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Sustainable exploitation of geological resources

International competition for rare minerals and raw materials is increasing. Also in this field, Norway has considerable natural resources. If we wish, we can stand on the threshold to a new era of modern, sustainable mining industry in Norway.

Throughout the history of mankind, the development and use of raw materials has been a crucial prerequisite for technical progress and improved living conditions. Today, researchers all over the world are focusing on the development of new materials which are stronger, more durable, lighter and more environmentally friendly, or possess completely new properties. In particular, we have expectations that nanotechnology will pave the way for a new industrial revolution.

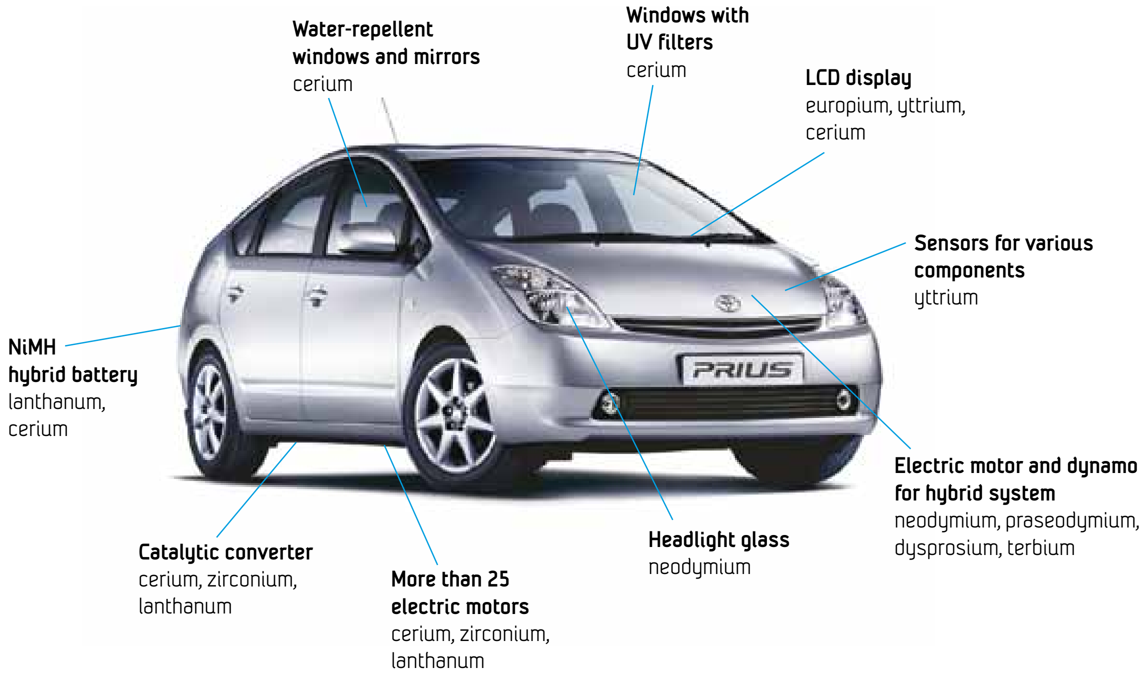
Materials science and nanotechnology form the starting point for wealth creation in other important sociological fields associated with health, transport, energy generation, environmental science and ICT. Mastery of materials science and nanotechnology, and the ability to translate them into industrial applications, will be crucial for the competitiveness of industrialised nations in this century. In other words, such expertise is extremely important for ensuring freedom of action, welfare and health (Avanserte Materialer 2020, (Advanced materials 2020) [in Norwegian], the Research Council of Norway, 2005).

In forty years, the population of the earth will have grown from the present 6.5 billion to about 9 billion people. At the same time it is expected that an ever-increasing proportion of the population will attain a higher standard of living and thereby also climb up the protein ladder. It is acknowledged that this will present significant challenges for the planet as regards access to food and energy, and issues connected with climate change and renewable energy are conspicuous in current debate.

In the international arena we see how broad-based political settlements lead to changed policy instruments "overnight". We also note that the university and research institute sector has responded rapidly, among other things by establishing Centres for Environment-friendly Energy Research (FME) in accordance with the Norwegian parliament's consensus on climate-related policy.

