AMERICA'S EARLIEST (EUROPEAN-STYLE) ASTRONOMICAL OBSERVATORY, FOUNDED AND USED BY GEORG MARGGRAFE IN DUTCH COLONIAL BRAZIL (1638-1643)

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Introduction

One of the earliest examples of the transfer of scientific instruments between Europe and the Americas, especially with regard to Brazil, is the case of the astronomer, cartographer and naturalist Georg Marggrafe (1610-1643/44), working in Dutch colonial Brazil from 1638-1643. He is probably best known as the co-author of *Historia Naturalis Brasiliae* (1648), the influential first account of Brazil's zoology and botany, presenting also an early form of antropology.[1] But Marggrafe was also the first European scholar to build a European-style astronomical observatory on the South American continent (Fig. 1). In the Dutch settlement of 'Mauritiopolis' in Brazil (now Recife) he performed astronomical observations from June 1638 until June 1643, with interruptions when he was on cartographic and perhaps other missions elsewhere in Brazil. In August 1643, also for cartographic reasons, Marggrafe was sent to Angola, where he unexpectedly died around the new year of 1644. This happened before Marggrafe had been able to finish the text of his book *Progymnastica Mathematica Americana*.[2] In this work – evidently inspired by Tycho Brahe's *Astronomiæ Instauratæ Progymnasmata* (partly printed 1598, finished by Johannes Kepler in 1602) – Marggrafe had hoped to present the results of his astronomical survey of the southern hemisphere.

In 1979, the historian of astronomy John North published a detailed account of Marggrafe's astronomical activities.[3] North was able to do so, thanks to the fact that a large portion of Marggrafe's astronomical legacy has been preserved, partially in Leiden and partially in Paris.[4] In his article, North assumed that the design of Marggrafe's Brazilian observatory had been particularly inspired by the descriptions of Tycho Brahe's observatory 'Uraniborg' as published in his *Astronomiae Instauratae.*[5] However, in this paper we will demonstrate that Marggrafe used the astronomical observatory of Leiden University as benchmark for his Brazilian observatory. Marggrafe had trained in practical astronomy at Leiden Observatory in the first 10 months of 1637. By comparing Marggrafe's description of the Recife observatory and the way he performed his observations there, we can show that, in Brazil, Marggrafe fairly accurately imitated the scheme of Leiden Observatory, including its observational apparatus and practices. In this paper we will restrict ourselves to a discussion of both the observatories and their instruments. A more detailed discussion of Marggrafe's observations and related practices, executed both in Leiden as well as Brazil will be presented in the near future in a extensively documented book, which also will include integral transcriptions of Marggrafe's observations.

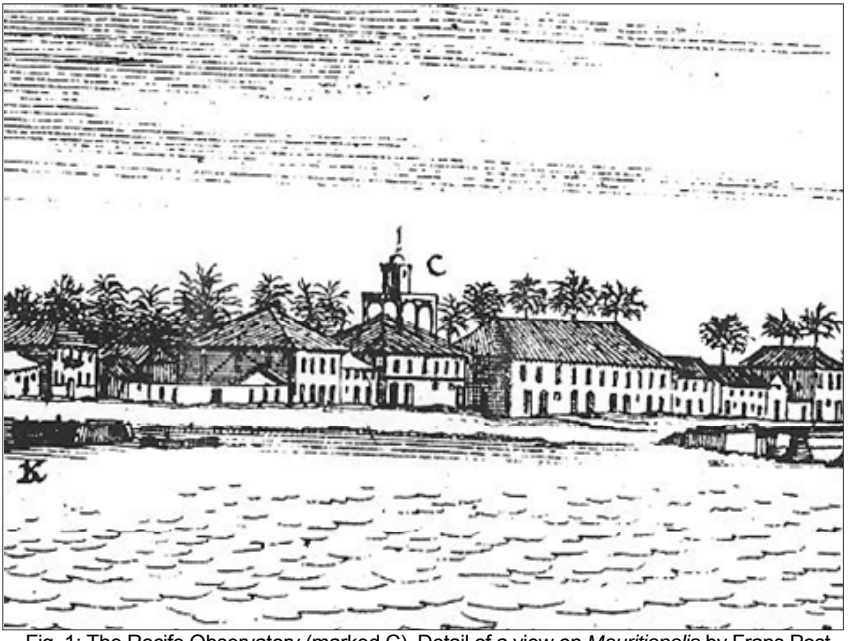

Fig. 1: The Recife Observatory (marked C). Detail of a view on *Mauritiopolis* by Frans Post, published in Caspar Barlaeus, *Rerum per Octennium in Brasilia* (Amsterdam 1647).

Georg Marggrafe: a short biographical note

Marggrafe was born on 20 September 1610 (old style, that is according to the Julian calender) in the German town of Liebstadt, in the Meissen region of Saxony. His father was a local schoolmaster, who taught Georg Greek, Latin, music and drawing. In May 1627, the young boy matriculated as a student at Wittenberg University. Probably because of the raging Thirty Years War, Marggrafe soon started to drift throughout Germany, entering Strasbourg University in November 1627 and Basel University in April 1628.[6] According to Georg's biography, published by his younger brother Christiaan, Marggrafe further visited Ingolstadt, Altdorf, Erfurt, Wittenberg (again), Leipzig, Greifswald, Rostock and Stettin, sailing from there through Denmark to Leiden.[7] Georg enrolled at Leiden University in September 1636.[8] Here he stayed until his leave for Brazil in the spring of 1638. In the ten years of his education Marggrafe studied botany, alchemy, medicine, mathematics, astronomy and some foreign languages. In Strasbourg he was a pupil of the astronomer Jakob Bartsch (the assistant and son-in-law of Johannes Kepler).[9] During his return to Wittenberg, in 1634, Marggrafe obtained a degree in Paracelcian medicine and alchemy from the famous alchemist Daniel Sennert, after which Marggrafe called himself a 'philo-chymiater';[10] in Rostock he followed lectures from the botanist Simon Pauli;[11] in Stettin, he was tutored by Lorenz Eichstädt, rector of the Marienstift Gymnasium, but better known as a calculator of planetary ephemerides.[12] Finally, in Leiden Marggrafe matriculated officially as a student of medicine, but in reality he foremost studied botany and practical astronomy. At that time, the observatory of Leiden University was the only operational astronomical observatory in Europe with equipment modelled after the dissolved Danish and Czech observatories of the late Tycho Brahe. Leiden therefore possessed a large Tychonic quadrant, build and used by two former apprentices of Tycho.[13] This fact was probably one of the reasons why Marggrafe had chosen to come to Leiden. According to his brother's biography, Marggrafe was "passing over the nights in the turret of the academy and spending the day in the botanical garden and fields", whilst being instructed by Jacob Gool (Golius) in mathematics and astronomy and by Adolph Vorst (Vorstius) in botany.[14] Given Marggrafe's later Brazilian career as a 'cartographer', he probably also frequented occasionally the so-called *Duytsche Mathematique*. This was the vernacular branch of Leiden University, where surveyors and military engineers were trained, and where a successful surveying instrument, the 'Hollandsche cirkel' (Dutch circle), was promoted.[15] It is known that other Leiden students followed the same dual path of instruction.[16] In the summer of 1637 Marggrafe must have succeeded in making the necessary contacts that enabled him to travel to South America. According to Marggrafe's younger brother, this had been his aim right from the start:

