Mineral Resources in Land Use Planning

Why Consider Minerals in LUP?

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1 Introduction

Although specific definitions may vary, land use planning (LUP) is generally about optimising land resource use for the benefit of society, both now and into the future. In many ways, LUP is about the implementation of sustainable development on a particular land-base.

Different potential land uses

In any given area, there can be many different potential land uses – agriculture, tourism, soil erosion prevention, climate control, etc. – and these can compete with each other. The process for deciding on future land use needs to incorporate an informed and balanced assessment of the different options. Transparent consultation and stakeholder engagement can play an important role in the integrity of the process and acceptance of land use decisions.

"*Mining as a land use can be particularly contentious, because even though the global 'footprint' of mining is relatively small (mines occupy no more than a fraction of 1% of Earth's land surface – much less than forestry or agriculture) mines can only be located where there are mineral deposits.*" [MMSD, 2002]

Mina primavera
Magnesitas Navarras, Spain

Mineral resources can be often overlooked in LUP processes. Sometimes this is because of assumptions about mineral extraction and its compatibility with other land uses, or a lack of appreciation of the potential benefits from mineral extraction. Arguably, this is most often because meaningful mineral resource information is seldom readily available to land use planners. Even when it is, it is challenging to estimate the potential value of mineral resources for the purpose of comparing with other land use options.

These challenges mean that in some cases development opportunities from mineral extraction are unknowingly written-off. In other cases, land use decisions are reversed in order to allow for mineral extraction, which can be both wasteful and disruptive. Decision-makers may decide that land uses other than mineral extraction take precedence in a given area. However, it is important that they arrive at this decision based on adequate geological information and mineral potential data, so as to avoid unnecessary opportunity loss for national, regional and local economies.

This document is intended to contribute to the understanding of mineral resource consideration in land use planning. The document has been written in close collaboration with representatives of different mining companies, experts and geological surveys. It is designed principally for use by competent authorities, as well as consultants and other practitioners who are involved in the design and implementation of land-use planning strategies. It is hoped that it will also be of interest to other organisations and the general public. It does not advocate for mineral extraction as a preferred land use and neither is it intended as an analysis of land use planning *per se*.

2 Why consider minerals in LUP?

Minerals have provided people with both tools and building materials since time immemorial. Minerals are essential for modern living and society remains highly dependent on them for technological innovations in energy, construction, communication, food supply, health delivery, most goods and many services. It is likely that the demand for many mineral resources will rise as populations and real per capita income increases (even with increased recycling). Continued development therefore relies on the ongoing availability of mineral resources.

Although we may accept that there is a global societal need for minerals, how does mineral exploration, development and extraction figure at the regional level where land use decisions are played out? The challenges involved in translating mineral wealth into socio-economic development have been well studied. However, many would recognize that mineral extraction can directly contribute to economic development through the creation of jobs and government revenue. A major industry initiative has focussed on identifying the factors that have allowed some countries to benefit from their substantial resource endowments through economic growth and poverty reduction and avoid the so-called 'resource curse'[1]. The study findings indicate that there is strong evidence that mineral extraction can provide an important and sometimes critical contribution to

1 See the Resource Endowment Initiative and Mining Partnerships for Development project at www.icmm.com/our-work

economic development and poverty reduction – provided the underlying conditions are right.

A fair assessment of the potential benefits and costs of mineral extraction is therefore very important when looking at different land use options. Perhaps this could be thought of as a "Geo-system Services Approach".


Rosia Montana Project, Romania
3D model in the Info Center

Another important factor is that the location of mineral deposits is very specific to the geological conditions under which they are formed. In other words, mineral resources are where they are found and that defines the locale of the mineral extraction operation. If mineral resources are overlooked in the planning process for a given area, they can't simply be extracted from elsewhere in the region the way other economic activities - such as livestock raising for example - could possibly be moved. If mineral resources are not considered in LUP, they can be unwittingly written-off on a permanent basis. To some extent, this has already led to extraction of lesser-grade ores, which only increases the energy intensity of the sector.