Another perspective connected with the future increase in population and prosperity is the generally increasing need for manufactured goods such as solar cells, guitar strings, roof tiles, toothbrushes, hairdryers, cars (conventional, hybrid and electrical), TVs, paint, batteries, concrete reinforcement bars, cosmetics, mobile telephones, iPads, cement, watches, bicycles (which are also gradually becoming electrified), agricultural equipment, kitchen utensils

All these products, and many, many more, have their origin in so-called geological resources (oil, gas, ores and minerals). Our acquaintance with this concept commences in the kindergarten sandpit (specialised sand products) and concludes with the gravestone. In the course of his life, the average man uses more than 850 tonnes of minerals or mineral-based products (including about 400 kg of iron and steel per year).



Rare earth elements in a Toyota hybrid car Source: Edmundson.com / A-Magasinet

Consumption of mineral raw materials has increased in step with the development of modern society. Some lines of development have progressed more rapidly than others. For example, in the course of the last 25 years we have consumed half of the cumulative volume of copper which has been found throughout history, and demand for the metal is expected to grow rapidly, among other things because of increasing amounts of copper in electric motors in universal use, increased electrical energy production (generators), electrical distribution grids, and so on.

Rare earth elements

Another example is the somewhat less well known element neodymium (Nd), which belongs to the group of rare earth elements (REE). This is an important material in magnets designed for use in, among other things, wind turbines. If all the wind turbines for which development licences have been granted or applied for were to be constructed using this technology, it would consume 2 500 to 5 000 tonnes of neodymium. The total world production of neodymium was approximately 22 500 tonnes in 2009, and demand is expected to increase by at least 50 per cent by 2014. This puts the concept of *sustainability* in a new light.

A similar situation is seen with regard to the element lanthanum (La) in the manufacture of hybrid cars. The battery of a Toyota Prius contains 10-15 kg of lanthanum. If the ambitious goals for the proportion of electrically powered road vehicles are to be achieved, this will require an increase in production of lanthanum exceeding what is practically possible. There are many similar examples, since so-called green technologies are often based on the use of rare raw materials. In other words: Sustainability in one context does not necessarily entail sustainability overall ...

The structure of a modern mobile telephone contains about 60 different elements, many of which are rare. These elements are often referred to as *special metals*[1] and *precious metals*[2]. China currently controls the production of and access to many of these materials and metals, including about 95 per cent of the rare earth elements (REE), while countries such as the Congo are important suppliers of others. China is among the three largest suppliers of 13 of the 19 most important ores and minerals.

A new strategy for the EU

The EU has inadequate supplies of mineral raw materials and in 2008 it focused attention on the issue by establishing the so-called *Raw Materials Initiative*. The ambition here is to develop a strategy which can be divided into three main elements:

- To ensure access to strategic materials and minerals (international trade agreements)
- to evaluate the basic resources in the EU's own region and establish a modern, environmentally-friendly technological platform, while creating a healthy climate for the establishment and development of its own industry
- recycling, re-use and substitution (reducing dependency on imports)

China and a number of other countries are increasingly tightening the screw through export restrictions for strategic raw materials, so the EU's freedom of action will primarily involve the last two elements above. In connection with this, a good deal of positioning is taking place, in which Norwegian R&D operators so far have not been particularly prominent. It is expected that *sustainable exploitation of mineral resources* will be an important theme in connection

[1] Tungsten (W), antimony (Sb), cobalt (Co), bismuth (Bi), selenium (Se), indium (In), among others
[2] For example, silver (Ag), gold (Au), palladium (Pd), platinum (Pt), ruthenium (Ru), rhodium (Rh), osmium (Os), iridium (Ir)

with the EU's 8th Framework Programme for Research and Technological Development in 2014.

Norway's situation

In the past 20-30 years, prospecting operations in Norway have been at a very low level – about one tenth of the level in Sweden and Finland. The industry has explained this in terms of unclear framework conditions (complicated laws) and inadequate basic data in the public domain. After fifteen years' work, the authorities have updated the legislation and combined it into the Minerals Act of 2010.

This is an important step towards clarifying the framework conditions and the mining industry's reaction has been positive, although it points out that it remains to be seen how the new legislation will function in practice. Some uncertainty is still associated with, among other things, the issue of indigenous peoples and the recognition that important ore and mineral deposits are national resources which authorities at several levels should take into account in their planning processes.

As regards estimates of resources, it is clear from the macro-geological picture that Norway has many exciting deposits. A number of new, interesting discoveries are expected if intensified prospecting commences.

The Geological Survey of Norway (NGU) has estimated that the value of our minerals can be compared with the size of the Norwegian Petroleum Fund (NOK 2 trillion, or about EUR 254 billion). The Bjørnevann iron ore deposits belonging to Sydvaranger Gruve AS have an estimated value of NOK 100 billion and the iron ore in Rana is estimated to be worth NOK 90 billion. Similar figures apply to the ilmenite deposits of Titania AS in Rogaland, and represent the value of a moderate-sized North Sea oil field. In comparison, industrial operations connected with ore and mineral *production* in 2008 amounted to a value of approximately NOK 11 billion.