> He burnt with a great desire of contemplating the southern stars. […] He knew […] that there was in America a harvest of no small praise: therefore he turned over every stone, he grabbed at every opportunity that could lead him to America.[17]

Early 1638 Marggrafe arrived in Brazil, not as a servant of the Dutch West Indian Company, but as the personal 'domestique' (servant) of Willem Pies, the newly appointed medical doctor of the governor of colonial Dutch Brazil, count Johan Maurits van Nassau.[18] Shortly after his arrival in Recife, Marggrafe set up a business in pharmaceuticals, and he also assisted Pies in medical affairs. However, before his leave to Brazil, Marggrafe had obtained a personal letter of recommendation to count Nassau, written by the Leiden merchant-scholar Johannes de Laet, one of the founders of the West Indian Company.[19] According to a later notary statement by Abraham de Vries, one of Nassau's Brazilian officials, De Laet had advised the count to employ Marggrafe as a mathematician.[20] With this recommendation in his pocket, Marggrafe grabbed his chances. Still on his way to Recife, he already wrote the governor to offer him his service. In order to arouse the count's attention, he included in this letter some drawings he had made on his journey to Brazil.[21] This indeed had the required effect. Johan Maurits almost immediately allowed Marggrafe to erect an astronomical observatory on top of his house. Some time later he also ordered the Dutch council in Recife to appoint Marggrafe as the Company's official mathematician.[22] Soon Marggrafe's prestige had been sufficiently increased to be included in the rank of people who were allowed to dine at the count's table.[23] Years later, in a letter to the trustees of Leiden University, count Nassau indeed referred to him as "my Mathematician, named Marggravius, who died in Angola".[24] In a contemporary list of Maurits's crew, Marggrafe is listed as the *den caertemaecker* (the cartographer).[25] This was also the assignment Marggrafe received in August 1643, when the board of the Dutch West Indian Company unexpectedly ordered him to chart the recently conquered coast of Luanda in Angola (Fig. 2).[26]

Nevertheless, Marggrafe did more than to chart maps. During his cartographic expeditions he noticed intensively the richness and variety of the Brazilian nature. By making notes and drawings, as well as by collecting all kinds of natural history specimens, he contributed substantially to the knowledge of Brazil's botany and zoology. Marggrafe's splendid, life-like drawings of natural history objects were among the first to be published in accounts of colonial Dutch Brazil (Fig. 3). One of Marggrafe's herbaria is still preserved in Copenhagen (Denmark)[27], and some of his coloured drawings of Brazilian animals have been rediscovered in the Jagiellon Library in Cracow (Poland).[28]

Fig. 2. Map of Paraiba in Dutch Brazil, surveyed by Marggrafe, and posthumously printed by Blaeu in Amsterdam, with additional scenes from Brazillian life, probably derived from drawings by Frans Post (Koninklijke Bibliotheek, The Hague).

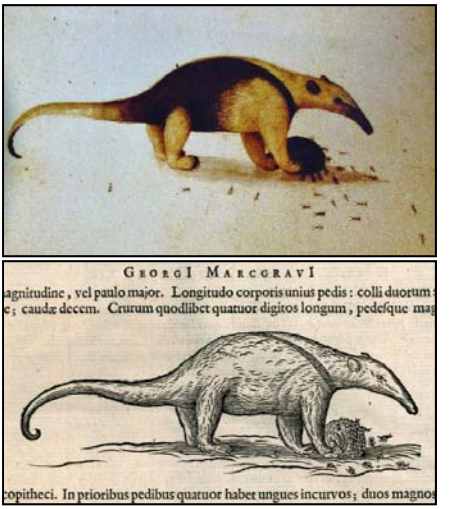

Fig. 3. Marggrafe's watercolor drawing of a Tamandua (or anteater) and the way this animal is depicted in the *Historia Naturalis Brasiliae*.

Marggrafe's scientific legacy

After his death, Marggrafe's belongings were sent to the Netherlands where, according to the commands of the former Brazilian governor count Johan Maurits van Nassau, his botanical and zoological papers were put into

the hands of the Leiden scholar Johannes de Laet. However, Marggrafe's astronomical papers were given to Jacob Gool, the Leiden professor who had supervised Marggrafe's training in practical astronomy during his sojourn in Leiden.[29] Both scholars received the explicit instruction to publish Marggrafe's findings. De Laet did edit Marggrafe's notes on the natural history of Brazil, but the astronomical part of Golius' editorial process remained unfinished.

In 1648, De Laet published the magnificent *Historia Naturalis Brasiliae* containing Marggrafe's notes on the natural history of Brazil, accompanied by notes by his former master Willem Pies (also known in Latin as 'Piso'). In an editorial note, De Laet remarked that Marggrafe also had planned to compose a book on astronomy, to be entitled *Progymnastica Mathematica Americana*.[30] Between Marggrafe's working papers De Laet had found the outline of this ambitious project. The scheme of the proposed book was divided into three parts. In a first chapter on 'Astronomy and Optics', Marggrafe intended to present observations of the southern stars (between the tropic of Cancer and the southern celestial pole), as well as findings relating to the planets. His main ambition was to propose a new theory for the inner planets (Mercury and Venus) based on his own observations. Further he intended to expand the current theories on astronomical refraction and the solar parallax. The chapter would be finished by a new determination of the obliquity of the ecliptic; some observation of sunspots and – if observed – other celestial rarities, such as comets, supernovae, among others). A second chapter on 'Geography and Geodesy' would follow, presenting theories on the determination of the terrestrial longitude and the size of the Earth based on the author's own observations, complemented with a discussion of errors made by ancient and other geographers. Finally, the book would contain a series of astronomical tables, based on all his observations, called the *Tabulae Mauritii Astronomicae*, honouring the governor of Dutch Brazil, count Johan Maurits van Nassau.

