Thus speak the stones...

Carl Linnaeus

Carl Linnaeus' contribution to geology merits greater attention. Nowadays, it is generally his achievements in botany and zoology that attract the limelight, but for Linnaeus himself, minerals, rocks, ores, fossils and superficial deposits were by no means unimportant.

The mineral kingdom was part of God's creation, and therefore just as worthy of being studied and ordered. It was equally entitled to be heard, and although the stones spoke of "our former earth" and therefore only "whispered", their many voices were something Linnaeus listened to.

This booklet gives a brief outline of Linnaeus' geological work, his ideas and his significance for the earth sciences.

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Keen naturalist

One of the things for which Linnaeus is remembered is his tireless enthusiasm for describing nature. In his *Instructions to Travelling Natural Historians* (1759), he urged his readers to "pay heed to everything", a principle he himself lived up to.

This may sound like an impossible goal, but in his accounts of his travels we find, alongside his observations of nature, descriptions of everything from diseases to local customs.

Linnaeus was not just enthusiastic, however – his writings show that he had a keen eye for detail. Like a scientific Sherlock Holmes, he registered the slightest nuance of colour or change in texture, and noted every coincidence or absence.

Studies, travels and works

From his early student days to the middle of the 18th century, Linnaeus undertook a series of journeys. His first significant excursion was as early as 1729, to the mine at Dannemora in northern Uppland. On all his travels in Sweden, Linnaeus made detailed studies of the geology of the areas through which he passed, and it was on these tours that he arrived at most of his conclusions on matters geological.

In 1733 he set off on a purely geological visit to the Bergslagen region, to study its mines and smelting works. It was a private initiative, paid for out of his own pocket. As a result, it attracted relatively little attention from his contemporaries, but for the rest of his life Linnaeus often spoke of the riches he had seen on this journey. He also took pride in his mastery of the art of assaying, i.e. analysing the minerals and metals in rocks.

Linnaeus' most outstanding contributions to geology were in the area of palaeontology (the study of fossils). Until around 1750, he was very active in the geological field, as a lecturer, teacher and writer. By then, he had developed a system for the mineral king-

dom and helped to raise the status of the natural sciences in Sweden.

Geological models and ideas

Whatever the level of knowledge of our day, we use (or create) a basic model for the phenomena we study. A round earth is one model, a world-view with a sun in the centre is another, and the biblical story of creation yet another. Linnaeus' sexual system for the classification of plants is an example of a devised structure that demonstrates relationships, but it is not a model in a large-scale sense.

The timescales and volumes of material encompassed within a modern-day understanding of geology were unknown in the 18th century. Man himself was the yardstick used to understand the world. With geological phenomena, the passage of time was not directly observable by the human eye – nothing seemed to be happening. The only changes people were aware of were the effects of water (and wind), and the scientists of this time were of course also influenced by the biblical idea of water as a transforming force.

In both the short and the long term, water could be understood on a human scale: rivers, lakes and seas, waves and rain changed before one's eyes, while beach ridges and wave-washed gravel bore witness to a very gradual retreat of the sea.

Bible versus science

In Linnaeus' day, ideas about how God was both at work in and the controlling hand behind nature, and about nature being designed for a purpose, formed a basis for scientific research.

Acceptance of the Bible as truth provided a starting point for the building of geological models, but it also made things more difficult for the scientists.

In several instances, however, Linnaeus was able to apply both biblical and scientific approaches, without



any conflict between the two. The lack of visible traces of the Flood in the landscape, for example, he addressed with scientific arguments. His conclusion was that the Flood must have occurred long before today's landscapes were formed.

Linnaeus and fieldwork

In the 18th century, geology did not exist as a scientific discipline in its own right, or as a separate profession. But Linnaeus did probe a range of geological issues, describing his findings under headings such as natural history, mineralogy or the study of ores.

Many of his enduring achievements can be traced to the way he worked. Unlike the great explorers, who opened up new parts of the world, Linnaeus mostly travelled in his own country and described nature as he found it, all around him. What he was doing, in short, was fieldwork.

He constantly took his students out and about to study nature – in other words, he organized field courses and field trips. Few before him had integrated theoretical and practical teaching in as advanced a way as he did.

Scientific achievements

Several of Linnaeus' other achievements may be mentioned. His famous descriptions of nature were widely emulated, and in his vivid language he also recorded many geological phenomena.

Linnaeus' conclusions about the sequence of different rocks to be found at Kinnekulle in the south-

QUICK FACT

Unfortunately, Linnaeus' surviving geological legacy does not include his collection of rocks and minerals.

Consequently, a study of his geological specimens is not possible, but thanks to his extensive documentation his conclusions have nevertheless been preserved.

Fossil corals. After Linnaeus.

A crystal. After Linnaeus.

west of the country were to be of significance for the development of stratigraphic geology.

His detailed accounts of the geology of various parts of Sweden are of great documentary value. His descriptions of the old beach ridges on the islands of Öland, Blå Jungfrun and Gotland, for example, are considered brilliant.

He also explained how "petrifactions", fossils, could be formed, and published a comprehensive account of the fossil corals of Gotland, Öland and Skåne. In addition, Linnaeus described and named numerous fossils, many of which are still known by the species names he gave them.

