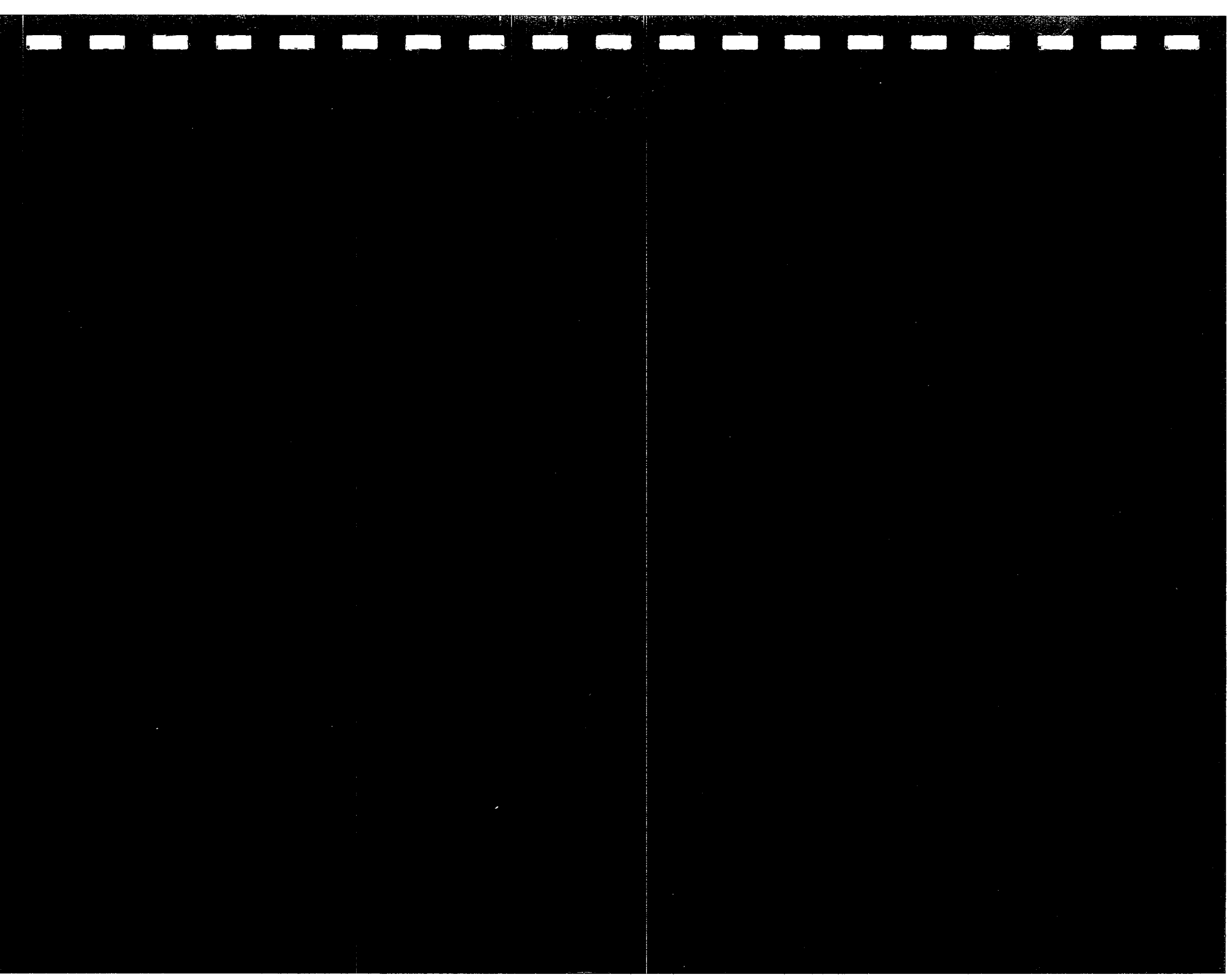
Astronomical and Physical Observations of the Axis of Rotation and the Topography of the Planet Mars

First Memoir, 1877-1878

Giovanni Virginio Schiaparelli

Translated by William Sheehan

Published by the Association of Lunar and Planetary Observers
A.L.P.O. Monograph Number 5
October, 1996



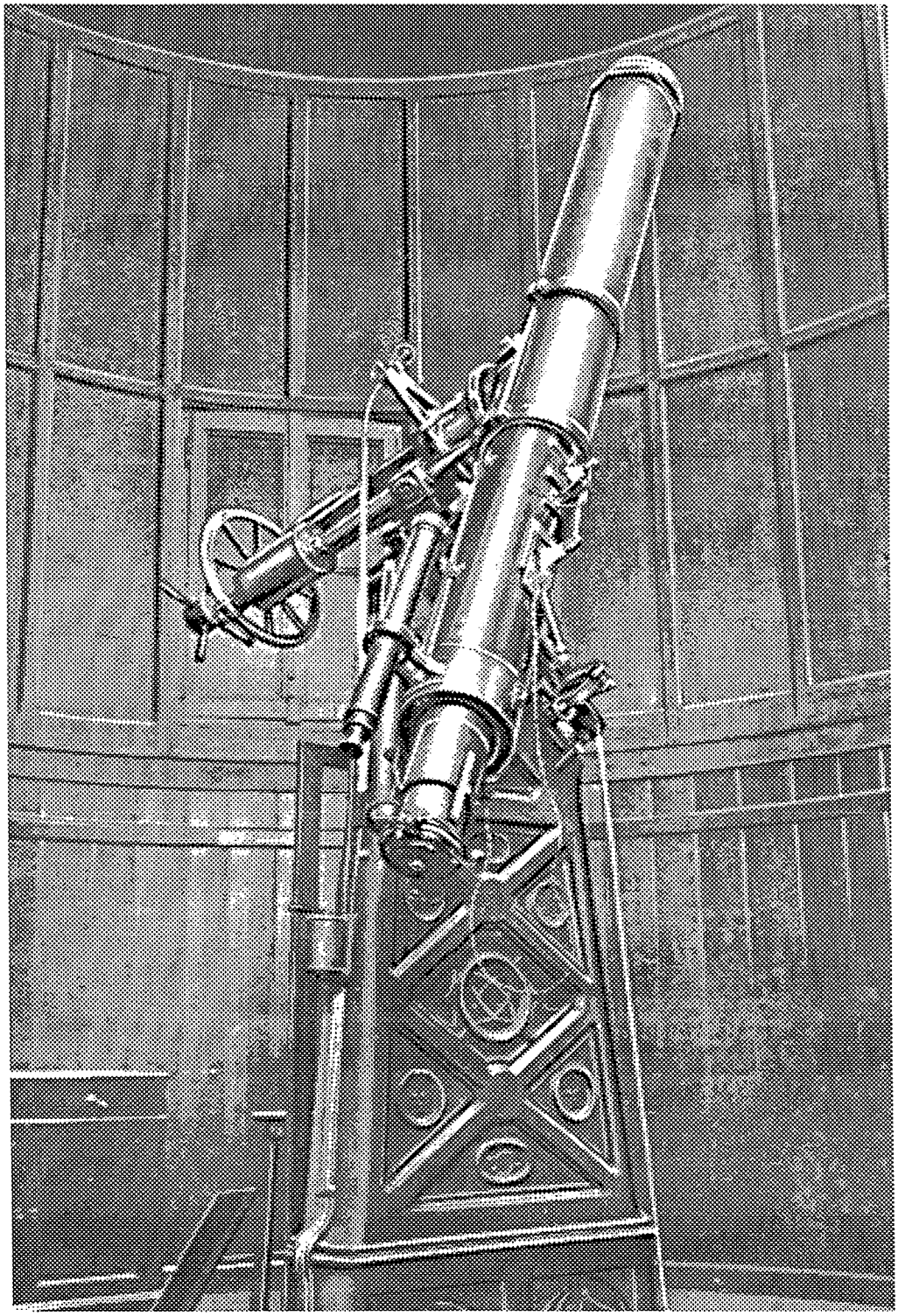


Figure I. Merz refractor, 21.8-cm aperture used for Mars observation. Brera Observatory of Milan, Italy.

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Foreword

by William Sheehan

1877 was a landmark year in the study of Mars. The planet came to a favorable opposition and approached within only 35 million miles (56 million kilometers) of the Earth. Taking advantage of this opportunity, Asaph Hall discovered the two dwarf satellites using the 26-inch (66-cm) refractor of the US Naval Observatory at Washington, DC, while Giovanni Virginio Schiaparelli, with the 8.6-inch (21.8-cm) refractor at the Brera Observatory of Milan, began his pioneering investigation of the planet's polar caps, surface, and atmosphere.

