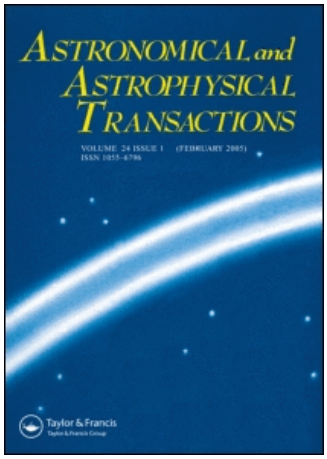

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Aratus' "phaenomena": Dating and analysing its primary source

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Online Publication Date: 01 January 1999
To cite this Article: Zhitomirsky, S. (1999) 'Aratus' "phaenomena": Dating and analysing its primary source', Astronomical & Astrophysical Transactions, 17:6, 483 - 500
To link to this article: DOI: 10.1080/10556799908244111
URL: http://dx.doi.org/10.1080/10556799908244111

Astronomical and Astrophysical Transactions, 1999, Vol. 17, pp. 483–500
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ARATUS' "PHAENOMENA": DATING AND ANALYSING ITS PRIMARY SOURCE

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(Received August 12, 1997)

The dating and analysis of the "Phaenomena" of Aratus are described, and a determination of the primary source of these poems is made.

KEY WORDS The age of the origin, the Zodiacal constellations

The astronomical dating of the material of Aratus' poem leads to the conclusion that its primary source might have been very ancient indeed (the early 2nd millennium BC), though this contradicts what we know about the history of the poem's creation, as well as the highly developed astronomical notions it contains. The present article is devoted to an analysis of the time the primary source of the "Phaenomena" was created. Made use of in it is the detailed method of Archie E. Roy (Roy, 1984), and it advances a hypothesis on the origin of the primary source and the possible ways of its penetration into Hellenic culture.

1 THE POEM AND THE ASTRONOMICAL DATING OF ITS MATERIAL

Aratus, the author of the famous didactic poem "Phaenomena", was born in the Cilician town of Soloi about 315 BC. He studied in Athens under Zeno of Citieus, the founder of the Stoic school of philosophy. King Antigonus Gonatus of Macedonia, a follower of the Stoics, invited Aratus to Pella, evidently as the court poet. We know that the "Phaenomena" were written on the king's order as a poetic exposition of "Phaenomena" or "Appearances" and "Enoptron" or "Mirror of Nature", two treatises of the mathematician and astronomer Eudoxus of Cnidus (about 408–355 BC), which have not reached us.

The content of the poem can be divided into three parts. The first part describes the mutual location of the constellations, the second is devoted to their simultaneous rise and set. In the final part, less interesting to historians of astronomy, the author speaks of celestial and earthly signs of weather changes. The star maps of Hipparchus and Ptolemy are based on the same constellations that Aratus mentions.

To a certain extent, this permits us to identify Aratus' "sky" with that of Ptolemy's catalogue.

Unlike the majority of literary monuments, the poem offers us the possibility to astronomically date its material ourselves. It would seem that this dating should lead us to the time of Eudoxus, i.e., to the middle of the 4th century BC. Investigations, however, suggested the conclusion that the primary source was much more ancient. E. W. Maunder (Maunder, 1909) and A. C. D. Crommellin (Crommellin, 1923) studied the dimensions and position of that part of the celestial sphere that was unknown to the author of the poem. Our investigations showed that the observations of the constellations described in the poem were made at a latitude of 36° N. Besides, the "zone of avoidance" proved to be noticeably shifted in relation to the south pole from the position it had occupied in Eudoxus' time, most likely due to the precession of the Earth's axis. An evaluation of this asymmetry has become one of the ways of dating the material of the poem.

According to Maunder, the primary source was created about 2500 BC, at a latitude between 35 and 40° N. Crommellin's date was 2460 BC and his latitude 36°. In 1966 M. W. Ovenden came to similar conclusions by analysing the data cited in the poem on the constellations' simultaneous rising and setting. According to him, the observations were made at a latitude of 36° ± 1.5° in 2600 BC ±800 years. To define the time of the primary source's creation A. Roy analysed as yet unknown data on the constellations' intersection with the celestial tropics and the equator. His result was 2000 BC ±200 years. Significant is the fact that the dates reached by different methods brought very similar results.

2 THE METHOD USED BY ARCHIE ROY

A. Roy selected from the text of the poem 34 concrete statements concerning the position of the celestial circles against the constellations and checked them to find out whether they fitted the observations for a number of epochs. He made use of a statistical approach, setting a score for each statement: 1 – if the statement fully coincided with the epoch, 0.5 – if it was marginally correct, and 0 – if it did not coincide at all. The work was carried out with the help of the planetarium of the Glasgow College of Nautical Studies, which consecutively demonstrated the skies of selected dates from AD 2000 to 5000 BC. The score for each one was then determined. The results of the investigation can be seen in Table 1, and the corresponding diagram in Figure 1.

Manifest is the increasing number of coincidences as the date approaches 2000 BC, while in Eudoxus' time (–0.35 thousand years) they make up less than half. A

Table 1. The resulte of Roy's investigation

Thousand years	+2	+1	0	−1	−1.5	−1.8	−2	−2.2	−2.5	−3	−4
Number of hits	4.0	4.5	13.0	21.5	30.5	32.5	33.0	30.5	25.0	13.0	3.0

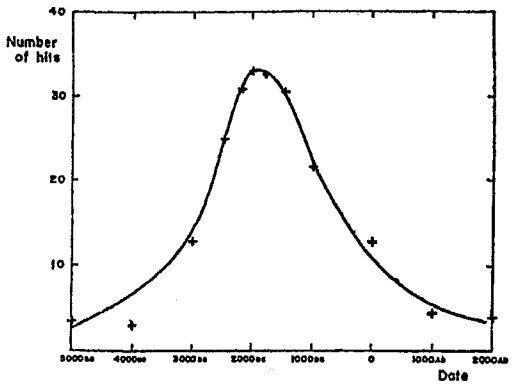

Figure 1 Graph showing A. Roy's results (from *The Origin of the Constellations*).

major result of the scholar's study is that he brought into view the fact that the authors of the primary source were aware of the celestial tropics and the equator. Unfortunately, Roy conducted his investigation visually and used his own evaluations, which makes it much more difficult to determine the degree of reliability of the results he obtained.

