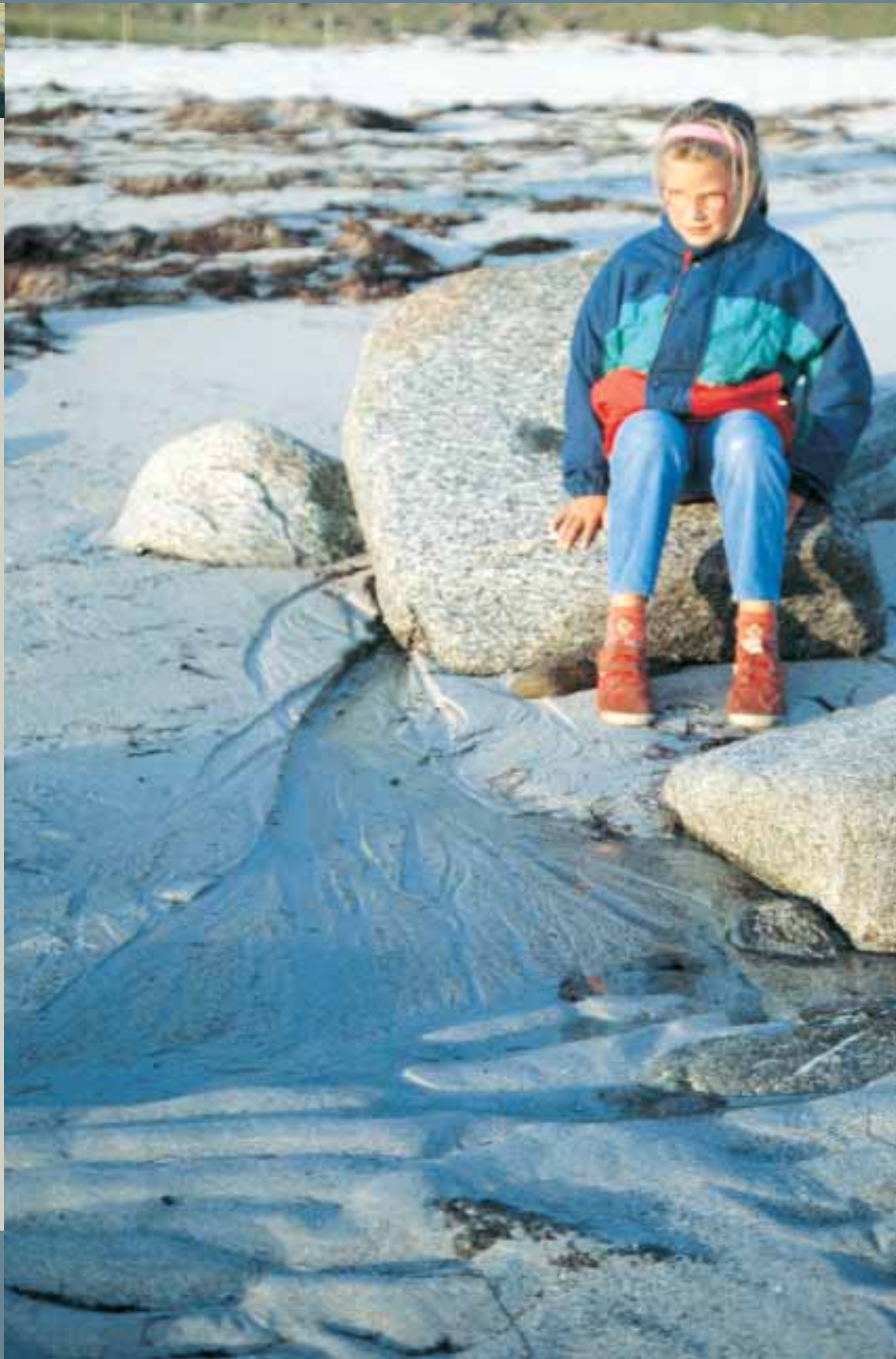


DIVERSITY IN NATURE

We see geodiversity every day.

The landscape around us expresses the variations in the bedrock, in soils, in the terrain and in all the processes that give landscape its distinctive character.

We base our way of life on the opportunities and resources that geodiversity gives us, whether it is land use, economic life or recreation.





The beautiful and rugged scenery of the Norwegian fjords attracts tourists from around the world who are captivated by sheer mountainsides, dazzling waterfalls and extensive vegetation. But the fjords are also the result of violent geological forces and processes acting over millions of years, and it is only through our knowledge of plate tectonics, mountain building, river and glacial erosion that these landforms can be truly understood.

Diversity in nature

National and International Nature management have concentrated on biodiversity with little attention paid to geodiversity. This should change as geodiversity is the foundation of nature, and it should be realised that biodiversity and geodiversity are vital for holistic nature conservation.

