Louwrens Hacquebord

The Geographical Approach of Carl Linnaeus on his Lapland Journey

The eighteenth century is called the Age of Enlightenment, during which empiricism and rationalism exerted a great influence on the development of science. Observation and reasoning were the most important activities in science; both showed an unlimited confidence in human ability. In this context it was obvious that "natural history" was defined by a description and classification of everything in nature. It is understandable that naturalists as Carl Linnaeus tried to chart and classify nature into one, global, system. According to him, he wanted to develop a general system, which he believed would bring order to natural history.[1]

Based on his experiences in Lapland, Linnaeus developed a classification system of plants, animals and minerals which he published in *Systema naturae*.[2] His classification system for plants and animals has been used by biologists a long time. The classification of minerals however, was not very successful. It lasted until the end of the eighteenth century, when earth scientists introduced a mo-

1 W.T. Stearn, 2001, 'Introduction', in: W. Blunt, *Linnaeus, The Complete Naturalist*. 6-9, and R. Rappaport 2003, 'The Earth Sciences', in: Roy Porter (ed.). *The Cambridge History of Science*, Vol. 4 Eighteenth Century, 417-435.

2 C. Linnaeus, *Systema naturæ, sive Regna tria naturæ systematice proposita per classes, ordines, genera, & species*, Leiden 1735.

© *TijdSchrift voor Skandinavistiek* vol. 29 (2008), nr. 1 & 2 [ISSN: 0168-2148]

dern classification system of minerals.[3]

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SYSTEMA
NATURÆ

IN QUO
NATURÆ REGNA TRIA,
SECUNDUM.
CLASSES, ORDINES, GENERA, SPECIES,
SYSTEMATICE PROPONUNTUR.

Editio Secunda, Auctior.

STOCKHOLMIÆ
Apud GOTTFR. KIESEWETTER.
1740.

Fig. 1. Front page of the Systema Naturae of Carl Linnaeus, second edition 1740, Stockholm.

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3 J. Maedows, 1997, *Geschiedenis van de Wetenschap. Samengevat in de spectaculaire levens van twaalf geleerden.*

Linnaeus made several journeys of which his Lapland journey in 1732 was his first and best known.[4] Financially supported by the Swedish Royal Society of Science, he traveled five months to Lapland in order to describe what he calls later the three kingdoms of nature. With the three kingdoms of natures he meant the kingdom of plants, animals and minerals. In the record of the journey, he presents himself as an excellent observer and a very good narrator. He uses a geographical approach in which he not only asks questions but also tries to explain why things are as they are.

Much has been written about Linnaeus but his geographical approach has been understudied so far. Using his record of the Lapland journey, I shall place the geographical qualities of Linnaeus' work in the context of a general eighteenth century earth science background.

Linnaeus' view of science

Natural history and especially botany attracted Carl Linnaeus. First of all, he was an excellent botanist but his aspirations went further. Together with Petrus Artedi (1705-1735), who drowned in a canal in Amsterdam, by the way, he had great plans to reform the whole natural history by classifying and structuring all living and non-living aspects of nature. Beside that, Linnaeus was a great collector and, already as a student, he had a large collection of naturalia, books and manuscripts. During his journey to Lapland, he extended his collection with many objects. This making of a collection was characteristic for the Age of Enlightenment. In that period, many scientists started a collection but only a few of them developed a classification system for the objects they collected.

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4 Linné, C. von, 1991. *Lapplandische Reise und andere Schriften*; C. Linnaeus, 1995, *The Lapland Journey*.

In the *Systema naturae*, Linnaeus developed a general classification system of the three kingdoms of nature. With this classification system he wanted to bring some order into natural history, which he found absolutely necessary for further research. As he wrote in his introduction to *Systema naturae*, "The first step in wisdom is to know the things themselves. This notion consists in having a true idea of the objects; objects are distinguished and known by classifying them methodically and giving them appropriate names. Therefore, classification and name giving will be the foundation of our science."[5] This opinion is characteristic again for the Age of Enlightenment in which observing and reasoning have played an important role. On his journeys Linnaeus was more or less the incarnation of these activities.

Developments in the 18th century earth sciences.