3 THE METHOD USED IN THE PRESENT INVESTIGATION

The problem solved by Roy with the help of the planetarium can also be resolved by the graphic-analytical method. For this purpose we made use of the constellations mentioned by Aratus, done in ecliptic coordinates with cylindrical projection. On it the ecliptic is a straight line, and the equator and tropics are a sine curve. The precession movement is then expressed by a simple shift of these curves along the ecliptic end does not affect the constellation figures. Having such a map, we easily discovered the places in which the equator and the tropics cut the constellations in various epochs. All we had to do was plot the lines of the equator and tropics on tracing-paper and dispose it on the map in positions corresponding to these epochs.

The map was drawn on the basis of the star catalogue in Ptolemy's *Almagest*, which was done in the ecliptic system of coordinates. As is known, it goes back, to a considerable extent, to the lost catalogue of Hipparchus, and in time is closest of all to Aratus' epoch. Taken into account likewise were the insignificant differences in the descriptions of the constellations made by Ptolemy and Aratus. When drawing up the figures of the constellations account was also taken of the engravings of Albrecht Dürer (1515) and Anton Venzam (1534).

Used as a foundation was the system of coordinates taken by Ptolemy. Nominally, it is the era of the Emperor Antonin Pius (i.e., July 20, 137) that is considered to be the epoch of the catalogue. However, due to a systematic error of Ptolemy, the catalogue corresponds to an earlier time, and its epoch may be the middle of the 1st century AD.

The celestial equator and the tropics were laid out using points computed by formulas of spherical geometry. For the epoch of Ptolemy's catalogue they were plotted on the map (Figures 2 and 3) in a continuous line, the dotted line showing their position in 2000 BC. The map shows all the zodiacal constellations and those adjoining ones that, according to Aratus, participate in intersecting the celestial circles. The only "extra" constellation is the Piscus (Fishes), not mentioned by Aratus in his description of the intersections. The designation of the stars corresponds to the numbers given them in Ptolemy's catalogue. Following the early tradition of representing the constellations, they are portrayed in mirror reflection. Quotations from the "Phaenomena" are given in C. R. Mair's translation.

The most important feature, for this investigation, of Ptolemy's catalogue is its description of the position of the stars in the constellation figures. Thus, the traditional image of the constellations helped to reveal their shapes with sufficient certainty. To achieve the purpose of our work we did not plot all the stars described by Ptolemy on our map, but only those significant for building up the constellation figures.

The Balance (Libra) zodiacal constellation was plotted much later in the place occupied by the ancient constellation of the Scorpion's Claws mentioned by Aratus. The Balance is included in Ptolemy's catalogue, but the position of the stars in it is given in conformity with the Claws. Therefore, we had no difficulty in drawing the figure of this ancient constellation.

4 EVALUATING THE EPOCH BY THE INTERSECTIONS

Aratus described the intersection of the constellations with the circles in different ways. At times he merely mentioned it – for instance, he wrote, about the equator: "... the Crow, some few stars of the Claws" (line 520). In such cases he took as the beginning and end of the epoch of intersection the times when the circle covered the extreme stars in the constellation. The same principle was adhered to when Aratus pointed to a definite part of the constellation's figure, for example, "the bright shoulders of the Serpent-holder". Here the stars that marked the shoulders were taken as the boundaries of the zone.

In some cases such a method is impossible. This concerns the constellations of the Bird (Cygnus), the Eagle (Aquila) and the Horse (Pegasus). According to Aratus, the "Bird's neck" is on the Tropic of Cancer. However, the latitude of the star on the Bird's head, according to Ptolemy, No. 1, "on the beak" (β Cyg), is $+49°$, i.e., is situated $3°$ to the north of the possible position of the tropic. Therefore, to find the date a zone with a radius of $5°$ around the star was taken. A similar condition can be observed in the mutual disposition of the Aquila constellation and the equator. The southernmost stars in Aquila – Nos. 1 and 8 (τ and σ Aql) – are at a latitude of $+26.7°$, and lie to the north of the equator also by $3°$. The dating zone was defined here in the same way as in Cygnus.

Aratus speaks of the "Horse's hoofs" situated on the Tropic of Cancer. But, first and foremost, both hoofs of the Horse simply cannot lie on the circle, so we