His utilitarian outlook and interest in economics led to a series of findings in applied geology, based on his studies of agriculture and occurrences of resources such as coal, shale, flint, fire-clay, hard-rock quarries and ores. He was the first person to discover petroleum in Sweden, for example at Osmundsberget in Dalarna.

Linnaeus' concern for utility went so far that he classified different sandstones on the basis of their practical uses, using terms like "millstone" and "grindstone" as rock names.

The taxonomy of the mineral kingdom which he put forward was one of many. Mineralogical theories and classifications of rocks had existed for hundreds of years, and an appreciable number of them were in circulation. Linnaeus, though, was not happy with the existing systems and therefore proposed one of his own.

The scientific importance of his work in mineralogy lies both in its documentary value and in the fact that he brought this field to the attention of scholars, thereby laying a foundation for crystallography.

Linnaeus' ideas

Linnaeus' geological conclusions and ideas derive primarily from the way he linked different phenomena. As he saw it, two phenomena that

Shells. After Linnaeus.

Fossile of a trilobite. After Linnaeus.

were physically adjacent represented a gradual transition. If A was located next to B, then one of them must originate from the other. This was why he so often confused cause and effect, or saw causal links where none existed. His ideas thus reflect a linear way of thinking. He believed, for example, that bedrock was formed from hardened gravel, and that clay containing shells turned into limestone.

So numerous were the linear processes (transitions) which Linnaeus identified, however, that in nature as a whole he saw cyclic processes. This notion of the cyclical nature of the earth's surface is in fact a correct one which enhances our understanding of geology.

Thoughts on fossils

To begin with, Linnaeus (like many others) was convinced that no species had ever died out. The fossil species that had not been found alive ought still to be at large in the depths of the oceans.

He believed that the gradual lowering of sea level had shifted these species' habitats away from their original sites. In time, Linnaeus became increasingly vague on this point, aware that no other scientist in Europe, either, had seen all the "petrified" species alive.

In the end, he stressed the need to explore the seas before concluding that a species was lost for ever. He is presumably smiling from his heaven at today's rediscoveries of "extinct" species in the deep oceans.

Curiosities

An aspect of Linnaeus' descriptions that was typical of the period was the considerable emphasis he placed on curiosities. The many "marvels" or "wonders" to be found reflected the riches of nature, and hence also "the all-wise Creator's ordering of our globe".

Something remarkable was regarded as very important or good. Spring water rich in iron and stink-

ing of sulphur (and preferably covered by a film of oil), for example, was considered both a delight to the palate and good for one's health.

Like a modern-day sommelier, Linnaeus described with fascination the subtle flavours of such spring waters, which today would be classed as unfit for human consumption.

Male and female

Linnaeus' classification of rocks and minerals reveals him at his least scientific.

Caught in an antiquated way of thinking, he comes across more as an alchemist in this context, mixing the basic principles of alchemy, ancient ideas of the four elements and the biblical symbolism of male and female with scientifically based investigations.

Linnaeus founded his thinking about minerals on the idea that they incorporated salts, and that these salts totally determined their crystallization. In line with Christian notions of creation's sacred union of opposite elements, male and female, he also developed several theories about geological processes, including the formation of minerals. Female earths (*terrae*), he claimed, had been fertilized by male salts (*salia*).

Linnaeus had many theories, some of them mutually contradictory, and he often had difficulty getting individual phenomena to fit both into his mineral system and into his larger geological models.

One of his major contributions to the natural sciences – the introduction of fixed, regular principles – stopped short of the field of geology. There, the various systems he proposed had only an apparent regularity.

With the passing years and advancing age, the focus of Linnaeus' interest shifted to the plant and animal kingdoms, and he left it to others to study the physical and chemical properties of minerals.

To sum up – the "King of Flowers", who paid heed to everything, contributed to the emergence of geology as a science in its own right.

Linnaeus' fascination with geological formations sprang from the fact that they told a story of the origins of the earth and the human race, a story available from no other source. There is a scientific and poetic force to Linnaeus' words: "Thus speak the stones, when all other things are silent."

About SGU

The Geological Survey of Sweden (SGU) is the national authority responsible to the Ministry of Industry, Employment and Communications for matters relating to Sweden's geological characteristics and mineral resources management.

SGU's main task is to meet the national need of geological information, for example with respect to sustainable supplies of natural resources, spatial planning, the environment, and the total defence and national vulnerability.

Information from SGU is used by exploration companies in their search for mineral resources and for the purposes of local authority planning, protection of groundwater resources, remediation of industrially contaminated soil, environmental monitoring, and locating buildings, plants, roads, bridges and railways.

SGU is also the principal agency for the Mining Inspectorate of Sweden and responsible for the decommissioning and environmental remediation of the sites that were previously used to store Sweden's emergency oil stockpile and for progress towards achievement of the national environmental quality objective Good-Quality Groundwater.

At present SGU has about 290 employees, most of whom work at the head office in Uppsala. We also have branch offices in Göteborg, Lund, Stockholm, and Malå.

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