Although this astronomical project was orphaned by Marggrafe's sudden death, early in 1644, his astronomical observations were comprehensive enough to be edited into a publication. Golius indeed worked on this task. Georg's younger brother Christiaan Marggrafe for instance wrote in 1652 to the Danzig astronomer Johannes Hevelius:

> Now at last I have seen the astronomical observations of my brother Georg. They concern a new theory of the planets, especially Mercury, who in the place where he lived, might be better seen than with us. They will be published shortly by the honorable Golius, together with other astronomical observations transmitted from Arabia.[31]

Golius himself testified in a lawsuit filed in 1655 by Christiaan Marggrafe about Georg's legacy that he indeed possessed Marggrafe's astronomical

papers, in order to publish them in due time.[32] A letter written by Marggrafe's former superior Willem Pies indicates that Marggrafe's former roommate, the mathematician and astronomer Samuel Kechel, had worked on a – now lost – planisphere of the southern stars, based on Marggrafe's observations.[33] This work undoubtedly had been done at Golius' request, who always allowed Kechel free access to the Leiden Observatory for making astronomical observations.[34] However, for reasons that remain unknown, the already edited manuscript of Margrafe's astronomical notes was still unpublished in 1667, when Golius suddenly died, to be followed by Kechel's death early in 1668. Melchisédech Thévenot from Paris, who happened to be in the Netherlands at the time, acquired the edited manuscript.[35] Through this route a copy of the manuscript has been preserved at the Observatoire de Paris.[36] This manuscript, combined with some of Marggrafe's working papers preserved in the Leiden Regional Archive (Erfgoed Leiden e.o.), are the main sources to examine his work on the astronomy of the Southern hemisphere.[37]

The Recife Astronomical Observatory

Marggrafe's project was ambitious enough to require the construction of a cutting edge permanent observatory that became the first one of modern conception in the New World, already endowed with a 'Galilean' or 'Dutch' telescope. The observatory was built on the roof of Nassau's first residence, a large Portuguese house in the fluvial island of Antônio Vaz that pre-existed the count's arrival. The building is depicted in a naïve style watercolor by Zacharias Wagener (Fig. 4), a member of the count's court. This watercolor constitutes an additional precious source of information.[38]

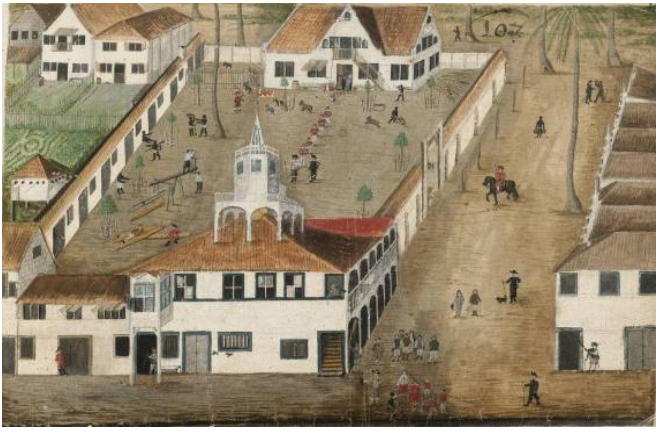

Fig. 4: Marggrafe's astronomical observatory, a platform with a hexagonal turret, built on the roof of Nassau's first residence in Recife. Drawing by Zacharias Wagener (1614-1668) in his contemporary *Thierbuch* (Staatliche Kunst Sammlungen, Dresden).

It is our hypothesis that in Brazil, Marggrafe used the Observatory of Leiden University as a benchmark. In Recife, he copied to a large degree the site, instruments, and methods that he had become familiar with when he was trained in observational astronomy at Leiden Observatory. To demonstrate this, we will compare the setting and apparatus used by Marggrafe in Brazil with those he used in Leiden.

The location of Marggrafe's Observatory

The precise location of the observatory in Recife was determined by Menezes,[39] through the comparison of maps and images from different time periods. The very location is the corner of the streets 'Primeiro de Março' and 'Imperador D. Pedro I' in the Santo Antonio quarter (Figs. 5a & 5b). This corner came into being during the implementation of the urbanization plan designed by count Nassau's surveyors. Today, this corner is the last physical remnant of the period, since all original buildings from the Dutch epoch were demolished and replaced. Since the Dutch period, the Capibaribe river bank has withdrawn considerably, with the result that Nassau's first house, which – as can be seen in the Wagener's watercolor – was originally on the bank of river, is situated today more than a block away from the river.

Fig. 5. *Left:* Marggrafe's observatory (red circle) in today's Recife at the corner of the street 'Primeiro de Março' (almost vertical) with the street 'Imperador D. Pedro I' (almost horizontal). North is to the right. *Right:* The location of Marggrafe's observatory in November 2011.

The interior of the Recife and Leiden observatories

The base of the Recife observatory was a platform that could be reached comfortably from the interior of the house climbing up a ladder of 43 stairs, starting at the first floor of the two-story residence. We have made a three-dimensional virtual reconstitution of this observatory, as well as of the main instruments, using the free software Google SketchUp (Fig. 6).

Fig. 6. Virtual reconstruction of the Recife Observatory, by the authors (2011).

The platform was square with sides of about 20 Rhijnland feet (≈ 6.3 m), surrounded by a balustrade.[40] According to one of the drawings Marggrafe has left us, the Recife platform had a square extension on the southern side, possibly referring to a staircase (Fig. 7).

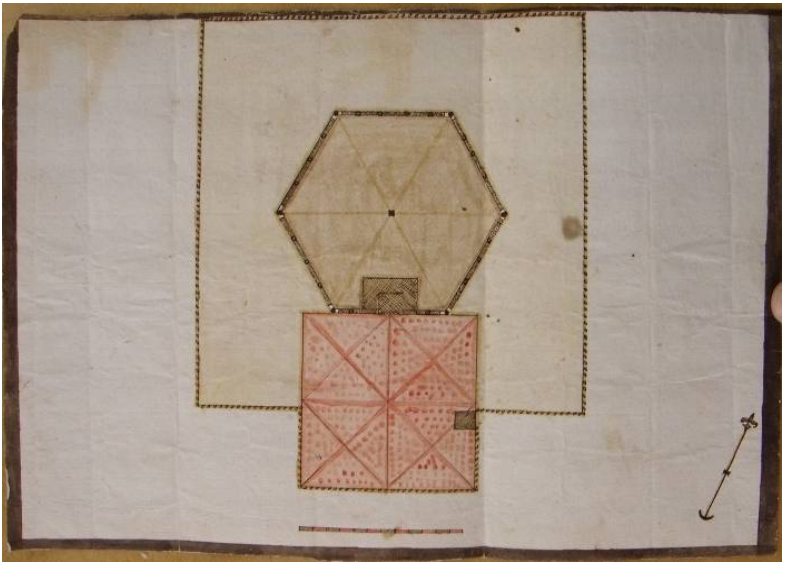

Fig. 7. Marggrafe's (undated) drawing of his Recife Observatory (Erfgoed Leiden e.o.).

