Critical, Historical and Geographical

Studies

of Fragments of

Hero of Alexandria

or:

'On the Egyptian Measurement System'

Considered

From its basis, in relation to the Greek and Roman itinerary measurements

and considering the modifications that have been applied to this data

from the reigns of the Pharaohs until the Arab Invasion

Written by the late Monsieur Letronne

and posthumously published

Crowned in 1816 by the Academy of Inscriptions and Literature

Edited and modified according to recent findings by **A.J.H. Vincent**

[Alexandre Joseph Hidulphe Vincent, 1797-1868]

TRANSLATED INTO ENGLISH BY ELIN LINDQVIST

[Quotes in Greek from Marcus Aurelius, *De Rebus suis*, Book VI, §21.]

Paris

Printing authorized by the Government

At the National Printing House

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Editor's Prefatory Note

The editor of this book finds it appropriate to relate to the reader the circumstances in which he found himself compelled to direct its publication, so that no one may one day accuse him of mishandling in a sacrilegious manner a text that the Academy has crowned and honoured on the pedestal of one of its most prestigious members.

Five years ago, around 1845[1], after having had the opportunity to speak to Monsieur Letronne about some historical and bibliographical research projects which I had conducted on the subject of printed and hand-written opuscules (minor works) attributed to Hero, I told him that contrary to common opinion, all those texts seem to originate from the same source, and he answered: "I think that you are right." He then went to fetch the manuscript of this very dissertation from a cupboard, despite the fact that he argues a contrary dogma in it, and asked me to skim through its main components. When I then expressed my surprise as to why he had not published this text that had been long ago crowned by the Academy, and which seemed to be very important in my eyes, he answered: "This is a text I wrote when I was young. Too much would have to be edited today, in order to update the text factually with new discoveries. I don't have time." He concluded the conversation by asking me: "Do you want it? I can give it to you." I did not fully understand the meaning of his words and simply insisted on thanking him, so Monsieur Letronne took back his manuscript. Yet, in his casual way, he claimed that there was a serious depth to his offer, and that perhaps I was wrong not to accept it. I therefore thought that it was appropriate to come back to this subject at a later date, and Monsieur

[1] The facts that I hereby relate were witnessed by Monsieur Letronne's family, and a few of his friends, amongst whom his close childhood friend, Monsieur Ruelle, son of the astronomer who was the Director of the Observatory.

Letronne reiterated the same sentence: “Do you want it? I can give it to you.” I realized then that this was a set idea for him, and this time I assured him that I would offer my services for the revision and publication of his words, and that when I should be working on my treaty on Hero that is yet to be published, and which relates to the Dioptre, or in other words, to the geometry practiced by the Greek, I could if he wanted me to, work on both at the same time since the two subjects are connected,. He seemed to agree with this suggestion. From then onwards, I considered the matter tacitly agreed upon.

Before going any further, I must highlight the consequences drawn from the above account:

1. Monsieur Letronne had the power to decide whether or not to publish his thesis, because the Academy does not in such cases impose any rules on the authors whom it crowns. Yet, he did not want to publish his thesis in 1816, which is when he was crowned, and he still did not desire to publish it - even less so in fact - thirty years later.
2. However, Monsieur Letronne regretted seeing the research that he had conducted and the results that he had obtained be completely wasted. He undoubtedly wished someone would take the lead, and either update his text with results obtained during the past thirty years so as to make it publishable, or use certain sections of this manuscript in some analogous publication that would then gain weight thanks to those particular sections written by Letronne.

Thus, I was considering this matter, when Monsieur Letronne unfortunately passed away and we lost a scientist. I reminded his heirs of their respected father and his intentions, and I reiterated my offer to help, which they accepted. Consequently, the manuscript was sent directly to the National Printing House, from where the first extracts were then sent to me, page by page, this being entirely true to the manuscript. Step by step, I then made the changes that seemed necessary to the text directly onto the printed pages. I thought it better that I did not look at the original manuscript.

This work as it is published now, is therefore neither what it was in 1816, nor is it what it would have been if the author himself had published it. Nor has it been been worked on in his presence. It is, in fact, a sort of intermediate edition, and I think I can claim that this is the only possible and permissible way to publish it.

In the interest of the history of science, it would perhaps have been preferable to publish this work in 1816, exactly as it was then, when it was crowned, but that is not for me to judge. The fact of the matter is that it was the author's choice whether or not to publish it, and he chose not to, both then, and also later. Therefore, I ask myself if publishing this text as it was and despite the fact that the author had been opposed to its publication all his life, would not have been a pious act of homage made by his heirs to honour their father, but in fact a most disloyal gesture. Moreover, even if one would have liked to print the original work, it would not have been physically possible. The manuscript's table of content is still intact, and clearly shows the modifications, additions and subtractions that the author was planning on doing. For instance, the pyramids of Giza have been added to the thesis, whilst a paragraph about the stadium of Eratosthenes has been cut, probably because it was later introduced as an essential part of the treatise 'On the Assumed Measurement of the Earth, Conducted by the School of Alexandria'. The author contributed that text to Volume VI of the treatises in the New Series of *Memoirs of the Academy of Inscriptions and Belles-Lettres*.

That is not all. When I received the second batch of pages from the printers, I discovered that a table full of numbers that had been used to establish the values of the Roman foot and mile had been replaced by another, more recent table that in fact cancelled out the first. And, what gave a certain sense of gravity to this circumstance is that the author had not had the time to apply the consequences of this second table to his thesis, which therefore remained logically based on the first table. What side was I then to take? Should I have erased the new table and brought back the old one? That would have meant that out of two codes established at different dates, the older one cancelled out the newer one. Now, if you assume, and one cannot resist doing so, that solely the last table should be adopted, we have to, if we don't want to put the author in perpetual contradiction with himself, modify all the references to the Roman foot, which basically means changing all the numbers in the book.

Faced with this serious dilemma, I felt that I first and foremost needed to ask his family about this, and they said, with some spontaneity which I honour, that they would leave this issue entirely up to my discretion.