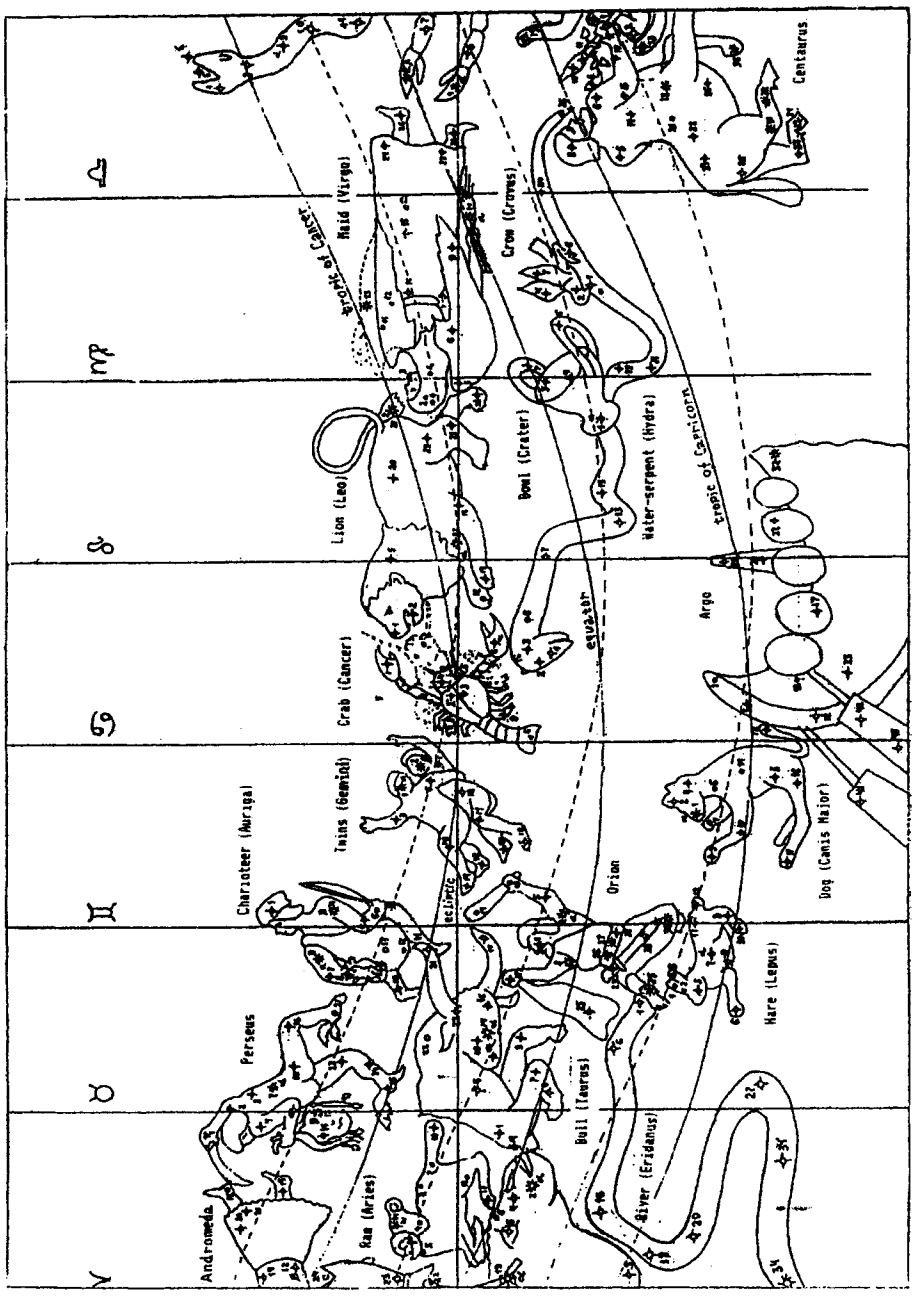

Figure 2 Star map (left side).

