



Norway's mining strategy to attract exploration



Siobhan Lismore-Scott

The Norwegian government is seeking to attract miners to the country and has developed a strategy for the minerals industry to do this by promoting the country's deposits and publicising the industries that are already in place and working.

The 72-page Strategy for the Mineral Industry was released in 2013 and outlines the geographic location of deposits of minerals such as olivine, graphite, limestone, dolomite and rutile; as well as providing details of mining legislation in Norway.

According to the government, and as a starting point, a forum is to be established following the Strategy.

"Increasing international demand for minerals and metals has resulted in higher prices and increased interest in the mineral resources of Norway. There is increasing optimism in the minerals industry and many minerals companies are active in exploiting the opportunities that lie in Norway's geology," Trond Giske, then Minister of Trade and Industry, explained.

The government has worked to simplify the legal framework for operations in the mining industry. In 2010 a new Minerals Act was presented which replaced the five acts that were in place for mining and mineral businesses alike. This, the government said at the time, was an important step towards simplifying the minerals sector and boosting transparency.

"When it comes to the unimaginable values in our bedrock, we leave far too much to chance. This must stop. These values must also be managed in a sustainable way and for the benefit of the population," Arne Haugen,

Industrial minerals in Norway

Minerals being explored	Notes
Ilmenite	Norway has current production of ilmenite from the Tellnes ilmenite-rich norite in the Rogaland Anorthosite. The deposit covers about 6 % of the world consumption of titanium dioxide (TiO ₂) feedstocks. The open pit mine is worked by the company Titania, owned by Kronos Worldwide Inc. Annual production in 2012 was 0.83m tonnes of ilmenite concentrate.
Rutile	In the Sunnfjord region of western Norway a number of rutile-rich eclogites represent possible future resources of TiO ₂ minerals. Best investigated is the Engebøfjellet eclogite, where license-holder, Nordic Mining, estimate resources of 250m tonnes rutile.
Graphite	In 2012 a new company, Norwegian Graphite, was established, with the aim to start production of graphite from known deposits of Jennestad and Rendalsvik. Company reports state that ground geophysical measurements have quadrupled the previously indicated reserves in the Jennestad area, and the company now reports indicated reserves of 3.6m tones.
Apatite	Norway has several potential deposits of apatite but there has been no actual production of apatite since the First World War. In the Larvik area, south of Oslo, the almost 2km long Kodal apatite-magnetite pyroxenite has been investigated through several exploration campaigns over the years for its potential as apatite raw material for fertiliser production. Kodal Minerals Ltd is currently active in the area drilling the deposit and doing beneficiation tests.



Olivine mining at Åheim, Western Norway

Scandinavia is an historic graphite-producing region, with past producing deposits becoming the target of redevelopment projects in a handful of areas across Norway and Sweden over the past three years.

In January 2013, Sweden's Chalmers University was at the head of a successful bid for a grant of at least €500m (\$672*) from the European Commission's flagship Future Emerging Technology (FET) initiative to research graphene.

The grant awarded, which is to be used for investigating production methods for the material, involving a total of 74 universities and companies, will be matched by financial support from other public and corporate sources, taking the total value of the award to €1bn and will be paid out over the next 10 years.

As well as boosting Europe's role in what is already an intensive global drive to develop and commercialise the properties of graphene, the single-atom thick layer of carbon which can be derived from natural graphite, will also help to raise the profile of Scandinavia's graphite mining industry.

Norway is looking to take advantage of its indigenous reserves of the mineral and its own world-leading research capabilities to establish a graphene science industry.

Abalonyx, a Norwegian technology start-up company, has been working with graphene and graphene derivatives since 2008.

"It is well known that certain natural graphites are excellent raw materials for producing graphene in the forms of graphene oxide, chemically converted graphene and reduced graphene oxide," Rune Wendelbo, founder and CEO of Abalonyx, told IM.

Abalonyx uses a modified version of the 'Hummers method' to develop a safe, scalable and reproducible process for making graphene

Scandinavia's graphene potential

Scandinavia is known for its iron ore deposits and fossil fuels, but it also holds vast amounts of graphite which could be used to develop a graphene industry in this exciting hub

Laura Syrett

from natural graphite, which has been automated and is now being commercialised.

Abalonyx has entered into a non-exclusive strategic agreement with Norwegian graphite junior Nordic Graphite to focus on developing a vertically integrated supply chain for graphene production and the companies are presently working jointly to scale up Abalonyx's process to demonstration scale.

"We are also looking at other interesting materials, such as vein graphite from Sri Lanka, and plan to start demo-production in 2014," Wendelbo said.

"For natural graphite to be the preferred raw material, it must be close to 100% crystalline, which is normally not the case with synthetic graphites," he explained.

"We ran a pilot reactor for two months in 2012 using purified natural graphite as the raw

material. The purpose of the pilot run was to confirm scalability, reproducibility and safety as well as acquiring a basis for our production cost estimates. Our cost estimate shows graphene oxide can be produced for €22 (\$30*)/kg," he said.

"With our process, most impurities can be tolerated, up to a level of 5% or so, because they are separated from the graphene together with other wastes," Wendelbo noted.

"In terms of flake size, there is no rule, but larger flakes will require a longer process time. For some end-uses, smaller flakes are preferred whereas for others, larger flakes are preferred."

"For example, our sister company, Graphene Batteries, uses our graphene for battery applications, which have special requirements for product properties in order to boost battery performance. Graphene Batteries optimises Abalonyx's graphene materials for their applications, as other end-users would do," he added.

Swedish graphite

In Sweden, ASX-listed Talga Resources Ltd is looking to develop graphite projects in the north of the country where its two most advanced developments are the Nunasvaara and Raitajarvi deposits.

Nunasvaara is a microcrystalline (commonly known as amorphous) graphite deposit, with a size range of 2-300 microns, but is predominantly less than 50 microns and has a total indicated and inferred JORC resource of 7.6m tonnes grading at 24.4% C.

Raitajarvi is coarse flake, and has a JORC inferred resource of 0.5m tonnes grading at 10.8% C.

"At Raitajarvi, there was some metallurgical work done [on the deposit] by the Swedish Geological Survey [between 1974 and 1991]. As a standard coarse flake deposit, [it has] a bell curve around the large flake size and an 11% jumbo component," CEO Mark Thompson told IM.

Potentially, Nunasvaara could be in production by early 2016, "but we have several stages of economic diligence to go yet; likewise, for Raitajarvi," Thompson noted.

However, although the local fervour for graphene, batteries and graphite-consuming renewable technologies is strong in Sweden, Thompson isn't throwing in his lot with next generation technology just yet. "I like traditional markets, the more basic the better. Batteries are exciting but growth is slower than anyone likes," he said.

"Graphene also is exciting technically, but it is very early days for seeing which technology will win and therefore what product, if indeed any natural product, is required," he added.

**Calculated February 2014*