Linnaeus lived in the eighteenth century, and in this century it was generally believed that the earth had come into creation only approximately six thousand years earlier, on October 22, 4004 BC, according to the seventeenth-century analysis of the Bible made by Archbishop James Ussher of Ireland (1581-1656). It was also believed that Noah's Flood had played an important role in the geological history of the earth. This way of thinking, called diluvialism, determined the direction of the study of geological phenomena in the course of the eighteenth century. In the spirit of his times, Thomas Burnet (1635-1715) in his *Sacred Theory of the Earth* (1681), reconstructed the earth's past by comparing natural evidence with written sources, in this case the Bible. The relation of Noah's Flood and the fossils he found in the sedimentary rock plays an important

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5 Linnaeus, 1735 *Observationes in Regna III. Naturæ 10*; Cited from P.L. Forber, 2000, *Finding Order in Nature. The Naturalist Tradition from Linnaeus to W.O. Wilson.*

role in his book. Burnet tried to find out where these fossils came from.

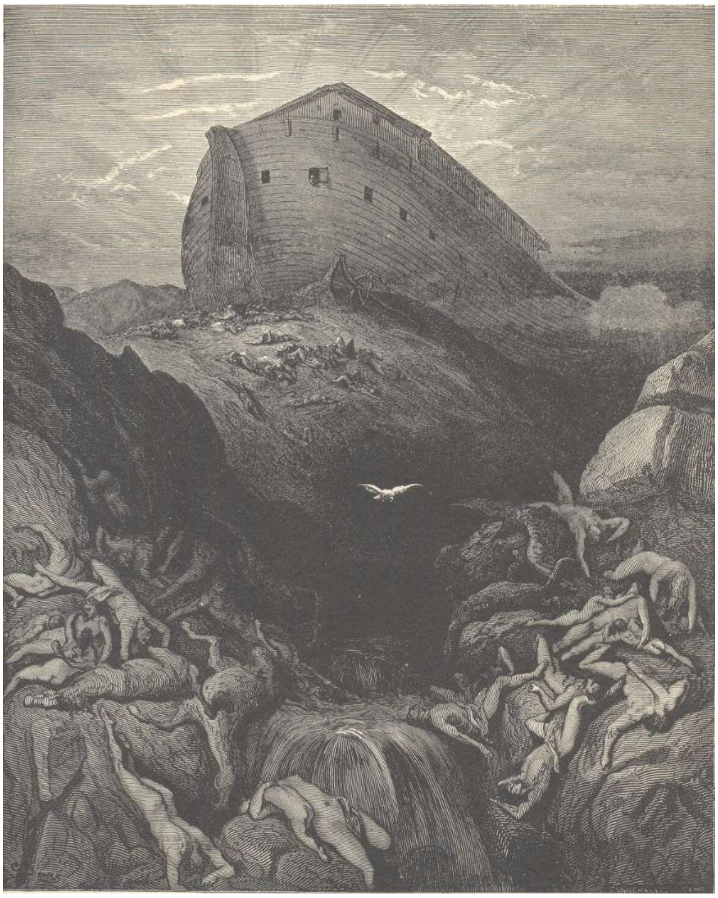

Fig. 2. The Dove Sent Forth after the Ark run aground. Engraving of Gustave Doré.

The debate about the origin of the fossils dominated earth-science discussion from the 1660s until about 1720. Some scientists thought that fossils were remains of real animals, but others absolutely could not believe that. They did not see any resemblance with the living creatures of their time nor did they understand why some fossils clustered in certain strata and why marine fossils were found so high in the mountains. These scientists believed that fossils were not remains of living creatures but products of the rocks they were found in.

John Woodward (1665-1728) elaborated on the fossil subject in his book *An Essay toward a Natural History of the Earth* (1695). As a fossil expert, he considered fossils to be organic in origin, allied with marine creatures still living on earth in his time. He also explained their transport and deposition by attributing them to the Flood and, third, he presented the Flood as a miracle in cause but natural in its effects. William Whiston (1667-1752) did not agree with him on the cause and the influence of the Flood. In his book *New Theory of the Earth* (1696), he defended the thesis that the Flood was caused by a comet passing the planet earth. He stated that the Flood was preceded by more catastrophes. It was only the last of a series of catastrophes. His ideas became known as the catastrophe theory which competed with diluvialism in the eighteenth century. However, Whiston was not the only critic of the Woodward's theory. In Paris, several scientists found their observations incompatible with diluvialism and Antonio Vallisneri (1631-1730) and Anton Lazaro Moro (1687-1764), who also examined Woodward's views in detail, rejected all use of the Flood. In their opinion miracle and science were not compatible. However, the controversy about the impact of the biblical flood continued throughout the century.