The Nordic Council of Ministers took the initiative in 1996 with a project to introduce the term geodiversity into nature management in the Nordic countries. The work was aimed at managers and policy makers, but also at schools and the general public.

Geodiversity allows us to understand the variation we see in rocks, superficial deposits and landforms and all the geological processes that build up and erode the Earth's crust.

Geodiversity or geoscientific diversity underlines the fact that the Earth sciences not only cover geology, but also geomorphology, meteorology, climatology, hydrology and oceanography. Geodiversity is related and equivalent to biodiversity.

The geological diversity is made up of different elements and processes that together form geotopes.

A geotope is a delimited area with defined geological attributes or phenomena. A geotope represents a special geological phenomenon or a combination of geological phenomena. All areas on the Earth are a part of one or several geotopes.

Geotopes are fundamental to biotopes. Geological and biological diversity are two parts of the whole that can be called the diversity of nature. We have a duty to take care of that diversity, for our own sake as well as for our descendants. This is a vital part of our understanding of the term sustainable development.

Sustainable development

The common definition of this term originates from the World Commission on Environment and Development (1987) and are based on: "to satisfy current human needs without depleting the natural resource base for future generations"



Photo: Ebbe Hartz

Many years of over-grazing combined with rough weather and a changing climate has resulted in drifting sand dunes at Nord-Jylland in Denmark. The fields have been covered in sand, houses invaded and churches buried. The eolian sands are steadily moving and to some extent can be stabilised by vegetation, but as seen here at the lighthouse at Rubjerg, built in 1906, the battle against the 25 m high sand dunes is over.



Banded gneisses, as seen here in the skerry archipelago of Åland, are characteristic of large areas of Norden. Sand, clay and volcanic ash were deposited as layers and through high pressure and temperatures deep in the Earth's crust they have been transformed into gneiss. Later molten rocks were squeezed into cracks and today we find them as dykes crossing the rock surface. Later still glaciers scoured and polished the rock surface and produced the characteristic skerry landscape.



Photo: Eb Storrånk

Geodiversity – the bedrock

Granites, gneisses, limestone, schist, sandstone and lava are the names of different rocks that are known to most of us; together with many others they make up bedrock. It is probably the shape and colour of rocks that are most noticeable to the public, but bedrock represents a geodiversity that is often crucial to the very existence of humans, animals, plants and other organisms.

Minerals and fossils are also a part of geodiversity. In some locations beautiful minerals and gemstones can be found, while in other places people search for spectacular fossils. The minerals tell a story of past geological processes and the fossils represent the biodiversity of animals and plants from the geological past.

The age of the rocks varies by several billion years. The oldest rocks in the Nordic countries are over 3.6 billion years old. These are the roots of old mountains worn down long ago. As a comparison, the Earth is more than 4.5 billion years old.

The Nordic countries, Denmark, Finland, The Faeroe Islands, Greenland, Iceland, Norway (with Svalbard) and Sweden, all have their own geological distinctiveness. Most of the known rock types are found here, most of the known geological processes can be recorded here, and most of the geological history of the Earth can be followed. The landscape changes from high rugged mountains to flat lowland plains. Individually and together these countries have an unusually high bedrock diversity.

Some areas are unique within global geodiversity and there are existing suggestions for geotopes in the World Heritage List. In both respects the Nordic countries make a significant contribution to global geodiversity.

Limestones are found in most of the Nordic countries. They are made of shell fragments or the minute skeletons of plants and animals that lived in ancient seas and lakes. In Denmark the coastal cliffs of Sjælland are well known; in Sweden limestone gives high quality agricultural land in Gotland and Öland and an attractive landscape for visitors. In Norway and Finland limestone is quarried for industrial purposes, and under the North Sea limestones are reservoir rocks for oil and gas. The picture shows the Svartå marble quarry in Finland. Quarries like this allow us to understand how landscapes form, the geological processes involved and show that we utilise the geological resource.



Mols Bjerge is a hilly area in eastern Jylland, Denmark. It is an ice marginal landscape with a high diversity of moraines up to 100 m high. Large erratics contribute to the landscape character. These moraines represent some of the oldest moraines in the Nordic countries. At the other end of this timescale are the moraines steadily forming in front of today's glaciers in Iceland, Norway and Sweden.

Geodiversity – superficial deposits and soil

Over the hard bedrock we often find superficial deposits of clay, sand and gravel, normally very much younger than the bedrock. The diversity linked to these deposits shows very clearly through land use and settlement pattern, especially in rural communities.

The geological processes that have formed these deposits in the Nordic countries are closely linked to glacial erosion and the transport of clay, sand, gravel and boulders towards the ice margin. At the same time large rivers have transported material out towards the sea. However there are differences between the Nordic countries. Denmark and the southernmost parts of Sweden have acted as a basin gathering superficial deposits from areas further north.

