## Summary

We have known for quite some time that deposits of metallic minerals can be found in the vast depths of the world's oceans. In some places, these deposits may be large enough to be commercially viable. Seabed mineral deposits are divided into three types: manganese nodules, manganese crusts and sulphides. All three types contain multiple metals (polymetallic), and they are located at significant ocean depths, mainly between 1500 and 6000 metres.

Manganese crusts and sulphides have been found on the Norwegian Continental Shelf. Manganese nodules on the seabed have not been found on the Norwegian shelf. For this report, we have assumed that conditions for the formation of manganese nodules are not present, due to a high sedimentation rate. For this reason, manganese nodules are not included in the resource assessment.

Onshore mining has played an important role in Norwegian industry since the early 1600s, and it is one of the oldest export industries in the country. Seabed Massive Sulphides (SMS) are said to be modern analogues to land-based Volcanogenic Massive Sulphides (VMS). Most of the copper sulphide mines in Norway started their existence as smokers on the seabed.

Since 2011, the Norwegian Petroleum Directorate (NPD) has carried out data aquisition in deepsea areas in the Norwegian Sea and the Greenland Sea, in cooperation with the University of Bergen, and from 2020 also in cooperation with the Arctic University of Norway. Data from the NPD's mapping expeditions and cooperation with scientific institutions form the basis for this resource assessment.

As regards sulphide deposits, the knowledge about proven deposits can be extrapolated. There are far more inactive deposits than active deposits on the Norwegian shelf. Knowledge about active deposits is a precondition for investigating inactive deposits. As regards manganese crusts, seabed topography and the age of underlying rocks is of great significance for the thickness of the manganese crusts, and thus also for the resource assessment.

The NPD's resource assessment spans a range of potential outcomes for the size of the mineral resources in place in the Impact Assessment area. Resources in place are resources that are proven or expected to be present. Some of the resources in place may be recoverable. The volume of recoverable resources depends on technology and economics. At present, knowledge about mining technologies and production solutions is not sufficiently matured to justify an assessment of ores or to estimate recovery rates.


**Expected values for total in-place sulphide resources**

| **Metal** | **Metal volumes (tonnes)** |
|---|---|
| Copper | 38,100,000 |
| Zinc | 45,000,000 |
| Gold | 2,317 |
| Silver | 85,200 |
| Cobalt | 1,000,000 |

The Mohns Treasure is modelled as a numerical example, with expected resources in place listed in the table below.

The average size of sulphide deposits in the assessment area is: 40,000 tonnes of copper, 47,100 tonnes of zinc, 2.4 tonnes of gold and 89.3 tonnes of silver.

**Expected resource figures for a selected sulphide deposit, Mohns Treasure, modelled as a numerical example**

| Metal | Metal volume (tonnes) |
|---|---|
| Copper | 20,332 |
| Zinc | 60,326 |
| Gold | 6 |
| Silver | 145 |
| Cobalt | 313 |

The prospective area for manganese crusts is estimated to cover more than 8,500 $km^2$ of the study area, with an expected value for total resources in place of:

**Expected values for total manganese crust resources**

| Metal | Metal volume (tonnes) |
|---|---|
| Manganese | 185,000,000 |
| Titanium | 8,400,000 |
| Magnesium | 24,100,000 |
| Lithium | 229,300 |
| Vanadium | 1,918,800 |
| Cobalt | 3,058,100 |
| Niobium | 73,000 |
| Hafnium | 14,700 |
| Tungsten | 80,300 |
| Gallium | 19,200 |
| Scandium | 55,800 |
| Yttrium | 300,900 |
| Lanthanum | 368,800 |
| Cerium | 1,681,200 |
| Praseodymium | 102,500 |
| Neodymium | 420,300 |
| Europium | 23,200 |
| Gadolinium | 99,900 |
| Terbium | 15,200 |
| Dysprosium | 86,400 |

A numerical example for a seamount in the Greenland Sea measuring 133 $km^2$ is expected to have resource figures of:

**Expected resource figures for a marine mountain in the Greenland Sea, modelled as a numerical example**

| Metal | Metal volume (tonnes) |
|---|---|
| Manganese | 6,900,000 |
| Titanium | 270,000 |
| Magnesium | 820,000 |
| Lithium | 9,346 |
| Vanadium | 79,080 |
| Cobalt | 131 586 |
| Niobium | 2,913 |
| Hafnium | 611 |
| Tungsten | 3,414 |
| Gallium | 756 |
| Scandium | 2,368 |
| Yttrium | 12,399 |
| Lanthanum | 14,475 |
| Cerium | 71,655 |
| Praseodymium | 4,067 |
| Neodymium | 16,600 |
| Europium | 926 |
| Gadolinium | 4,053 |
| Terbium | 614 |
| Dysprosium | 3,519 |

The NPD's assessment is that the resources in place are significant. For several of the metals, the mineral resources compare to many years of global consumption. The modelled volumes give metal content – not oxides or sulphides.

The resource assessment provides an initial, overall assessment of seabed minerals in the study area. This data basis can be further reinforced, and the methodology for resource modelling can be refined and developed. Technological development, along with more and better data, will improve understanding of the resource potential, and thus also quantification of the uncertainty associated with the resource estimates. It will also provide an opportunity to move resources to more mature resource classes.