Once I had entered the path of modifications, and also because I knew that a publication would only be possible at that cost, it was necessary to adjust the Egyptian cubit just like the Roman foot. In other words, substitute the average of all the standards known at the time of the author's death to the cubit of the Nilometer, sole standard known for this measure in 1816. Finally, another element used by Monsieur Letronne to develop his theory, is the value of the degree of the latitude, which varies according to the parallels under which the extreme points of the Meridian arch - that we consider the value of - are located. The author had to use the tables of [Jean Baptiste Joseph] Delambre [1749-1822] at his time of writing. However, since then, new observations have been made on a multitude of locations around the world. In India, by English researchers under the supervision of Lambton and Everest, in the North, by Messieurs Gauss, Schumacher, Struve, etc. Indeed, these observations have been admirably synthesised in an excellent little book entitled *Physique du Globe* (*Physics of the Globe*), which was printed eight years ago, authored by Monsieur [Émile] Saigey [1828-1875]. The new data that these observations reveal about the shape and dimensions of the Earth are certainly equivalent to the figures that the author of this thesis would have substituted for the numbers in Delambre's table, now out-dated, if he would, whether alone or with a collaborator, have worked on this particular publication. If I should have consciously and purposefully omitted the use of the new table, I would have had to blame myself for not appropriately and properly completing my mission.

I should in fact applaud my choice to follow this path, and I think that the respected author would have been delighted to see the results that his methods obtained, when those are applied to more exact numbers than the figures upon which he had to rely during the time of his writing. Indeed, as is clear throughout this thesis, Monsieur

Letronne was convinced that the Egyptian soil had been measured according to a triangular principle from very ancient days. These measurements had enabled Egyptians to know with extreme precision and to use [Nicolas] Fréret's [1688-1749] expression, 'down to one cubit', the dimensions of all things. According to his conclusions, Letronne was further convinced that the stadion, also known as the Eratosthenes, and defined as contained 700 times in the degree of the latitude, essentially belonged to and originated from Egypt. This should be verifiable by examining whether the cubit, 300 times contained in the stadion, represents 210 thousand times the degree. Yet, because of some details that the author may have added, the determination of the cubit did not and could not allow him to obtain the desired results.

The author deducted these details from calculations based on an average, considered through its known connection with the Roman foot and the standard of the Nilometer. However, he was unable to obtain the desired results, despite the importance that he might have placed on one or the other of these two elements. By measuring with his cubit the degree of the latitude of Lower Egypt, which is higher than the one of Upper Egypt, he obtained a total of 210 000 cubits, which always remained inferior to the latter degree. The author tried[2] to bypass this consequence, and Delambre's tables encouraged him to search for this degree of latitude as far away as in India. This must have been very frustrating for Monsieur Letronne, and I would not be surprised if this inability to obtain the results so strongly foreseen[3] might in fact explain the long sleep to which the author had condemned his work.[4]

So, after having established the value of the cubit to 527.5 mm, according to the method and views of the author, and after

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[2] There are numerous notes that prove that the author tried with conviction, and it is clear that he would undoubtedly have obtained the correct results, if only these figures would have been compatible with the numbers that he used.

[3] "Not only does the stadion, almost exactly 700 times contained in the terrestrial degree, exist with all its elements in the Egyptian metric system – a fact on which I do not want to further insist upon here, but also…" (Letronne, 'On the Assumed Measurement of the Earth', in *Memoirs of the Academy of Inscriptions and Belles-Lettres*, New Series, Volume VI, Paris (no date given), p. 279.)

[4] A fact that was confirmed by Monsieur E. [Eugène] Burnouf [1801-1852] since this text was written proves my assertion: Monsieur Letronne said that he would not publish his work until he had found in Egypt its degree of latitude.

adjusting it to the data of the standards discovered during these past years, we obtain the following results: In the centre of Upper Egypt, a part that according to Monsieur Letronne, might have been the most anciently inhabited, located almost exactly under the 25th parallel (at 2' difference), is the ancient Apollinopolis Magna (*Apollōnos polis megalē*), today known as Edfu.

It is in this little city that Champollion discovered those astronomical scenes and that calendar-like evidence from which he was able to extract the hieroglyphs characterising seasons, months and days[5]. It would then not be unbelievable in any way to admit that there was a college of researchers there who had established their observatory. Yet, let's push all these complications to the side and focus on the date that is the most impressive: If one were to measure the degree of the latitude of this city by walking in a north and central direction at the same time, and then average the two results, one would obtain exactly and rigorously 210 000 cubits[6].

However, one must not attribute to such exactitude an infinite confidence: the figures used here can only be approximations, and it is most certainly true that one slight fraction of a millimetre less or more would have an impact on the value of the average cubit. For example, a tenth of a millimetre would create a difference of 21 metres on the total. Since we cannot guarantee that tenth of a millimetre, based on the nature of the data used, we can only make reasonable assertions, having obtained a most approximate result. I even feel the need to add that the value of the cubit has been established and printed long before I thought of substituting the numbers shown in the table of Monsieur Saigey to those in the table of Delambre.

In fact, I had already obtained my 'Ready to be printed certificate' for the manuscript in which the value of the degree of the latitude is used, and a stamp had been placed on this certificate by the

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[5] See his *Memoir concerning the Signs Used by the Ancient Egyptians for the Notation of the Divisions of Time*, in *Memoirs of the Academy of Inscriptions and Belles-Lettres*, New Series, Volume XV, Paris (no date given), p. 73), and Plates CXXIII-CXXVIII in his *Monuments of Egypt and Nubia* and *Descriptive Notices Lithographed*, F. Didot Paris, 1844. p. 281.

[6] Here is the proof:
527.5mm x 300=158.25m=1 stadion
158.25m x 700=110,775m=1 degree
On the other hand, the 24th degree of latitude, plus the 25th, meaning 110,768 + 110,782m, represents a sum that of which half is also equal to 110,775.

respected and appointed representative at the National Printing House. Only then did I decide to modify Monsieur Letronne's text after having seen that those changes were necessary, considering the data that already been altered. I simply had to cancel the printing process and review the writing. It is therefore unquestionable that a small part, however small one might consider it to be, of the surprising exactitude of my results, may be traced back to a happy encounter. Yet, this is a moment when it is truthfully possible to quote a spiritual member of the Academy: 'Fate is intelligent.'

These are the changes that I have made and had to make to the text that I was commissioned to publish. As for little details in calculations or in writing that I thought best to slightly alter, I am sure that the author would have agreed, in the readers' interest, and to facilitate the study of the work, … . I would even add, not to dissimulate anything, that when it comes to slight inadvertences that the author may have committed, *quas humana parum cavit natura*, it was my duty to rectify those inadvertences and it would be a waste of time to stop at them.