Schiaparelli's *Memoria Prima*, in which he described his observations made between September 1877 and March 1878, is undoubtedly one of the most important works on Mars published in the pre-spacecraft era, yet strangely it has never appeared in English. In this work, he published a map which was more accurate than any that had gone before it (though he himself was modest enough about what he had accomplished, and pointed out that he had brought areographical studies only to the point that terrestrial geography had achieved in the time of Eratosthenes and Ptolemy). Moreover he introduced upon it the nomenclature which is now so familiar, giving currency to such romantic names as Solis Lacus, Juventae Fons, Chryse, Elysium and Tharsis. His map also showed the famous *canali*—a term which I have here rendered as "channels," since evidently that comes closest to what Schiaparelli himself had in mind, though the term which was later adopted in English, with only too fateful consequences, was "canal." Clearly many of the *canali* recorded traces of real features lying at the threshold between visibility and invisibility, and their detection bears out E. M. Antoniadi's claim that as "a record of fleeting impressions, Schiaparelli's stands unrivalled." Finally, it was in 1877-78 that Schiaparelli made the first detailed observations of what later were recognized as dust clouds on Mars.

Schiaparelli carried out further observations of the same high quality at the opposition of 1879—among other things, he discovered a small whitish patch, which he named Nix Olympica (the "Snows of Olympus"); it has now been shown to correspond in place with the mightiest of the Martian volcanoes.

Unfortunately, from 1881-82 onward, Schiaparelli's drawings and maps are not so good. In part this may be explained by the fact that the planet was by then retreating through a cycle of less favorable oppositions, but this can hardly be the full explanation—after all, some of the best results in 1877-78 had been obtained when the disc was equally small. His later drawings and maps are marred by the presence of bizarre doublings which affected most of the *canali*, and which he referred to as "geminations." Though Schiaparelli was convinced that what he was seeing was real, there can no longer be any doubt that the effect was purely optical—apparently it involved some form of astigmatism, and indeed Schiaparelli's vision began to deteriorate in later years (even in his prime, he was badly nearsighted—something that did not matter at the eyepiece—and suffered from red-green color blindness). It is probably no coincidence that in 1882, when the geminations began to appear with alarming frequency, he had just commenced his long series of observations of the planet Mercury near the Sun, which in 1889 led to his celebrated announcement of the "captured" rotation period of that planet (it was considered a triumph of observation at the time, but is now known to have been incorrect). These observations of Mercury, as he later admitted, were "dangerous" to the eyesight and "reduced his sensitivity to faint illuminations." By the 1890s, his field of vision was growing darker, and he began to notice distortions of the images. Nevertheless, he continued to make at least occasional observations of Mars as late as 1909—they show the canal network in characteristic form—though he did not publish any made after 1890. He died in July 1910.

But though his later results were untrustworthy, in returning to those of 1877-78 we have the privilege of seeing a great master at work. Even now there is much to be gained from following at first hand his descriptions of the revelations that awaited him at the eyepiece during that exhilarating season of Martian discovery. Most of what he recorded can still be traced by the ob-

server with a good telescope when Mars is favorably placed, since, though changes take place over time due to the scattering of windblown dust around the surface, overall the main markings of the planet are stable. The reader who has formed his impressions based on Schiaparelli's role in the notorious Martian canal controversy will come away with a very different impression, and discover that Schiaparelli still has much to say to the Martian observer even today.

Hutchinson, Minnesota
December 1994

NOTE ON THE TEXT

Schiaparelli's work was published as "Osservazioni astronomiche e fisiche sull'asse di rotazione e sulla topografia del pianeta Marte, fatte nella Reale Specola di Brera in Milano coll'equatoriale di Merz durante l'opposizione del 1877." The texts I have followed here are: for parts I, II, and IV, the abbreviated version with the same title, which appeared in *Memorie della Società degli Spettroscopisti Italiani*, Appendice al volume VII (Palermo, 1878). Part III, which contains Schiaparelli's detailed descriptions of the Martian surface and which he himself stated "is not readily susceptible to abbreviation or extracts," is from his *Memoria Prima*, in *Atti della R. Accademia dei Lincei*, anno CCLXXV, 1877-78, serie III. Both are reprinted in *Le Opere di G. V. Schiaparelli*, pubblicate per cura della Reale Specola di Brera (Milano, 1930), vol. I.

Introduction

When in August 1877, Mars approached one of its more favorable oppositions, I directed my attention to this planet, not intending from the beginning to devote myself to a continuous series of regular observations. Instead I desired only to experiment to see whether our Merz refractor, (see *Figure I, frontispiece)*which had given such good performances on double stars, possessed the necessary optical qualities to permit the study of the surfaces of the planets. I desired also to verify for myself what books of descriptive astronomy had to say about the surface of Mars, its spots, and its atmosphere. I must confess that on comparing the aspects of the planet with the recently published maps, my first attempt did not seem very encouraging. I had the misfortune of making my first observations on those parts of the surface of Mars that had ever been the most difficult and doubtful: that is, the region designated in this memoir with the name of Mare Erythraeum [the ancient name for the Persian Gulf and the Indian Ocean]; also that which, according to the diurnal rotation of the planet, immediately follows the Mare Erythraeum onto the disk. At first, I didn't know how to orient myself at all. Only later, and then with difficulty, was I able to recognize any of the forms on the planet which are shown in my drawings. But when I began to examine closely the very handsome sketches made by Professor Kaiser and Mr. Lockyer at the opposition of 1862, I found that the configurations they showed were almost identical to those in 1877, and that their sketches agreed in essential respects with my own. Thus I was able to convince myself that, despite some disagreements, I saw the planet as others had seen it; that the apparent differences were due to the different ways observers have of representing things, and that on the whole, much remained to be done on the topography of the planet, even with the limited means at my disposal. I therefore resolved, on September 12, 1877, despite the fact that the opposition had already passed on September 5, to make observations whenever possible. The atmospheric conditions favored my plan, by allowing me to depict the southern hemisphere of the planet completely and with a great abundance of detail, as well as to make a start on the northern hemisphere as far as latitude 40° north. The magnification used was almost exclusively 322×, which was produced by our positive ocular IV. Only in January, February, and March 1878, when the apparent diameter of the planet was reduced to a few seconds of arc, did I find it necessary to employ our negative ocular V, which gives a magnification of 468×.

My basic plan was to describe the planet, not by making disc drawings or portraits of Mars based on eye estimates only, but by relying thoroughly on geometric methods. To this end I have first determined the basis of all areography, that is the direction of the axis of rotation and the position of the south polar cap. In like manner I have measured micrometrically on the surface of Mars a certain number of fundamental points, from which to deduce the areographic coordinates of latitude and longitude. From these last, the topographical description of the regions in between can be inferred without too much uncertainty from the sketches, precisely in the way that a geographer finishes the description of a country on earth by interpolating between the geometrically determined points.

In preparing this memoir, I have utilized every possible opportunity for observing the planet between September 1877 and March 1878. To each of the three subjects just mentioned I have devoted one chapter. A fourth summarizes the observations of a physical nature, and contains discussions relative to the constitution of the surface of the planet and its atmosphere. The map of the planet which is included here, although still necessarily very defective, is nevertheless richer in detail than any others that have been published: the advantage in this respect owing to the excellent definition supplied by our Merz refractor. This noble instrument, despite its modest size*, has revealed an abundance of minute objects, which during previous oppositions have escaped the gigantic telescopes of which other nations justly boast. No doubt considerably more could have been achieved had I been able to use a lens like those which are the splendid ornaments of the observatories of Vienna, Gateshead, and Washington. But I am satisfied at present with what I have been able to achieve, and have made up for the inferior optical power of my instrument by my diligence.

* Focal length 3.25m, aperture 218 millimeters.