In 1744, the French biologist and head of the Royal Gardens of King Louis XV George-Louis le Clerc du Buffon (1707-1788) wrote his *Histore et Théorie de la Terre*, in which he gave more or less the state of knowledge at that moment. In his book, Buffon refused to use ancient texts to explain the world's geological history. In his opinion and own words: *le grand ouvrier de la Nature est le Temps.*[6] Since he believed that the earth was a hot liquid mass in the beginning which became solid after a long cooling period, the history of the earth must have been longer than the proposed 6000 years.[7] He used the worldwide occurrence of fossil mollusks to argue for a long history of marine sedimentation after the cooling period. Buffon also described the motion of the sea, with its constant alteration of shorelines, and argued that in the past marine currents had built landforms on the seafloor but how these submarine landforms had emerged from the seafloor was still a question. In the discussions after the publication of Buffon's book, consensus has been reached on the fact that volcanoes and earthquakes were superficial phenomena and that the earth did have internal heat, even in non-volcanic regions, but an explanation of the elevation of landmasses was not found.

In the second half of the eighteenth century, earth scientists were divided into two schools concerning the origin of the earth: Neptunism and Plutonism. The main supporter of Neptunism, Abraham Gottlob Werner (1749-1817) believed in a universal ocean or Flood that gradually receded to its present location while depositing all the rocks and minerals in the earth's crust. According to Werner, is the earth "a child of time" and has been built up gradually. He divided the earth into five formations (igneous, transition, stratified, alluvial and volcanic formations) which played an important role in his classification. This classification was similar to

6 The great maker of Nature is Time. G.L. le Clerc de Buffon, 1761, *Histoire Naturelle des Epoques de la Nature* IX.

7 De Baar, M.C.M, 2007, *Order, Change and Chance in the European Perspective on nature (1600-1800).* PhD-thesis University of Groningen.

that of Johann Gottlob Lehman (1719-67) and other earth scientists active in that period but different from the classification of Linnaeus. Werner's *External Character of Minerals* (1774) can be considered as a guide for fieldwork with a description of the properties of minerals and rocks representing one of the distinguished formations.

The general image of an approximately 6000 year old geological history and a Flood that had determined the sediment layers on earth did not change very much during the rest of the eighteenth century. The Plutonist James Hutton (1726-1797) was the first earth scientist who looked at the development of the earth's crust from a totally different direction. He drew attention to the slow genesis of sediment layers and argued that the interior heat of the planet earth played an important role in the formation of the earth's crust. He concluded that the earth was forming and reforming itself constantly and that formation, erosion and sedimentation were continue processes. In 1788, Hutton presented his ideas in a paper to the Scottish Royal Society in Edinburgh. Based on his field observations, he described an image of the geological world very different from the world of the Bible, a world that was formed by a continuous cycle in which rocks were transferred into sediments and sediments transferred into rocks again. He recognized that the development of the earth's crust could only be reconstructed by understanding how geological processes, such as mountain-building, erosion and sedimentation, work. With this idea, Hutton changed the concept of the history of the earth totally and became the founder of modern geology.

In 1732, after he returned from his journey to Lapland, Carl Linnaeus wanted to bring some order in the stone samples he brought with him. In his classification of the kingdom of minerals, he distinguished three classes: stones, minerals and fossils. In the spirit of his time he placed fossils in a separate group. As a deeply pious eighteenth-century Christian, Linnaeus believed in the creation of the earth. Based on Burnet (1681) and Woodward (1695), he must have seen fossils as creatures drowned in one big Universal Flood and, as such, different from stones and minerals. After his return from Lapland, he went to Bergslagen, in Dalarna, for the studies necessary for him to set up a system of classification of minerals. It seems that the miners in that region were enthusiastic about his system but, since Linnaeus did not take part in the global earth science discussion, his classification of minerals did not impress the earth scientists of his time enough that they started to use it. They probably did not know the classification of Linnaeus at all. The classification most well-known in those days was the classification based on the ideas of Werner and, later, the one based on Hutton.