Now, would these be the only changes that the author would have made to his text, would he have had the chance to modify his own manuscript? I do not think so. I would even say that I am sure of the contrary. Indeed, as I mentioned in the beginning, the author seemed to have come back to the opinion that all works and fragments of works that we have access to signed by Hero, seem to have originated from the same source. But [as there were three relevant persons named Hero in antiquity] was it in the work of ancient Hero, the third Hero? Or, according to the opinion that he expressed in the Universal Biography (see his article 'Hero') and again in this present thesis, since he attributed the vestiges left of the Egyptian metric system to the master of Proclus, were the texts about mechanics, physics and military art, written by the second Hero (Hero Secundus)? The opportunity to find the answer to these questions having not arisen, I have had to stop there, so as not to risk basing data on my own opinion rather than on the author's. As for the rest, I have clearly indicated with brackets the passages, observations and notes of any importance that would have represented in any manner the responsibility of the author. That is why I have used brackets for the paragraph relating to the determination of the degree of the average latitude of Upper Egypt, which I mentioned above. However, I have left the characteristic passage in which Letronne says that ‘Upper Egypt seems to have been the most anciently inhabited’ as it is, and it embodies the essence of the entire paragraph.

It is therefore, and without any doubt, certain that Monsieur Letronne would have altered many aspects of his work - modifications that are beyond the limits of my competence. For instance, he would probably have shortened the many details that are rather minor, yet remarkably fine, around his delicate analysis in which he proves that the Italian foot that Hero mentions is the same as the Roman foot. He would have marched more quickly towards his goal at a time when his method, so certain because prudent, should have strengthened his self-confidence. Furthermore, he would probably have spent less time arguing against theories that today have lost a lot of their significance and authority. Yet, to try and make those modifications myself would have been overstepping lines, as it would have meant substituting purely arbitrarily the discretionary power with which he had entrusted me.

In any case, the critical, historical and geographical research project on the fragments of Hero of Alexandria, despite the contradictory observations that the data inevitably leads to and which would be completely inappropriate to include here, remain one of the most important works of the author. And in the midst of some traces of inexperience, and despite some actual errors, I have no doubt that competent judges will be able hereby to recognise the primary evidences of *L’ongle du lion*, ‘the claws of the lion.’

A. J. H. Vincent

Question

Suggested by the class of Ancient History and Literature in the year 1816:

'Explain Hero of Alexandria's metric system and determine its connections with other ancient methods of measuring lengths.'

Author’s Prefatory Note

The author of this thesis would have liked to stay within this particular question, as the Class formulated it. But the in-depth research that he conducted as a consequence of wanting to satisfy the expressed desire, forced him to develop his work in an unexpected manner.

He was rather happy to discover in Greek manuscripts, in the Royal library, fragments of Hero that were unknown to other researchers, and that seem to prove that the measurements we have conserved of this author correspond to two different time periods. The author of this text then found himself confronted with the obligation of determining what those time periods were, linking the measurements with all the historical and geographical facts that they may clarify, and following them through the political revolutions in the country where they would have been used.

Thus, the author has expanded his research in his stubborn quest, raised by the Class, *to explain the measurements of Hero of Alexandria*. In order not to do less than what the Class expected, he had to do more.

The work that he hereby presents to the Class, hopes to solve the problem in question, and it may be defined by the following title, which indicates both the subject matter and the depth of it:

Critical, historical, and geographical studies of the fragments of Hero of Alexandria; or: On the Egyptian metric system from its basis, in its connections to the itinerary measurements of the Greeks and the Romans, and the modifications through which it has gone since the reign of the Pharaohs to the invasion of the Arabs.

Critical, Historical and Geographical

RESEARCH

On Fragments of

HERO OF ALEXANDRIA

PROLEGOMENA

BASIC UNDERSTANDING OF ANCIENT MEASUREMENTS – CURRENT SITUATION - OUTLINE OF THE THESIS

Since the Renaissance, researchers have for many reasons had a profound interest in the history of human thought. But few areas of study have attracted as much attention as the determination of the units of measurements which were used in antiquity. This quest has led to countless unfruitful and hazardous hypotheses, and it has given rise to numerous different systems. Any critical reader would therefore naturally have to assume that it is impossible to find the correct answers to this problem.

Indeed, wherever one turns one's gaze, the situation looks uniformly gloomy. Previous research has proven insufficient either because important combinations had been discarded or because certain difficulties that are inherent to the subject matter itself have stood in invincible opposition to a comprehensive solution. So how could anybody hope to perceive what the most talented critical researchers have missed? How could anybody conceive of attempting to overcome all those obstacles which have so far prevented scholars and scientific geniuses from succeeding?

The theory put forward by the Institute's Third Class [*the 'third class' refers to a sub-group of the Academy of Sciences and Inscriptions, of which Letronne was a prominent member*] in 1814 shows that those who are the most appropriate judges in these matters have not yet given up attempting to define the measurement system used by those who played the most significant role in antiquity. By drawing Europe's academics' attention to Egypt's measuring tables as found in Hero of Alexandria's fragments, the Institute's third class thought - and undoubtedly rightly so - that a comprehensive explanation of this precious monument of knowledge could be linked to a multitude of historical facts of great importance.

These fragments, which are the shapeless debris of a large and beautiful whole, have challenged the wisdom of our greatest minds. Almost all of those who have studied measurement units mentioned by ancient authors have tried, with greater or lesser success, to adapt measurements found in those fragments to their own particular ways of reasoning. And yet, honest, critical researchers will have to admit that these measuring systems remain unruly mysteries which we have yet to solve.

The Institute would thus not have encouraged further research into this field without on the one hand acknowledging the importance of potential findings, and on the other hand admitting the shortcomings of previous attempts. The Institute realises that in order properly to rise to this challenge, it is not enough simply to present yet another new theory, because that would only further fuel the general sense of uncertainty. This issue requires all-encompassing, comprehensive analysis that can answer all questions that have been asked about it. It is necessary to unveil the origins of Hero of Alexandria's fragments, to determine when the measurements mentioned in these documents were made, and to look at how those numbers in turn were used, and how they were later modified throughout Egypt's historical revolutions. Moreover, through close observations of Egypt's monuments and geography, we shall identify the units used for these measurements and compare them to those used by the Greek and Roman civilisations. And it is only once all those aspects have been considered, and all contradictions have been resolved, that the Institute will feel satisfied with what it puts forward.

I am well aware of the inherent difficulties of this research topic, and of the sheer size of the challenge that I have chosen to address. For my own sake, I have had to point out how far modern critical researchers have taken ancient scholars' doctrines of distance measurements. I have also felt it necessary to combine all of the general notions thereby included, in order not to fall into a trap of reiteration, which could otherwise have happened. Most importantly, I believe it will be easier for readers to follow my reasoning once they become familiar with the ideas and facts that I thought must be accepted as truths. In this initial outline, as well as throughout my work, I speak honestly, despite individual opinions expressed by several members of the Institute's Class. I have been fully committed to my mission, as well as to the truth, and I have therefore pursued my research no matter what its consequences, and without making any excuses. I have always been convinced that if what I do is right, then I will win sceptics over to my side. Critical minds are all most attracted to the truth, they all seek it with the same passion, and thus it is inconceivable that they would not be able to recognise that opinions have to be considered based on facts. Facts cannot be considered facts when they are based upon opinions.