Centered in the platform a hexagonal two story observatory was built, four sides of the hexagon facing roughly towards the cardinal directions. The chime of a bell of an iron clock below the platform, inside the roof, announced the hours for the population and Marggrafe often refers to it in his observations. At the Leiden Observatory the platform had a rectangular shape. This was a consequence of the configuration of the roof it was constructed on (Fig. 8). It measured 18 by 13 Dutch Rhijnland feet (≈ 5.7 by 4.1 m) and was also surrounded by a balustrade.[41] In both observatories a polygonal turret stood in the middle of the theatre. In the centre of both turrets a solid vertical pole was erected, around which a wooden quadrant could revolve. In Recife the turret was hexagonal, and the vertical walls of this hexagonal room had glass windows. These windows were not used during the astronomical observations (then the hatches were opened), but these windows were useful to monitor ships approaching Recife. That the observatory also was used in this way is demonstrated by Wagener, who in his drawing depicted someone in the window at the right of his watercolour, watching with a small telescope (see Fig. 4). The Recife tower was topped with a copper wind vane bearing the insignia of count Nassau.

Fig. 8. Leiden Observatory constructed in 1633-1634 on the attic of the Academy Building at the Leiden Rapenburg: details from (*left*) a view on Leiden, dated 1669, and (*right*) the frontispiece of Paulus Herman, *Horti academici Lugduno-Batavi catalogus* (Leiden 1687), drawn in 1686 from the adjoining hortus botanicus by Willem van Mieris.

In both observatories, the lower chamber (*zolder* in Dutch) of the turret was used for the housing of a few globes.[42] According to the Paris manuscript, Marggrafe brought to Brazil two pairs of celestial and terrestrial globes of different sizes. The celestial globes represented the stars according to Johann Bayer's *Uranometria* (1603). This room on the lower floor was also used as a dark room for optical experiments and observation of the Sun (Fig. 9).

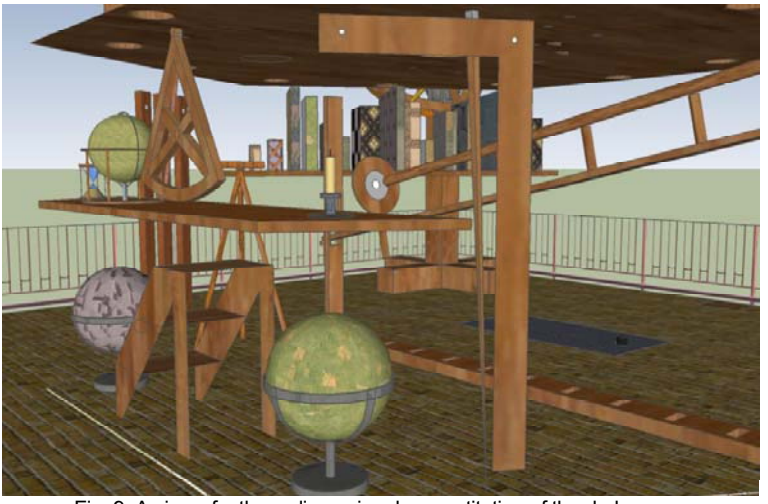

Fig. 9: A view of a three-dimensional reconstitution of the dark room.

On the walls to east and west there was a hole that allowed the entry of the solar rays for observation near sunrise or sunset. The Paris Manuscript describes a sturdy wooden mounting holding the *tubus* (telescope) that could project the solar disk with the sunspots on a screen. From his Leiden period several original observations of sunspots made by Marggrafe in such a way have been preserved. Probably in this room Marggrafe also stored his smaller equipments, such as his level, rulers, squares, night lamps, sandglasses and some books (all cited in the Paris Manuscript), as well as a portable 52 cm radius sextant with a Polish hammer that he used on expeditions.[43] Here stood also a bench with a slate.

The quadrant

The main purpose of astronomical observations in the seventeenth century was to check the accuracy of the ephemerides. (An ephemeris is a table of values that gives the positions of astronomical objects in the heavens at a given time). For this purpose a precision measuring device was needed, such as a large quadrant. The Leiden quadrant, made of wood with brass fittings with a radius of six Rhijnland feet and eight inches (≈ 2.1 m), is still extant (Fig. 10a). Its limb, or graduated scale, is divided in degrees, subdivided in intervals of ten arc minutes. To allow further accuracy the scale has transversals (Fig. 10c), following the measuring instruments used and described by Tycho Brahe, in his *Astronomiæ instauratæ Mechanica* (1598).[44] In Brazil, Marggrafe also used this arrangement for a similar quadrant (Fig. 10b & 10d).

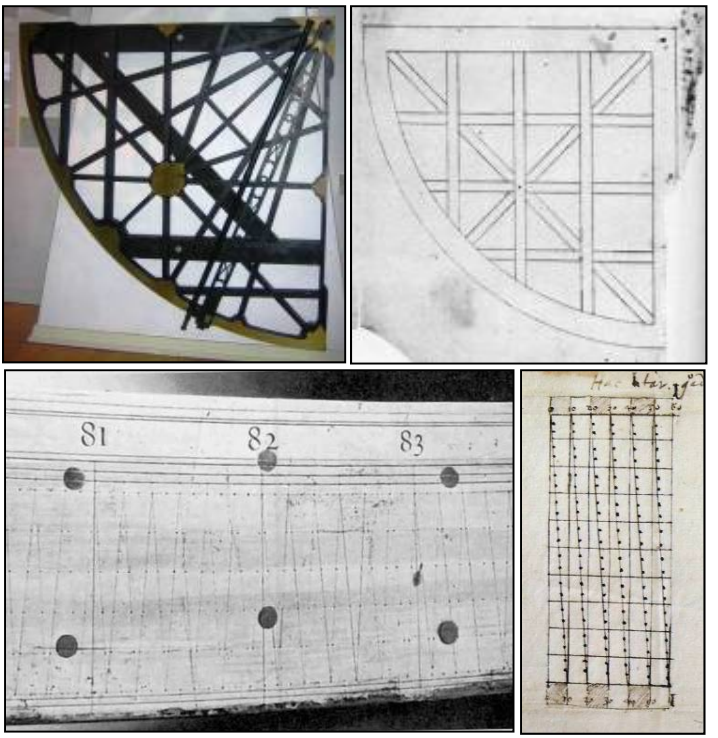

Fig. 10: Top left: (a) Snel's quadrant built by Willem Jansz Blaeu c. 1625, used by Georg Marggrafe in 1637 (the long telescope tube was added in 1669) (Museum Boerhaave, Leiden). Top right: (b) Marggrafe's quadrant made in Brazil. (Erfgoed Leiden e.o.). Bottom left: (c) Transversals on the limb of the Leiden quadrant. Bottom right: (d) Marggrafe's design for transversals on the Brazil quadrant (Erfgoed Leiden e.o.)

