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## Jean-Charles Houzeau and his relief map of Europe (1857) presented by contour lines

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## J.C. Houzeau: a scientist

- 1 J.-C. Houzeau, the author of the map, is a scientist who has been totally forgotten. This is unjustified since autodidact Houzeau was in fact one of the 19<sup>th</sup> century's great scientists, particularly well regarded for his competence in the fields of engineering and earth sciences, with a special interest in astronomy, geography and geology.
- 2 J.-C. Houzeau was part of the Alexander von Humboldt (1769-1859) intellectual, scientific and philosophical movement.
- 3 The academic world, especially that of Belgium and France was very interested in J.-C. Houzeau's work and was aware that he had studied Humboldt's works in great detail, particularly his monumental and well known work called "Cosmos".
- 4 Houzeau was made a corresponding member of the Royal Academy of Brussels in December 1854 and a full member in December 1856 at the early age of 36 (in an unpublished letter to his father dated 17<sup>th</sup> December 1856, he told him that in fact he was the youngest member in all three classes).
- 5 The subject matter is the hypsometric map of Europe at scale 1:5,000,000. It is worth noting that this map is part of a book called "Histoire du sol de l'Europe"<sup>1</sup> and that three years earlier in 1854, Houzeau had published an essay called "Essai d'une géographie physique de la Belgique"<sup>2</sup>. At the time, these two monumental books received a lot of acclaim from both the national and international scientific communities.

- 6 These two publications are complementary and perfectly timed within Houzeau's intellectual development. His literary and scientific style appealed to the academic world. Jean-Servais Stas, a renowned chemical scientist commented. "J'ai [...] lu en entier et avec infiniment de bonheur votre ouvrage sur le sol de l'Europe que vous m'avez fait l'amitié de m'envoyer. Votre introduction est admirable de pensée et de style. Je ne connais pas de préface qui la vaille sous ce double rapport. Le corps du livre écrit avec tant de simplicité et tant de grandeur à la fois, démontre que vous êtes aussi habile historien et tacticien que savant géographe"<sup>3</sup>.
- 7 It is worth noting that these two books are not the result of chance. Houzeau, immediately after his somewhat chaotic departure from the Royal Observatory of Belgium in 1849, made numerous trips in Belgium and Europe, either on foot, by train or by stage-coach, and spent several months in Paris' or Lyon's scientific libraries amongst others. In addition, from November 1854 until June 1857, he worked for Belgium's War Depot and led astronomical orientation operations for the country's geodesic network. The Depot's Director, the academic General Nerenburger, had given him special facilities so that he might finalise his geographical research about Europe.

Figure 1. J.C. Houzeau (1820-1888).

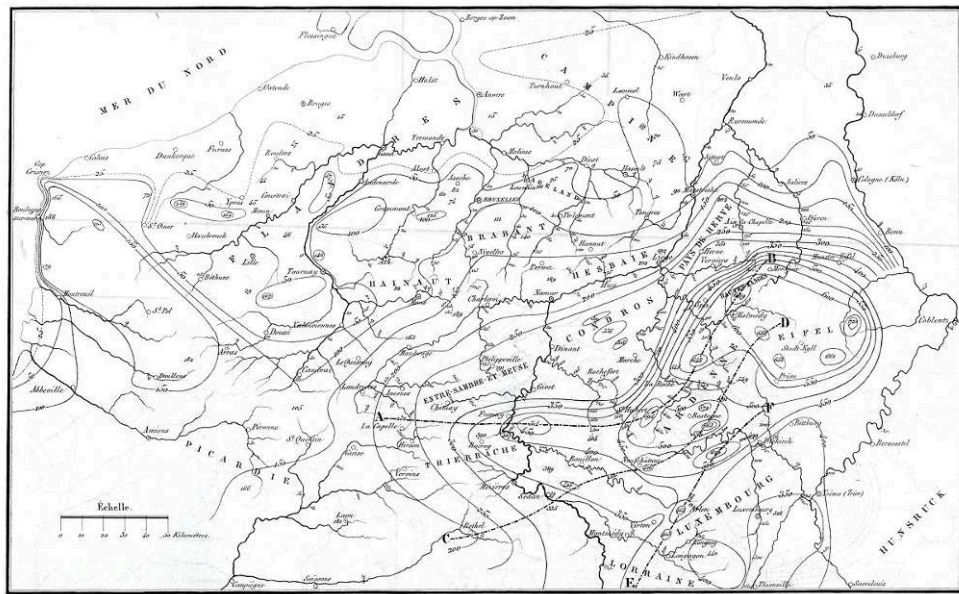


## The hypsometric map of Belgium

- 8 It is interesting to note that in Houzeau's first book, he produced and published a hypsometric map of Belgium at a scale of 1/1,200,000. This was a first !
- 9 "La carte hypsométrique que nous présentons ici est la première représentation de ce genre qu'on ait faite pour la Belgique. On ne possédait jusqu'à ce jour que des essais absolument fautifs"<sup>4</sup>.