Part I: Determination of the Axis of Rotation

The geometric description of the surface of Mars requires that one know as exactly as possible the direction on the apparent disc in which the polar axis of the planet projects at any moment. This can be determined with high precision, and is greatly facilitated by the fact that one can observe the movements of the snowy patch that lies a short distance from the observable pole (in 1877 the southern pole). If we imagine for any given time a straight line drawn from the center of the disk to the center of that patch, this line will, during the daily rotation of Mars, describe a conical surface, and the generatrix of that surface gives the apparent direction of the axis which is the true axis of the planet. With this purpose in view, I obtained, between September 12 and October 13, 1877, sixty-six measures of the position, relative to the center of the apparent disc, of that point on the polar canopy which could be considered the point of brightest intensity. Although during this interval the polar snows underwent marked changes in size and form, it seemed that the position of this point remained immovable on the surface of Mars, or at least sufficiently so for me to accomplish my purpose. The calculations from these observations proves that the direction of the axis as determined long ago by Bessel is in need of essential revision, and needs to be turned counterclockwise 1°40' in order to give perfect agreement with the observations. The corrections to the inclination with regard to the visual ray are negligible, or at least indistinguishable from the errors of observation. From the final measure of the zero of areographic longitude in the cape designated on my chart Fastigium Aryn,† I find that the center of the southern polar snows during the interval covered by my observations occupied the position:

Longitude	29°.466 with probable error 1°.077
Southern latitude	83°.853 with probable error 0°.123

The uncertainty of these two coordinates, translated into linear measures, would not be more than about 7 kilometers in the sense of the parallel, that is the meridian. But they will be considerably greater if, as is probable, the apparent center of the snows has suffered any small displacement in consequence of the melting which was apparent and continuous throughout the period of the observations.

† The Vertex of Aryn or Dome of Aryn was, according to some of the Arab cosmographers, an imaginary point in the Indian Ocean, situated on the terrestrial equator at the exact midpoint between the eastern and western limits of the known earth, which for them served as the origin of longitudes. The Vertex of Aryn of my chart is identical with the point designated by Maedler with the letter A which has also been taken by this astronomer as the origin of longitudes; however, he has counted them from right to left, not from left to right as I have done.

Part II: Determination of the Fundamental Points

In order to establish the topography of Mars on an exact basis, I have followed the same principles that have been adopted in terrestrial geography. A certain number of points, distinct and easy to recognize, distributed with as much uniformity as may be over the surface of the planet, creates a fundamental network for which the positions are determined with the greatest possible precision. Between these are interpolated the lines of the tracing and the minute details by simple estimates of the eye. The selection, measurement, and calculation of this network, and the compilation of a catalog of areographic latitudes and longitudes, makes up the second problem [after the determination of the axis of rotation] that presents itself in the geometric description of Mars.

The fundamental points which I have chosen for the application of these principles are sixty-two in number, and can be located readily on the chart, where each is marked with the number corresponding to that given in the catalog below. Not all are definable with equal exactness, nor are all equally opportune for measurement. Given the limits of time and the almost total novelty of my purpose, I was required to measure first those points that were well known and represented on previous charts, and have proceeded cumulatively by taking measures each time the object presented itself in moments of good seeing, without being able to ascertain whether there were better points available for measurement in the near vicinity. These points were, then, determined in some cases more than once, and for the sixty two points there were 124 measures taken in all.

An idea will be had of the degree of precision attained by noting that the probable error of a measure not too close to the pole is 1°.94 in latitude and 1°.81 in longitude. The following table contains the catalog of fundamental points: the first column gives the numbers corresponding to those on the chart; the second the name or description of the points; then the areographic longitude and latitude (southern indicated with a - sign, northern with a + sign);* and in the last column the number of measures obtained.

When only one measure was obtained, it was for both the latitude and longitude. Where there were two measures, the first was for the longitude, the second for the latitude.

Table of the Areographic Positions of the Fundamental Points

No.	Denomination	Long.	Lat.	Number of determinations
1	Vertex of Aryn	0°.00	-4°.56	1
2	Second horn of Sinus Sabaeus	3 .54	+2.37	1
3	Isthmus of Deucalion land	17.82	+2.52	2, 1
4	Shading on the same isthmus	17.83	-4.56	2, 1
5	Margaritifer S., mouth of Indus	23.59	+4.90	3
6	Mouth of the Hydaspes	27.38	-4.41	1
7	Aromata Promon.	38.40	-8.30	2
8	Horarum Prom. in Argyre	39.78	-39.38	2
9	Charitum Prom. in Argyre	51.86	-53.84	2
10	Aurorae Sinus, mouth of Ganges	55.74	-2.32	2
11	point of Aurea Cherso	61.49	-25.26	2
12	first point of Thaumasia	66.36	-23.79	3
13	confluence of Chyrsorrhoas/Nilus	84.16	+18.88	1
14	Solis Lacus, center	90.24	-25.22	3
15	Lacus Phoenicis, center	106.45	-19.42	2

Continued.

* Schiaparelli indicated southern with a + sign and northern with a - sign, to correspond with the view in the telescope; but to avoid confusion, I have adopted the more usual, modern, convention. [Trans.]

Table of the Areographic Positions of the Fundamental Points—*Continued.*

No.	Denomination	Long.	Lat.	Number of determinations
16	Mouth of Phasis	106.93	-44.88	2
17	Herculis Columnae, mouth external	119.81	-44.88	2
18	Icaria, center	119.92	-37.86	1
19	first point of Mare Sirenum	131.37	-31.32	2
20	first point of Thyle I	134.12	-65.08	1
21	Herculis Columnae, mouth internal	138.02	.....	2, 0
22	center of Thyle I	151.86	-65.08	1
23	southern base Atlantis I	159.80	-37.54	1
24	first point of Mare Cimmerium	165.80	-37.49	2
25	gulf of Titans	174.24	-18.17	1
26	ultimate point of Mare Sirenum	176.52	-25.34	2
27	Ulysis Fretum, middle	187.08	-74.08	1
28	point on southern bank of Oceanus	188.15	+7.12	1
29	river Laestrygonum, mouth on Oceanus	200.19	+4.50	1
30	Gulf Laestrygonum, inner sinus	201.79	-18.01	3
31	Scamander, mouth on Mare Chronium	202.52	-55.41	2, 1
32	Scamander, midpoint	202.57	-48.98	2, 1
33	river of Cyclops, mouth on Oceanus	205.05	+15.77	2
34	southern base of Hesperia	211.10	.....	1, 0
35	northern prom. Thyle II	221.61	-62.28	1
36	center of Thyle II	223.53	-69.93	1
37	gulf of Cyclops	224.98	-12.43	4, 2
38	first point on Mare Tyrrhenum	226.41	-37.81	3
39	center of Hesperia	231.62	-22.79	1
40	southern mouth of Xanthus	234.11	-51.13	3, 2
41	ultimate point of Mare Cimmerium	238.87	-9.85	2
42	Hesperia, northern base	250.28	-13.22	2, 1
43	Syrtis Minor	256.94	-6.24	4
44	Prom. Circeum in Ausonia	266.59	-15.68	2
45	point on coast of Ausonia	266.79	-22.70	1
46	Lacus Triton	267.15	+20.38	3
47	first point of Hellas	270.74	-49.49	3
48	Lacus Moeris	277.09	.....	1, 0
49	bifurcation of Ausonia	282.32	-13.33	1
50	conjugation of Nepenthes with Nilus	286.25	+28.26	1
51	Syrtis Major and mouth of Nilus	290.45	+17.09	6, 5
52	southernmost point of Hellas	.....	-57.99	0, 2
53	center of Hellas	294.12	-46.30	4
54	northernmost point of Hellas	.....	-30.38	0, 2
55	ultimate point of Mare Tyrrhenum	296.09	+0.67	2, 1
56	ultimate point of Hellas	315.07	-44.08	4
57	Hammonis Cornu	318.32	-10.40	4
58	Scylla et Charydbis	324.17	-20.31	2
59	Hellespontus, midpoint	326.11	-48.22	3, 2
60	first point of Noachis	334.82	-48.40	2
61	mouth of Phison in Sinus Sabaeus	338.85	-5.05	2, 1
62	first horn of Sinus Sabaeus	357.27	+2.37	1

A comparison between these results and twelve definite points measured by Maedler at the opposition of 1830 and another eight by Kaiser at the opposition of 1862 shows a general agreement, which indeed is as perfect as one can expect. It proves that the formations delineated on our chart are truly stable and have not undergone sensible changes in the interval of forty-seven years.