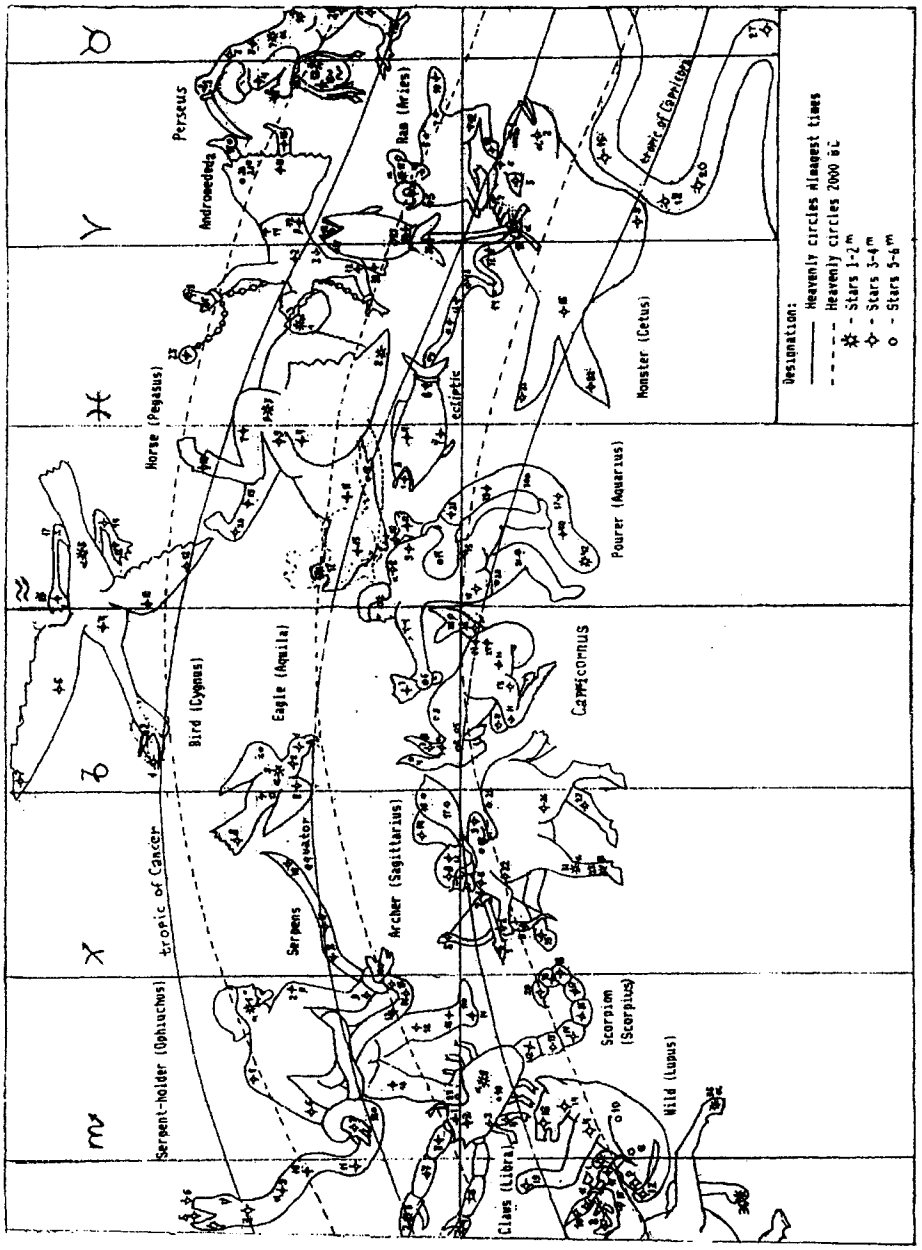

Figure 3 Star map (right side).

Figure 4 Picture of constellation Auriga by A. Dürer (1515).

can presume that there is a mistake in the text (the plural being used instead of the singular). Secondly, the star nearest to the "hoof", No. 18 (π Peg), Ptolemy called "the star on the knee tendon". Possibly, however, in ancient times it marked the end of the leg, therefore, for purposes of dating we took a zone with a radius of 5° around it, which complies both with Ptolemy's designation and our own supposition. The same dimension is accepted by the constellation of Andromeda for the distance from star No. 7, "the northernmost of the three at the end of the right arm" (ρ And) to the elbow which is not marked by stars.

A more difficult situation cropped up when it came to the "knees... of the Charioteer" (Auriga), which are not marked in any way. Stars define only the Charioteer's shin. Dürer portrayed him in a rather unnatural posture, standing on one, the left, knee (Figure 4). The right knee is situated not far from star No. 6 (θ Aur), which lies "on the right wrist". On our map the Charioteer is shown kneeling. For dating purposes we took the zone between the "wrist" and the "edge of the robe" – stars Nos. 6 and 12 (θ and χ Aur) – as in any natural position of the legs the knees just could not be outside these limits.

5 DISCREPANCIES IN THE TEXT AND THE CONSTELLATION FIGURES

Besides the above-mentioned "Horse's hoofs", there are several other discrepancies between the nature of the intersections and the text. Thus, about Perseus the text says that his left shin and shoulder lie on the Tropic of Cancer. Such an interpretation is utterly impossible, yet it fits in well enough with the tropic's intersection

with the left shoulder and right shin. Here we can assume that there is a mistake in the text, and this assumption was accepted when dating.

More complicated was the situation with the constellation of Canis Major. Describing the position of the Tropic of Capricorn, Aratus wrote: "The Hare is on it; of the Dog not much it takes, except his feet" (lines 503, 504). True, the "Dog's feet", stars Nos. 7 and 9 (ν and β CMa) really can "touch" the tropic, but at the same time it intersects likewise the figure of the constellation, leaving Sirius to the north of the "feet".

Fortunately, Hipparchus in his commentary to the poem concerning this perticular point cites Eudoxus' book which served Aratus as a source: 'Eudoxus says: "On it (the Tropic of Capricorn) are the middle of the Goat, the feet of the Water-bearer, the tail of the Sea Monster, the curve of the River, and the Hare, as well as the tail and feet of the Dog, the stern and mast of the Argo, and the Wild..."' (Hipp. 1, 2, 20).

The cited communication shows that Aratus far from always followed the text of the source literally. The intersection of the Dog constellation described by Eudoxus does not contradict reality. Besides, the astronomer mentions the Tropic of Capricorn's intersection with two constellations – the River and the Wild – which Aratus omitted. They were also taken into account when analysing the material.

There are as well slight discrepancies in the description of the constellations made by Aratus and Ptolemy. Some of them have nothing to do with the points of intersection, but in three cases changes were made in the constellation figures to correspond with Aratus' text. This concerns the constellations of the Maid, the Crab and the Horse.

Describing the Maid constellation, Aratus lets fall that next to it is bright star – Vindemiatrix (Vine-grower) – which Ptolemy designates as "the northernmost of the three on the right wing". Consequently, by Ptolemy's time the constellations had somewhat expanded by embracing this star.

More essential is the discrepancy connected with the constellation of the Cancer (named the Crab in "Phaenomena"). Describing its intersection with the Tropic of Cancer, Aratus makes one of his most definite statements: "(the zone cuts)... the Crab beneath the shell from end to end, where a straight line would best divide it with an eye on each side of the zone" (lines 495, 496). As to Ptolemy, he doesn't even mention the stars marking the eyes. It would seem that for Aratus, the role of the "eyes" was played by the couple of northern stars from the group of "four stars on the shell", which Ptolemy does mention. These are stars of the third magnitude, Nos. 4 and 5 (γ and δ Cnc).

A correction was likewise made concerning the Horse's head. The bright star No. 17 (ε Peg) in Ptolemy's catalogue is designated merely as "a star on the muzzle", while Aratus mentions it as the star "on the edge of the chin". Artists place it between the eye and the ear, and the head proves to be hanging lower than the ancients saw it. After the correction, Aratus' statement that the constellation cuts the equator ("on it the Horse's head and neck revolve", line 524) begins to make sense. If the head hangs, the equator cannot touch the neck.