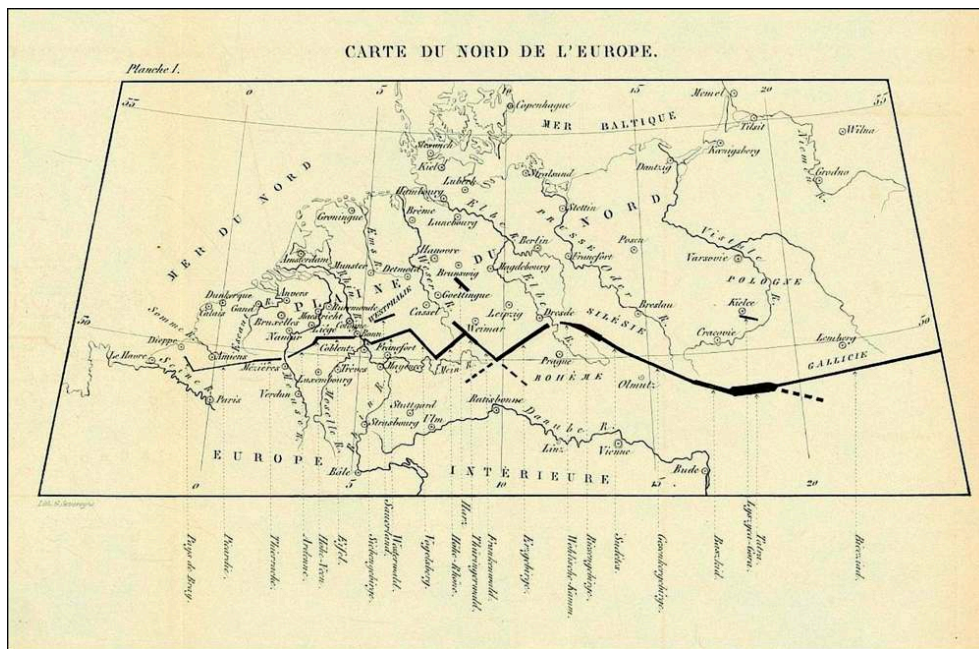
- 10 Houzeau also pointed out that a map of the French Empire, published in 1805 by Dupain-Triel drew the 200 meter hypsometric curve outside of our borders when in fact, some measurements were above 600 meters. The same map shows a one hundred meter curve along the right hand banks of the Sambre and the Meuse, when in fact within a short distance of the left banks of these rivers, some points reached between 180 and 200 meters in altitude.
- 11 In the absence of exact levelling in the Ardennes, their real height was to remain unknown for a long time.
- 12 Houzeau writes : “Ainsi, M. Wolf, de Spa, donnait plus de 1300 m au massif des Höhe-Veen, entre Spa et Malmédy, tandis que Decker réduisait cette saillie à 865 m. M. Schmidt plaçait Arlon 200 m trop haut. Même dans nos plaines, M.Drapiez attribuait positivement 280 m à la colline du Mont-Panisel, près de Mons, bien qu’elle n’en atteigne nulle part 102”<sup>5</sup>.
- 13 At the time of Houzeau’s research on the hypsometry of Belgium, neither the 1:40,000 ordnance map nor the 1:20,000 polychrome version existed (this one would only be completed in 1880!).
- 14 However as of 1835, numerous canal, road and railway line projects provided levelling profiles which were more accurate for some parts of the country and were based on surveying done by the Public Works. Before 1856, general surveys were based on a Zero Z level which was related to the average low tide during ordinary spring tides. This would prove to be fairly close to the future Zero D level which was to be established by the General War Depot and which, as of 1856, would become the reference point for calculating heights (the difference was 0,1665 m).
- 15 The zero level reference point used by Houzeau is the average sea level (between high and low waters) and was in fact the norm chosen by other European countries. The difference of levels between the two surface references was known and was about 2 meters thus allowing Houzeau to take it into account when adapting Belgian points reference levels. However, within the context of small scale map-making which was quite usual from a graphical point of view, the difference was insignificant.