Wind and frost have also had an impact that in places can be very dominant in the landscape; steep mountainsides have resulted in rock falls and avalanches. Locally this is an important geological process but is also seen as a natural disaster.

In the Nordic countries the superficial deposits and soils have been formed mainly over the last two to three million years, a period with dramatic changes in global climate and with many ice ages. The superficial deposits therefore reflect relatively few geological processes in a cold climate and over a limited period; they represent a more limited geodiversity than the bedrock.

On the other hand, Nordic geodiversity is very valuable as a core area for ice age studies, and the Nordic countries therefore have a responsibility for an important part of global geodiversity.



Swarms of moraine ridges in waters of the Vasa area in Finland produce a characteristic landscape. The ridges were formed during the retreat of a large glacier when the ice front rested in water. The combination of moraines, trees and water make the area attractive for leisure and recreation.



Iceland is known throughout the world as a geological laboratory where we can study geological processes and better understand the nature and development of the Earth. Iceland's topography and geology perfectly illustrates the diversity of geological processes, and is one of the best places to see the dramatic elements of those processes. Regular volcanic eruptions demonstrate the enormous power of the processes, often a direct threat to people and their settlements. We are fascinated by these spectacular images, and sometimes we are frightened when we see how small and helpless people are compared to the forces of nature. The picture shows the volcano Hekla in the winter of 2000.

Geodiversity -geological processes

Geological processes are part of a global cycle, some parts creating rocks and others wearing down what has already been made. Together the processes have created the geological diversity that we find all over the world.

The geological processes have formed the bedrock, deposited the superficial deposits and formed the landscape. All geotopes are the result of geological processes working today and in the past.

Some of these processes are global and very slow measured on a human time scale. The continents move over millions of years changing their position and shape and forming mountains. Other processes such as avalanches, landslides and volcanic eruptions happen locally, sometimes without warning. They are, however, closely linked to the global processes. Some are of a regional character and occur with a speed that humans can observe and measure; glaciers form the landscape, rivers transport clay, sand and stones towards the sea, wind blows sand into big dunes and waves crash and steadily form coastlines.

Geological processes have formed the landscape. They occur today as they did in the past. Many of the characteristic Nordic landscapes such as fjords, mountains, lakes, skerries and moraines were formed by repeated ice ages during the last two million years.

Many of the geological processes experienced by us are seen as catastrophes, or on a less dramatic scale, natural disasters. Earthquakes and volcanoes kill people and destroy land, and after heavy rain or thaws we experience floods and landslides. To understand this natural world we are a part of, and to protect ourselves from harm and destruction, we need knowledge of the geological processes. The diversity of processes not influenced by humans can give us such an understanding, and they are naturally a part of what we call geological diversity.



Photo: Harald Severoy

In the Easter of 1998 the "troll wall" – Trollveggen in the valley of Romsdalen in Western Norway became a new tourist attraction. Over a period of two weeks rock falls were happening all the time, and three or four of them were large enough to register as earthquakes with a magnitude of 2.2 on the Richter scale; 150.000 cubic metres of rock fell from a fracture surface 100m wide and 300m high near the top of the cliff.



Geodiversity – biological diversity

Biodiversity is a term most of us relate to, through the media and public debate we have learned that it is necessary to protect and conserve biological diversity to secure sustainable development.

There has been far less attention given to geodiversity, but geological diversity is a vital prerequisite for biological diversity. Geotopes together with climate control the basic conditions for life on Earth. Geodiversity and biodiversity are inextricably linked; they are inseparable.

Therefore we should concentrate on the diversity of Nature. This is included in the convention for the conservation of biological diversity of 1992 (the Rio-convention), in which biological diversity is described as the richness and variety of genes, species and ecosystems.

An ecosystem is all things living in a habitat within a certain area; the bedrock and deposits form the basis of the ecosystem while water, air, plants and animals are the dynamic units moving around within it.

Plants and animals, bedrock and deposits are elements of the ecosystem. Plants and animals are the living (biotic) elements, while bedrock, deposits, water and wind are the non living (abiotic) elements.

Geodiversity is crucial in forming the basis of habitat quality. While the bedrock in some places gives fertile soils it can elsewhere be poisonous to plants with only a few able to survive the conditions.



P.O. Nordell

This special kind of "mountain pink" (Lychnis alpina var. Serpenticola) is adapted to serpentine, a rock containing nickel. Its former name was Viscaria alpina, after the Viscaria copper mine in Kiruna, Sweden, where it was found. The plant has a high tolerance for heavy metals and can be used as an indicator for ore deposits.