This 5 feet quadrant (≈ 1.57 m) was built in Brazil under Marggrafe's supervision. Except for the metal parts, the bulk was made of hardwood designated *pao sancto* (holy stick) by the Portuguese. Both in Leiden and Recife the quadrant could revolve in all directions around a sturdy vertical wooden pole, to which it was attached by its center of gravity. In Brazil, a large azimuthal circle of ten Rhijnland feet diameter (≈ 3.1 m) was fitted at the base of the quadrant, supported by 12 pillars, with a gnomon indicating the azimuth (FIG. 11). This is in accordance to Brahe's original description of the instrument, but in Leiden the horizon itself was used as an azimuthal circle.[45] The quadrant had a *Pinacidium Tychonicum* (a Tychonic sight), which cleverly exploits the differential method for minimizing parallax errors of ordinary sights. Presumably, the original sight of the Leiden quadrant was also of this sort, but the view finder on the Leiden quadrant was replaced in 1669 by a telescope tube.[46] In both observatories the quadrant room also housed a stepladder used in the observations. Probably there was also a desk with a night lamp, pen, ink and papers and a celestial globe.

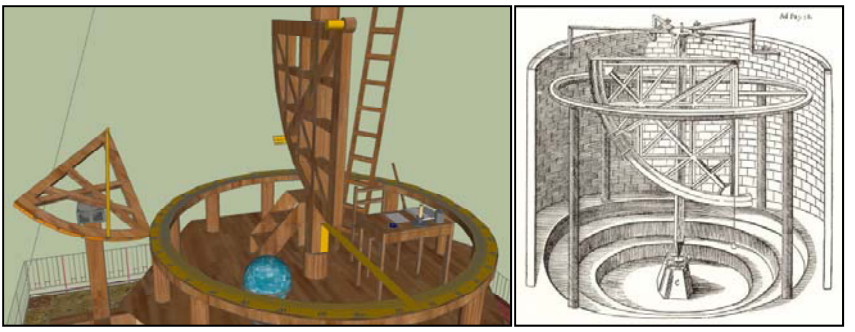

Fig. 11. Left: a view from the three-dimensional reconstitution of the 5-feet quadrant room. Right: a quadrant similar as the Leiden copy depicted in Hedraeus, *Nova et accurata […] quadrantis astronomici azimuthalis* (Leiden 1643).[47].

The sextants

In Recife Marggrafe also constructed a large wooden sextant (Fig. 12), with a radius of five Rhijnland feet (≈ 1.6 m), with sights as on the quadrant. It was stored under the steps leading to the upper observatory. A mount for this large sextant, with a ball joint, also five Rhijnland feet high (1.6 m), stood outside on the 'theatre'. According to the Paris Manuscript, Marggrafe had another, smaller sextant in Brazil made with a radius of 20 Rhijnland inches (≈ 52 cm), probably for geodetic work and astronomical fieldwork. A drawing in Marggrafe's Leiden manuscripts suggests that this was a sextant of a design invented by the Dutch scholar Adriaen Metius.

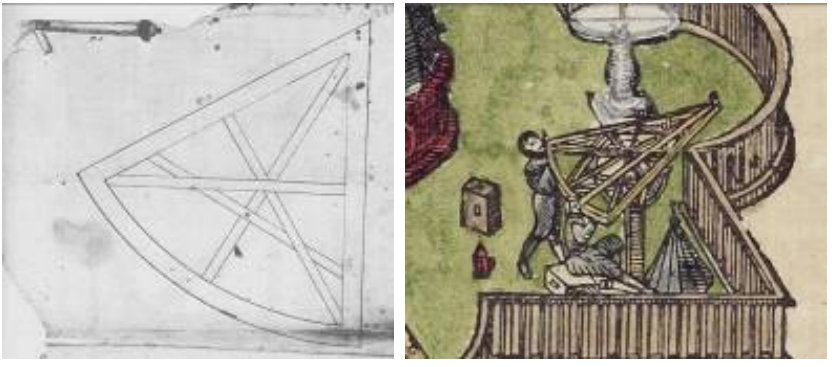

Fig. 12: Left: Marggrafe's drawing of the large sextant he had made in Brazil (Erfgoed Leiden e.o.). Right: A sextant simultaneously used by two observers at Tycho Brahe's 'Stjärneborg' observatory [detail from Brahe, *Astronomiæ instauratæ Mechanica* (1598)].

Clock, *clepsydra* and pendulum

Time accuracy was very difficult to achieve in Marggrafe's time. The invention of the pendulum clock by Christiaan Huygens was still several decades in the future. To measure time intervals Marggrafe used two timepieces, both in Recife and in Leiden. First there was the *clepsydra*, a device that measures time by the regulated flow of liquid from one vessel into another. The amount of liquid transferred is then a measure for the time elapsed. In Brazil he possessed two *clepsydrae* (one was probably a sand glass) and in Leiden he used at least one. Marggrafe also used the pendulum (*perpendiculum mobilis*), counting the oscillations (*pulsus*) of a swinging cord. According to the Paris Manuscript, Marggrafe brought to Brazil a pendulum made of a turned metal cylinder of 41¾ ounces (≈ 1.8 kg), suspended by a chord with a length of 29 Rhijnland inches (≈ 76 cm). Details of the Leiden pendulum are not known.