Linnaeus' observations during his Lapland journey in 1732

During his Lapland journey, Linnaeus made a day by day report of the landscape he traveled through. He described the natural beauty of Lapland and the relation of the Lapps with that nature.[8] Besides the flowers, animals and minerals, he described the roads, villages, fields, rivers, lakes and hills on his way through the north. He wanted to share his experiences with his readers when he traveled over the coastal plains around the Gulf of Bothnia and when he traveled inland along the rivers Umeå and Luleå and through the Scandinavian Highlands to the Norwegian Atlantic coast and along the river Torneå. The coastal part of his journey brought him through well-known and well-settled areas but the inland expeditions were special because they had not been done before by a southerner. Here

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[8] Sörlin, S., 2006, 'Science, Empire, and Enlightenment: Geographies of Northern Field Science', in: *European Review of History*. Vol. 13, no 3, September 2006, 455-472.

he met the Lapps who fascinated him and their fish-and-water diet filled him with admiration. His records of these inland journeys are very special because they contain information about the landscape, flowers, animals and people no one had written before.

His description of the landscape of the northern regions of Scandinavia is mostly very detailed. Most descriptions by Linnaeus start with the surface. He tells us if the land is flat, with or without outcrops, hilly or mountainous. Then follows a report on the vegetation, where he tries to explain the relation of the vegetation to the physical environment. In his explanation, the hydrology, soil, and type of soil mostly play an important role. About Västerbotten he wrote:

> As I approached Västerbotten the high hills, stony areas and alder woods began to get fewer and *pinus*, of which there had been a great lack, began to become more common.
> And a little further: the country is fairly flat, composed of sand with some clay and great worthless mosses cover various parts of it.[9]

Linnaeus observed and reported natural resources wherever he came but he was sad to see that they were not used as much as they should be.[10] The land around Piteå he described as follows:

> The land was fairly flat though there were large outcrops here and there, not particularly high and steep but sloping down at an angle. The rocks in them had the appearance of curly grained wood, often rusty and eroded and leaving behind a deposit of glittering sandy grains.[11]

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9 Graves, P. 1995, *Carl Linnaeus. The Lapland Journey*, 55.
10 Sörlin, 2006, 457.
11 Graves 1995, 90.

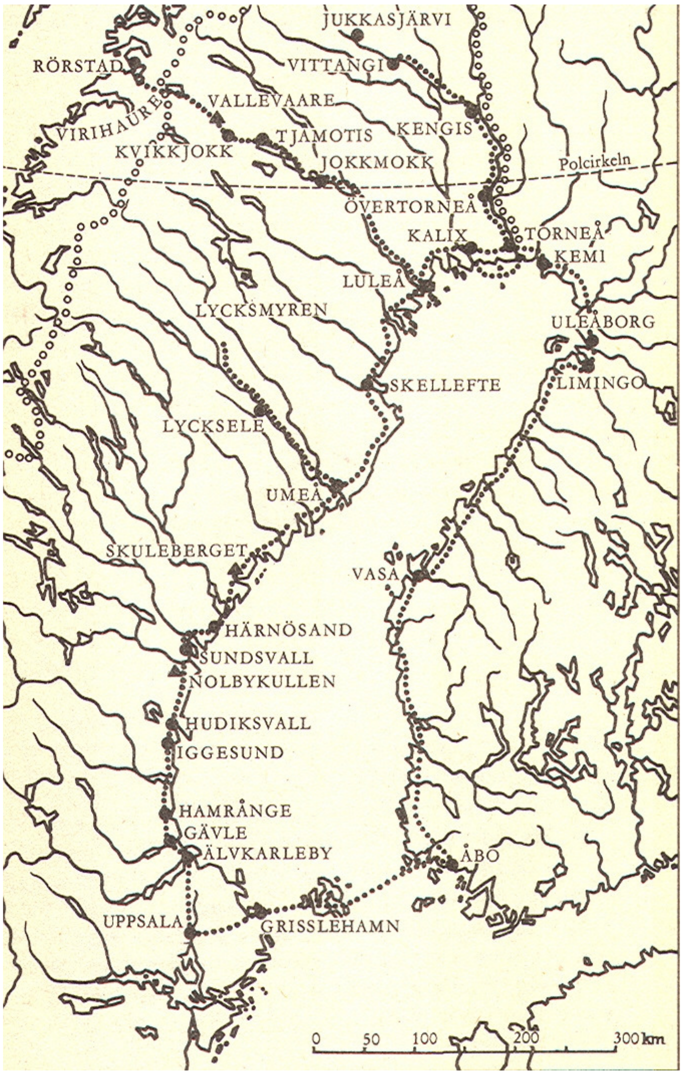

Fig. 3. Linnaeus Lapland Journey in 1732 from Carl von Linné, 1991 Lapplandischereise und andere Schriften. Leipzig.

