A letter by Nicolaus Steno about a cavern near Como

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Abstract. The present work is based on a letter that a Danish scientist of the 17th century addressed to Cosimo III, grand duke of Tuscany, to report about a recent excursion to a cavern on the mountains near Como. Niels Stensen (Niccolò Stenone) was born in Copenhagen in 1638 from a family of goldsmiths. He enrolled at the faculty of medicine in the local university, continued his medical studies in Amsterdam, and finally in Leyden where he obtained a medicine degree in 1664. Meanwhile Stensen had been appreciated for his anatomical research. Later he lived for some time in Paris where he continued his anatomical research and published his 'Discourse on Brain'. In 1666 he settled in Florence where he was appointed as professor of anatomy at the Santa Maria Nuova hospital and became a member of the 'Accademia del Cimento'. In Tuscany he continued his anatomical research and got involved also in other sciences. Stensen converted to Catholicism in 1667 abjuring the Lutheran faith, was ordained as a priest in 1675 and finally was appointed as a bishop in 1677. He was then transferred as apostolic vicar to Hannover and later to Hamburg. Stensen died in Schwerin in 1686. His body was transported by sea to Florence and buried in the church of San Lorenzo. Among Stensen's geological activities there were his research excursions made in 1671 in Northern Italy to visit two Alpine caverns: the cavern of Gresta (in Trentino) and the cavern of Moncodeno (in Lombardy). The purpose of the excursions was to study the build-up and the presence of ice even during summer in those caverns. The outcome was reported in two letters addressed to the grand duke in the same year. The letter examined here, written from Milan in June 1671, reports about Stensen's observations in the cavern of Moncodeno, situated in the Pre-Alps near Como. The scientist refutes the Aristotelian theory of 'antiperistalsis' that hypothesised the build-up of ice in the caverns during summer as a reaction to external heat. He states, instead, that the cold air coming from the bottom of the caverns was caused by winter ice melting because of summer heat. In this letter Stensen describes the inside of the cavern in detail, also using some drawings. That cavern, located in the Grigne and known as 'Ghiacciaia di Moncodeno', has also been studied recently by geologists from Milanese universities. Overall, Stensen's letter highlights the geological and speleological interests of an author who extended his research in the field of natural sciences well beyond the old boundaries of anatomy.

Key words: geology, speleology, temperature range.

While staying in Milan, Niels Stensen wrote this on 19th August 1671 to Cosimo III, Grand Duke of Tuscany:

Having arrived at the cavern, tired because of a road full no less of terror because of the precipitous cliffs, below and above that road, than because of my exertion for the difficult ascent, and overwhelmed by so many new things, I forgot to make many observations that now are coming to my mind, and that I would otherwise had made if it had been a place closer to the built-up area, and not a land frequented more by little goats and chamois than by human beings [1, 2].

The cavern in question is the so-called 'Ghiacciaia di Moncodeno', situated in the northern Grigna at the

altitude of 1,640 metres near Lecco. It was visited by Stensen in August 1671 while transiting in Lombardy (Fig. 1).

Stensen's visit to the cavern of Moncodeno was linked to his more general interest for geology, mineralogy and palaeontology, despite his education and his activity as a physician and an anatomist.

Niels Stensen was born on 1st January 1638 in Copenhagen (3). The religion of the members of his family was Lutheran and they were professional goldsmiths (4). He showed great interest in natural sciences since his childhood. In 1656 he enrolled in the faculty of medicine at the local university. Then he continued his studies in Amsterdam and finally in Leyden, where he obtained his degree in 1664. After a short stay in Florence he moved to the Grand Duchy of Tuscany, where he stayed permanently in Florence where he could continue his studies and anatomical research that he had started when he was younger. When he arrived in Tuscany he changed his name into Niccolò Stenone (the Italian equivalent of Nicolaus Steno in Latin) and joined the Grand Duke Ferdinando II de' Medici as his personal physician (Fig. 2). In addition he became professor of anatomy at the ancient hospital of Santa Maria Nova and a member of the prestigious Accademia del Cimento. Alongside his medico-anatomical interests, soon Stensen involved himself in geology and palaeontology by travelling to study not only in Tuscany, but also in other Italian regions and in other European countries. Between 1672 and 1674 he was in Denmark again, hoping to obtain a chair of anatomy in the local university. However, as such possibility did not materialise, he returned permanently to Tuscany and became tutor of the new Grand Duke Cosimo III de' Medici. Meanwhile the Danish scientist became progressively closer to the Catholic religion, abjuring the Lutheran faith in 1667. Stensen was ordained as a priest in 1675 and was appointed as a bishop in 1677, after having