The telescope

In Marggrafe's days the telescope was still a novelty, almost more an object of curiosity than an instrument of research. Moreover, telescopes still lacked a well-defined function in an observatory, whereas the roles of quadrants and sextants in checking the theory of astronomical calculations were well established.[48] At that time, only the Dutch (or Galilean) and Kepler configurations were known. The first configuration had the disadvantage of a rather low magnification. Magnifications of more than about 20 times restricted the field of view so much that the instrument became virtually useless, whereas the Kepler telescope suffered from a serious spherical and chromatical aberration, making the images almost useless for astronomical observers.[49]

Marggrafe used a *tubus* – a small refracting telescope with an upright image – for several observations. In Brazil, Marggrafe used a telescope of seven Rhijnland feet (2.2 m). In Leiden he seems to have had a smaller one at his disposal. He observed the phases of the inner planets Mercury and Venus; saw all four satellites of Jupiter; recorded conjunctions and occultations; and in Leiden he even projected solar images in order to monitor sunspots and their rotation in successive days.

To allow for comfortable observations of celestial objects, in Brazil Marggrafe installed a pedestal to which the *tubus opticus* could be coupled. The Paris Manuscript mentions a hollow wooden base, 63 cm high, in which a stick with a length of 1.6 m could be fastened, adjustable to a proper height by means of a screw. A similar pedestal, adjustable in height, was still in use at Leiden observatory when Von Uffenbach visited it in 1711.[50]

Concluding remarks

Thanks to the patronage of the governor of Dutch colonial Brazil, Johan Maurits, count of Nassau, the German scholar Georg Marggrafe was able to found in 1638 the first European-style astronomical

observatory at the South American continent. Marggrafe's main ambition with this observatory was to compose a book entitled *Progymnastica Mathematica Americana*, intended to be the austral counterpart to Tycho Brahe's *Astronomiæ Instauratæ Progymnasmata* (1598-1602). However, Marggrafe's death, early in 1644, caused a sudden end to this ambition. Given that Marggrafe's astronomical observations were never published, over time his astronomical achievements were largely forgotten. However, thanks to preserved manuscripts of Marggrafe's observations, scattered over different locations, we were able to make a detailed survey of his astronomical achievements.

Our investigation of Marggrafe's astronomical legacy, raised in Leiden in 1637 and in Brazil in the years 1638-1643, reveals that, in Recife, he imitated for a large part the site of Leiden Observatory, as well as its equipment. This Dutch institution had been founded in 1634, only a few years before Marggrafe's arrival in Holland. At that time, Leiden Observatory was the only operational astronomical observatory in Europe with equipment modelled after the dissolved Danish and Czech observatories of the late Tycho Brahe.

The Marggrafe's case is one of the earliest examples of transfer of instruments, knowledge and practices between Europe and the Americas. In Brazil, Marggraf not only carefully copied the Leiden quadrant and sextant, but he also introduced into the procedures of an observatory new instruments such as the telescope, which at the time had not a well defined role as a scientific instrument. His papers however demonstrate his skilled usage of this optical device in observing various celestial phenomena. He even designed a pedestal tray with a type of altazimuthal mounting. A discussion of Marggrafe's observations is beyond the scope of this paper and will be presented and analysed in the near future.

In sum, we can establish that the Marggrafe episode constitutes a remarkable landmark for the history of astronomy in Brazil and the New World, in a hectic interregnum of the history of astronomy between Kepler and Newton. Unfortunately, largely because of the fall of Dutch Brazil in 1654, the episode remained an isolated and rather short event, with no follow-up in Brazilian science and scholarship. Only much later, in the early nineteenth century, science by European standards emerged, first in the Portuguese colony and after the Brazilian independence, as a national enterprise.

Acknowledgements

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Notes

1 Over the years the spelling of Marggrafe's name has been extremely polymorphic. We follow the Latinized form of his name 'Georgius Marggrafe', in accordance with his autograph, as can be found on a book in the University Library of Bonn (sign. O4'236/1). Marggrafe used this spelling also on his printed alchemical thesis, defended in 1634 at Wittenberg University. By lack of an earlier signature, P.J. Whitehead has guessed that the spelling of his name would have been 'Marcgraf'. See: Whitehead, 'The Biography of

Georg Marcgraf (1610-1643/1644) by his brother Christian, translated by James Petiver', *Journal of the Society for the Bibliography of Natural History* 9:3 (1979) 301-314.

2 Johannes de Laet, 'Benevolos Lectores' to 'Georgi Marcgravi de Liebstad, Historiae Rerum Naturalium Brasiliae, libri octo', in: *Historia Naturalis Brasiliae* (Amsterdam/Leiden 1648), page 2.

3 J. D. North, 'Georg Markgraf, an astronomer in the New World', in: E. van den Boogaart (ed.), *Johan Maurits Van Nassau-Siegen 1604-1679: a humanist prince in Europe and Brazil. Essays on the occasion of the tercentenary of his death* (The Hague 1979), 394-423; reprinted with a new addendum in: John North, *The universal frame: historical essays in astronomy, natural philosophy and scientific method* (London / Ronceverte, 1989), 215-234.

4 Erfgoed Leiden e.o., bibliotheek no. P. 7000; Observatoire de Paris, MS A.B.4.5. See: North, 'Georg Markgraf' (n. 3), footnote 14.

5 North, 'Georg Markgraf' (n. 3), 227.

6 Meijer has found Marggrafe's entrees in the matriculation registers of the universities of (1) Wittenberg (May 1627), (2) Strasbourg (November 1627) and (3) Basle (April 1628). Cf. Th.J. Meijer, 'De omstreden nalatenschap van een avontuurlijk geleerde', *Leids Jaarboekje* (1972), 63-76, esp. 75.

7 Christiaan Marggrafe, 'Vita Georgii Marggravii', in: the same, *Prodromus medicinae practicae dogmaticae & verè rationalis* [second edition] (Leiden 1685). This biography was composed by Georg's younger brother, the chemist and medical doctor Christiaan Marggrafe. An English translation by the apothecary James Petiver (1663-1718) was published in 1979 by Whitehead, 'Biography' (n. 1). Other biographical details are summarized in R. P. Brienen, 'Georg Marcgraf (1610-c.1644): A German Cartographer, Astronomer, and Naturalist-Illustrator in Colonial Dutch Brazil', *Itinerario. Bulletin of the Leyden Centre for the History of European Expansion* 25 (2001) 85-122.

8 W. N. du Rieu, *Album Studiosorum Academiae Lugduno Batavae 1575-1875* (Leiden 1875), 280.

9 Jakob Bartsch (c. 1600-1633) studied astronomy and medicine in Strasbourg. In 1624 he published several celestial maps, entitled Usus astronomicus planisphaerii stellati, which included several new constellations introduced around 1613 by Petrus Plancius. Bartsch had married Kepler's daughter Susanna. After Kepler's death in 1630, Bartsch edited his posthumous work Somnium.