Most of these observations are followed by an explanation of why the landscape is as he sees it. On his trip along the Luleå river to Norway, Linnaeus observed the northern part of the Scandinavian Mountains with its summits about 2000 m. high. It was the first time that he saw mountains of this height, and glaciers. Many of his observations are based on astonishment. He remarked on July 11th 1732:

> [...] and we arrived very quickly at the ice mountain, which was a very high mountain covered in eternal snow. I noticed that the snow was very hard, as if frozen, and we sometimes walked on the crust and sometimes went down through it just as if we were walking in sand. Every so often there were rivers which ran under the snow, and in some places the snow had fallen through so that it was possible to see many consecutive strata of snow.[12]

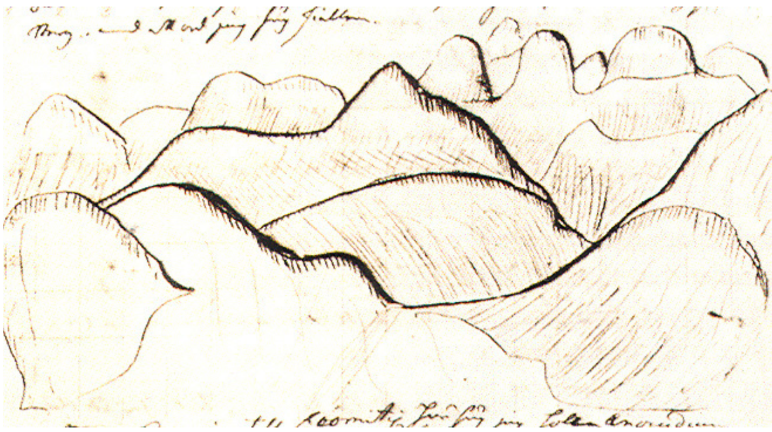

Fig.4. Drawing of the mountains of Lapland, then northern part of the Scandinavian Mountains from the report of the Lapland Journey, Graves 1995.

[12] Graves 1995, 122.

In this area Linneaus' observations are very interesting because they go much further than the usual ones, and he tries to explain the things he observed by placing them in a global perspective.

> We know that these mountains are higher than all the other hills in the world because there is not a single river that runs over them: the western rivers run into the western sea and the eastern rivers run into the eastern sea. If we then take into consideration all the waterfalls and cataracts that lie between the mountains and the sea, we must conclude that the mountains have a considerable height both on the seaward and on the landward side.[13]

Linnaeus remarks about Norway show his great general knowledge:

> I walked on the shore in the morning when the tide was low. The tide comes in twice in every 24 hours and takes 6 hours between the low and the high tide. That is 4 tides each day, 2 ebb--tides and 2 flood tides. They increase with the moon.[14]
>
> […] I now saw the full expanse of the Western Ocean and was told that if one were to travel due west one would come to Greenland.[15]

Linnaeus' knowledge about the climate and the weather is interesting. He not only asks questions about these phenomena but also tries to find answers by placing his observations in a wider perspective here, too.

> It is usually colder in the country in general. The Jämtland Mountains are colder than Torneå even though they are 670 miles farther south. The reason for cold is thus not solely proxi-

13 Graves 1995, 134.

14 Graves 1995, 128.

15 Graves, 1995, 130.

> mity to the pole but also the height of the land, and careful note of this should be taken. This is why the flora of northern Lapland survives the cold and why there is snow on the Alps in Italy.[16]

Here, again, the comparison of his observations in Lapland with other regions in the world shows his general knowledge of other parts of the world. He compares the situation in Lapland with the Alps in Italy and a little further he wonders if the sun is visible at the pole.