3 Mineral extraction as a land use: can mineral extraction be compatible with other land uses?

A common assumption is that mineral extraction is always incompatible with other land uses, particularly conservation or natural land uses. Although mineral extraction can have a significant 'footprint', the size and nature of the footprint can vary with each project and the question of compatibility with other potential land uses is best determined on a case-by-case basis in the process of planning land-use, mining and mine closure.

Mineral extraction is a temporary use of land which means that land use options after mineral extraction ceases should be considered. Post-mineral extraction land uses are very dependent on the nature of the mineral extraction activity and the extent to which planning for the post-closure phase takes place. Some types of mineral extraction allow for 'restoration' of mineral extraction land to pre-mineral extraction status, whereas others alter the landscape on a permanent basis which can nevertheless allow for new land uses. Some types of mineral extraction also allow for other land uses to

New Hippodrome, town of Most
successful reclamation of the spoil bank
of the Jan Šverma surface mine

take place at the same time that mineral extraction is occurring.

Of course, the integrity of any land use that is either sequential and/ or concurrent to mineral extraction will be highly dependent on the extent to which responsible mineral extraction is being practiced. This means that the environmental risks are understood and managed appropriately. Modern mineral extraction techniques allow for better management of social and environmental impacts than in the past and thus expand the possibilities for compatibility in the form of either concurrent and sequential uses.

A broader understanding of mineral extraction can therefore be useful for LUP purposes. The following section is a general description of the mineral extraction process as well as a summary of the different types of mineral extraction activity and implications for other land uses.

3.1 Mineral extraction Overview

Each stage of mineral development is characterised by a number of activities that vary in their potential to impact land use. Exploration for minerals requires access to large tracts of land if there is to be a reasonable chance of finding new mineral deposits. Although the area of land under exploration is sometimes vast, there are few land-based activities and these generally have a low impact. In the mineral extraction phase, the focus is on a smaller land area, with higher impacts.

The most significant impacts on land take place during the construction and operation of mine sites. Land impacts can differ widely depending on the mineral being extracted, the way it is extracted (e.g., open pits) and its physical and chemical characteristics. For example, the mineral extraction/quarrying of most construction materials (such as sand, gravel and building stone) will result in land disturbance but normally remain chemically

Open pit Lulec in Czech Republic – aggregates extraction

stable. In contrast, the extraction of most metallic ores involves the storage and processing of materials on surface and the possibility of a variety of chemical processes which can have effects on the environment if not properly controlled. The risk of long-term water contamination through Acid Rock Drainage (ARD) is arguably the most significant potential issue.[2]

An initial separation of the mineral from the total material extracted from the earth is normally carried out at the extraction site (the mine). The portion of this material rich in ore minerals (the ore) is often

2 See the website of the International Network for Acid Prevention (INAP) for further information on Acid Rock Drainage http://www.inap.com.au/what_is_acid_drainage.htm

View of the new pelletizing plant MK3 in Malmberget
LKAB, Sweden

concentrated on-site (at a processing plant) before being shipped off-site for extraction by smelting and refining. In some cases, the ore is shipped directly off-site without undergoing concentration.

Two kinds of waste emerge from the separation processes at the mine site: the waste rock which is the part of the material extracted from the earth that does not contain the ore; and a fine material, known as 'tailings' arising from the concentration process. Both of these waste streams are stored in large waste deposits on land and can result in significant land footprints. However, these waste