Figure 2. Hypsometric map of Belgium.



- 16 However, levelling operations of the Public Works presented significant spatial gaps.
- 17 This is why Houzeau carried out numerous personal measurements in order to perfect his hypsometric picture of the country.
- 18 The result was well received since for the first time it revealed Belgium's main geographical and morphological structures. This impressive work also allowed him to draw up a geological cross-section of the country (from the coast to the Gaume area) which was properly gauged thanks to a correct scale of altitudes.
- 19 It is also worth noting that in Houzeau's book about the physical geography of Belgium, particularly in the second chapter which described the general aspects of the country, he gives a remarkable three page description of "Belgium in relation to Europe".
- 20 Using a system of broken lines, Houzeau also drew up a "map of Northern Europe" which showed the mountain masses or secondary mountain chains which run from West to East starting from the Picardie, through the Thierache, the Ardennes and all the way to Galicia in Poland.
- 21 Houzeau explains that the direction of the lines indicates that of the ridge and that the width of the line is proportional to the height of the mountain mass.
- 22 This introduction to his book "Histoire du sol de l'Europe" shows how much Houzeau's two studies were complementary.

Figure 3. Map of Northern Europe.



## Description of the Europe's hypsometric map

### Berghaus' map

- 23 First, a reminder. In 1840, Berghaus published a first edition of a black and white map of Europe where the relief was represented by contour lines and a system of hatched lines. This map was a first at the time. Indeed, it was the first time that the large European mountain masses were represented in this way with a fair degree of accuracy. However, this first trial at giving a synthesized picture lacks legibility especially for the densely mountainous regions. The equidistance of a thousand feet of Paris (325 meters) and especially the scale of the map (1/6,640,000) did not allow for an accurate representation of the relief. This is why J.-C. Houzeau decided to draw up a new and more detailed hypsometric map thereby enabling him to describe the relief's major shapes and the corresponding tectonic movements (see map extract).



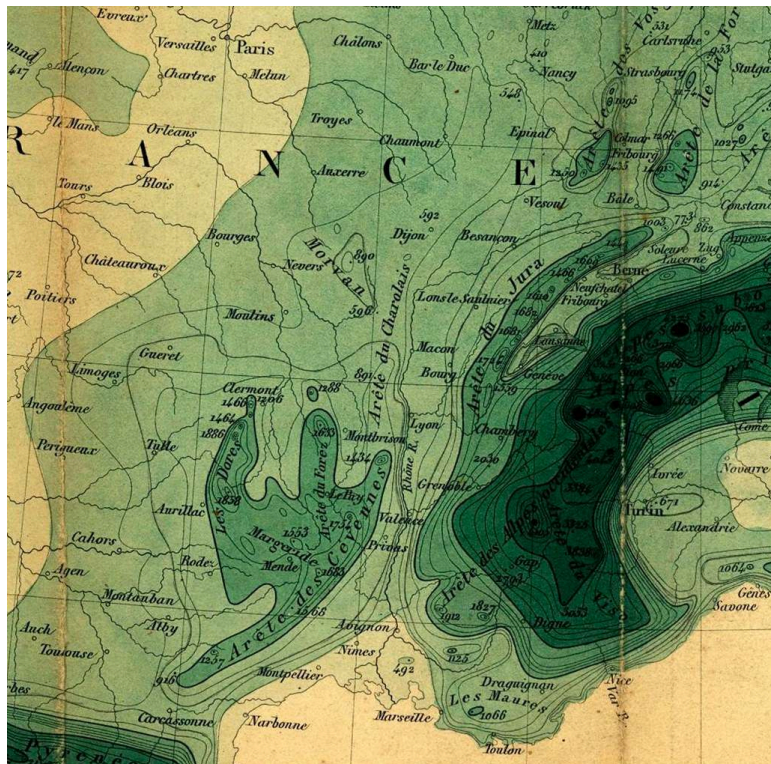
Figure 4. Berghaus' map.



