money exploring less prospective ground. In addition, geoscience information also informs government policy decisions in respect of land use planning, infrastructure development and environmental protection. This information is critical to reduce the financial risk associated with exploration decisions. In Australia, the Australian (Commonwealth), State and Territory governments undertake various geoscience programmes to support mineral and petroleum exploration. These programmes acquire and make available precompetitive geoscience information and datasets, particularly covering important areas, as a basis for exploration.

- ***Well-developed and dynamic exploration cluster***: Canada slipped from the world's top destination for exploration spending in 2012 to the second spot behind Australia in 2013. Canada has been particularly successful in fostering the development of junior mining firms that focus on exploration, and this contingent of junior firms (based in Toronto or Vancouver) has created a number of key advantages for the Canadian mining sector as a whole. Canada has also been successful in the collection of a cluster of around 2,000 junior mining exploration firms. A key reason for the establishment of this cluster has been the Canadian tax and finance system which has provided junior firms (via the Canadian Mineral Exploration Credit and the above mentioned flow-through shares), with capital that they could otherwise not obtain from banks, which tend to be averse to exploration given that it represents high-risk investment.

Exploitation phase

- ***Politically and institutionally stable framework***: this involves a high respect for the rule of law and security of tenure, attractive for mining investments from domestic and international sources. It has been and remains a key factor for the USA, Canada and Australia, less for South Africa which has faced more instability. However, in spite of the significant social problems, South Africa remains one of the most stable countries on the African continent with indices indicating a favourable business and investment environment. The USA has had stable mineral laws for over 100 years and a well-defined protection of property rights. Likewise Canada and Australia have traditionally been considered low (political) risk environments for mining investments. Canada as a country and most of its provinces have consistently been placed very high in the Fraser Institute´s ranking for the most attractive locations for mining investment; Australia has been consistently considered the world´s most secure location for mining investment in the Behre Dohlbear ranking during the period 2005-2013 (Wyatt & McCurdy, 2014).

- ***Access to land, energy and water***: in Australia access to land for exploration and development has been enabled by the ownership rights scheme (mineral rights are held by the state, making ownership and access negotiations easier). By engaging in negotiations with Indigenous Australians to secure land access agreements sufficient energy and water infrastructure is now available. In South Africa, at present, with increased population numbers and as a result of urbanisation the supply of energy and water are constrained. This challenge is recognised by the South African government, and efforts are being made to increase the energy output.

- ***Efficient permitting procedures***: the Canadian permitting procedure for mining is considered stringent but very effective with a permitting delay of around two years, similar to Australia, and lower than that for the USA (average of ten years) (SNL Metals & Mining, 2015). Also permitting times in South Africa have acted as an incentive, i.e. permitting takes on average currently 12 months for exploration licenses, and the conversion between the exploration and the mining permit is straightforward, providing security of tenure. In Australia fast and low cost permitting has been a key driver of the mining industry; recent best practice examples are given by the Nova (nickel-copper) or the DeGrussa (copper-gold) projects (Murguía, 2015a). It is also important to note the role of the government, proactively working with exploration companies to ensure that documents are appropriately prepared for lease and permit applications. Usually the government assigns case managers (or project officers) to complex projects (a service called comprehensive case management services in the Department of Mines and Petroleum, WA, or a "one stop shop" in South Australia). The case manager works closely with the company to assist in the resolution of bottlenecks and to negotiate agreed approval timelines across government (Tyne, 2015).

- ***Granting of the social licence:*** Canada´s mineral sector has seriously considered the issue of the social licence and understands that dealing with this issue requires ongoing dialogue between the agencies in government that issue the mineral tenure and control the land use management regime and industry and local communities and other agencies of government to ensure all stakeholders understand at all stages the nature of the work and possible outcomes of the mining investment. Australia has had a different situation. On the one hand, Australia-based companies have seriously engaged in leading best available practices and mitigating the social and environmental impacts of the mining industry. On the other hand, Australia has also benefited from the location of most major mining centres in remote areas, away from major population centres and areas of intensive agriculture. This has been influential in reducing community objections to mining. The social licence issue remains a challenge in many states of the USA. Although this differs per state, the nation-wide overall perception is that the USA does not view itself as a mining country anymore and the public view of mine operations is generally negative, mostly because of ongoing impacts from abandoned mines from the 19th and early 20th centuries.