Figura 1. Interno della caverna di Moncodeno, nel gruppo montuoso delle Grigne, presso Lecco.

Figura 2. Ritratto di Niccolò Stenone (1638-1686) in veste episcopale.

been chosen by the pope Innocent XI as apostolic vicar of Hannover. In his late years he completely abandoned his scientific activity, devoting himself to his new pastoral duties, living in the territory of the vicarage (in Hanover, Munster and Hamburg). He died in Schwerin on 25th November 1686. The following year Stensen's body was transported to Florence and buried in the church of San Lorenzo.

In addition to his works with a medico-anatomical subject – such as *Observationes Anatomicae* (1661), *Discours sur l'Anatomie du Cerveau* (1662) or *Elementorum Myologiae Specimen, seu Musculi Descriptio Geometrica* (1667) – Niels Stensen published works with a geologic subject, such as *De Solido intra Solidum Naturaliter Contento Dissertationis Prodromus* (1669). In this work the Danish scientist, starting from research and personal observations, deals with the terrestrial crust and its modifications, the processes of sedimentation and erosion, the geological layers and the fossils that are within them, the formation of minerals and the structure of crystals. Stensen's interest in geology is also shown in two letters, addressed to the Grand Duke of Tuscany in 1671, about two caverns that he had visited recently: the 'Cavern of the ice' in Val Gresta (Trentino) and the 'Ghiacciaia di Moncodeno' on the Grigna (Lombardy). In fact the Danish scientist, urged by his colleagues at the Accademia del Cimento, in the summer of 1671 went expressly to northern Italy to inspect some caverns characterised by the perennial presence of ice. After having visited one in Trentino, then while being in Milan became aware of another cavern of the type that he was looking for and therefore decided to make an excursion on the mountains near Lecco.

Having arrived at the 'Ghiacciaia di Moncodeno', Stensen described it in this way:

The cavern of Moncodeno has exceeded by far what I had expected, giving me some peculiarities never read before from other authors, nor come to my mind on other occasions . . . The main peculiarities consist in the structure of the ice, very different from what I had seen before, and in some parts similar to the structure of crystal, so that I am no longer amazed that many have regarded the crystal as hardened ice, as they have found them similar not only in their transparency, but also in their shape [. . .] *Some of the ice is found is found in the middle of the cavern in the shape of columns, and that in places where drops of water fall continuously; some along the rock on the side opposite to the entrance, in as much variety of shapes as of sorts of incrustations, and that in places of the rock that are always wet; some at the bottom of the cavern around the columns. But I did not find water at the bottom of the cavern, nor ice with a horizontal surface . . . There was no perceivable wind in the cavern; and by putting the candle near the fissures of the rock as far as one could go, no movement of the flame could be observed. However, there was very perceivable cold, so that my feet were nearly freezing; and the snow can be found here in great quantity at the entrance of the cavern* [(2)].

During the exploration of the cavern, Stensen sketched some characteristics of it on a piece of paper in order to illustrate it better for his colleague scientists and the public interested in the subject; and particularly he produced 'a profile made alongside the cavern' and 'a profile made across the cavern'.

At the end of his examination of the cavern, Stensen drew the following conclusions:

1. *That there is no heat in the cavern when it is cold outside it.*
2. *That ice is produced in it also in summer.*
3. *That the water which freezes in it does not become much, but nearly imperceptible, mainly carried in by the air that comes through the fissure in the rock.*
4. *That the cold in the cavern does not come from the concentration of the internal cold, but from the coldness of the snow, which, being near the opening, keeps the innermost parts of the cavern always cold*[(2).]