### Houzeau's map

- 24 In his book "Histoire de l'Europe", Houzeau describes his methodology, the data source, the map's scope ("champ cartographique"), the geographical outline developed using the Paris meridian as a reference (the projection), the list of reference books, the spelling used for the various regions (for which he was particularly careful), the wherefore and to a certain degree the how of the tables developed for describing major European relief lines (the "arêtes" as he called them), etc.
- 25 His description was both general and very sober. Some details were missing. For example, the projection used – nowhere does he mention that it is a conical projection (conform). Of course, one realizes that this is the case when studying the positioning of the meridians and parallels on the map.
- 26 However, thanks to numerous unpublished letters one is able to fill in some of these gaps. Indeed, Houzeau's correspondence with his father and his brother Auguste<sup>6</sup> provides interesting geographical information and helps one to understand the scope, the difficulties encountered and the rigorous methodology used.
- 27 It is also thanks to these letters that we were able to establish the key role played by Auguste Houzeau in undertaking numerous tasks and verifications based on very detailed instructions received from Jean-Charles. Auguste Houzeau (1832-1922) was Jean-Charles' younger brother and was a strong scientific personality. In 1870, he became professor of political economics, physical and industrial geography at the "Ecole des Mines" in Mons.
- 28 We will endeavour to list a number of interesting and scientific features which illustrate the breadth of the task Houzeau had set himself.

Figure 5. Houzeau's map.



## The utilisation of numerous levelling points

- 29 J.-C. Houzeau used tens of thousands of levelled points made either by some geometers or by the official army surveyors responsible for drawing up the ordnance maps in various European Public Works Departments. He also used over 12,000 barometrical levels. We know that barometrical measurements are less accurate than those obtained from land levelling. Houzeau points out however, that from the 12,000 barometrical measurements he examined, he chose only those which best fitted by comparison with those obtained through geodesic methods.
- 30 But Houzeau recognized that in spite of all the documentation and the sources used, there were still some summits and passages for which no exact measurement was available.
- 31 “Alors, il nous restait pour l’ordinaire des points voisins ; souvent aussi nous possédions sur leur altitude divers indices. Par exemple, sur le thalweg des cours d’eau, nous pouvions généralement interpoler entre des points plus ou moins rapprochés. Nous avons hasardé alors des cotes approximatives qui sont toujours suivies d’un point d’interrogation. En outre, dans ces circonstances, la colonne destinée à faire connaître l’autorité n’est pas remplie. Cette colonne contient, dans les autres cas, le nom de l’observateur. Un signe particulier y indique la méthode de nivellement employée”<sup>7</sup>.
- 32 This gives an idea of the breadth and depth of Houzeau’s scientific achievement.
- 33 He also had many surprises. “Il est arrivé dans plusieurs circonstances, qu’à la suite de mesures plus complètes, les sommets les plus connues et les plus apparentes d’un massif ont été dépossédées du premier rang, qu’elles étaient sensées occuper. C’est ainsi que le massif du Mont Pelvoux, près de Grenoble, possède un point culminant plus



élevé encore que le Pelvoux lui-même. Il en est de même dans un grand ensemble de cas”<sup>8</sup>.

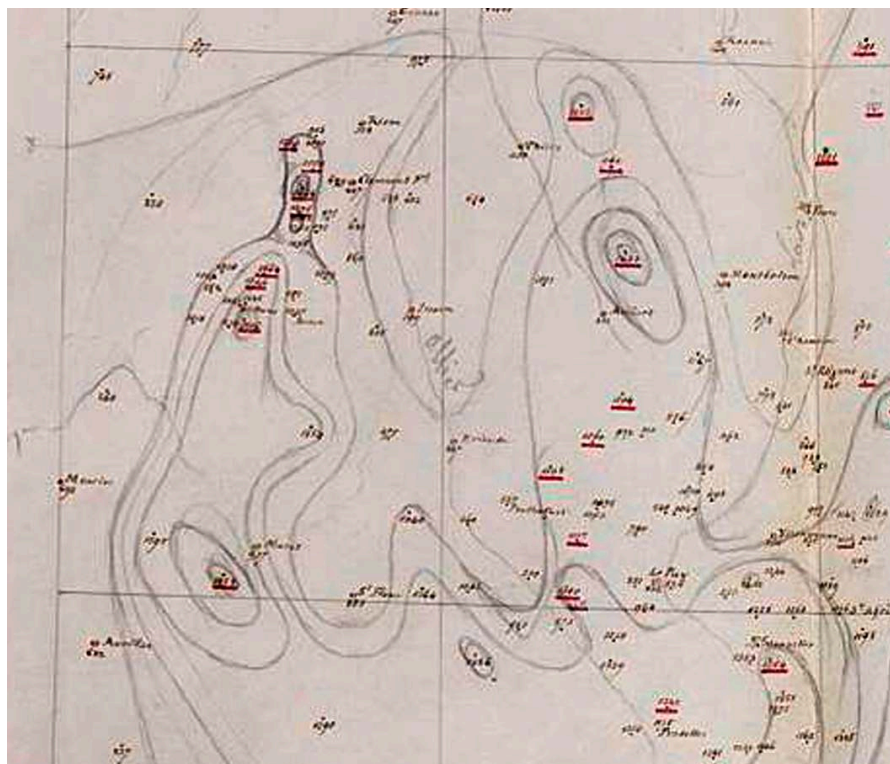
## Equidistance, name spelling, cartographic field and the projection used