Description of the Chart

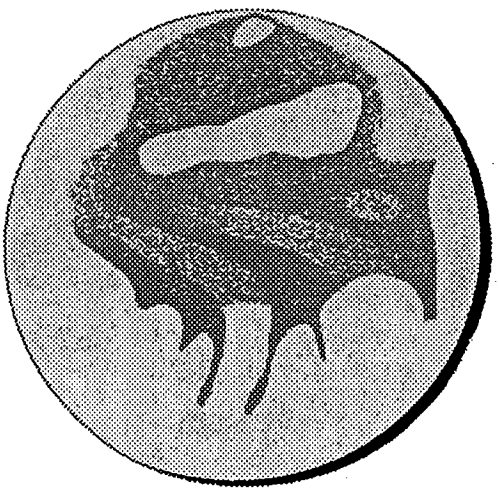
The projection was made by indicating the fundamental points, according to the given coordinates, and then tracing in the lines and marking the shadings by direct observation at the eyepiece. The sketches used were of two kinds: complete discs numbering thirty-one in all, and sketches of particular regions of the planet of which there were about 100. It has often happened that an instant of excellent air allowed the discovery of new minute details that were not indicated in the general sketch of that evening. In such cases, the precious instants did not allow the entire disc to be redrawn, but only those parts were sketched which at the moment seemed to be of the greatest importance. Many times a sketch was not deemed satisfactory enough, and another was made, until the final likeness was acceptable. In all of these drawings I have tried to obtain accurate representations of the details relative to the larger markings. These relationships are a good deal more certain in the case of the fundamental points than for those obtained by mere estimates of the eye, since that is easily deceived by the continual changes which the rotation of the planet produces in the aspects of the visible disc. [Four sample sketches are shown in *Figure II*, p. 6.]

The opposition having taken place on September 5, 1877, one might expect that the most favorable period for the exploration of the planet would have been during the months of August and September, when the apparent diameter of the planet ranged from 20" to 25". Instead, however, the views obtained during the month of October were generally more favorable, even though the diameter was then between 16" and 20"; indeed the most delicate explorations belong exclusively to this month, when on some evenings the condition of the air was superb, and allowed the full defining power of our Merz refractor to be used to advantage. Nevertheless, the searches performed in succeeding months up to March 1878, when the diameter of the planet was reduced progressively from 16" to 6", were not entirely fruitless, because during that interval the clouds that in preceding months had covered the greater part of the zone between the equator and 40° northern latitude disappeared. Thus despite the smallness of the disc it was possible to delineate a great number of details which until then had been invisible. I am hopeful that eventually many of them will be confirmed by other astronomers. It is clear that for areographic researches, the quality of the atmospheres of the Earth and Mars are more important factors than the apparent diameter of the disc. From this the corollary follows that it should be possible to do valuable work even at those oppositions in which Mars does not make its closest approach to the Earth.

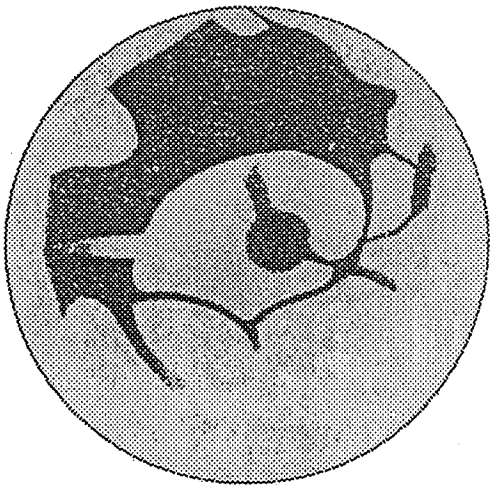
The interpolation of distinctive details between the fundamental points is easy enough, in most cases. However, it has happened sometimes (especially in places where the fundamental points are further apart than on average) that it is not possible to combine the positions of these points with the tracings of the sketches, without doing great violence to them. Then I have tried to adapt the sketches to the fundamental points less exactly, but still within the limits of error which could be assumed for these objects. The principal cases in which this was so concern the points 7, 16, 22, 27, 36, 39, 45, 59 and 60. Further work at the next oppositions of Mars, by increasing the exactness of the catalog, should resolve many of these difficulties.

Our chart is based on the projection of Mercator, and has the inevitable defects inherent in such a projection in that it presents regions of different latitude on a different scale. In order to make clear the connection of regions occupying the right edge with those on the left, I have repeated the corresponding parts of the projection. Finally, the northern part of the chart is truncated at the 40° parallel, since beyond this it was not possible to secure satisfactory observations at this opposition. The missing zone and in general the entire northern hemisphere of the planet will be better presented at the oppositions of 1881 and 1884. [The Mercator chart is shown in *Figure III* (p. 7) and the chart of the southern hemisphere in *Figure IV* (p. 8).]

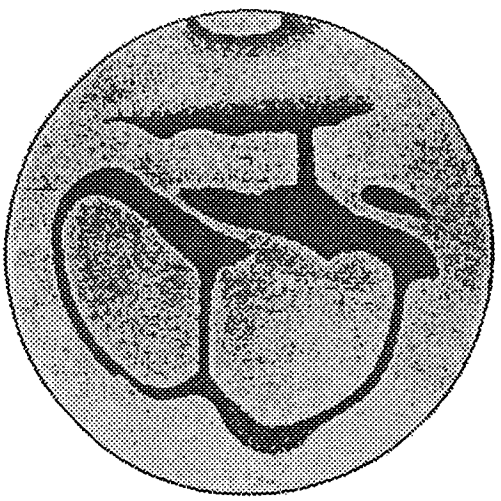
XX
2 Ottobre
$\omega = 18^\circ \quad \delta = -24^\circ$



XVII
26 Settembre
$\omega = 85^\circ \quad \delta = -23^\circ$



XIII
18 Settembre
$\omega = 181^\circ \quad \delta = -23^\circ$



XXV
14 Ottobre
$\omega = 298^\circ \quad \delta = -25^\circ$

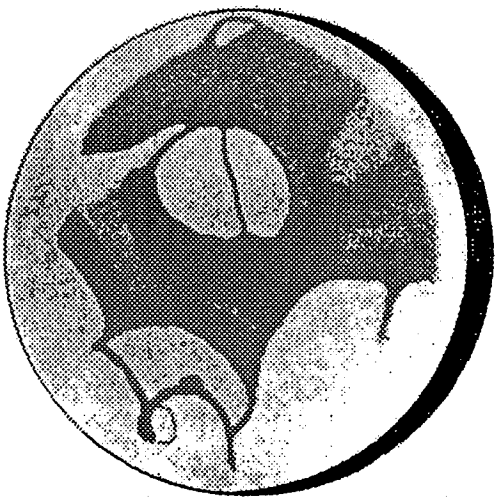
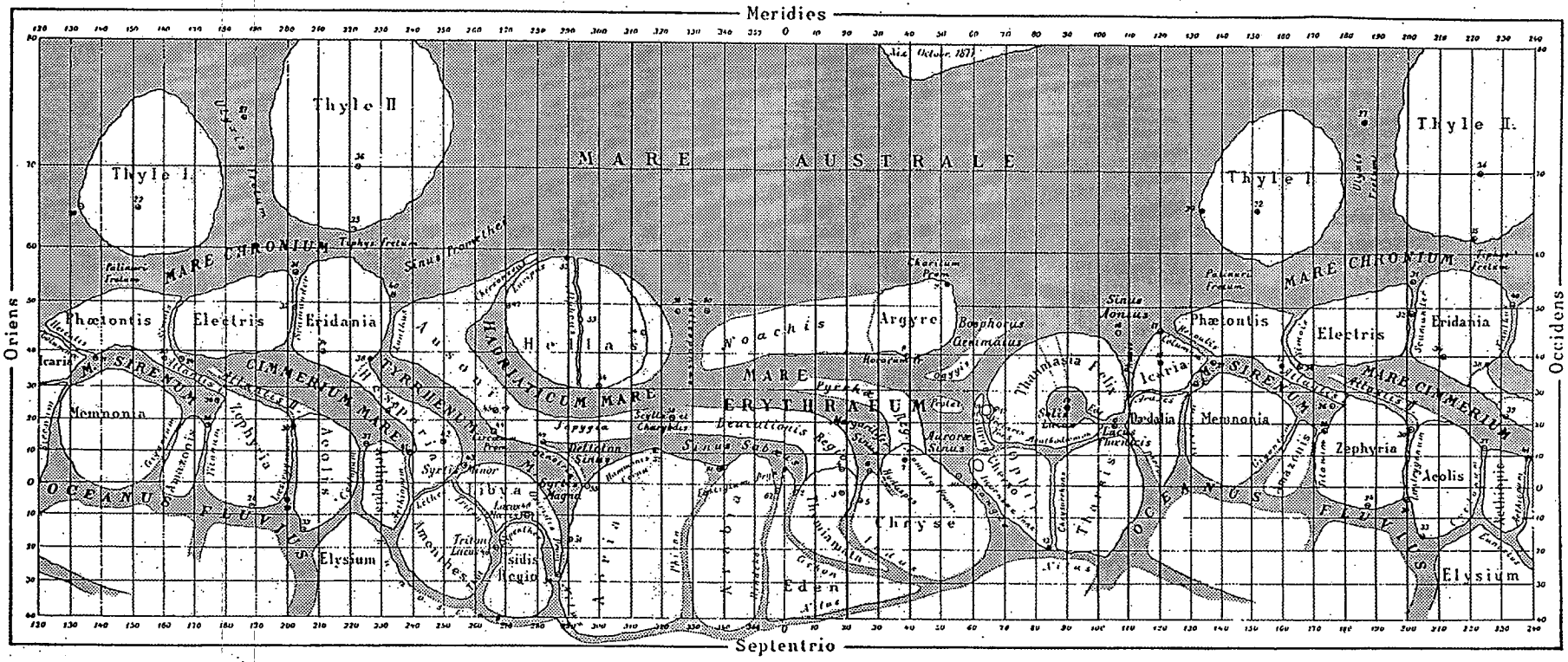


Figure II. Sketches of Mars.