§ I. INHERENT DIFFICULTIES WITH ANCIENT MEASUREMENTS.

The debate of ancient distance measurements is one of the most delicate aspects of antiquity studies. No other branch of research in the field includes so many wild goose chases, while also leading to an abundance of false theories formulated by people who are certain that they are correct.

The reason for this is found in the conversations that this subject matter triggers. They are always shrouded in something vague and undetermined that a calculating or rather insincere person can take advantage of in order to promote his own agenda, or to simply make us believe that his theory is the truth.

The uncertainty mentioned above is itself a consequence of realities that I can only quickly mention here. Firstly, transcribers have successively introduced erroneous numbers into calculations, which in and of itself can sometimes be enough to put the best thought-out and most correct theories into question. These mistakes are a natural and necessary consequence of the manner in which books were transmitted before the invention of the printing press. We have to take into account that the symbols that were used to express numbers were letters of the alphabet, and could therefore just as easily be misspelled. However, because they were most often separated from a body of text, transcribers were unable to use grammar or linguistic knowledge to identify errors and correct them.

Another reason for the general feeling of uncertainty stems from ancient scholars' lack of critical thinking. They were also rather careless when having to translate measurements made by foreigners into their own languages: most often, the translation is erroneous. Scholars simply chose a measurement unit used in their own language, falsely believing it to be analogous. For instance (in order to pick just one example among hundreds that crowd my mind), when translating from Latin to Greek, Plutarch substituted *plethron* with *jugerum*[1], despite the fact that a jugerum would have been twice the length of a plethron. Another illustration is the fact that Strabo replaced the Roman silver denarius with the word drachmē, which actually represents another currency with a different value[2].

I would like to add two more reasons to this list.

Firstly, ancient scholars had a tendency to give approximate numbers. They would round the numbers up and omit units, tenths and sometimes hundredths. This explains why the majority of their measurements are expressed in numbers ending with several zeros. Conversely, they would not either hesitate to round numbers down or to simplify results; thereby altering all fractions: they were forced to do this because of the simplicity of the arithmetic they had at hand, which turned the easiest calculations into complicated equations as soon as a fraction was introduced[3].

Secondly, a vast number of distance measurements were transmitted to us by geographers and historians in antiquity who did not themselves verify those distances. Sometimes, they did not even bother to indicate how the measurements had been made.

Despite all the uncertainties and errors mentioned above, we thought it possible to consolidate key measurements made by ancient scholars, and you will find

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[1] Plutarch, *Life of Camillus,* §8, Vol. IV, p. 621, ed. R. [*'R.' presumably refers to Dominique Ricard, who translated the whole of Plutarch's Lives and Moralia into French between 1783 and 1803. The Lives commonly appeared in four volumes. This reference to chapter 8 appears however to be erroneous, and may refer to chapter 18 or some other chapter, hence being a typographical error.*]

[2] Strabo, Book IV, p.315, A. *Hoi ge de Dekinon Brouton* [Decimus Brutus] *Phygonta ek Mountinēs* [Mutina], *eprazanto drachmēn kat' andras* (read *andra*). Cf. [Pascal Francois Joseph] Gosselin. *Notes on Strabo*, Volume II, p. 94, note 2. [*This extraordinarily obscure reference could only have been discovered by someone truly expert in the minutiae of detail recorded in the work of Strabo! In the Loeb Library edition and translation of H. L. Jones of 1923, reprinted 1988, this passage is found in IV, 6, 7, near the end of C205. The passage reads in English: '... they exacted even from Decimus Brutus, on his flight from Mutina, a toll of a drachma per man'. And, as Letronne and doubtless other scholars had suggested,* andras *was indeed corrected to* andra *in the Greek text of the Loeb edition*. The reference to the Loeb volume, which is Strabo Volume II, is pp. 278-9.]

[3] Cf. Note *infra*, 1st part, Book II, Chapter II, § 3.

the results of this here below. We have chosen to use the Roman mile, which, up until now, has proven to be the least uncertain *positive* distance measurement.

As you know, this mile represented 1000 *steps* and 5000 *feet*. One step was equal to 5 feet, and one foot = 12 *ounces* or *inches*, and 16 *fingers*. One *cubit* could be divided into 2 sextants, and it was equal to 1½ feet, 18 inches and 24 fingers.

According to official comments made by Pliny, Vitruvius, and other authors, the Greek *stade* was equal to 625 Roman feet, and 125 steps. Because we know that this stade was equal to 600 Greek feet, we deduct that 625 Greek feet = 600 Roman feet. In other words, the ratio becomes 25/24. Furthermore, 1 Roman mile = 4,800 Greek feet or 8 stades.

In addition, Roman distances measured in miles were also reduced to stades, based on feet: 10 stades = 1 mile. Examples of this can be found in Strabo's work.[4] We therefore had to take another stade into account, shorter than the first one mentioned, in a ratio of 4/5. The larger unit was named Olympic stade, because we have assumed it referred to the Olympia quarry, and the smaller unit was named Pythic stade, because it must have referred to Delphi's quarry.[5]

Following these basic notions, we are able to deduct ratios between Greek and Roman measurements. With the Roman mile as a unit:

Pythic Feet = 1/6000
Olympic Feet = 1/4800
Roman Feet = 1/5000
Pythic Stade = 1/10
Olympic Stade = 1/8

As for ratios between Greek and Roman measurements and those used in Asia and in Egypt, please see here below how we have established them.

Herodotus and Xenophon consistently referred to one *parasang* as being equal to 30 stades for several distances in Asia. However, because we do not know to which stade they referred, we do not have the slightest idea of what these distances represent. In addition, the authors do not give us any other details, so we have had to use our analogical and deduction skills to dig deeper into this issue.

The Antonine Itinerary = 75 miles between Tyana and Tarsus, in Asia Minor[6]. Xenophon established that the same distance (meaning between Tarsus and Dana[7])

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[4] [Jean Baptiste Bourguignon] d'Anville, *Analyse Géographique d'Italie*, p. 192. *My Travels,* p. 71-82. A*cademy of Inscriptions* Volume XXX, p.214, and ff.
[5] [Jean-Denis] Barbié du Bocage, *Analyse des C. Pour le J. Anacharsis*, p. 7, edited by [Pierre] Didot.
[6] *Itin. Veter.* [*Vetera Romanorum Itineraria*], pp. 577-579. [The original publication of this work by Hierocles Petrus Wesseling was at Ghent in 1735. It is readily available in modern reprints.]
[7] Xenophon, *Anabasis*, Book I, Chapter 2, §20, ed. by [Benjamin] Weiske.

measured 25 parasangs,[8] which is equal to 75 Roman miles. In other words, one mile = 1/3 of a parasang.