Along the coasts of Western and North Norway, the Faeroe Islands and Iceland there are sheer cliffs where hundreds of thousands of sea birds gather to nest. The cliffs are very special habitats where the relationship between geotope and biotope is clearly demonstrated. Geological processes form cliffs, and here the nature of the bedrock favours the formation of sheer cliffs giving safe ledges for the birds to nest.



When the ice started to melt at the end of the last ice age, melt water rivers carried huge amounts of clay, sand and gravel and transported them into lakes, fjords and the sea. The smallest particles remained suspended for a long time in the water before they were deposited on the seabed to form layers of clay. The coarser particles were deposited in deltas that are today the sand and gravel resources used by the construction industry.

Geodiversity and society

Geological diversity has had a big impact on the economic basis and settlement patterns of the Nordic countries. Stone age hunters used flint and medieval people built stone houses in many places, and in modern times mineral and ore deposits have provided the economic basis for some settlements. Today spectacular geological formations generate tourism over a wide area.

Current examples illustrate this very clearly. The Norwegian economy is based to a large extent on the extraction of oil and gas from the continental shelf; in Denmark ground water dominates the supply of fresh water; in Sweden mining, based on rich mineral resources, is still a major industry; in Iceland volcanism, geothermal phenomena and glaciers attract many tourists as does Finland, which is known as the land of a thousand lakes. All important elements of geodiversity.

Geological processes also explain the distribution of superficial deposits and soils. The best agricultural land, as well as sand and gravel resources (so important as building materials), is linked to ice age deposits. But geological diversity is gradually being understood in society. Tourism and outdoor recreation become more significant and underline the importance of the diversity of nature from an holistic perspective. It is therefore necessary to balance industrial use of natural resources with an effort to conserve their diversity. This balance is a part of "sustainable development" and is true for all of nature and the use of natural resources, both geological and biological diversity.



The spoil heaps of the mining town (City) of Røros in south Norway are a well-known memorial to its mining history, spanning more than 300 years. The discovery of ore in 1644 was the start of mining and a community was formed that could not exist without it. Røros is a World Heritage Site (UNESCO); the town (city) buildings and the mining history are the reason for the designation, but it is the special geotopes in these highland areas that form the basis of the mining.

Geodiversity – our responsibility

Geodiversity has an impact on land use, economic life and recreation and therefore on the fabric of society. It is up to all of us to conserve this diversity. All activities should take account of the diversity of nature, both biodiversity and geodiversity.

We have to start with individuals, whether land owners or citizens. No one can deny their responsibility by hiding behind that of the government.

Industry, companies and all sections of society should also understand the meaning of the diversity of nature. For example farmers should be responsible for their industry and manage their resources and activities in a sustainable way, as should forestry, manufacturing and all other industries. No one should believe that this does not apply to them.

Voluntary organisations and societies contribute in a positive way. Local authorities in towns, cities and counties have a responsibility to manage diversity through land use planning. Central agencies and government departments have the overall administrative and political responsibility.

Schools, museums and the media, undertake the responsibility for education and promotion to the public, and all over the Nordic countries geological museums and information centres are spreading the message.

The Geological Surveys, universities and other knowledge-based institutions also contribute with their experience and knowledge to this important work.



Photo: Anders Damberg

Erratics are found as monuments in all Nordic countries. They often form important landscape elements linked to old legends, stories of trolls and other supernatural beings, and have an important place in the consciousness of local people. Some of these erratics are protected, but most of them are not and they are an excellent example of the need for local involvement in the conservation of the local geodiversity.



Photo: C. E. Johansson

The limestones plains on the island of Øland in Sweden have a specific vegetation adapted to the area called the Great Alvar, which shows a close relationship between geodiversity and biodiversity. There is great community involvement to keep the landscape open. The walls of this interpretation centre are built from *Orthoceras* limestone; the roof is covered with reed from the calcareous wetlands. The responsibility for the management of the Great Alvar and its unique natural and cultural heritage falls on many different levels in society.



Nordic COUNCIL OF MINISTERS

The net version of the leaflet can be downloaded from:

www.norden.org and
www.progeo.se

This leaflet is prepared by a group of Earth science professionals established by the Nordic Council of Ministers. The aim of this text has been to introduce the term geodiversity into Nordic nature conservation. The leaflet is based on the report "Geodiversitet i nordisk naturvård" (Geodiversity in Nordic nature management), written in Swedish (ISBN 92-893-0572-2000).

Front picture: Geodiversity is about rocks, soil and small and large processes. We are fascinated when the powers of nature are displayed with force, during floods and storms, but also when we discover the processes at a very detailed and small scale as on a beach on a calm day. Photo: Lars Erikstad.

Back picture: Time is an important factor for geodiversity. The picture shows a fossil till (tillite) on a striated Precambrian sandstone surface at Bigganjarga, northernmost Norway. This indicates a glaciation at the margin of an old continent more than 600 million years ago.