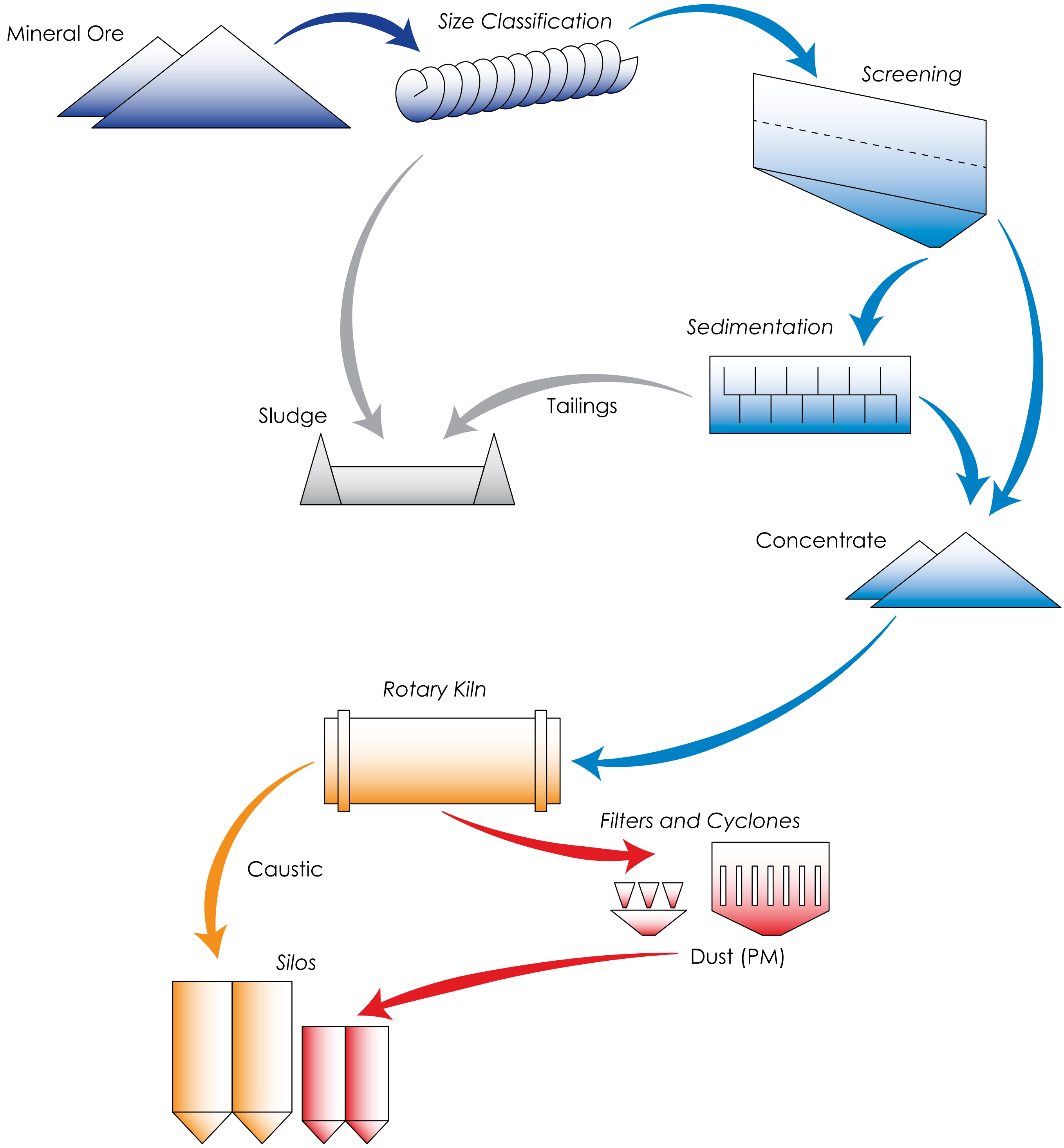
Potash transport by rail
K+S, Germany

deposit areas are engineered to be stable (both physically and chemically)[3] and although many of them stay behind after mineral extraction ceases, are being rehabilitated to a level which makes further use of the land possible.

Mineral extraction can also require significant infrastructure development, such as rail, road and port facilities. When mineral extraction takes place in remote areas, this infrastructure can have a much larger area of influence than the mineral extraction itself.

Mineral extraction operations can also attract other activities with impacts on land (e.g., aerospace industries in northern Sweden) and although they are harder to predict, they need to be taken into account.

3 This is now a legal requirement in the European Union as per Directive 2006/21/EC.



Typical example of how a particular industrial mineral product might be beneficiated at the mine-site.