Large potential

In the light of the increased global demand for both "traditional" raw materials such as iron and steel, copper and aluminium, as well as the emergence of major markets for special metals and rare earth metals for use in electronics and green technologies, it is interesting to note that the *Fennoscandian Shield* is becoming one of the most interesting regions in Europe. In this region there are interesting deposits of iron ore, base metals[3], industrial metals[4], precious metals and special metals[2], including rare earth metals[5], with the northern part, the Barents Euro-Arctic region being particularly interesting.

It is natural to conclude that, with the underlying trends towards continued growth, the market for refined products from these deposits will persist into the foreseeable future. With ever-stronger control on the part of dominant countries such as China and India, increased pressure is expected on a range of minerals, with subsequent rising prices.

Norway has natural advantages also in this field. Our geology indicates the existence of considerable potential for land-based industrial and commercial development. Norway is a long, narrow country with an ice-free coastline. This is a decided advantage in connection with logistics and transport, because the majority of deposits will be located in proximity to the sea and hence marine transport. This is also of interest to the neighbouring countries to the east. Sweden, Finland and Russia all envisage the development of shared infrastructure in the northern regions.

Norway is standing, **if you like**, on the threshold to a new era for the continued development of a modern, environmentally friendly mining industry. In the Norwegian parliament a broad-based positive attitude is emerging to support the growth of a new golden age in this sector of industry. The mining industry is in the process of revitalising itself after many years in the shadows, in part by creating a common trade association (Norsk Bergindustri) in 2008.

What is needed for Norway (and its neighbours) to succeed in making the best of the new situation? Some ideas:

- immediate increase in prospecting operations – What was not commercially exploitable yesterday may be today
- investments from both the authorities and private investors
- active use of tax incentives for exploration companies
- regular updating of framework conditions and legislation as we learn from experience
- establishment of value chain arenas (from prospecting to finished product). A goal must be to improve the level of processing and value creation in Norway: we should avoid becoming a raw materials supplier to the EU
- establishment of technology arenas (e.g. for clean-up and environmental issues)
- establishment of policy instruments with regard to R&D and innovation
- adequate educational capacity in technical colleges, university colleges and universities
- establishment of relevant R&D expertise and adequate capacity in research institutes
- establish an R&D strategy according to models from OG21 and Energi21 (MINERAL21?).

This industry will meet many of the same problem issues which are faced by the petroleum industry, smelting industry and others. Important issues connected with the environment and efficient energy consumption must be addressed. Companies' requirements with regard to profitability will necessitate the development of technological and transportation systems, and in the interface between the petroleum industry and the smelting industry *(where gas meets ore)*, ground-breaking new processes and products will be born.

A possible scenario

We can envisage the following desirable scenario: A broad consensus is reached regarding industrial policy which defines clear objectives for future industrial development on mainland Norway. Funding for R&D and innovation is arranged in accordance with this and new thematic areas of involvement are defined. In the field of minerals, the institutions in the mining community of "Bergbyen", Trondheim (SINTEF, NTNU, NGU and DirMin), in collaboration with other national knowledge-based communities, are given responsibility for preparing a national R&D strategy, seen in an international

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[2] For example, silver (Ag), gold (Au), palladium (Pd), platinum (Pt), ruthenium (Ru), rhodium (Rh), osmium (Os), iridium (Ir)
[3] Copper (Cu), zinc (Zn), lead (Pb), tin (Sn), aluminium (Al)
[4] Quartz/quartzite, ilmenite, graphite, limestone and dolomite, anorthosite, nepheline syenite, olivine
[5] Lithium (Li), beryllium (Be), niobium (Nb), tantalum (Ta), scandium (Sc), among others

context. In the wake of this strategy (MINERAL21), a new thematic programme is established by the Research Council of Norway (NORMIN21), taking effect from 2012.

Recommendations

- Initiate work on an R&D and innovation strategy aimed at achieving *sustainable exploitation of mineral resources in Norway (MINERAL21).*
- Establish dialogue with the EU and the EU *Raw Materials Initiative.*
- Define objectives for new industrial activity

Important participants

NGU – The Geological Survey of Norway (www.ngu.no)
DirMin – the Directorate of Mining (www.dirmin.no)
Norsk Bergindustri – The Norwegian Mining and Quarrying Industries (www.norskbergindustri.no)

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