Niels Stensen intended to verify the theory of 'antiperistalsis' – formulated by Aristotle – through the exploration of caverns with perennial ice. According to the Greek philosopher, two opposite qualities, such as hot and cold, had the capability of reacting reciprocally increasing the strength of both. In particular, the increase of the quantity of ice visible in mountain caverns during the summer season must be caused by the increase of ambient temperature outside the cavern, because heat and cold repelled one another (and in fact it is commonly noticed that underground places are cold when the weather is hot, while they are hot when the weather is hot). Such theory still had many supporters in the sixteenth century. In fact, if René Descartes (1596–1650) in *Principia Philosophiae* (1644) and Bernhard Varen (1621/1622–1650) in *Geographia Universalis* (1650) had not distanced themselves much from the Aristotelian conceptions on underground cavities, Athanasius Kircher (1601–1680) in *Mundus Subterraneus* (1655) fully resumed the Aristotelian theory of the antiperistalsis, by stating that was a common observation the fact that the air current coming from mountainous cavities were colder when the external temperature was higher in the hotter hours of summer months. Stensen had already involved himself in underground cavities in part III of *Prodromus* where he had stated that the formation of ample caverns was due on one side to the erosion caused by underground water streams, and on the other side to the swelling caused by the pressure of underground on the waters. However, the Danish scientist was aware of the conjectural character of his theories on underground cavities and of the scarcity of empirical data coming from the direct exploration of the caverns. His intention therefore was to perform an investigation in the field to record the phenomena under study. Therefore, the visit to the two mountain caverns characterised by the presence of perennial ice offered Stensen the occasion for experimenting a new research methodology as regards the theories on the Earth. Such a methodology, for example, required the measurement of the dimensions and temperature of the cavern with adequate instruments, the graphical representation of the cavern with planimetry and profiles, the collection of information from the inhabitants of the zone, and performing periodical visits.

In the light of his personal experiences Stensen contested the theory of antiperistalsis. Actually he stated that the ice contained in mountain caverns was produced only by cold air coming from their bottom, which was freezing the water present there. On the other hand, the external heat caused by the summer climate had the only effect of melting the frozen snow amassed during winter, starting from the parts closest to the entrance of the caverns.

The 'Ghiacciaia di Moncodeno', explored by Stensen in 1671, had probably already been visited by Leonardo da Vinci (1452–1519) during an excursion in the Grigne when he was staying in Lecco. The same cavern was probably explored later by Lazzaro Spallanzani (1729–1799) in the eighteenth century and by Antonio Stoppani (1824–1891) in the nineteenth century.

Indeed Stoppani wrote this about the formation of ice in the cavern of Moncodeno:

Can we know the origin of a quantity of ice in a location at a height where no snow at all remains outside as soon as summer comes? It is a very simple phenomenon. See that the mountain around the cavern has almost the shape of a large and very regular funnel, where the cavern itself is the tube. It is natural that, during winter, snow will not only descend directly into the cave, but also slide everywhere from the steep walls of the funnel, so that it

accumulates in a quantity sufficient to obstruct and block that natural well. When snow has gone into that hole, there are no sun rays that can disturb it. Having been pushed and compressed by its own weight, exactly like the snow in parts of the Alps, that snow is converted into ice similar to the ice that flows from the same parts of the Alps, producing the glaciers.

The 'Ghiacciaia di Moncodeno' was visited by geologists and speleologists during the twentieth century. Then it has been the subject of research performed by geologists of the Università degli Studi di Milano and of the Università di Milano-Bicocca. Such research has produced a thesis for a degree in geological sciences entitled *Study of the sediments of ice and snow in Moncodeno* (discussed at the Università degli Studi di Milano in the session of April 2002).

Going back to Niels Stensen and to his excursion to the Grigna up to the cavern of Moncodeno, we can conclude that his letter to the Grand Duke of Tuscany about such an experience highlights his interest in a discipline apparently far from his education as physician and anatomist, but equally important for his 'modern' scientific mentality [(5).]

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