10 G. Marggrafe, *Theses Hasce De Caussa Continente* (Wittenberg 1634). Marggrafe used the title 'philo-chymiater' signing a laudatory poem in Lorenz Eichstädt's *Ephemerides novarum et motuum coelestium* of 1634. According to J. Ramminger, *Neulateinische Wortliste* the phrase can be translated as 'friend of the alchemical way of healing'. Cf. www.neulatein.de.

11 Simon Pauli (1603-1680) studied medicine in Rostock, Leiden (1623) and Paris. In 1634 he became professor in medicine and botany at Rostock University. In 1635 he married Elisabeth Fabricius, daughter of the physician and astronomer Jacob Fabricius, who from 1592-1596 had served Tycho Brahe as a 'famulus'. In 1639 Pauli became professor for anatomy, surgery and botany in Copenhagen. Cf. John Robert Christianson, *On Tycho's Island. Tycho Brahe and his assistents 1570-1601* (Cambridge 2000), 276-277.

12 Lorenz Eichstädt (1596-1660) lived in Stettin until 1645, when he was appointed professor of mathematics and astronomy at Dantzig University.

13 The Leiden quadrant had been ordered in the mid-1620's by Willebrord Snel (or Snellius), professor of mathematics at Leiden University. The instrument was constructed

by Willem Jansz Blaeu. Both men had been apprentices to Tycho Brahe. Cf. Christianson, *On Tycho's Island* (n. 11), 254-256; 358-361.

14 Marggrave, 'Vita Georgii Marggravii' (n. 7); Whitehead, 'Biography' (n. 1), 308. Jacob Golius (1596-1667) was a Dutch Orientalist and mathematician. He founded Leiden Observatory in 1634; Adolph Vorst (1597-1663) was professor in medicine and botany since 1624.

15 Cf. P.J. van Winter, *Hoger beroepsonderwijs avant la lettre. Bemoeiingen met de vorming van landmeters en ingenieurs bij de Nederlandse universiteiten van de 17e en 18e eeuw* (Amsterdam 1988).

16 Cf. H. J. Witkam, 'Jean Gillot, een Leids ingenieur', *Leids Jaarboekje* 59 (1967), 29-54 and idem, 61 (1969), 39-70, esp. 39. Gillot matriculated at Leiden University in 1630.

17 Marggrave, 'Vita Georgii Marggravii' (n. 7); Whitehead, 'Biography' (n. 1), 308.

18 Willem Piso (Amsterdam) to the Curators of Leiden University, February 1655. In this letter Willem Pies asserts that in the first two years in Brazil, Marggrafe served as his 'domestique'. Cf. Meijer, 'De omstreden nalatenschap' (n. 6), 68.

19 All Marggrafe-De Laet correspondence has been lost. One – currently also missing – letter, dated 6 February 1640, is cited in B. J. Stokvis, *Les Médicins Hollandais du 17me siècle* (Amsterdam 1883), 28. See also: W. J. C. Rammelman Elsevier, *Inventaris van het Archief van de Gemeente Leiden*, vol. 2 (Leiden, [1865]), 23.

20 Statement by Abraham de Vries before notary Martin Beeckman in The Hague, 1 June 1655 (University Library Leiden, ASF 290).

21 Marggrafe (St. Salvador in Bahia) to Johan Maurits van Nassau (Recife), 15 May 1638. Currently missing letter, cited in Stokvis, Les Médicins Hollandais (n. 19), 26. See also: Rammelman Elsevier, Inventaris (n. 19), 23.

22 According to De Vries (n. 20), Marggrave had been granted a fee of 750 Dutch guilders for this job, to be paid after his return in Amsterdam. Regrettably, this Brazilian appointment was not passed on to the Amsterdam office of the West Indian Company. Because Marggrafe had been short of money in Recife, he had lend some funds from a certain Mr. Zetsky, the steward of Johan Maurits, giving his salary as mathematician as security. This appeared a major problem after Zetsky's return in 1647, when the WIC refused to redeem this pledge, saying that Marggrafe had not left for Brazil in this capacity.

23 'Lijste van de domesticquen aant hoff van Sijn Extie. Johan Maurits, Grave van Nassou etc., Gouverneur capitein ende admirael Generael van Brasil op den 1 April anno 1643, genietende de vrije taeffel', *De Navorscher* 48 (1898) 557-558.

24 Johan Maurits van Nassau to the curators of Leiden University, 6 February 1655, printed in: P. C. Molhuysen, *Bronnen tot de geschiedenis der Leidsche Universiteit*, vol. 3 (Leiden 1918), 107. See also Meijer, 'De omstreden nalatenschap' (n. 6), 66-67.

25 'Lijste van de domesticquen' (n. 23). Whitehead suggests that Marggrafe obtained his position as the count's cartographer in 1641, after the leave to Europe of the count's earlier cartographer Cornelis Bastiaensz Goliath. Cf. P. J. Whitehead, 'The Marcgraf Map of Brazil', *The Map Collector* (June 1987), 17-20, esp. 17. See also Kees Zandvliet, *Mapping for Money. Maps, plans and topgraphic paintings and their rol in Dutch overseas expansion during the 16th and 17th centuries* (Amsterdam, 1998), 204-206.

26 Letter to the Directors of the Dutch West Indian Company at the Coast of Southern Africa, 14 August 1643, cited in: Brienen, 'Marcgraf' (n. 6), 120 [note 128]. On Georg's cartographical activities in Brazil, see also: Victor Hantsch, 'Georg Marggraf', *Berichte über die Verhandlungen der Koniglich Sächsischen Geselschaft der Wissenschaften zu Leipzig, Philologisch-historische Klasse* 48 (1896), 199-227.

27 For Marggrafe's herbarium, see: Bruce MacBryde, 'Rediscovery of G. Marcgrave's Brazilian Collections (1638-1644)', *Taxon* 19 (1970), 349. See also: Dardano de Andrade-Lima, Anne Fox Maule, Troels Myndel Pedersen & Knud Rahn, 'Marcgrave's Brazilian Herbarium, collected 1638-44', *Bot. Tidsskr*. 71:3/4 (1977) 121-160 and Peter Wagner, 'Das Markgraf-Herbarium', in: Gerhard Brunn & Cornelius Neutsch (eds.), *Sein Feld war die Welt: Johann Moritz von Nassau-Siegen (1604-1679). Von Siegen über die Niederlande und Brasilien nach Brandenburg* (Münster [etc.] 2008), 233-245.