- 34 The equidistance of contour-lines is 200 meters (the line used for multiples of 1000 meters is thicker). Furthermore, a large number of points are clearly positioned in order to indicate the location and altitude of more prominent summits. It should be added especially since Houzeau’s geographical effort was widely recognized, that he was particularly good at topographically describing significant geographical features especially the ridges which were masterfully described.
- 35 “L’orthographe de ces noms si souvent défigurée dans le passage d’une langue à une autre, a fait l’objet d’un soin particulier. En général, les noms ont été écrits dans la langue qui est parlée au lieu qu’ils occupent. Les traductions d’appellations géographiques ont été évitées, à l’exception de celles qui sont tellement passées dans l’usage, en français, qu’il serait ridicule de ne point y avoir recours. On a joint alors le véritable nom local, entre parenthèses. Mais il est absurde de parler du Fichtelgebirge sous le nom de Mont-des-Pins, et du Monte-Calvo sous celui de Mont-Chauve”<sup>9</sup>.
- 36 As far as the cartographic scope is concerned, it is worth noting that Portugal and the western part of Spain are included in his study – this was not the case for Berghaus’ map. On the other hand, Houzeau does not include Russia and Scandinavia about which he commented “le relief est très bas ou bien peu compliqué. En Russie particulièrement d’immenses surfaces n’auraient été traversées que par une ou deux courbes seulement”<sup>10</sup>.
- 37 Notwithstanding the above, the cartographic scope is significant. In terms of latitude, he went from 35° to 56° and of longitude in relation to the Paris meridian, from 16° West to 28° East.
- 38 Regarding the projection method, as mentioned before, no comment was recorded regarding his choice of the conical projection method. Fortunately, in a letter we found addressed to his brother which was written in Paris and dated 23 November 1855, he gives detailed instructions for drawing up a canvas of meridians and parallels at a scale of 5,000,000. He thus specified the size of the sheet of paper to be used; the positioning of the Paris meridian (which was not central) in relation to the left and right edges; the size in millimetres of the meridians between the two extreme meridians of 35° and 56°; the method for constructing them graphically through the use of a table; the manner in which to construct the other intermediary parallels by referring to another table which gave the distances in millimetres in relation to the 35° base parallel.
- 39 It is important to note that the levelled points used for a number of European countries refer to geographical coordinate systems which are not those used in France (the international Greenwich system did not yet exist). This meant that Houzeau had the tedious task of converting the coordinates of numerous measurements. Houzeau does not even mention this in his book.