Table 2. The dates

Constellations and place, where they are crossed by the circle	*Circle and group*	*Thousands of years*		*Position of the circle with respect to stars (numbers according to Almagest)*
		from	*to*	
Twins, heads	tn, 1	−3.4	−2.2	between N1 and N2
Perseus, shin and shoulder	tn, 1	−3.2	−2.6	between N16 and N21
Charioteer, knees	tn, 2	−2.6	−1.0	between N6 and N12
Andromeda, right arm	tn, 2	−2.4	−1.4	within 5° south from N7
Serpent-holder, shoulders	tn, 2	−3.6	−1.8	between N4 and N2
Serpent-holder, knees	e, 2	−2.4	−1.0	between N12 and N19
Lion, breast and loins	tn, 2	−2.2	−0.8	between N8 and N23
Crab, between the eyes	tn, 2	−2.4	−1.4	between N4 and N5
Dog, fore feet, tail	ts, 2	−2.4	−1.0	between N9 and 3° from N18
Centaurus, back	ts, 2	−2.4	−0.6	between N1 and N2
Scorpion, sting	ts, 2	−2.4	−2.0	1° from N20
Wild, lies on the circle	ts, 2	−2.4	−0.6	between N16 and N6
Ram, lies on the circle	e, 2	−2.2	−1.2	between N6 and N12
Bull, knees	e, 2	−1.4	−0.6	between N7 and N9
Crow, lies on the circle	e, 2	−3.4	−1.2	between N1 and N4
Maid, a little to the south	tn, 3	−0.4	0.0	3° north from Nil
Monster, tail	ts, 3	−0.6	+1.0	between N15 and N22
Horse, head	e, 3	−0.8	+0.6	between N17 and N22
Horse, hoofs	tn, 4	−2.0	−0.2	between N2 and N18
Hare, lies on the circle	ts, 4	−2.0	0.0	between N12 and N10
Bowl, lies on the circle	e, 4	−2.6	+0.6	between N1 and N7
Claws, lies on the circle	e, 4	−2.0	0.0	between N2 and N5
Eagle	e, 4	−2.8	+2.0	5° south from N1 and N8
River, lies on the circle	ts, 4	−3.0	+2.0	between N1 and N34
Bird, neck	tn, 5	−2.4	+2.0	5° south from N1
Goat, body	ts, 5	−4.4	+1.4	between N5 and N24
Pourer, feet	ts, 5	−5.0	+0.8	between ecliptic and N20
Argo, lies on the circle	ts, 5	−5.0	+2.0	between 1 and N29
Archer, bow	ts, 5	−4.6	+2.0	between N1 and N7
Orion, belt	ts, 5	+0.4	+2.0	4° north from N26
Water-serpent, bend	e, 5	−6.0	+2.0	between N3 and N18

Designations: tn, Tropic of Cancer; ts, Tropic of Capricorn; e, equator.

6 RESULTS OF THE WORK ON DATING

Altogether, 31 intersections were studied. The discrepancies with Roy's data (he earmarked 34) are, most likely, connected with the fact Roy separately examined intersections actually joined together, such as "Perseus' shin and shoulder" or "the Twins' heads". Here they were taken jointly. The dating was conducted for the period from AD 2000 to 4000 BC every 200 years.

The constellations are divided into five groups, depending on what epoch they permit us to date the monument to.

(1) Very ancient dates: epochs up to 2200 BC – two constellations.

(2) Ancient dates: epochs up to 600 BC and not including Eudoxus' era (350 BC) – 13 constellations.

Table 3. Graphic picture of date

Constellations and place, where they are crossed by the circle	*Circle and group*	*Thousands of years* −4 −3 −2 −1 0 +1 +2
Twins, heads	tn, 1	
Perseus, shin and shoulder	tn, 1	
Charioteer, knees	tn, 2	
Andromeda, right arm	tn, 2	
Serpent-holder, shoulders	tn, 2	
Serpent-holder, knees	e, 2	
Lion, breast and loins	tn, 2	
Crab, between the eyes	ts, 2	
Dog, fore feet, tail	ts, 2	
Centaurus, back	ts, 2	
Scorpion, sting	ts, 2	
Wild, lies on the circle	ts, 2	
Ram, lies on the circle	e, 2	
Bull, knees	e, 2	
Crow, lies on the circle	e, 2	
Maid, a little to the south	tn, 3	
Monster, tail	ts, 3	
Horse, head	e, 3	
Horse, hoofs	tn, 4	
Hare, lies on the circle	ts, 4	
Bowl, lies on the circle	e, 4	
Claws, lie on the circle	e, 4	
Eagle	e, 4	
River, lies on the circle	st, 4	
Bird, neck	tn, 5	
Goat, body	ts, 5	
Pourer, feet	ts, 5	
Argo, lies on the circle	ts, 5	
Archer, bow	ts, 5	
Orion, belt	ts, 5	
Water-serpent, bend	e, 5	

Designations: tn, Tropic of Cancer; ts, Tropic of Capricorn; e, equator.

(3) Antique dates: epochs from 800 BC to AD 1000, which embody Eudoxus' times – three constellations.

(4) "Mixed" dates, covering the period between 2000 BC and AD 1600, i.e., both the ancient and antique epochs – six constellations.

(5) Indefinite dates, i.e., constellations whose intersections remain for a very long time or are altogether absent, such as Orion – seven constellations. When analysing the material, the constellations belonging to this group were excluded from the study.

The division of the constellations by groups is shown on the general map (Figure 5). The data received can be seen in Table 2, and the same data in graphic form in Table 3.