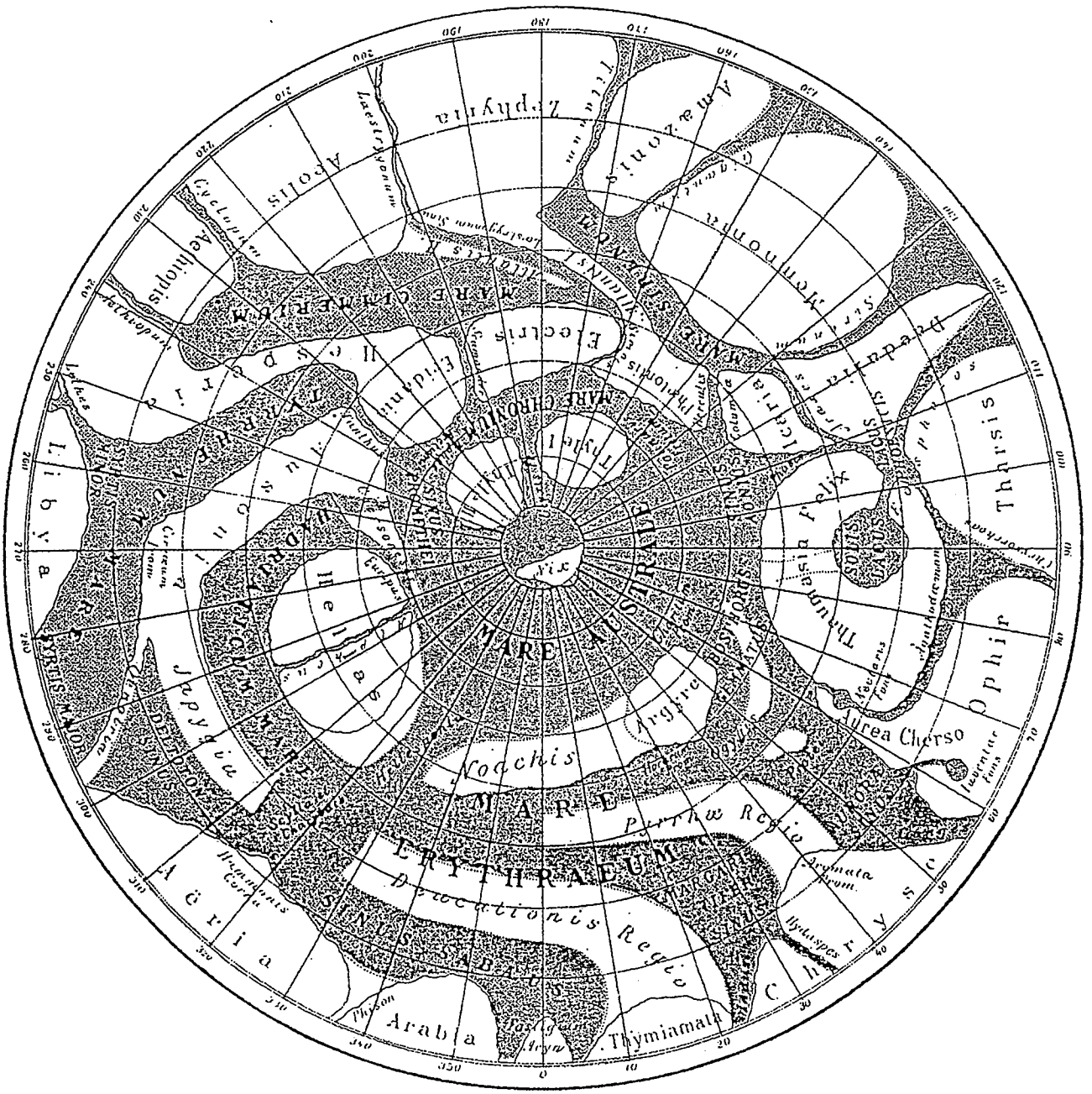


MAPPA AREOGRAPHICA

*Exhibens Planetæ Martis Chorographiam inter Polum Australem et Parallelum 40^um^*
Latitudinis Borealis;

Ex propriis Observationibus atque Mensuris ope Tubi Merziani decempedalis
in Specula Braydensi Mediolani habitis
composuit, supputavit, atque delineavit J. V. SCHIAPARELLI
1877 — 1878

Figure III. Mercator chart of Mars.



STEREOGRAPHICE DESCRIPTUM

Figure IV. Southern hemisphere chart of Mars.

Part III: Description of the southern hemisphere of Mars and of part of the northern hemisphere

[The boldface numbers at the beginning of each paragraph are those given in Schiaparelli's *Memoria Prima*]

Section I. General overview.

47. Our verbal descriptions can promise nothing of the precision one hopes to achieve when speaking of the terrestrial surface. Areography, in the fullest sense of the word, does not yet exist, nor will it exist for a long time to come. By that name I refer here only to the collection and arrangement of observations of the regions of the planet that I made at the opposition of 1877, and propose also to compare my results with those assembled by previous astronomers, in order to determine how far they agree and, wherever possible, the causes of the numerous and often considerable disagreements. I will here preface some comments about the suppositions adopted in the interpretations and the nomenclature used in this memoir.

48. The interpretation of the phenomena observed on Mars is still largely hypothetical; different observers may differ considerably, even where the results of their observations record the same appearances. One may wish to restrict oneself to what is seen without making any interpretations at all; but this is difficult in practice, since interpretations necessarily find their way into the very descriptions themselves. I have found, indeed, that in order to record the things that were seen at the telescope, I had to attach names to each of the variously shaded areas, lines, and points observed on the planet. In general the configurations present such a striking analogy to those of the terrestrial map that it is doubtful whether any other class of names would have been preferable. And do not brevity and clarity compel us to make use of words such as *island, isthmus, strait, channel, peninsula, cape*, etc? Each of which provides a description and notation of what could otherwise be expressed only by means of a lengthy paraphrase, and one, at that, which would need to be repeated each time one spoke about the corresponding object. Our map, then, like others already published, includes a complete system of geographical names which they who wish to avoid prejudice concerning the nature of the features on the planet may regard as a mere artifice to assist the memory and abbreviate the descriptions. After all, we speak in a similar way of the *maria* of the Moon, knowing full well that they do not consist of liquid masses. If we understand the matter in this way, the names I have adopted will do no harm, nor will they interfere with the rigorous expression of the facts. As to the positive notions that can be put forward concerning the nature of the spots of Mars, this will make up the matter of the fourth part of this treatise.