3.2 Types of mineral extraction

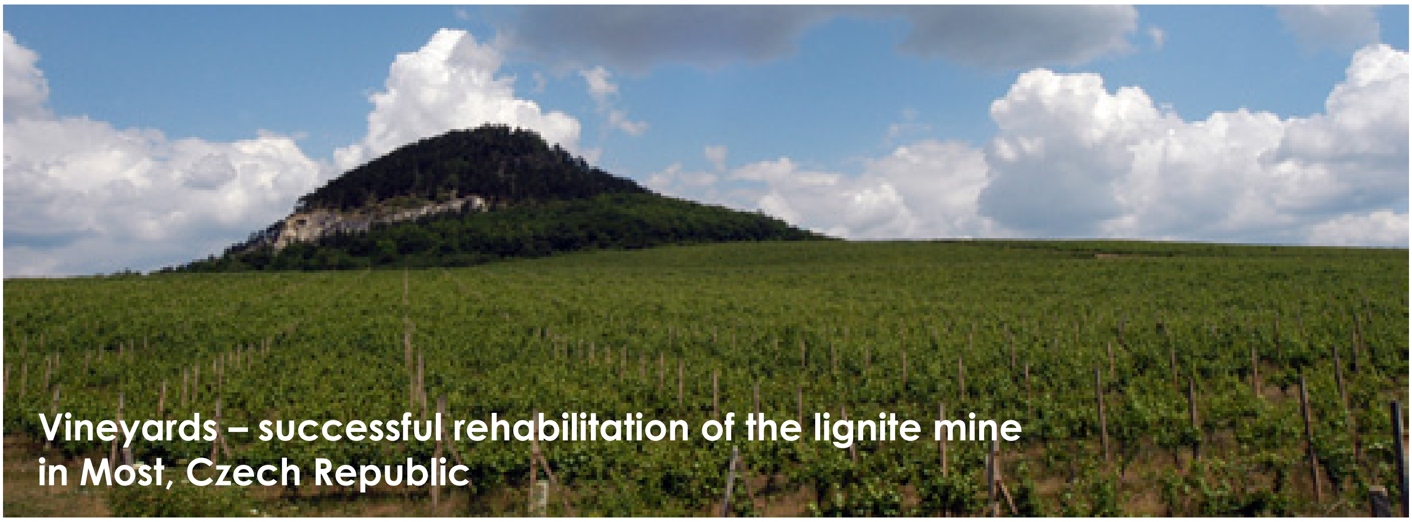
The type of mineral extraction method will influence which land use options will be available. This is summarised below.

Surface open cast mineral extraction

Coal extraction operations typically practice open cast mineral extraction by stripping the coal seam from an area of land with mechanical equipment such as a 'dragline'. The trenches that are formed behind the dragline are filled in with the waste material as it is extracted and ongoing rehabilitation takes place at the same time as extraction. At any given time, only limited land areas are being mined which means that land is available for other uses. Over time, the total area mined is large and could be 1,000s of hectares in extent. However if done well, the rehabilitation results in the return of the land to a previous state in a few years. Particular success has been achieved in this type of mineral extraction in the case of post- extraction land uses for agriculture.

North Greece West Macedonia Lignite Centre of Public Power Corporation SA. – Before rehabilitation

North Greece West Macedonia Lignite Centre of Public Power Corporation SA. – After rehabilitation



Vineyards – successful rehabilitation of the lignite mine in Most, Czech Republic

Dredging

Dredging is common for the mineral extraction of mineral sands and is often located along sand dunes. This mineral extraction involves the flooding of a trench with water and the dredging of the mineral from the sands in the trench. The material is processed on the lake formed in the trench and the waste material is deposited behind the active part of the trench with rehabilitation occurring in an ongoing manner, very much like the coal mining example. Risks are mainly water related, though like with open cast extraction, good rehabilitation can result in a return of the land to pre-mining conditions relatively quickly.

Halamky sand pit – revitalisation process in parallel to the current extraction activities, Czech Republic

Surface open pit extraction

This type of mineral extraction can leave behind a large open pit and waste facilities (waste rock deposits and tailings dams), which together can cover a large area of land. According to new EU legislation, operators need to provide at the beginning of the operation a plan for the rehabilitation and future land use, which can include "backfilling" the pits, which reduces the footprint of the areas where tailings and waste rock were stored. The chemical and physical stability of the pit and waste facilities need to be managed carefully to avoid contamination of surface and ground water, harmful diversion of waterways and air pollution (dust). The post-mining land use options for these areas will be determined by the way these risks are managed and the options in some cases may be limited. Land shape (e.g., steep slopes) will also have an influence. In some cases, there are opportunities for new land uses, for example bird habitats in old pits.