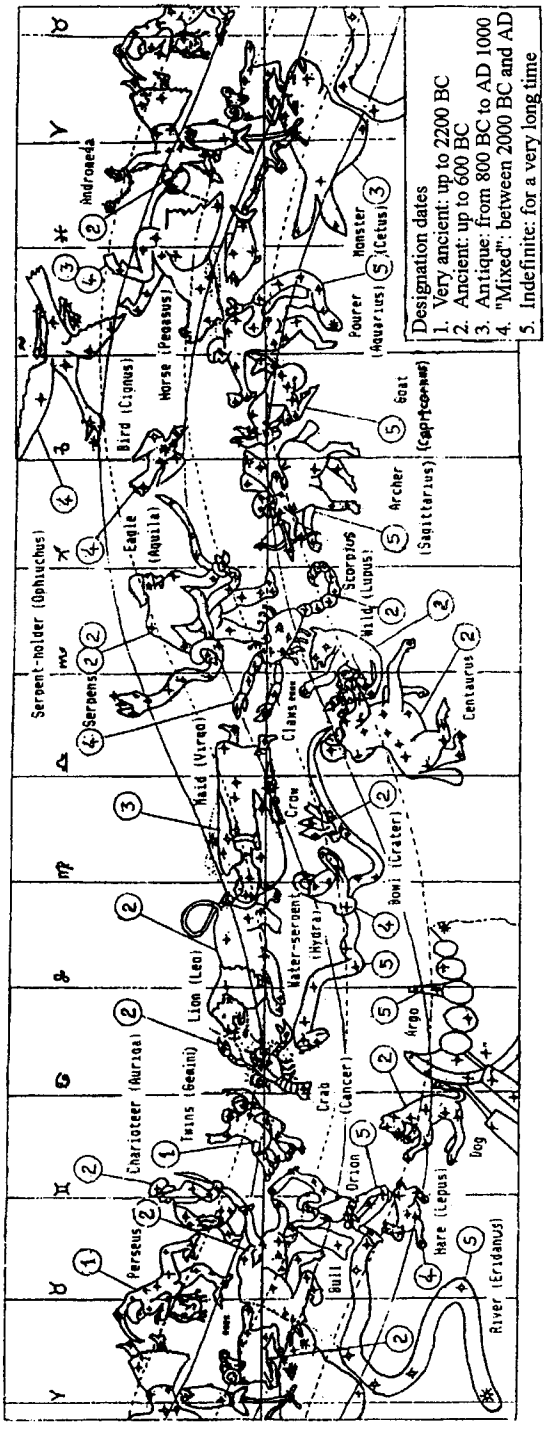

Figure 5 General star map.

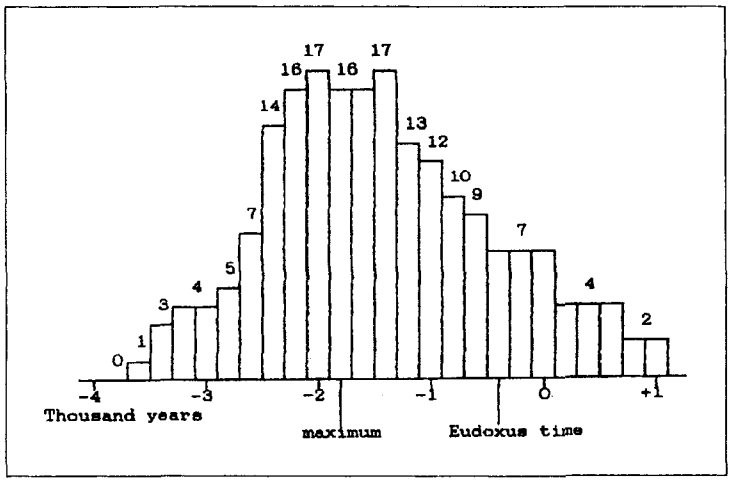

Figure 6 Number of relevant dates.

7 AN ANALYSIS OF THE RESULTS

To analyse the data received we made use of the method suggested by A. Roy – to sum up by epochs those facts of the intersection of the celestial circles with the constellations that agree with the text. All significant datings were given one and the same score: 1. The results were put together in Table 4 and shown on a histogram (Figure 6). Our investigation confirmed A. Roy's conclusion on the statistical maximum observed on the borderline between the 3rd and 2nd millennia BC – the time, most likely, that the material of the monument was pinpointed.

Yet the intersection of the circles with the constellations of the Maid, the Horse and the Sea Monster definitely points to the antique epoch. This can, probably, be explained only by the subsequent partial editing of the text. The choice of the constellations which the text "correction" touched on was far from incidental – all of them are situated near those points on the zodiac that in antique times marked the equinoxes. It is quite possible that Eudoxus or one of his predecessors observed

Table 4. Number of relavant dates

Thousand years	−4.0	−3.8	−3.6	−3.4	−3.2	−3.0	−2.8	−2.6	−2.4
Number	0	0	1	3	4	4	5	7	14
Thousand years	−2.2	−2.0	−1.8	−1.6	−1.4	−1.2	−1.0	−0.8	−0.6
Number	16	17	16	16	17	13	12	10	9
Thousand years	−0.4	−0.2	0.0	+0.2	+0.4	+0.6	+0.8	+1.0	+1.2
Number	7	7	7	4	4	4	2	2	2

the rise and set of the Sun and stars during the equinoxes, and noticed the disparity in the position of the circles in the text of the primary source in connection to these constellations.

There can hardly be any other explanation for the results of this work than that the primary source of Aratus' poem was created long before the pre-polis period in Hellenic civilization. This conclusion, in turn, calls for an answer to several questions.

How could the creators of the primary source, the "astronomers" of the Aeneolithic age, observe and pinpoint the intersections of the constellation figures with the celestial circles?

Could it be that in that epoch they had a clear notion of the celestial equator and the tropics? What were their notions of the structure of the world?

In what way could the ancients' astronomical knowledge become the possession of the Hellenic scholars? What effect did it have on the development of Greek and, consequently, world astronomy?

To this day one can no more than advance hypotheses on the subject.