## Houzeau's hypsometric sketches ("minutes") at a scale of 1:1,000,000

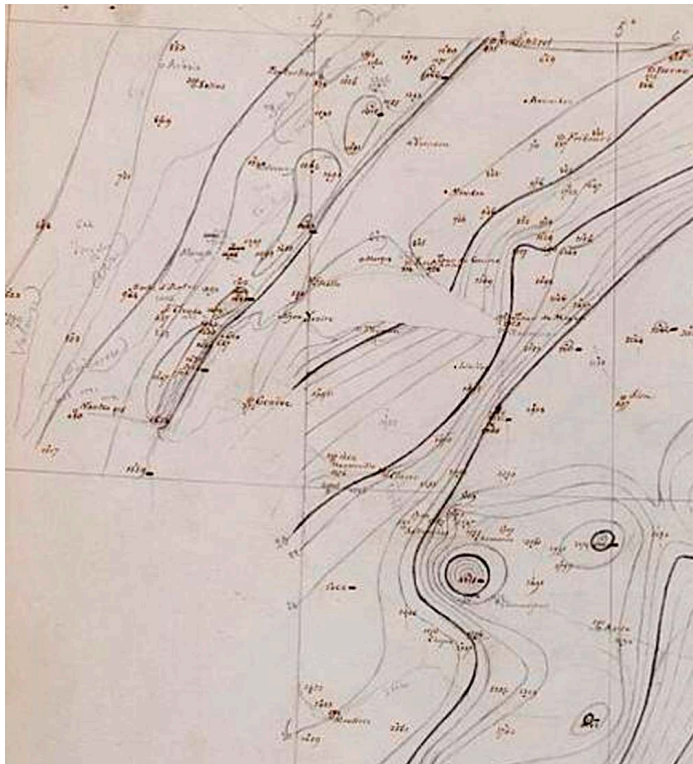
- 40 His methodology was remarkable: it corresponds to a reduction of sketches down to a scale of one to one million. Houzeau says in his text : "Le soin de dessiner à nouveau une carte d'Europe était peut-être superflu pour le tracé des côtes, mais il ne l'était certainement pas pour la situation des points culminants, principalement dans les arêtes de médiocre hauteur. Notre dessin a été entrepris à l'échelle du millionième, qui donne un rapport simple entre la carte et le terrain ; un kilomètre est représenté par une longueur d'un millimètre, nous avons porté sur la carte d'après leurs positions, les cotes de hauteur, et à l'aide de ces cotes, nous avons tracé enfin les lignes de niveau"<sup>11</sup>.
- 41 These contouring lines were then reduced to a scale of 1:5,000,000 by using a pantograph. This fastidious task was undertaken by Auguste. It is worth noting that recently a number of sketches were found at the Ermitage (Houzeau's family residence). Some of these have been scanned by the "Maps and Plans section" of the Royal Library of Belgium.
- 42 Each minute has a standard canvas which defines a cartographical area of 4° extension in longitude and 3° in latitude with the drawing of the meridians and parallels.
- 43 Taking the scope of the map into consideration, some 70 sketches were thus made. Putting them together would lead to a height of 2.5 meters and a width of 3.5 meters.
- 44 The most significant levelled points are positioned. Those underlined in red (see letter dated 23 November 1855) were drawn using a scale of 1:5,000,000.
- 45 Major waterways are drawn as well as a number of important towns (the department's chief towns) using a scale of 1:5,000,000.
- 46 An example of a sketch is this one which represents the hypsometry of the Massif Central and the Rhone Valley (figure 6).

**Figure 6. Hypsometry of the Massif Central and the Rhone Valley (minute extract).**



- 47 The following picture is that of the sketch immediately to the East of the previous one and describes the hypsometry for the Lac Lemán environment, the Mont Blanc, the Pennines Alps and the Aosta Valley (figure 7).

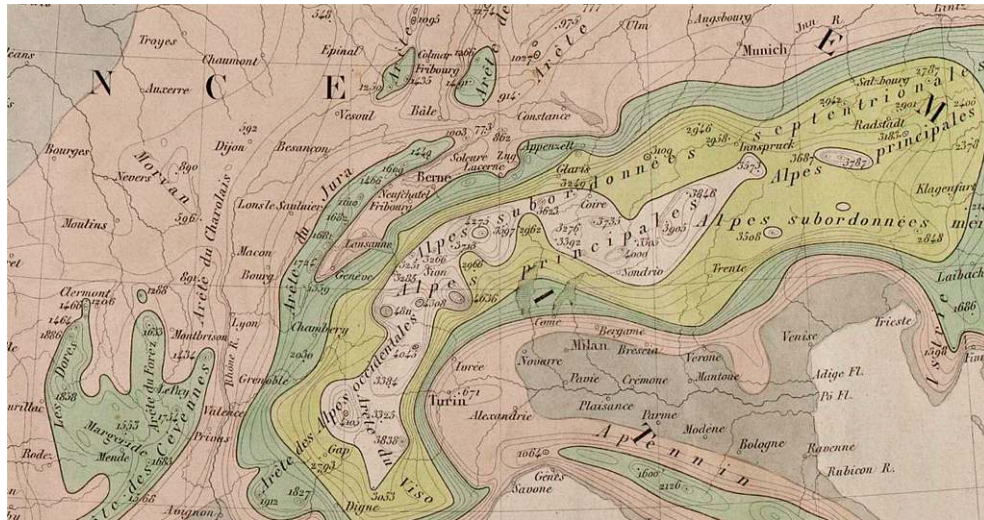
**Figure 7. Hypsometry for the Lac Lemman environment, the Mont Blanc, the Pennines Alps and the Aosta Valley (minute extract).**