Open pit Aitik, copper extraction Gällivare, Sweden

Underground mineral extraction

With underground mineral extraction the activity is out of sight, but the infrastructure and waste disposal normally occurs above ground. The footprint is typically less than for an open pit mine, but can take a large area of land, some of which - such as waste rock deposits and tailings dams - may also have limited post-mining land use options. As with open pit mineral extraction, underground mines can be backfilled with the waste material, but even when this occurs, some waste material will need to be disposed of on the surface. When

The Kiruna pit was converted to an underground mine – LKAB, Sweden underground mineral extraction is shallow, subsidence risks need to be addressed and can result in some surface areas being unsafe for other activities.

Karvina Mine Lazy Site – OKD/NWR, Czech Republic

In situ leaching

This involves using solution mineral extraction techniques for extracting soluble ores such as uranium, potash and salt in situations where conventional mineral extraction techniques are uneconomic. A solution is pumped into the ore body (in the ground) through a network of injection bores or wells and then pumped out together with salts dissolved from the ore body through a series of extraction bores. The mineral product is precipitated out of the solution in a processing plant on site. The control of the solutions, management of waste brines and risks around surface subsidence all need to be managed. In-situ leaching generally has a small footprint - the area of land used is limited and can be rehabilitated for other uses on mine closure.

K+S's underground waste disposal facilities

3.3 Integrating mineral extraction into regional planning

When looking at mineral extraction within a mix of land use options in a given area, it is also important to consider how the mineral extraction activity could interact positively with other land uses. For example, mineral extraction can bring an influx of resources to remote areas with little infrastructure. There can be scope to design a mine and infrastructure development plan so as to support other land uses (for example by building a port or road in a location that opens up access to markets for local farmers, or by establishing a green corridor to link existing natural areas). There has been some good work done in this area, for example the on Dynamic Mineral Resources management by the World Bank. Companies can also support broader regional goals and plans as part of their sustainability policies that may have little to do with the mineral extraction activity itself.

Zinc smelter Odda – Boliden, Norway

4 How can LUP processes incorporate mineral resource considerations?

The land use planning process can be broadly divided into two phases:

1. **Assessment** of the current situation and future development needs; analysis of the data; identification of opportunities and constraints; and evaluation of alternatives.

2. **Decision-making** on the best alternative and developing a plan; implementing the plan; and monitoring.

These activities are essentially iterative in nature as new information and changing conditions might require retracing earlier steps.

Stakeholder participation can inform both phases of LUP: providing local knowledge to the assessment of the current situation and building buy-in to the land use decisions. Stakeholders in land use planning are diverse, representing numerous interests. They range from government to civil society and can even include international agencies.

So how can mineral resources inform both phases of LUP?

When mineral extraction or exploration is already taking place, a good stakeholder consultation process would arguably go a long way to providing the necessary mineral information in both the assessment and decision-making phases of LUP. Mineral stakeholders are from government and the private sector. For example, the department of mines and/or natural resources, national geological departments, the registrar of mineral right holders and mineral exploration licensing authority, exploration and mineral extraction companies as well as national or regional chambers of mines and even informal or artisanal miners in some parts of the world.

However, the inclusion of mineral resource considerations in LUP becomes challenging when minerals have not yet been discovered and/or their value is not clear. The process by which the value of a mineral resource is understood is not straight-forward, so meaningful mineral resource information is seldom readily available or sought by land use planners. Even when it is, it is challenging to estimate the potential value of mineral resources for comparison purposes with other land use options.

The following sections outline sources of mineral data, their limitations, and the relevant stakeholders. These information sources and stakeholders would ideally provide sufficient basic mineral data to alert planners to the need for further analysis of mineral potential.

5 Mineral Data

5.1 Accessible Data

There are several different types of mineral data. Coverage, quality, accessibility etc often varies, but there are some forms or types that occur more commonly than others.