8 CELESTIAL CIRCLES AND "HORIZON" ASTRONOMY

The pinpointed epoch of the creation of the primary source of Aratus' poem is marked by a wide diffusion of archaeoastronomical monuments of the Stonehenge type. Archaeologists have discovered a great many sanctuary-cum-observatories with orientators indicating the rise and set of the Sun at times of solstices and equinoxes. These points earmarked on the horizon directly relate to the celestial equator and the tropics. Quite true, the celestial equator passes through the points of the Sun's rise and fall during equinoxes, and the Tropics of Cancer and Capricorn, through the points of its rise and fall during solstices. Therefore, the priest-

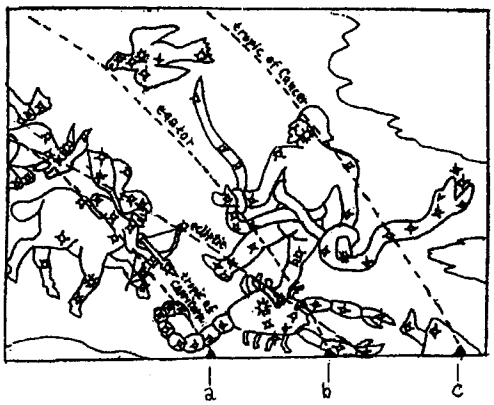

Figure 7 The picture shows the setting of constellations at 36° North in approximately 2200 BC. (*a*) the point of sunset during the winter solstice, (*b*) equinox, (*c*) summer solstice.

astronomer of such an observatory, observing the rise and fall of the stars in points of the horizon earmarked by the orientator, automatically received data on the tropics and equator cutting the constellations. Knowing the Sun or Moon's inclination near the horizon, he could mentally follow their way to the intersection with the stars in familiar constellations. The possible sketch of such an observation is shown on Figure 7. As Roy remarked, knowledge of the equatorial and tropic constellations could have served as a reliable navigational aid. The skill of orienting oneself at night could have been useful not only to seamen but to nomad cattlebreeders as well.

The second part of the poem, which is totally devoted to the simultaneous rise and set of the constellations, is evidence of the connection of the primary source with "horizon" astronomy. Michael Ovenden's work is based on its analysis.

9 THE ASTRONOMICAL NOTIONS OF THE PRIMARY SOURCE'S CREATORS

In his poem Aratus almost always calls the sky Zeus. The fact that the sky is given the name of the supreme god and not, say, of Uranus, the god of the starry sky, shows that something more than a mere poetic licence is behind this epithet. Scholars of the "Phaenomena" see in it the influence of the Stoics' philosophy which idolized the Universe. However, more ancient roots of this tradition, linked with Orphism, are also indicated. Thus, in the hymn to Zeus from the "Rhapsodical Theogony", whose possible author is considered to be Kerkop, a Pythagorean, the "body of Zeus" is identified with the sky (DK1, B1, 68, 7–8). Consequently, the idolization of the sky was, most likely, already present in the primary source and was upheld, since it became a natural element of Hellenic culture as well.

Let us now turn to the text of the poem. In it the vault of heaven is looked upon as something solid, regularly revolving and carrying the immutable stars that are rigidly attached to it. A direct reference to this can be found in lines 251–253 of the poem. It also contains very definite ideas on the closed nature of the celestial sphere embracing the Earth, on the poles, the axis of the world and the major celestial circles (lines 21–23):

> Yet never doth the axis change the least,
> Aye fixed e'en as it is; and has in midst
> The earth in equipoise, and carries round the sky.

Further on, lines 525–529 give a description of the mutual disposition of the axis, the equator, the tropics, and the zodiac. It is difficult to say whether this description belonged to the primary source or was added later on, yet beyond doubt the authors of the source had a clear notion of the disposition. It should be noted that the picture drawn by the poet fully corresponds to the original premises of modern spherical astronomy.

The poem contains traces of the archaic notions of a flat Earth, possibly floating in primitive waters. Aratus everywhere calls the horizon the Ocean, which is in accordance not only with the ancient Greek myth, but also with the even more

ancient Vedaic one about the World Egg swimming in the waters. Both these myths are linked with the ideas of the flat Earth and the existence in nature of the absolute direction up-down. These ideas are completely impossible for Eudoxus who strove to prove the sphericity of the Earth, so their presence in the poem throws doubt on his authorship.

There is direct reference to the flatness of the Earth – Aratus calls the horizon "the earth". Of the equator he writes: "In midst of both, vast as the Milky Way, a circle trends neath earth like one in twain" (lines 511–512). The notion of the flat Earth is confirmed by the fact that the poem speaks of the inclination of the tropics towards the horizon. Ending his description of the Tropic of Cancer, Aratus writes: "Signs eight in number measure out the band, five roll above the earth in upper realms, and three below". There is a similar remark about the Tropic of Capricorn, but in it "in upper realms" there are three signs and below the horizon there ere five.

In the described position the tropics are seen at a latitude of about 49°. Should Eudoxus be the author, the very fact that this magnitude was pinpointed would be illogical. If is well known that though the scholar was not as yet aware of the method of defining latitudes, he clearly understood their significance. Should Eudoxus himself have compiled the astronomical part of his book, he could have added: "That is how the tropics appear in Scythia, while in Athens this ratio is already equal not to 3/8 but to 2/5".

One need not expect any particular exactness in the above data. Evidence is the rough division of the celestial circles into eight parts. A rounding off of the observational results appears to be more probable than their actual multiplicity of one-eighth of a circle.

Of the unquestionable conclusions connected with the present investigation mention should be made of the fact that the ancient astronomers did have an idea that when setting beyond the horizon the heavenly bodies passed under the Earth.