28 R. P. Brienen, 'From Brazil to Europe: the zoological drawings of Albert Eckhout and Georg Marcgraf', in: *Intersections: yearbook for early modern studies* 7 (2007), 273-314.

29 Cf. Meijer, 'De omstreden nalatenschap' (n. 6), 70-71. Georg's brother, Christiaan Marggrave never saw the astronomical documents, as he testified in 1685: 'His other writings, astronomical, optical, geographical etc where they are concealed, and in whose hands they are, perhaps may be discovered'. Cf. Marggrave, 'Vita Georgii Marggravii' (n. 7); Whitehead, 'Biography' (n. 1), 309. A fragment of what has been claimed to be Marggrafe's travel journal to Ceará, dated 1639, was recently discovered and published: See: E. van den Boogaart and R.P. Brienen, *Information from Ceará from Georg Marcgraf (June-August 1639)* (Rio de Janeiro 2002).

30 De Laet, 'Benevolos Lectores' (n. 2).

31 Christiaan Marggrafe (Leiden) to Johannes Hevelius (Dantzig), 20 july 1652 (Observatoire de Paris, Hevelius Correspondence, vol. 3, no. 355).

32 Testimony by Jacob Gool, written down in a judicial document ('dingboek'), dated 19 June 1655. (Leiden University Library, ASF 290, 15-27).

33 Willem Piso (Amsterdam) to the curators of Leiden University, 12 May 1655 (Leiden University Library, ASF 290, 15-27).

34 Several observations by Samuel Kechel are recorded in: A.-G. Pingré, *Annales Célestes du dix-septième siècle [ed. G. Bigourdan]* (Paris 1901).

35 In 1668, directly after Thévenot had acquired the Marggrafe manuscript, he informed Halley about some Brazilian observations, who passed this information to the English astronomer John Flamsteed. In 1694 Thévenot's Latin Manuscript 'Observationes Astronomicae à Marggravio in Brasilia factae cum earum usu' was auctioned and bought by the French astronomer Philippe de La Hire (1640-1718). See: *Bibliotheca Thevenotiana* (Paris 1694), 210 and North, 'Georg Markgraf' (n. 3), note 17.

36 Cf. J.J. Le François de Lalande, *Astronomie*, vol. 1 (Paris 1764), 537; idem, *Astronomie*, second ed., vol. 2 (Paris 1771), 160. idem, *Histoire de l'Academie Royale des Sciences Année 1766* (Paris 1769), 450.

37 Observatoire de Paris, MS A.B.4.5 and Erfgoed Leiden e.o., P. 7000. The Paris Manuscript consist of a set of 114 A4 format sheets. The first ten pages describe the observatory and its instruments. The following pages describe the observations in chronological order.

38 In 1979 North has suggested that Marggrafe's observatory had been (re-)located to the Vrijburg palace, build in the years 1641-1642 for count Johan Maurits at the end of the isle Antônio Vaz. However, as Jorge Polman already has pointed out in a paper published in 1984, the description of Marggrafe's observatory in the Paris Manuscript fits far better with Wagener's drawing of Nassau's first residence, than with the contemporary drawings of the Vrijburg palace. See: North, 'Georg Markgraf' (n. 3) and Jorge Polman, 'First observatory in the Southern Hemisphere', *Sky and Telescope* (1984), 388. Our analyses of Marggrafe's observations also have led to the conclusion that North's hypothesis is a hoax.

39 José Luiz Mota Menezes, *Atlas Arqueológico do Recife, Módulo 7, Presença Holandesa* (Recife 1998). A copy was kindly provided by the author.

40 The 'Rhijnland feet' was the common standard for measuring length in the Dutch Republic. One Rhijnland feet (containing 12 'duim' or inches) had a length of 31.4 cm.

41 Specifications for the contractor of the platform, dated December 1632. (Univ. Library Leiden, AC I, inv. 22, fol. 91-95). The original contract is in AC I, 43-3.

42 In Leiden this lower room (a 'solderken om te stellen de globen') was made on Gool's request, 'opdat de voorsz. Gool sal mogen ghebruiken de twee grote glooben die nu op de publique bibliotheque staen' ('for the use of the two large globes that came from the public library'). See Resolution 9 August 1633 (Univ. Library Leiden, AC I, inv. 22).

43 The handle of the Polish hammer was pointed to be stuck into the ground. The hammer had two orthogonal cubes to attach the sextant to measure, by turn, the azimuth or the altitude.

44 For more details on the still existing Blaeu-quadrant see: N.D. Haasbroek, *Gemma Frisius, Tycho Brahe and Snellius and their Triangulations* (Delft 1968), 22-23 and H.J. Zuidervaart, *Telescopes from Leiden Observatory and other collections, 1656-1859. A Descriptive Catalogue* (Leiden 2007), 24.

45 How the horizon itself could be used as an azimuthal circle using the Snel quadrant, is explained by the Leiden professor of astronomy, Johan Lulofs, in his *Inleiding tot eene natuur- en wiskundige beschouwing des aardkloots* (Leiden, 1750), 476-480. Lulofs fixed the quadrant at night in a certain position, and measured at daylight the angle between the meridian and the point at the horizon towards which the quadrant was aiming.

46 See about the *Pinacidium Tychonicum*, Brahe's clever sighting device: Henry C. King, *History of the telescope* (London, 1955), 22. See also Stephen Straker, 'Kepler, Tycho, and the 'Optical Part of Astronomy': the Genesis of Kepler's Theory of Pinhole Images', *Archive for History of Exact Sciences* 24:4 (1981), 267-293.

47 Bengt Hedraeus (1608-1659) from Uppsala (Sweden) matriculated at Leiden University in October 1641 as a student of 'practical mathematics'. He used the Leiden quadrant in 1642 and 1643. His experiences were published in Benedictus Hedraeus, *Nova et accurata astrolabii geometrici structura […] quadrantis astronomici azimuthalis […] claris & perspicuis exemplis illustrato* (Leiden 1643).

48 Zuidervaart, *Telescopes from Leiden Observatory* (ref. 33), 11.

49 Albert van Helden, 'Gassendi and the telescope: toward a research community', *Actes du Colloque International Pierre Gassendi*, vol. 2 (Digne les Bains, 1994), 329-339, esp. 330.

50 Zacharias Conrad von Uffenbach, *Merkwürdige Reisen durch Niedersachsen, Holland [1711] und Engelland*, vol. 3 (Ulm und Memmingen 1754), 434. See also: Zuidervaart, *Telescopes from Leiden Observatory* (ref. 33), 14-fig. 2.