Another example: According to the Itinerary of Jerusalem, 45 miles separated Tarsus from Mantissa, on the Pyramus.[9] According to Xenophon, there were 15 parasangs between Pyramus and Tarsus.[10] Thus, one parasang = 3 Roman miles, and since Xenophon established that one parasang = 20 stades, then this stade = 1/10 of a Roman mile, and it is therefore a Pythic stade.

Using similar logic, we were able to define distances in Egypt as well.

On the North Eastern coast of Egypt, there was a place called Pentaschoenus in the Antonine Itinerary. That Itinerary placed it between Pelusium and Mount Casius, 20 miles from each one of those two locations.[11] Undoubtedly, this location was thus named (*Five Schoeni*) because it was also located 5 schoeni from both Mount Casius and Pelusium. Since that distance is equal to 20 miles according to the same itinerary, 20 miles = 5 schoeni. In other words, one schoenus = 4 Roman miles. This has been confirmed by other similarly convincing deductions.

Furthermore, according to Herodotus, one schoenus = 60 stades, but according to other authors, one schoenus = 30 stades. Thus, Egypt used one type of schoenus (= 4 Roman miles), and two types of stades, of which one was = 1/60 of a schoenus, which was 1/15 of a Roman Mile, and the other schoenus was = 1/7.5 of a Roman mile.

According to our classical authors, ancient distance measurements can therefore be limited to 1 mile, 1 parasang, 1 schoenus, and 4 stades, of the latter of which two are Greek and two are Egyptian, and these are reciprocal in the following way: 7½, 8, 10 and 15.

We note that therefore, all these measurements are actually part of the very same system, and they can all be used together.

§ II. ANCIENT MEASUREMENTS' VALUES, BASED ON THE ROMAN MILE.

Obviously, if we definitely knew the length of one of those units of measurement, then we would be able to deduce the values of all the others. It would then be possible to go from the Roman foot to the parasang and the schoenus, and from the schoenus to the Roman foot, via all other intermediary units of measurement. It therefore seems that the main difficulty resides in finding the basis upon which one of those line- or distance-based measurements was founded.

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8 [Jean Baptiste Bourguignon] d'Anville, *Mes. Itinér*. [*Traité des Mesures Itinéraires Anciennes et Modernes (Treatise on Ancient and Modern Measures of Itineraries)*, 1769], p. 78.
9 *Itinér. Veter.*, p. 152
10 Xenophon, *Anabasis*, Book I, Chapter 4, 1.
11 *Itinér. Veter.*, p. 152.

This is the issue that we have spent a long time looking into. We have carefully measured all standards of the Roman foot that have survived until our days, and we have measured the distance that separates all boundary markers that are still standing. However, it has not been possible to find two measurements that are equal. Regarding the mile, the difference between two distances may vary by 2-3 *toises* [fathoms].

We cannot imagine that Romans used feet of different lengths, and so we have to discard the slight differences and assume that these are due to simple and natural reasons.

Comparing various different foot standards inscribed into various different monuments, we can assume that these differences had the following possible causes:

1. Time has simply caused deterioration of the inscriptions in such a way that the lines' extremities can no longer be precisely established, and therefore vary by a fraction. This small fraction of a unit, if repeated 5000 times, can lead to significant differences in a mile. Assuming for instance that there is a difference of 1/3 between two feet, in other words1/432, then this may become a difference of 2 toises [fathoms] on a mile.
2. Imperceptible but constant alterations have occurred when measurement standards were established, based on comparing two reproductions to one another, rather than bringing them back to the original standard for comparison. In France in 1668, for instance, the Abbé Picard set out to compare the toise unit that bricklayers used to the original standard engraved in Châtelet, and he discovered a difference of 5 lines, or 1/173. Thus we may assume that if Roman land-surveyors, architects and bricklayers did not have to frequently check the accuracy of their measurements by comparing their unit, or *decempeda,* to the standard kept at the Capitol,[12] then their units would eventually have become imperceptibly altered. Nothing more is needed to explain the difference of ½ line found between different feet measured.

The very same reasoning can be applied to the interval between two milestones, on which the distance of a mile has been established. This distance was established by measuring the distance between two milestone boundary markers, and therefore, any alterations made to the *decempeda* used would have affected the length of the next mile. Moreover, Roman land-surveyors may sometimes have been a little negligent, and it is also possible that milestones were moved slightly over time.

All of these reasons are more than enough to explain why results have varied. Logically, none of these standards should therefore be trusted as fully accurate, because each one may have been slightly erroneous. In addition,

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[12] J[acobus] Gothofred, *in Cod. Theodos.* [*Commentary on the Code of Theodosius*] XII, tit. 6, 19 [published 1665]; Volume IV, p. 551.

because some may be smaller and some may be larger, the truth has to reside somewhere in the middle, and we have therefore chosen to consider a theoretical average of all units measured, despite the fact that this can never be completely accurate either. So:

According to [Nicolas] Fréret,[13] the average of all (12) measurements of Roman feet (= 130.75 lines), becomes 0.2949m

We then must add:

1. The distance between two feet drawn on the Rock of Terracina:[14]
   The first --------0.2921m
   The second ----0.2948m.
2. The distance between boundary marks 42 and 46 in the Pontin swamp: this measurement, according to all the surrounding conditions, is, amongst all the others, the one that we should trust the most, and it establishes the mile as equal to 1473.233m, and the feet to 0.2942m.
3. The average of all these numbers establishes the Roman Feet to 0.2947m.
   As a result, one Roman mile = 1473.5m.

Assuming this average estimate, which although it is a construct, is reasonably correct, we may deduct with satisfactory precision the value of all measurements that we earlier defined in relationship to the Roman mile.
Thus:

Pythic Stade (1/10 of a Roman Mile) ………..… 147.35m
Olympic Stade (1/8)…………………………….. 184.19m
Small Egyptian Stade (1/15)……………………....98.23m
Great Egyptian Stade (2/15)……………………...196.47m
Parasang (3Miles)……………………….…………4,420.5m
Schoenus (4Miles)……………………….…… ….5,894.0m

§III. ASTRONOMICAL MEASUREMENTS USED IN THE SCHOOL OF ALEXANDRIA'S GEOGRAPHICAL SYSTEM

Do the tables that we constructed above embrace all the measurements that have played a role in ancient geography? Hardly. We have only been able to establish a ratio system between Greek and Roman units of measurement. The parasang, the schoenus and the two stades that have to be taken into account are only tied to the first two units mentioned by loose links that are not reliable enough for this particularly delicate research topic.