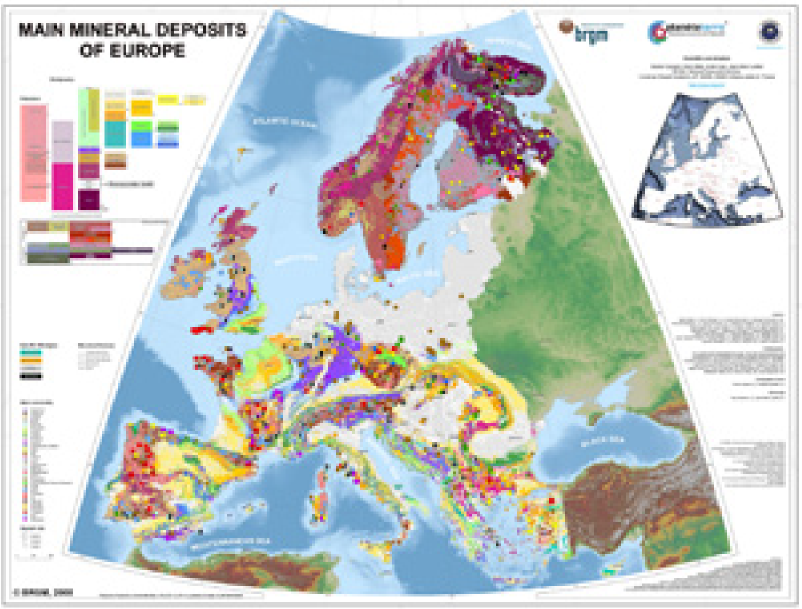
The most available form of mineral resource information is a geological map. These maps indicate the locations that have a likelihood of hosting mineral deposits of different types. A basic geological map is usually readily available in many countries from the national geological surveys, but will only provide a very rough indication of potential mineral resources.

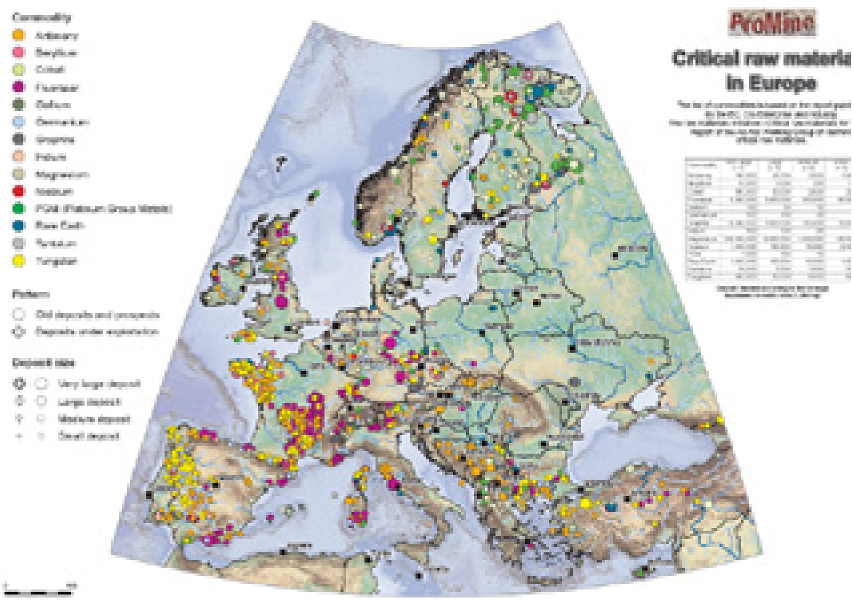
Best Practice on knowledge sharing: The Fennoscandian shield ore deposit database and metallogenic map

The public-domain Fennoscandian Ore Deposit Database (FODD) contains data on more than 900 metal mines, unexploited deposits and significant occurrences within Fennoscandia (the Precambrian shield and the Caledonides in Norway, Sweden, Finland and northwest Russia). Information on the deposits includes the location, mining history, tonnage and commodity grades, together with a commentary on data quality, geological setting, age, ore mineralogy, style of mineralisation, genetic models, and the primary sources of data. Information on mineral resources is mostly based on in situ geological estimates, which should not be confused with the present industrial resource and reserve standards.

Databases covering extensive areas are important working tools for modern exploration; the associated metallogenic map is at a scale of 1:2000000. Public mineral deposit databases are used by governments to attract investment, helping investors to select larger areas as targets for more detailed work.