49. In general, the nomenclature I have adopted differs from the names others have been accustomed to use. It has seemed to me easier and more justifiable to introduce new names from classical geography and myth which can be easily distinguished from others of the kind. Indeed I found myself forced to do so. Astronomers before today who have constructed areographic maps have followed different systems of nomenclature. First was Maedler in 1830, who distinguished the most salient points on the surface of Mars with the letters of the alphabet; in this he was followed and imitated by Kaiser. Proctor, in the map he constructed on the basis of the observations of Dawes, invested Mars in a system of geographical names like those I have adopted; but in his case, the names were drawn from those of the most eminent astronomers who concerned themselves with the planet. You have, then, on this map the *Kaiser Sea, Jacob Island, Strait of Dawes, De la Rue Ocean*, etc. When I began my observations, I fully intended to use the names of Proctor, but at once I found it necessary to abandon some names and replace others by creating a large number of new ones. The existing nomenclature simply proved insufficient

for the vast quantity of new objects that had somehow to be named, to say nothing of the extensive modifications that had taken place in still other features. Thus the four large continents of Proctor had broken up into a multitude of islands, and there was every reason to believe that this process would progress further still. Some of his seas have been eliminated from our map, or been reduced to insignificant proportions (*Main Sea, Dawes Sea*), while others had since come into being (*Mare Sirenum, Mare Chronium*). An entire ocean (*Dawes Ocean*) found no place on our map. Great islands had apparently subsided into the sea (*Islands of Phillips and Jacob*) and are no longer islands. Thus, in order to avoid ambiguity, I decided to adopt a special nomenclature for my own use; and in establishing it, I did not care to follow the system of personal names adopted by Proctor. My nomenclature, which was devised at the telescope and probably suffers from many shortcomings, is preserved in this memoir only because it describes perfectly what is seen. *I seek neither the collective approval of astronomers nor the honor of seeing it pass into general use.* To the contrary; I am ready to adopt later whatever scheme will be recognized as definitive by the proper authority. Until then grant me the chimera of these euphonic names, whose sounds awaken in the mind so many beautiful memories and are linked together in a way that is more easily retained than the letters of the alphabet tortured to agree with the names on previous maps.

50. The comparative study of the maps of the surface of Mars obtained prior to 1873 has already been accomplished with all possible care by M. Terby of Louvain, in his erudite *Aréographie*, published by the Royal Academy of Belgium:[1] to repeat that work here would have been useless. Also, in making my own observations, I have felt it proper to pass quickly over those points which from the discussions of Terby could be regarded as firmly established. Instead I have employed all possible diligence in the examination of those things which remained to Terby a matter of doubt, and of others, which I have been the first to make out satisfactorily. Many details which in earlier sketches had been imperfectly represented or seen on only a few occasions are here confirmed; still others are interpreted more exactly than had hitherto been possible. Many things I have been able to correct and rectify about the earlier observations, and I await that time when the present work, whose defects no one knows better than I, must also be subject to rectifications and criticisms, such being the nature of scientific progress.

51. The principal series of sketches employed by me in the comparisons and in the examination of the various questions are (apart from those included in the aforementioned *Aréographie* of Terby) the following:

For the opposition of 1830: Maedler, *Astronomische Nachrichten*, Vol VIII, p. 447.
For the oppositions of 1832 and 1837: Maedler, *Beiträge zur physischen Kenntniss der himmlischen Körper*. Weimar, 1841.
For the opposition of 1858: Secchi, *Memorie dell'Osservatorio del Collegio romano.* Vol. 1, no. 3.
For the opposition of 1862: Secchi, *Memorie dell'Osservatorio del Collegio romano.* Vol. II, no. 10. Lockyer, Rosse, Lassell, vol. XXXII of the *Memoirs of the Royal Astronomical Society of London.* Kaiser, vol. II of the *Annals of the Observatory of Leyden.* Phillips, *Proceedings of the Royal Society*, 1863, 1863 February 12.
For the opposition of 1864: Kaiser, vol III, *Annals of the Observatory of Leyden*; Dawes, *Monthly Notices of the Royal Astronomical Society*, Vol. XXV, p. 225; Franzenau, *Sitzungsberichte der k. k. Akademie der Wissenschaften zu Wien.* Vol. LI, part II, p. 509.
For the opposition of 1873: Knobel, *Monthly Notices of the Royal Astronomical Society.* Vol XXXIII, p. 476.

Other minor series of sketches by Schmidt, Green, Harkness, etc. have been consulted and

1. *Aréographie ou étude comparative des observations faites sur l'aspect physique de la planète Mars depuis* Fontana (1636) *jusqu'à nos jours* (1873), by M. F. Terby, Mém. des Savants étrangers de l'Académie Royale de Belgique. Volume XXXIX.

are cited from time to time. Additionally continual reference is made to the charts of the planet by Maedler, Kaiser and Proctor. The first is founded upon the observations of 1830 and annexed to Volume VIII of the *Astronomische Nachrichten*. In the second Kaiser has assembled his observations of 1862 and 1864; it is published in Volume III of the *Annals of the Observatory of Leyden*. The third has been composed by Proctor from the sketches of Dawes at various epochs, but chiefly in 1864; I have used that version which is annexed to the work of Proctor entitled *The Orbs around us*, London 1872. All of these charts will be described more fully in what follows.

Section II. *The great diaphragm and the Hammonis Cornu .*

52. As the basis of his description of the then known world, Dicearchus, the ancient Greek founder of mathematical geography, established his celebrated *diaphragm*, a fundamental line running from the pillars of Hercules to Asia, along the northern shore of the Mediterranean as far as the Taurus Mountains and thence to the east.[2] A similar guide to the description of Mars is offered by the serpentine line that extends from the bottom of Syrtis Major [Gulf of Sidra] to the Hammonis Cornu [Horn of Ammon], and that then travels along the northern shore of Mare Erythraeum, bends around the Land of Marvels (*Thaumasia*) to the Columnis Herculae [Columns of Hercules], and from thence reaches along the shores of the enclosed seas of the southern hemisphere, Mare Sirenum [Sea of Sirens], Mare Cimmerium [Sea of the Cimmerians], and Mare Tyrrhenum [Tyrrhenian Sea], and finally back to Syrtis Major again. This line divides the surface of the planet into two irregular parts; crossing the equator, it extends from 45° southern latitude to 20° northern latitude. Its course is rather anomalous; nevertheless, it is well suited for the present purpose. The great diaphragm makes a strong impression even on the most superficial acquaintance with the planet, and is sufficiently demonstrated by our orthographic projection. In general it will be seen that below the diaphragm the surface of the planet is everywhere a good deal brighter than it is above it. The importance of this line was already grasped by the geologist Phillips in 1862.[3] Now we will follow it, in the direction of increasing longitude, beginning from the point called *Hammonis Cornu* or Horn of Ammon (long. 318°.3, lat. 10°.4 S).

53. Although not forming a very acute point, the Horn of Ammon occupies an important and prominent position in the topography of Mars in certain views of the planet. The seas that lie in this part of the equatorial region of Mars appear somewhat obscure in their western part; to the east the coastline is better defined, and the dark areas are clearly marked along the lower projection of the region called Ausonia. The land contiguous to the Horn of Ammon and the west shore of the Syrtis Major and Aeria (the name of ancient Egypt) is the *largest continuous bright space* that I have so far found on the planet Mars. During the entire period covered by my observations (September 1877-March 1878) this region was always very splendid, and it was not possible to notice any patch or shading in it. Perhaps in part the splendor of this line is a mere effect of contrast with the great darkness of the sea bordering its confines. The line of the coasts toward Syrtis Major, and also toward the Sinus Sabaeus [Sabaean Gulf], is barren of indentations of any great importance, although in instants of steady air I have had the impression of a great number of minute sinuosities not easily distinguishable from one another.

54. I observed the Horn of Ammon on a great many nights between September 10, 1877 and March 9, 1878, during which period I have drawn it well on 12 or 15 occasions. Each time I have seen it in the form of a blunt angle like that represented in Fig. II, sketch xxv. Thus also

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2. According to the later commentator Agathemeros, "Dicaiarchos divides the earth ... by a completely straight line from the Pillars through Sardinia, Sicily, Peloponnese, Caria, Lycia, Pamphylia, Cicilia, Tauros, and on to Imaos. Of the regions thus formed he names one part the northern, the other the southern." [Trans.]

3. *Proceed. of the R. Soc.*, vol. XII, p. 434: "A great part of the northern area appeared bright, and often reddish, as if it were land, while a great part of the southern area was of the grey hue which is considered to indicate water, but relieved by various tracts of a tint more or less approaching to that of the brighter spaces of the northern hemisphere. The *principal boundary of light and shade*, for the most part very well defined, ran obliquely across the equator of Mars so as to reach latitudes from 20 to 30° N and S of that line."

has it been drawn by many other observers, such as Maedler, Secchi, Rosse, Lassell, Phillips, Dawes, etc. In the sketches of some astronomers, the Horn of Ammon is given a sharper and more pointed figure in its southern part: as in those by Kaiser on October 31 and December 10, 1862 and November 19 and December 28, 1864. A similar form appears in the sketches of Lockyer on September 23, 25, and October 3, 1862. Characteristic of all the sketches of Kaiser is a kind of tongue or bright filament, which curves sharply toward the south in almost all of his sketches of 1862 and also of 1864; again, this is shown in Kaiser's chart in the region designated by the letter *e*. I find this detail occasionally hinted at by other observers. Lockyer shows it weakly on October 3, 1862. Rosse on July 22 of that year shows this filament indistinctly, also on October 6; his sketch of November 6 has *two* bright filaments diverging from the Horn of Ammon, the one lying almost perpendicular to the other; Lassell in September 1862 has recorded it as I have, but on November 4 and 5 he has represented the coast of Aeria with several indentations on the left hand side of the Horn of Ammon.