- 48 Compared to modern atlases, there is a difference of barely 1, 2 or 3 meters for the altitudes shown for the highest peaks.
- 49 In the published map at a scale of 1:5,000,000, the contouring lines, the levelled points, the geographical canvas and the writings have been printed lithographically in black.
- 50 On the other hand the beautiful presentation of the hypsometric gradient in six tones of green is the result of painstaking manual colouring, one copy at a time. The darker surfaces represent the highest zones. The six hypsometric surfaces are as follows: less than 200 meters, from 200 to 1000 meters, from 1000 to 2000 meters, from 2000 to 3000 meters, from 3000 to 4000 meters and finally over 4000 meters.
- 51 We know, thanks to the unpublished letters, that 2 copies of Houzeau's map at a scale of 1/5,000,000 were painted using different colours. They were presented to Houzeau by the publisher – "l'Etablissement géographique de Bruxelles" run by Philippe Vandermaelen. According to one of his unpublished letters dated 26 June 1857, J.-C. Houzeau gave one of these copies to his brother just before leaving for England and the United States.
- 52 It is interesting to note that the Maps and Plans section of Belgium's Royal Library also owns a coloured hypsometric map of Europe. Maybe it is one of those presented to J.-C. Houzeau, unless it is the copy which belonged to Philippe Vandermaelen, the "Etablissement géographique de Bruxelles", director (figure 8).
- 53 It is probably this copy which was scanned and presented at the exhibition<sup>12</sup>.



**Figure 8. Coloured hypsometric map of Europe owned by the Maps and Plans section of Belgium's Royal Library.**



## BIBLIOGRAPHY

- LANCASTER A. (1889), *Notice biographique sur Jean-Charles Houzeau*, Bruxelles, Hayez.
- LIAGRE J.B.J. (1889), "Notice sur Jean-Charles Houzeau", *Annuaire de l'Académie royale de Belgique*, t. LVI, pp. 207-310.

## NOTES

1. HOUZEAU J.-C. (1857), *Histoire du sol de l'Europe*, Bruxelles, Librairie internationale, 496 p., 1 map.
2. HOUZEAU J.-C. (1854), *Essai d'une géographie physique de la Belgique, au point de vue de l'histoire et de la description du globe*, Bruxelles, M. Hayez, 331 p., with 4 illustrations in the annexes.
3. Quotation drawn from the book by VERHAS P. (2002), (p. 76) : *Jean-Charles Houzeau et son temps*, Académie Royale de Belgique, 239 p. (translation : "I read the work you were kind enough to send me concerning the soil of Europe with enormous pleasure. Your introduction is admirable both in terms of thought and style. I know of no other preface which does better. The body of the book is written with such simplicity and grandeur and proves that you are an equally good historian and tactician as a geographical expert.").
4. HOUZEAU J.-C., *op. cit.*, p. 35. (translation : "The hypsometric map presented here was the first representation of its kind for Belgium. Up until then, only a few totally flawed attempts had been made.").
5. HOUZEAU J.-C., *op. cit.*, p. 36. (translation : "M. Wolf from Spa, estimated the height of the Höheveen massif, between Spa and Malmédy, at 1300 meters, whereas Deckers reduced it to 865 meters. M. Schmidt put Arlon 200 meters too high. Even in our plains, M. Drapiez gave a height of

280 meters to the hill called Mont-Panisel, near Mons, when in fact it is no higher than 102 meters.”).

6. These letters and other documents are at the “Château de l’Ermitage” near Mons, in the heart of the “Mont Paniseul”, which has been the Houzeau family’s residence since the beginning of the 19<sup>th</sup> century. I sincerely thank Claude Houzeau (J.-C. Houzeau, great great nephew) and his wife Marie-Claire who recently allowed me to consult these precious archives.

7. HOUZEAU J.-C., *op. cit.*, p. 184. (translation : “We therefore had to rely on neighbouring point measurements and quite frequently on various other indications we had relating to their altitude. For example, concerning the rivers’ thalweg, we could generally interpolate between measurements relatively close to each other. We then guessed approximate measurements which were then always followed by a question mark. In addition, in these cases, the column which shows the authority is not completed. In all other cases, this column gives the observer’s name. A special indication gives the levelling method used.”).