10 A VERSION OF THE PRIMARY SOURCE'S ORIGIN

The pinpointed area of observation of the sky described by Aratus was at a latitude of about 36° N, i.e., considerably to the north of the places where at that time (the border between the 3rd and the 2nd millennia BC) the developed civilizations – the Sumerian and the ancient Egyptian – were located.

The fact that the primary source of Aratus' poem appeared far before the birth of antique civilization is confirmed by the existence of some, probably oral, unbroken tradition which passed on to the Greek scholars of the classic era the picture of the starry sky drawn by the ancient astronomers. More likely than not, this source was of the nature of a religious precept, which explains the "conservation" of its material and its extremely long life.

Here is one of the possible hypotheses of the origin and fate of the primary source: the archaic features preserved in the poem permit the assumption that it was created by a people linked with the mythology of the "World Egg" belonging to the Vedaic

Aryans. Traces of the World Egg myth can be found in Persian Zervanism and Greek Orphism, which have quite a few features in common. A. V. Lebedev notes the links between the philosophy of Anaximander and Orphic notions (Lebedev, 1978). The same links are known to exist among the Pythagoreans, too. It cannot be ruled out that the Greek translation of the primary source served the Orphics as a holy text.

According to Sudas, among Anaximander's writings there was one called "On Immobile Stars" (DK12, A2). Possibly, it was based on this Orphic text. Anaximander's book or the orphic "precept" could have been valued by the Pythagoreans who were also very close to Orphism. Well known is the fact that Eudoxus learnt astronomy from Archytus of Terentinus, a Pythagorean. Perhaps it was from his teacher that Eudoxus received a copy of the primary source, the text of which he later used in writing his "Mirror".

11 CONCLUSION

Summing up everything said above, we can note that: Aratus' poem "Phaenomena" may be considered a unique literary work. The astronomical date it includes permit us to assume that its primary source was crested at the beginning of the 2nd millenium BC at a latitude of about 36° N. Therefore, it allows us to some extent to judge what the notions of the creators of the archaeoastronomical monuments of the Stonehenge type and their contemporaries were like.

Our study confirmed that the description in the poem of the intersections of the celestial tropics and equator with the constellations was based on ancient observations. That means that these celestial circles, as well as the passage of the heavenly bodies under the Earth, were already known to the creators of the primary source.

Noted is the probable connection of the poem with "horizon astronomy". Suggested is a hypothesis on the way in which the ancient astronomers were able to find the points of intersection of the celestial tropics and the equator with the constellation figures. It was, most likely, based on the employment of observatory-sanctuaries which marked the points of the rise and set of the Sun during equinoxes and solstices.

It might be presumed that the primary source of the poem was a verbal canonized description of the starry sky, and that its nature was that of a religious commandment. That explains why it has been preserved for 15 centuries without any substantial editing.

It might likewise be presumed that the astronomical notions of the creators of the primary source about the closed celestial sphere surrounding the Earth, about its rotation, about the celestial equator, tropics and zodiacal circle were founded on the myth of the World Egg that belonged to the Vedaic Aryans. Aratus' poem contains traces of the archaic ideas of a flat Earth possibly floating in the Ocean. Calling for attention is also the rough division of the celestial circles into eight parts, rather unusual for the astronomy of later times.

Accepting the ancient dating of the source used by Eudoxus obliges us to recognize the existence of an unbroken tradition linking the culture of the creators of the description of the starry sky with the founders of originating antique science. These links were realized through a certain religious trend that in Greece took the form of Orphism.

Accepting the existence in ancient times of developed astronomical notions brings historians of ancient cultures, first and foremost, archaeoastronomers, up against the problem of whether these notions were widespread or unique, the problem of their influence on the further development of science.

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Appendix. The fragments from Aratus' "Phaenomena"

1. The section dealing with the Tropic of Cancer:

The northern blast dawn-sweeping one is near,
And on it moves the heads of either **Twin**:
The knees, too, of the neighbouring **Charioteer**,
Perseus' left shin and shoulder lie on it,
The right hand of **Andromeda** it holds
Above the elbow: but the hand itself
Lies higher, nearer north, whilst south the elbow turns.
The **Horse's** hoofs, the **Bird's** neck, and the head,
And the bright shoulders of the **Serpent-holder**
Around the zone, as driven on, revolve.
A little to the south is borne the **Maid**,
Nor touches it, as do the **Crab** and **Lion**.
These two lie placed together. But the zone
The one beneath the breast and belly cuts
Unto the loins: the **Crab** beneath the shell
From end to end, where a straight line would best
Divide it with an eye on each side of the zone.
Signs eight in number measure out the band,
Five roll above the earth in upper realms,
And three below: in it the summer trunings are.
And in the north tis fixed about the **Crab**.

2. The section dealing with the Tropic of Capricorn:

Another in the fronting south divides
The **Goat**, the **Pourer's** feet, the **Monster's** tail;
The **Hare** is on it; of the **Dog** not much
It takes, except his feet; **Argo** is on it,
The **Centaur's** mighty back, the **Scorpion's** sting,
And on it is the glittering **Archer's** bow.
From the clear north when passing to the south
This last the sun arrives at, here he turns
In winter. Of the eight three roll on high,
The other five revolve below the earth.

3. The section dealing with the equator:

In midst of both, vast as the Milky way,
A circle trends neath earth like one in twain;
And on it twice are equal days and nights,
At summer's close and when the spring begins.
As mark there lies the **Ram**, and the **Bull's** knees;
The **Ram** along the circle stretched at length,
But the **Bull's** crouching legs alone appear.
And on it the bright **Orion's** belt,
The **Water-serpent's** gleaming bend; The **Bowl**
But small, the Crow, some few stars of the **Claws**;
The **Serpent-holder's** knees are in it borne.
It does not share the **Eagle**, messenger
Of might who flies nigh to the throne of Zeus.
On it the **Horse's** head and neck revolve.