55. These appearances can be accounted for by supposing that the varying spots are clouds (something of which we have many examples), which under the illumination of the sun will appear very bright. If the same region is observed to be at one time dark, at another bright, we must conclude that in the first case it is the surface of the planet that is being seen, in the other a layer of clouds or fog. Given this principle[4] (whose application provides a coherent explanation of the facts in every case) we will judge that the sharp form of the Horn of Ammon is a temporary apparition, and that the real form of this cape is that which invariably presented itself to us in 1877. This year was notable for the usual clarity of the atmosphere of the planet, which could not be said of other years, especially 1862, when the Mare Erythraeum seemed to be covered almost constantly by a layer of clouds. As we will see later, this is one of the regions of Mars in which atmospheric disturbances are most frequent.

Section III. *Sinus Sabaeus: Phison, Hiddekel, and Gehon.*

56. The Sinus Sabaeus stretches toward the west for almost fifty degrees, between Aeria and Arabia on the one side and the great peninsula of Deucalion on the other. If, as we believe, this peninsula is actually a submerged land, the name of sinus (gulf) applies rather imperfectly to this formation, which more properly should be considered a lowland extending from the northern part of Mare Erythraeum. The color of Sinus Sabaeus is not uniform, but from its northern side, which is among the darkest parts of the whole planet, it gradually shades to approximate the same color as the northern limb of Deucalion land. For this reason the Sinus Sabaeus, when examined with insufficient optical power, presents at first as a simple black serpentine line; the double horn that forms the western extremity appears indistinct, like a group of ill-defined shadings. The northern side, whose dark color presents a strong contrast with the bright and very uneven continent alongside it, shows in good atmospheric conditions and with sufficient magnifying power (not less than 300) various gulfs and capes, among which I am able to discern well only those occupying the western half around the 340° meridian. In this meridian a small gulf (the *Bay of Schmidt*, according to Terby) picks up the Phison channel that comes from the northern hemisphere and divides Aeria from Arabia. The Phison, around the 40° parallel north, is connected with the Nilus, as indicated in the map. Beyond the mouth of the Phison the Sinus Sabaeus becomes very narrow and curves along the southern coast of Arabia in an almost semicircular course, until it almost touches Deucalion land. The passage here is indeed so narrow that when bad air ripples and diffuses the image, it can seem entirely closed for moments. In calm air the hairline breadth of the gulf again becomes visible, and always looks very black. Further on the gulf widens again, and makes a right angle, forming at its extremity two sharp horns, which we have denominated Horn I and Horn II of the Sinus Sabaeus. In Horn I, I believe, the Hiddekel (a branch of the Nilus which runs almost even and parallel with the Phison)

4. Enunciated in 1862 by Lockyer (*Mem. of the R. Astr. Society*, Vol. XXXII, p. 183).

has its mouth; in Horn II the mouth of the Gehon, that comes from the Nilus via its branch the Indus.

57. All of these details were discovered only little by little. On October 1, 1877, I saw for the first time the Sinus Sabaeus in poor air, and under these conditions was not even successful in making out the two horns. On October 2, with the central meridian at 19°,[5] I succeeded in making out the horns and also distinctly recognized the Fastigium Aryn [Dome of Aryn], and I saw the mouth of the Gehon, which seemed to widen somewhat as it traversed the land, as if it contained an inland lake. Clouds, which then occupied much of this part of the equatorial continent, did not however allow me to see more than a short track of the Gehon. On October 4 I again saw the Gehon and discovered the mouth of the Phison, which appeared to me as "a branch very pale and doubtful, proceeding through the land toward the Sinus Sabaeus." On October 10 the Phison was visible crossing the continent as far as the 15° N parallel; but only with great difficulty. This was also indicated in my sketches of October 12, 13, and 14, which make no pretension to exactness. Thereafter I believed I could learn no more about the courses of the channels of this region, but toward the end of February and the beginning of March 1878 they unexpectedly emerged from the vapors that had hitherto covered this part of the equatorial zone, and I was able to follow the course of the Nilus between Syrtis Major and Oceanus and to describe some of the channels that communicate with Mare Erythraeum. The diameter of the planet being reduced to only 6" at that time, only in the best moments and with the greatest magnification (468×) of our refractor was I able to be certain of anything. On February 26, 1878, I discovered that the Gehon branched from the Indus, and in my later glimpses, I judged it to be more visible than the Indus. On February 28 I confirmed this observation, and discovered the Hiddekel, without being able to discern its precise relation to the Gehon. On March 3, 4, and 5 I again saw the Hiddekel, which I believed to run directly north to south, but could only conjecturally designate its southern mouth. Since the planet was so small, it was impossible to distinguish the two horns of the Sinus Sabaeus one from the other so as to trace the channel to the correct mouth. Nevertheless, from the manner in which the Hiddekel and the Gehon separated from one another immediately below the Sinus Sabaeus, I was inclined to think it more likely that the Hiddekel emptied into the first horn: which *opinion*, still in need of confirmation, serves as the basis for the course indicated in the chart. As for the Phison, I have been able to follow it fairly well throughout its course on March 3, 4, and 5, and thus have succeeded in approximately recording the place where it separates from the Nilus.

58. The Sinus Sabaeus is denominated with the name of strait in the chart of Proctor (*Herschel II Straits*); while the peninsula of Deucalion receives, by a transverse isthmus, a prolongation of this gulf, so as to be reduced to an island. According to this plan, the two horns of Sabaeus do no more than form a double bay in the inferior continent (*Dawes' forked bay*). But this is in open contradiction to what I myself have observed and many others before me. Equally respectable authority holds for a different version. So great has been the difficulty of reconciling all this that Terby has proposed it to astronomers as a problem in need of resolution. Another problem which has concerned me is the exact nature of the land of Deucalion and the others like it that are scattered across Mare Erythraeum. So far it is possible to say that the peninsula of Deucalion consists of something different from the inferior continent, not only on account of its much darker color but also because of the very clear and sharp manner in which different tints meet in the isthmus, forming a well-defined boundary, as I had the opportunity of noticing on October 2 and 4, 1877: so well defined was this, that I was able to try and determine the position of a fundamental point in it, which is no. 4 of our catalog. This boundary forms a line that is

5. From now on, instead of pointing out the hour and minute of each observation, I will instead indicate the value of ω, that is the areographic longitude of the meridian, which in that instant has passed the center of the disc. This will allow one to judge immediately the position that the observed objects have with respect to the center or limb of the planet. For brevity the value of ω will be written in parenthesis immediately after the date: thus October 4 (356°) signifies the moment on October 4 at which the center of the disk was at longitude 356° on our chart.

slightly convex at the top as it reaches from the Sinus Sabaeus to the Margaritifer Sinus, cutting neatly across the interposed isthmus. For now we will consider this line as belonging to the shore of Mare Erythraeum in this part. The bright isthmus is truncated so as to form a blunt prominence, almost rectangular in form, which was very well seen and figured by Kaiser on November 11, 1864. It is known that this astronomer also made out the Phison on this occasion, indicating it as far as the right limb on his sketch of November 22, 1864. It is the only drawing that has been made of this channel. Neither the Hiddekel nor the Gehon have been indicated by any of the earlier observers.

Section IV: *Margaritifer Sinus: Indus and Hydaspes: Chryse.*

59. Beyond the truncation of the isthmus in the lower Region of Incenses (*Thymiamata*) lies the vast and deep Margaritifer Sinus [Gulf of Pearls], of which the dark color may be quite as great as that of the Sinus Sabaeus; and even when less observable on the left hand side of the disk, it still appears far more prominent than the lower part of Mare Erythraeum. When the air is bad, and one is not well oriented, it is easy to confuse the Margaritifer Sinus with the Great Syrtis itself.[6] The Margaritifer Sinus forms a kind of vast triangle of which one side makes up the western limit of the peninsula of Deucalion, the other goes straightaway to the Aromata Promontorium [Cape of the Aromas]. From the inferior vertex the wide channel of the Indus departs, which travels north and then northeast; and after the branching of the Gehon, joins with the Nilus, to which it is attached by a much more considerable arm. The coast, between the mouth of the Indus and the Aromata Prom., is generally straight, except where broken by a deep indentation. This is very black, and forms the mouth of the Hydaspes. This channel could not be followed for more than 5 or 6° of the maximum circle through the land, and appeared truncated, without any sense of a depression at its terminus; nor did it show any prolongation across the bright continent of Elysium even when the Indus and the Ganges appeared observable throughout their entire extent.