For instance, assuming that the parasang actually had the value that we imply it had through our ratio system, it is still the only Asian unit of measurement included in our tables. Yet, looking at the vast variety of units of measurement used in one single European country, Italy for example, where we have counted up to ten different miles used, we must ask ourselves whether it is reasonable to assume that there was only

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[13] [Nicolas] Fréret, *Academy of Inscriptions and Belles Lettres*, Volume XXIV, p. 483, and ff.
[14] [Antoine] Mongez, in the Report of the Work of the Third Class of the Institute, for the year 1813, pp. 6 and 7.

one parasang used from the Mediterranean shores to the banks of the Indus. Can we pretend that people in Asia Minor, in Syria, in Persia, in Babylonia, people who were different in so many ways, all used the same unit to measure distances?

On the contrary, it would be natural to assume that the great nations of this vast region each had at least one particular system put into place. Their various different metric systems may have led to the same measurements, but the fundamental value of their main units surely differed. Greek and Roman systems were based on the same units combined according to certain ratios, such as *finger, palm, spithamē, foot, cubit*, etc., but the length of each one of these units was different. As a consequence, measurements radically differed despite at first seeming identical. After having carefully studied various units of measurements used in Syria, Palestine, Armenia and Assyria, we can only assume that the same phenomenon occurred there as well. Almost all these nations had their own particular Cubit or Foot, which could be multiplied a certain number of times and become a schoenus or a parasang that could then be divided either into 3 parts of 1000 steps, or into 30 parts of 100 steps. Yet the *real* value of these various different parts *depended* on that of the foot or the cubit that was at its basis.

We must add here that throughout antiquity, historians and travellers alike have almost never taken different units of measurement into account when travelling across foreign lands. They simply wrote down distances they were told in each one of those countries, without bothering about the actual unit used for those measurements. Because parasangs were uniformly divided into 30 parts or 100 steps each, writers simply applied the Greek word stade to describe these distances because a stade also equalled 100 Steps. But was the distance expressed in parasangs the same? The Greeks thought they could reduce it down to stades by multiplying the distance by 30. But had the distance been expressed in 1/30 of a parasang? They assumed these parts to be stades. And that is how we quickly realise that the word stade was simply a Greek word here applied to an Asian measurement,[15] the value of which was undeniably less than that of the parasang. However, the distance had originally been measured in parasangs. Today too, travellers transport names of units used in their own countries to nations that they visit. For instance, [Abraham Hyacinthe] Anquetil du Perron from France calls India's *coss* "Lieue" and [Joseph] Tieffenthaler [Tiefenthaler/ Tiefentaler] from Germany calls it "mille",[16] despite the fact that India's coss does not equal either the French "lieue" or the German "mille".

Consequently, geographic distances defined in Asia by ancient scholars had actually rarely been measured in Greek stades, but rather in that particular nation's unit of measurement.

If we focus on Greece, Italy, and a few parts of Asia Minor, we may recognize distances expressed in Greek stades, but as soon as we travel to other nations in Asia, or to Egypt, we face seemingly insurmountable obstacles. More specifically, it is very

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[15] See [William] Vincent, *Voyage of Nearchus*, Preliminary Elucidations, p. 58 (the page reference is to the French translation from Vincent's English translation of the original, which was published at Paris, 1799).
[16] See [James] Rennell, *Historical and Geographical Description of Hindustan [India]*, Volume II, p. 384 [of the French translation].

difficult to establish the basis on which geographers from the School of Alexandria created their units of measurement. Today, we realise that almost all of their measurements were incorrect, even in places they knew well. However, their errors are so significant, that we cannot blame them on the basis of ignorance. Rather, we may be the ignorant ones, because we do not know what units of measurement were actually used to express those distances.

Did ancient scholars base distances on different units, and not solely on the Olympic and Pythic stades? If yes, then can that not be the reason why certain measurements seem erroneous?

According to ancient scholars, there have been five different ways of measuring the Earth's circumference in stades:[17]

The first one, mentioned by Aristotle, established the Earth's circumference at 400,000 stades, which is equivalent to 1,111 1/9 stades per degree.

The second one, according to Archimedes, estimated it at 300,000 stades, or 833 1/3 stades per degree.

The third one, which Eratosthenes, Hipparchos and Strabo exclusively used, measured the Earth's circumference at 252,000 stades, or 700 stades per degree.

The fourth one, which Posidonius mentioned, assumed that the Earth's circumference equalled 240,000 stades, or 666 2/3 per degree.

Finally, the fifth one, which the same Posidonius used, and which was also mentioned by Marinus of Tyre and Ptolemy, established the Earth's circumference at 180,000 stades, or 500 per degree.

We have to understand that these enormous differences are simply due to the fact that the value of the stades mentioned are not the same. Moreover, we cannot help but noticing that it was during Alexander's reign that the most ancient measurement was used, and that two of those estimates were used by scholars at the School of Alexandria, who later used them to immortalize measurements made during the conquest of Macedonia. We may therefore assume that these different units of measurement were in use in the places that Alexander visited in Asia and Africa, and that their values consequently played a significant role in ancient geography.

In fact, our colleague [Jean Baptise Bourguignon] d'Anville has brought further light to an assumption that both [Jean-Baptiste Louis de Romé de] l'Isle[18] and [Nicolas] Fréret[19] had already put forward.

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[17] [Pascal Francois Joseph] Gosselin, *Mes. Itinér.*, p. 4; or *Recherches* [*Recherches sur la Géographie Sytématique et Positive des Anciens*, Paris, 1813], Volume IV, p. 292.

[18] [Jean-Baptiste Louis de Romé] de l'Isle, *Academy of Sciences and Inscriptions*, for the year 1721, p. 61.

[19] [Nicolas] Fréret, *Academy of Inscriptions and Belles Lettres*, Volume XXIV, p. 507 and ff.

D'Anville showed that the stade apparently used by the Egyptians seemed to be a lot shorter than the Pythic and Olympic stades. After analysing the schoenus as well, he concluded that one Egyptian stade represented a 1/15th of the Roman mile,[20] in other words one degree would have contained it 1.125 times, and the Earth's circumference would have contained it 405,000 times.