8. Houzeau J.-C., *op. cit.*, pp 185-186. (translation : “It happened on a number of occasions following more detailed measurements that some of the mountain ranges’ more well known and apparent summits were re-qualified and downgraded. For example, the culminating point of the Mont Pelvoux massif near Grenoble is in fact higher than the Mont Pelvoux itself. This is also the case for a number of mountain ranges.”).

9. Houzeau J.-C., *op. cit.*, pp 180-181. (translation : “The spelling of these names which so often suffers when translated was the subject of particular care. In general, the names were written in the places’ locally spoken language. Translations of geographical names were avoided with the exception of those which had become common usage in French and where therefore it would have been ridiculous not to use them. In these cases, the local name was added between brackets. It would be absurd to speak of the Fichtelgebirge by calling them Mont-des-Pins (Hill of the Pines) and of Monte-Calvo as that of Mont-Chauve (Bald-Hill).”).

10. Houzeau J.-C., *op. Cit.*, p. 178. (translation : “The relief is very low or not complicated. In Russia particularly, vast regions would have been crossed by one or two contour-lines only.”).

11. Houzeau J.-C., *op. cit.*, p. 178. (translation : “Drawing a new map of Europe may seem unnecessary as far as the hills are concerned but this was certainly not the case for the highest points and particularly for their medium height ridges. Our map was drawn using a scale of one million, making it a simple relation between paper and land : one kilometre is equal to a length of one millimetre. According to their positions, we have drawn the height measurements and then by using these measurements, we drew the contouring lines.”).

12. I thank Jennifer Schubert who willingly agreed to translate this article into English.

## ABSTRACTS

The relief map of Europe by contour lines (hypsometrical curves) in a 1:5,000,000 scale is a monumental work produced by J.-C. Houzeau when he published his “Histoire du sol de l’Europe” (1857).

This hypsometrical map of Europe is a genuine masterpiece: contour lines on the recently discovered minute-maps, worked out in a 1:1,000,000 scale, were reduced to a smaller 1:5,000,000 scale, with the aid of a pantograph.

This work by J.-C. Houzeau, carried out with the help of his brother Auguste, is a breathtaking achievement from a scientific and geographic point of view. J.-C. Houzeau made use of tens of

thousands of altitudes obtained from the engineers-surveyors of the “Ponts et Chaussées” (roads and bridges), civil servants (if any) in the various countries concerned and the engineers-geographers of the military services, in charge of laying out in the Ordnance Survey Maps. More particularly, he used more than 12,000 barometrical marks! All the points that were used are positioned (in a 1:1,000,000 scale), in latitude and longitude, in one single frame which he created (conical projection with the Paris meridian as origin), involving thus an important number of conversions (the standard of the Greenwich meridian had not yet been established).

La carte du relief de l'Europe par courbes de niveau (courbes hypsométriques) à l'échelle de 1 : 5 000 000 est le produit d'un travail monumental de J.-C. Houzeau. Elle fut publiée en 1857 dans son ouvrage “Histoire du sol de l'Europe”.

Cette carte hypsométrique de l'Europe est un authentique chef-d'oeuvre : les courbes de niveau sur les minutes récemment découvertes ont été rédigées à l'échelle de 1 : 1 000 000, et ensuite réduites à 1 : 5 000 000 à l'aide d'un pantographe.

Cette oeuvre de Houzeau, réalisée avec la collaboration de son frère Auguste, est une réalisation époustouflante d'un point de vue scientifique et géographique. J.C. Houzeau a utilisé des dizaines de milliers de points cotés, obtenus d'ingénieurs topographes des Ponts et Chaussées ou de fonctionnaires dans les différents pays concernés, ainsi que des géographes-ingénieurs des services de l'armée chargés de dessiner les cartes topographiques d'Etat-major. Plus spécifiquement, Houzeau a utilisé plus de 12 000 points barométriques ! Tous les points utilisés ont été positionnés (à une échelle de 1 : 1 000 000), en latitude et en longitude, dans un seul et unique cadre (projection conique axée sur le méridien de Paris), ce qui a impliqué un nombre impressionnant de conversions (la norme du méridien de Greenwich n'avait pas encore été établie).

## INDEX

**Mots-clés:** hypsométrie, courbes de niveau, cartographie, Jean-Charles Houzeau

**Keywords:** hypsometry, contour lines, cartography, Jean-Charles Houzeau

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