- ***Skilled workforce***: all four considered countries have had and still have sound educational institutions training the workforce. The USA, for instance, has a solid, well-educated general workforce, and a large (though ageing) workforce in the geosciences (Gonzales & Keane, 2010). The mining specific workforce is much more limited and has been declining for generations as the size of the necessary mining labour pool has shrunk, but this is expected to be solved with hiring of non-U.S. professionals. In Australia the lack of skilled workforce in the country has been traditionally resolved via employment-based immigration, and local shortages have been overcome using fly-in fly-out or drive-in drive-out schemes. For more than a decade, the Canadian mining sector has been involved in a skills shortage process with fierce competition from companies in other countries. The industry, educational institutions and governments are coordinating efforts to address this challenge (e.g., Canada Job Grant Programme by the federal government, the introduction of a Federal Skilled Worker category to recruit trained workers from abroad, etc.) but it is not yet clear whether efforts will successfully bridge the increasing shortage.

These key factors are general and may not be representative of all the states or regions in each country. However, they have been agreed by a large number of experts and represent a good guidance point for investors and governments seeking to improve the framework conditions of the industry alike. Other key factors have been identified and can be consulted in the Country Reports.

European International Observatory for Raw Materials

The Observatory will be launched before 2018 aiming at the establishment and maintenance of strong long-term relationships with world key players in raw materials technology and scientific developments. It will be part of the EC raw materials infrastructure that will remain operational after the project completion. In terms of functions the Observatory is relatively broadly defined in the INTRAW Grant Agreement as "*a permanent body that will ensure improved co-ordination of an effective research and innovation programmes, funded research activities, and synergies with international research and innovation programmes for the EU raw materials sector*."

This relatively broad definition provides sufficient room to fine-tune the Observatory concept to match present and expected future requirements. In doing so the project relies extensively on the suggestions and recommendations from external experts, who contribute to the work of the project's Advisory Panel. During the Workshop held in September 2015 in the city of Bled, Slovenia, several ideas were collected as to the desired functions and immediate impact of the Observatory.

The experts felt that the immediate support to “small-scale” cooperation, exchanges, networking and scholarships would likely generate substantial interest, whilst it would not result in resistance from any of the global key players. Better harmonisation of national programmes, added value generated from international cooperation, providing information on EU raw materials research for a better uptake of results, and an opportunity to bring together existing research groups by merging resources (and avoiding duplication of research efforts) were some of the key benefits emphasized. The Observatory could play an important role in the standardisation of best practices such as reporting codes in H&S, mineral reserve/resource classification, harmonisation of terminology relevant for raw materials research, etc.

In terms of potential negative feedback loops experts warned of the danger of adding to bureaucracy instead of making things easier and the possible birth of a new type of resource colonialism, with the EU taking the lead, that can expect resistance from other global players. Others warned that maintaining funding for the Observatory could be difficult and if it comes from EU sources then the EU may be aiming to enforce its own agendas that can lead to a loss of flexibility, which the decisive majority of the experts considered an added value at the first place. The need to develop new, innovative funding models was emphasized on several occasions together with the need to continuously develop the Observatory’s services in order to avoid the creation of yet another passive “repository-type” web platform.

In the longer timeframe the Observatory was seen as an important catalyst in aggregating international research, resulting in a better availability of data, including data for basic/academic research. Elimination of overlapping research activities on a global level was mentioned as a long-term benefit that could result in improved technological solutions and the speeding up of the deployment of sustainable raw materials technologies. Industry participation in the work of the Observatory was seen beneficial as it could lead to investment in applied research and raw materials exploration, exploitation and recycling.

In terms of project vision it has been agreed that the Observatory will not only continuously monitor cooperation possibilities but will also actively promote these via facilitating the establishment of dedicated bilateral and multilateral funding schemes and incentives for raw materials cooperation between EU and technologically advanced countries outside the EU. In addition the Observatory could act as a flexible advisory service, providing an overview of global market opportunities for trade and well-documented investment and/or cooperation opportunities for each country within the EU.

CONCLUSIONS

The global challenges being faced by the non-energy minerals industry such as skill shortages, price volatility, market distortions and supply risks, lack of social licence to operate, and others, need to be approached by means of international cooperation, and not only via competition mechanisms. The historical analysis of the five reference countries has shown that bilateral trade partnerships can be a long-term source of mutual benefits for countries or regions, allowing stable economic growth and a politically and institutional stable environment attractive for investments. The key drivers of mining success have shown that countries face similar challenges but are resolved in different ways and can learn from each other. Results have shown that cooperation should not only be among governments, but also between governments and the industry. The close relationship of the government, its agencies and the industry in Japan is a good example. Another example is given by the constant support of the Canadian and Australian governments to the exploration sector by financing the public availability of digital data on exploration or by assigning case managers to projects in order to ensure the smooth approval of necessary permits.

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