Furthermore, he also came to the same conclusion that de l'Isle had previously suggested,[21] namely that this smaller stade was the only really convenient one to use when measuring the coasts of the Persian Gulf in Arrian's *Indica*.[22] Generally speaking, it was the unit of choice in Asia for Alexander's historians. This observation has also been confirmed by [Pascal Francois Joseph] Gossellin who looked at its use in Gedrosia and Persia;[23] as well as by [Baron Charles-Athanase] Walckenaer, who looked at how it was used further inland.[24]

Although this observation may not actually apply to the Egyptian reality, it does show that the various different ways according to which the Earth was measured were not based on purely systematic ideas or illusory notions. As a matter of fact, this reasoning proves that a stade that was equivalent to a global circumference of 400,000 was in use. All these measurements are interlinked and seem to originate from an ancient source. Aristotle's stade is the most ancient one, and yet traces of it have been found in Egypt, and in important places in Asia. Therefore one must assume that other measuring systems were also based on commonly known dimensions, which may have trickled down to distance measurements as well.

To be able to conclude on this simple and yet significant note is already a great step forward. Unfortunately, our systematic minds, which always look at general ideas with caution, have rapidly twisted the original message.

[Jean Sylvain] Bailly grabbed hold of the concept, and wrote a book that had golden moments of ingenuity, and that went out of its way to prove that all ancient measurements were based on the Earth's dimensions. Yet, instead of holding back a little, which would have been a more reasonable approach considering the rather surprising character of this hypothesis, Bailly dove headfirst into his favourite antediluvian theory. He altered the applications, which blurred his conclusions, and in turn, this cast a shadow of doubt over a great and eminent scientific theory.

His successors went even further. [Alexis Jean Pierre] Paucton and [Jean Francois] Lesparat claimed that they could trace every single measurement from the ancient continent straight back to the determination of the Earth's circumference. This

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20 D'Anville, *Sur le Schène* (*Concerning the Schoenus*); *Academy of Inscriptions*, Volume XXVI, p. 83.

21 De l'Isle, *op. cit.*

22 D'Anville, *Sur le Golfe Persique* (*Concerning the Persian Gulf*); *Academy of Inscriptions*, Volume XXX, p. 132.

23 Gosselin, *Géogr. Système* (*Recherches sur la Géographie Systèmatique, op. cit.*), Volume III, pp. 125-165.

24 [Baron Charles-Athanase Walckenaer,] *Mémoire sur les Anciens Itinéraires de la Perse et de l'Inde*, read at the public seminar of July, 1814.

also included one of the sides of the great pyramid of Gizeh, which was equivalent to the 180,000 degree part. This magnificent system relied on two basic assumptions: on the one hand, the ancient Egyptian cubit that would have to be equal to the cubit of the Mekyas [the nilometer of Rodah at Cairo], and on the other hand, one would have to assume that the common perception of that particular side length measurement of the pyramid was correct. Unfortunately, French researchers have been able to demonstrate that those two assumptions were incorrect. The ancient cubit was 0.014m shorter than the current cubit used at the Mekyas, and the base of the pyramid is actually 22 feet longer than what was first assumed. Consequently, the entire system crumbles down like a scaffolding of bad assumptions.

Still, this beautiful idea based on astronomical measurements did not get completely lost to science. It has however been necessary to apply it in a critical, knowledgeable and vigorous manner. It was essential to stop putting hazy theories forward, and to apply a geographer's lens to all countries where it could potentially be possible to find traces of the use of those measurements.

Gosselin took on this difficult challenge.

In his works entitled *Greek Geography Analysed*, and Studies in *Greek Systematic Geography*, he strongly established the basis of antique science, and opened a new road for researchers to walk down. He refers to the opinions of Eratosthenes, Hipparchos, Marinus of Tyre and Ptolemy, and shows that the use of a stade contained 400,000; 300,000; 252,000; 240,000 and 180,000 times in the Earth's circumference is used over and over again. Gosselin was able to prove that all those geographers altered distances described by using their culture's particular stade to define them. Eratosthenes, Hipparchos and Strabo used a stade that was equal to 700 degrees. On the other hand, Marinus of Tyre and Ptolemy described the same distances with a different stade (=500 degrees), and yet, they omitted to adjust their measurements accordingly. All expressed their ideas as if they were using the same stade. Nobody seemed to have been aware of the fact that there could potentially be different measurement systems put into place. And this is how certain distances, despite perhaps being accurate to begin with, became distorted through various different later applications. Today, we notice that there are differences in measurement variations that are proportionate to the inherently varying lengths of different stades used when making the original measurements.

Gosselin was in this manner able to trace back all errors committed over time regarding these different ancient measurement systems, right back to their very origins. He shows us that regarding our Earth, Eratosthenes was off by 20 degrees, Hipparchos by 14.25 degrees, Marinus of Tyre by 120 degrees and Ptolemy by 71 degrees. He demonstrated that all those major mistakes were due to one and the same reason, and that if all measurements were to be expressed in their respective stades, then they all turn out to be surprisingly correct. In his work, Gosselin identifies traces of ancient beliefs in those of our present day, establishes limits to the extent of ancient authors' knowledge, and pinpoints intermediary locations along distances that they describe in their accounts.

As a direct consequence of Gosselin's work, there can no longer be any doubts regarding the use of different stades, and how these were related to the dimensions of the Earth's circumference.

It then became important to determine the actual *absolute* values of those measurements. Gosselin went about this in a very committed way. Firstly, he let go of all conclusions hastily drawn from monuments because they ended up not matching one another. He then considered all ancient astronomical measures as contained 400,000; 300,000; 252,000; 240,000; 180,000 times in the Earth's circumference, or 1111 1/9; 833 1/3; 700; 666 2/3; 500 times in one degree of latitude. In his work, Gosselin refers to the average degree, and based on how it has been measured by modern researchers, he makes the following calculations: he divides the 111,111 1/9m described, by 1,111 1/9; 833 1/3; 700; 666 2/3; 500 and ends up with stades of 100m; 133.333m; 158.73m; 166.666m; 222.222m.