(EC, 2010)





The key to using sub-surface information from Earth Observation data and related value-added products is to integrate the many disparate datasets to generate a 3D model of the sub-surface. Such models are the modern equivalent of the geological map; at a minimum, they are built from digital geological map and borehole data plus terrain models. Integrating more sub-surface information, like geophysics, improves the resulting 3D model. Only a few countries are ready to do this systematically, with all necessary digital data, 3D tools and know-how. Examples include France and the UK (EC, 2010).

A second public source of mineral information is the publicly registered mineral rights of a given area. While these rights would not necessarily indicate a viable mineral deposit, they would certainly identify some legitimate mineral stakeholders in the land use planning process. The national registrar of mineral right holders indicates where there are existing mineral rights and the mineral exploration licensing authority holds information on active mineral exploration activity. Historical data showing mineral rights during the past few years also constitutes a valuable source of information.

A third and probably more valuable source of mineral information is existing mineral extraction activities in or near the planning area. Mineral extraction companies often publish information relating to the extent of their proven ore reserves on existing operations. This public domain information can be helpful in assessing possible future extraction activities in the area, but any extrapolation of probable resources outside the immediate extraction area require additional information and expert knowledge.

Quantitative methodologies, such as the Global Mineral Resource Assessment Project led by the United States Geological Survey (USGS) (USGS, 2003), analyse geological data and provide economic assessments. These can be used to translate the basic mineral data into mineral potential information that could be useful for land use planning. These methodologies require specialised implementation and interpretation. The geological survey departments of the UK, Australia, France, Germany, Spain and Portugal, also operate global mineral data bases that can be accessed for these purposes.

5.2 Restricted Data

Most national governments retain a classified data record of their known and likely mineral deposits which is made up from private and government reports on mineral exploration and extraction. In some countries such data records are in the public domain (eg Sweden, Finland, Norway).

In some countries, the national geological departments carry out research to predict the likely presence of mineral resources. Geophysical data from ground, air and satellite surveys is used to model and interpret geological structures while geochemical data and sediment sampling help confirm the presence of minerals. Existence of and accessibility to such data will vary from region to region and country to country. In some cases institutions such as the World Bank or government agencies from developed countries have conducted basic geological surveys that are publicly available. In some cases more restricted mineral resource data would not necessarily provide details on specific deposits, but would likely confirm the presence of certain minerals in specific areas – the result is a map showing areas where certain types of minerals may be present in sufficient quantities for mineral extraction to be possible.

While land use planners might be able to obtain more detailed mineral data from national geological departments, the proprietary nature of this mineral data will often limit its availability.

5.3 Proprietary Data

The actual value of a mineral deposit is determined through detailed study, sampling and analysis. This detailed mineral assessment requires substantial investment; and is carried out for commercial incentive (i.e., the possibility of future profits from mineral extraction). This assessment is undertaken during exploration which incorporates geological, geophysical, geochemical and geographic studies along with intensive sampling. This is intended to locate and define the extent and distribution of a mineral deposit.

Understandably, companies investing in the high cost of mineral exploration wish to secure their future extraction rights before embarking on such investments. Some form of future extraction right is therefore generally negotiated by way of an exclusive exploration authorisation provided for through statutory regulation. These access rights may extend over large tracts of land (though actual mineral extraction would invariably only occur on a small fraction of this land).

Kittila mine, examining core samples
Agnico-Eagle Finland

In instances where future extraction rights have not been secured, any privately acquired data relating to viable mineral deposits and their extraction feasibility would be highly sensitive and obviously kept strictly confidential by companies. When an exploration organisation has secured future rights to extract a mineral deposit, they may be willing to share some of the detailed exploration information. It is most unlikely however that they would share all their information as some of it may be of substantial strategic and commercial importance. In some countries, it is mandatory for companies leaving claims (areas claimed for exploration) to hand over the geological, geophysical and geochemical data resulting from exploration. The data becomes public domain, either immediately or after some period of time.

6 On the ground knowledge

The sources of information described so far are all from formal channels. Mineral extraction, like other livelihoods, can also take place on a less formal basis. Artisanal and small-scale mining (ASM) is a common activity in many developing countries carried out by individuals using rudimentary techniques. Much of ASM activity occurs outside regulatory frameworks – whether illegal or not – and the fact that it is taking place is generally a good indication that mineral resources are present. On the ground knowledge is therefore an important part of land use assessment. To understand the nature and extent of informal activity of this sort, stakeholder engagement with these groups is also key.