> The sun was seen until towards 12 o'clock midnight, when a small patch of cloud covered it though it still remained above the horizon. In winter, however the sun does not go completely below the horizon and is still visible at the solstice. I wonder if it is visible at the pole.[17]

About the role of the sea in the weather, Linnaeus made the following remarks:

> I was told that they often hear the rolling of thunder in the mountains in winter. Cold weather in the Torneå Mountains comes from the south and mild weather from the north; And the explanation: this is because of the sea.[18]

The stones

The stones Linnaeus collected on his journey through the north were important for his later classification. In his record of the journey, he gives a description of the size, colour, external, structure,

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16 Graves, 1995, 170.
17 Graves, 1995, 171.
18 Graves, 1995, 178.

crystallization, and, because of his mineralogical interest, ore content of these stones. His descriptions are so detailed that the stones he found can now be divided into three groups namely: stones originating from igneous rocks, stones from sedimentary rocks, and stones from metamorphic rocks.

About igneous rocks, he says: "On the road I found a large stone, reddish in colour and showing rough, sparkling yellow mica or scales."[19] About sedimentary rocks, he notes:

> There was a shaly rock, grey and brittle and containing much loess on the hill nearby.[20]

> There was limestone everywhere along the road in Norrbotten; it was yellow on the outside, white on the inside.[21]

He has this to say about metamorphic rocks:

> There were conglomerates of sand and small stones on the shore and they were so firm that they were used as oven-bricks. At one spot in the sand, where the river had eroded it away, I observed that the fixative for such rocks was nothing more than iron rust that bonded the sand together.[22]

However, this division into igneous, sedimentary, and metamorphic rocks was not known by Linnaeus and he divided the stones he found just in: stones, minerals and fossils.

The extensive description of the minerals he collected shows the importance of these kinds of stones in those days and probably also the influence of his trip to. "It shone just like copper but the pyrites was markedly whitish-yellow, an unmistakable sign that it

19 Graves 1995, 45.
20 Graves 1995, 74.
21 Graves 1995, 184.
22 Graves 1995, 186.

mainly contains iron".[23]

Sedimentation and erosion

When Linnaeus traveled along the Gulf of Bothnia, he observed how the sea deposited sand on the beach. This description of the sedimentation by the sea as a daily but long-lasting process indicates that he was aware of how long maritime sedimentation processes took. In this context his observations of the erosion and sedimentation of the rivers are interesting:

> I came to a fast running stream with a bank which, on the outside of the curve, was very high and steep like a wall. I attribute this to the alders that are standing there right by the water. I have seen places where lakes erode away the soil more and more and by so doing gradually threatens great castles and churches, so that buttresses have to be built on the shore at the cost of much effort, to no great effect, however. But where alders have been standing on the shore the water has been able to accomplish little or nothing.[24]

Conclusion

In the spirit of the Age of Enlightenment, Linnaeus observed and tried to explain all new phenomena he saw on his journey in Lapland. He kept a diary and beside all plants, animals and minerals he described the people, roads, villages, fields, rivers, soils, lakes, and hills he saw on his way through the north. The inland part of the journey is interesting because this part had never been done before and many of his observations were made for the first time. Lin-

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23 Graves 1995, 46.

24 Graves 1995, 31.

naeus was especially impressed by the high mountains of the northern part of the Scandinavian Mountains. He not only observed these mountains but explained the low temperature, the snow and ice and the strong wind in the mountains as well. When he arrived in Norway, he observed and explained the midnight sun, the sea, and the tides. He was impressed by the Lapps, the people of the mountains, and described their way of living in the highlands. His journey through the mountains gave him the possibility to observe the rise and the erosion of the rivers and, in the lowlands, he described and explained erosion and sedimentation processes.

Retrospectively, we can say that, in his record, Linnaeus asked typical geographical questions, such as what and where and, secondly, why and why there? This means that in his diary of the Lapland journey, Linnaeus not only observed but also explained. In other words, he asked the same questions as a twentieth-century geographer would do when he is doing field research, and this makes his approach very modern. The comparison of Linnaeus' observations in Lapland with those from other regions in the world shows his geographical approach and his great general knowledge of other parts of the world.

On the other hand, his classification, partly based on contemporary ideas and partly on conservative, religious, ideas, has not been used by earth scientists. He divided the stones into minerals, stones and fossils. In the spirit of his time, he placed fossils in a separate class because of their different origin. However, already in the eighteenth century, his classification of the minerals did not find general acceptance, mainly because it did not fit in with the existing general ideas about the formation of the earth's crust.

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