In a similar way, Gosselin estimates the Roman mile (= one 75th part of the average degree) to equal 1481.481m, which is 8 metres more than 1473.5m, which is what one obtains when one averages all the Roman feet which have been measured.[25]

In this manner, Gosselin avoids walking forward in blindness, which one had had to do up until then because of the differences registered over the years.[26]

However, this re-evaluation of ancient measurements has not been unanimously approved by academics. Some criticism has been voiced, and here below follows the main argument used against it:

It may be true that geographers from the school of Alexandria included astronomical stades in systems that they assumed to be contained 500; 666 2/3; 700; 833 1/3; and 1,111 1/9 times in a latitude degree. Consequently, every time they converted those degrees into stades, or vice versa, the stades were regarded as aliquot parts of a degree.[27]

However, in order to obtain the real value of those measurements in actual numbers, one would have to know the *a priori* dimension that the geographers based the degree on. Reciprocally, in order to establish the value of the degree they used, one would have to know the *a priori* length of a stade. If one assumes that modern degree measurements can be used as a model for ancient measurements, then one makes the assumption that one has proved what one questions. In other words, ancient scholars looked at the Earth's dimensions through the same lens as we do.

Thus, opinions diverge on the actual lengths of ancient measurements.

Some, following Gosselin, have based their reasoning on our average degree.

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[25] *Supra*, § 1, p.10

[26] [Pascal Francois Joseph] Gosselin, *Mes. Itinér.*, pp. 3-77; *Recherches,* Volume IV, pp. 291-365.

[27] Cf. [Jean Baptiste Joseph] Delambre, *Base du Système Métrique*, preliminary discussion. p. 3; *Astronomie théorique et pratique*, Volume III, p. 573.

Others focus on the result of average calculations of all measured Roman feet and miles.

The actual results of those two separate methods only differ by 8 metres, or 4 toises (fathoms) and 7 ½ inches for the Roman mile. Yet, although this difference is only a slight one, it becomes all the more important because it puts into question whether or not ancient scholars actually were aware of the Earth's dimensions.

§ IV. STUDIES TO BE CONDUCTED

The above summary shall suffice to reach the goal that I had initially set, since it quite clearly identifies the studies that still need to be conducted.

Excluding the discussion that is relative to the actual systems of ancient measurements, because it does not seem to be possible to fully shed light on it, one realises that the ancient measurements should be divided up into two categories:

The first one includes the Roman mile, and two Greek stades, the schoenus and the parasang – all linked to the Roman mile as previously established.

The other one includes the five different kinds of stades that Gosselin found by analysing the geography considered by the school of Alexandria.

Those stades seem to have been widely used, especially throughout western Asia, and must in all likelihood have been included in a specific measurement system. But what was this system? In what countries was it in use? What was the origin of the units of measurements used according to this system? Those are the questions that are left to be answered, and that could solve several historical problems.

Undoubtedly, our Class [*he is referring to the 'class', i.e., sub-group. of the Institute*] knew that analysing Hero's measurements would touch upon those questions, and this must have been one of the class's reasons for asking me to bring clarity to ancient measurements.

After all, those measurements were used in Hero's country Egypt, and there are still traces of them left there: that is actually the only thing we know for sure.

Moreover, the school of Alexandria was actually located in Egypt, and it is that school's geographic systems that Gosselin managed to identify. It is indeed possible that various authors used and combined, in their very own ways, the units of measurements commonly used in their respective countries. Therefore, one should be able to identify all the details of the combinations in Hero's table.

We thus realise just how important it would be to discover Egypt's metric system and to establish the actual value of the fundamental unit of their system.

This discovery could lead to great things. Comparing Hero's table with other metric tables from Syria, Phoenicia, Judaea and Armenia, there are stunning similarities, either between denominations of measurements, or between relative values. The first thought that comes to mind is that it is the same measurement system that was put into use in all those places, and that would be why there are these consequences. Could all those Asian countries have used measurements that originated from the same system? If yes, then discovering Egyptian measurements would lead to other discoveries in Asia as well.

Yet, one mustn't blindly walk down the path of similarities. It has been proven that people who communicated with each other in ancient times could sometimes use units of measurement that had the same names, and that were more or less combined in the same ways, and yet the actual values of these units could be drastically different. For instance, looking at Greek and Roman measurements, it becomes apparent that despite the fact that Greek units were a lot bigger than the Roman ones, they actually used the same units.[28] Another example, which is closer to us, is the comparison between French and British measurements: both countries use a foot unit that is equal to 12 inches, one toise (*fathom*) of 6 feet, and yet British inches, feet and fathoms are actually shorter than French inches, feet and toises (fathoms).

However, immediate comparisons cannot be drawn concerning similar links between the Asian and Egyptian systems. No critical mind should presume to know what those systems included exactly, unless the real value of fundamental units, such as the cubit and the foot, have not been *a priori* established. In other words, by basing combinations and general conclusions on those systems, one may easily fall into the same trap as those hidden behind the comparing of the Greek foot and the Roman foot.

This is why studying Hero's table can only be useful as long as this research is conducted in a reasonable way - that is by resisting falling into excessive audaciousness or caution. If the Egyptian measurement system turns out to be at the basis of the school of Alexandria's' astronomical stades, and if it is possible to link it to the other measurement tables that I have mentioned, then we will have taken a great step forward. If, on the contrary, we can only establish links to one particular type of stade, the 700 one for instance, and that all others, including the Asian ones, end up not being linked to it, then the result will not be as useful, and therefore the leap forward not as great. It would however be a more certain success. In any case, establishing the nature of Egyptian measurements, even if those are isolated from all others, can only shed light on a series of historical and geographical facts that have long and fruitlessly been debated.

I thought it best to choose this high standpoint from which to start my unveiling of a solution to the problem that the class presented, and I shall maintain this vast perspective throughout my research, no matter how steep the hills might get.

Thus, I shall focus on analysing Hero's measurements, and I will make sure to use all possible lenses, without exiting the one country where it is certain that those measurements were used, and without considering the fact that they might have travelled across its borders.

The outline of my work is very simple: it includes two major parts.

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[28] *Infra*, first part, Book II, Chapter 1; and *supra*, p. 12.

The first part establishes the basis of the Egyptian metric system, and it is divided into two books.

In the first book, I travel back to the source of Hero's measurements. I collect and compare all relevant - and mostly unknown - fragments present in various places of the manuscript, and I establish the time in which the author lived.

In the second book, I take a closer look at the actual measurements. I put all erroneous explanations aside, and I identify the right explanation, or at least the one that I consider to be the right one. I also determine links with distances measured in Greek and Roman times.

The second part is divided into three books and it applies this knowledge to Egyptian geography. It also outlines the history of modifications done to this measurement system.

The first book looks at how measurements were used during the Pharaohs' reigns, as well as during Persian times, until the arrival of the Greeks.

The second book dives into Ptolemy's reign, until Roman times.

I analyse and explain all ancient passages that are relevant to the general and particular Egyptian geography throughout both books.

Finally, the third book turns to the history of the measurement system's development, up until the time of the Arab invasion.