7 Estimating the value of minerals


Gold stamping Boliden, Sweden

When a mineral reserve is found through exploration, technical and economic conditions are assessed to evaluate the profitability of extracting the mineral with the available mineral extraction and processing technology and within a given timeframe. Generally, the future value of mineral resources is initially difficult to predict due to a number of factors including:

- the changing price of the minerals and developments in markets;
- changing knowledge of the particular mineral reserve;
- the economics of mineral transport and handling;
- changing extraction technologies.

8 Conclusion

In this paper, we've looked at why it's important to include mineral considerations in LUP. Most people accept that minerals are valuable to society at the global level, but also that they can contribute substantially to socio-economic development at both the national and regional scale. As LUP is about optimising land use for the benefit of society, overlooking mineral resources in this process could compromise the outcomes.

Another factor that should not be overlooked are the available synergies of combining mineral extraction with other land uses. In some cases other land uses are possible at the same time that mineral extraction is taking place. As it is a temporary use of land, subsequent land uses – after mineral extraction ceases – are also possible. Both of these depend on the type of mineral extraction, specific conditions in the area and the planning that takes place for post mine-closure.

The task of evaluating competing land uses and assessing the benefits and disadvantages of mineral development as a component in the natural resource mix is both complex and difficult. The biggest challenge is estimating the potential value of a mineral resource which has not been developed (mined) or which has not yet been discovered.

Various sources of mineral data are available to inform this question, though there are significant challenges to getting this data in a form that is useful for the LUP process. Detailed data (from mineral exploration) is of a proprietary nature and is sometimes highly confidential. Even if detailed exploration data is available, the value of a mineral resource can only be estimated, because fluctuations in mineral prices and market developments and the variability in mineral extraction and processing costs over time can have a substantial impact. Conservative estimates are therefore always advised.

These challenges highlight the need for engaging with stakeholders around mineral resource questions. Consultation with relevant government bodies (e.g., geological department) is an important first step that would ideally alert planners to the need for further data gathering on mineral resources in a given area. An understanding of existing mineral extraction and exploration activity is also vital, via consultation with exploration and mineral extraction companies, national or regional chambers of mines. This should also include on the ground knowledge – for example from artisanal miners and their communities.

Given all these challenges, a suggested methodology for including minerals considerations into LUP is outlined in this paper. Although this methodology may not be entirely applicable in every situation, the hope is that – along with the suggestions on mineral data and stakeholder engagement – this will be useful in incorporating mineral considerations transparently and fairly within LUP.

Suggested methodology for considering minerals in LUP

A step-wise methodology for the incorporation of mineral resource consideration in land use planning is proposed below.

1. A comprehensive geological appraisal is conducted by a mineral resource expert based on available data. This should provide an informed and independent assessment of the mineral resource value in a manner that can be used by decision makers in the land use planning process. The geological appraisal should be made available to all stakeholders involved in the land use planning process.
2. Further mineral resource information is obtained where possible by consulting mineral stakeholders, such as:

- The department of mines / natural resources;
- National geological departments or geological survey;
- National registrar of mineral right holders, the mineral exploration licensing authority;
- Mineral right holders – exploration and mineral extraction companies;
- National or regional chambers of mines; and
- Artisanal miners and their communities.

3. After consultation with mineral stakeholders, criteria for the identification of the mineral resources of importance in the planning target area are established. These criteria might include such things as value, rarity, unique properties and strategic interest.
4. Applying these criteria to the mineral resources in the area, sites of high mineral importance - if there are any – are identified and mapped.
5. The potential mineral resource extraction of these sites is then evaluated. If necessary, modelling is carried out with the appropriate specialised inputs and rigorous methodology. Land use options, including sequential and concurrent land use alternatives are mapped out and decided according to LUP processes.
6. If there is a decision to keep the option of potential mineral extraction at sites of high mineral potential, interim land use options are decided accordingly.
7. If mineral extraction does take place, careful management of activities that may cause long term impacts must be enforced to ensure that future land use options are not compromised.
8. The planning for land use options subsequent to mineral extraction should take place early and the post closure responsibilities must be clearly assigned.

9 References

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