60. The delineation of the Margaritifer Sinus on our chart is deduced from only two evenings of observation, October 2 and 4, 1877, on which the conditions of the atmosphere were superb and permitted the full power of the instrument to be used to advantage. A general confirmation of everything that was seen then was obtained on the evening of November 7, in perfect air, despite the fact that the apparent diameter of the disc had dwindled to only 15". But on none of these occasions did it prove possible for me to trace the Indus beyond 10° north, and this for the reason earlier mentioned, that there were masses of clouds then occupying Aeria, Arabia, Eden, and Chryse. The course of the Indus was not discovered until February 24, 1878, and I examined it consecutively until March 10, when the diameter of the planet was only 5".7. The best observation was on February 26, when I discovered the branching of the Indus and the Gehon. Nevertheless, all this part of the chart ought to be regarded as only a rough draft, and only from accurate observations at future oppositions can it be given the necessary degree of exactness.

61. The Margaritifer Sinus has been seen by many observers,[7] and is located on the chart of Proctor, where it receives the designation *Beer's Bay*. Its form there is similar to ours, but there is no sign of the channel that we call the Indus. Instead he may have indicated something of the Hydaspes. The sketch of Kaiser, November 11, 1864, seems capital for this part of the planet, showing, after the truncation of the isthmus of Deucalion land, the Margaritifer Sinus, the mouth of the Hydaspes, and the Aromatum Prom. in a form that agrees with our sketches in a remarkable way. But not even Kaiser continues the course of the Hydaspes through the land. Dawes, however, whose sketches are almost exactly contemporaneous with those of Kaiser

6. This I noted on September 4, 1877; see also Terby, *Aréographie*, p. 78

7. Terby, *Aréographie*, pp. 72-77.

(November 10, 12 and 14, 1864) sketches a wide channel crossing the equatorial continent in the direction of the meridian, which empties by a wide mouth into Mare Erythraeum, thereby giving to all this coast a form completely incompatible with that of other areographers. On November 9 and 11 of the same year Kaiser has seen nothing of all this. Contradictions between the best observers I hardly know how to explain: I simply repeat that I have seen exactly what Kaiser has seen. These doubts extend, naturally, to the chart of Proctor, seeing that it has been based exclusively on the observations of Dawes. His *Dawes Strait* for me doesn't exist.

62. In his *Aréographie* Signor Terby has published a sketch made in 1871 by Signor Lehardelay (see no. 32 in the series attached to his work), in which a long and tortuous channel appears to run northward from Margaritifer Sinus. The position of the southern mouth renders it probable that Lehardelay has seen all of the Hydaspes. But in his sketch there is no trace of the Indus, neither of the Ganges. In no respect does his tracing agree with that of Dawes. Still it is best for us to withhold our judgment.

63. The two dark ovals that Kaiser depicts on his chart at longitudes 70° and 54° (18°.8 and 34°.4 according to our way of reckoning) are apparently the mouths of the Indus and the Hydaspes, which are interpreted in his usual judicious manner.

64. The region of Chryse, which is one of the brightest on the planet, forms an irregular polygon bounded by the Mare Erythraeum, the Nilus, the Indus, and the Ganges. Its more southern extremity is formed by the Aromata Prom., an obtuse angle formed by the convergence of two nearly rectilinear coasts: and this is a prominent point, observable even in mediocre atmospheric conditions. Along all this shore the Mare Erythraeum is very dark, but more so close by the shore than at greater distances from it. From the Aromata Prom. the line of the coast runs, without any interruption worth noting, directly to the mouth of the Ganges, forming the eastern side of the great Aurorae Sinus. On the same meridian as the Aromata Prom. stretches the long isthmus of another peninsula; it lies parallel to Deucalion land, and is of exactly the same form, though a little inferior to it in size and of a somewhat darker color. In the chart it is marked with the name of Pyrrhae Regio. In a cursory view, it appears like an island whose diffuse contours are of the same color as the rest of Mare Erythraeum: but in excellent conditions (October 2 and 4, 1877) I have distinguished with complete certainty that it is indeed an isthmus, and reaches to the land of Chryse. The color of the peninsula grows darker toward its base, and all along the coast in the vicinity of the Aromata Prom., the Mare Erythraeum is black, which makes it difficult to see this isthmus: but there is no doubt whatsoever that it exists, and that it here forms a passage to the cape.

65. The Aromata Prom. is omitted from the sketches of Dawes, and also from the chart of Proctor: but different observers have represented it more or less distinctly, even where they have not seen the peninsula of Pyrrhae. It is very well shown in the discs made by Maedler on September 14 and October 13 and 14, 1830. Secchi sees it as a roundish prominence, and the discs of Lockyer (September 17 and 23, 1862), of Knobel (no. 31 of the *Aréographie* of Terby), and above all of Kaiser (November 9 and 11 and December 18, 1864) bear a close resemblance to our own. In his sketch of December 18, 1864, Kaiser has indicated in a more or less evident way the base of the peninsula of Pyrrhae, of which I will have more to say later.

Section V: *The Ganges and the Aurorae Sinus. Ophir, Aurea Cherso.*

66. Succeeding the Aromata Prom. is the other of the two gulfs that extend northward from the Mare Erythraeum, which I have called Aurorae Sinus [the Bay of the Dawn]. It is observable even in poor atmospheric conditions because of its great extent and dark color, and on this account has been well delineated by many observers, making useless a detailed discussion of it here. Into its basin disgorges the mouth of the Ganges, one of the widest and most observable of the channels that exist on the surface of Mars. It was evident on all occasions, in bad air and in good, from its first appearance on August 28, 1877 until its last on February 25, 1878. The con-

fluence of the Ganges with the Nilus forms a vast triangular estuary, of which I saw the first traces on November 4, and at the end of February was clear and very observable despite the greatly reduced diameter of the disc. The Ganges follows a nearly rectilinear course tending southeast to northwest: its width is certainly quite a few degrees of the maximum circle, but I would not dare to characterize it exactly, since its banks always seemed to me rather diffuse. Possibly the breadth of the channel is not uniform along its length and there are branches and divisions which were not discernible with the optical power employed.

67. Despite its easy visibility, I have searched in vain for an acceptable record of this channel among the earlier observers, apart from Secchi, who in the first four of his sketches of 1858 presents it exactly as it was seen here, and calls it the *Channel of Franklin.* Secchi terminates the Ganges in a lower dark space, which is certainly the same as the triangular estuary observed by me; but otherwise the form given by him is rather different. As the entire region at the opposition of 1877 was too near to the inferior edge of the disc to be delineated with great exactness, one ought to regard the tracing of Secchi, in those few things in which his differs from my representation, as probably being closer to the truth.

68. Kaiser has captured the Ganges on the evening of December 18, 1864. He has represented it in the form of a dark but indistinct cloud, which from the Aurorae Sinus (well indicated in this sketch, and in his chart as well) drops down toward the lower part of the disc. The coincidence in position and direction leaves nothing to be desired. Also the Ganges seems very probably indicated in the disc made by Kaiser on October 24, 1862.

69. Beyond a northern latitude of about 20°, beyond all the equatorial lands until now described and in a direction little different from that of the meridian, I have made out another channel; it is indicated on the chart as the Chrysorrhoas, and empties eventually into the Indus close to its confluence with the Ganges: this point consists of an expansion under the form of a diffuse shade, which in 1877 seems to have been less distinct than at other times. The Agathodaemon, after an unusual turn, disgorges into the western part of Mare Erythraeum and Aurorae Sinus. The shores of this gulf together with the Agathodaemon, Ganges, Nilus, and Chrysorrhoas enclose a polygon of very anomalous shape, which during the observations seemed to me to be less bright than Chryse nearby; to this I have given the name Ophir. The southern part forms an acute and narrow peninsula, called the Aurea Cherso [the Golden Peninsula], whose base may be cut by the Agathodaemon, although of this I remain unsure.

70. Along the coasts of Ophir, Mare Erythraeum begins to lose some of the indistinctness that characterizes it above the Sinus Sabaeus, and shows up more strongly in the Margaritifer Sinus and the inner part of Aurorae Sinus. Between the mouth of the Ganges and the base of Aurea Cherso, the shore forms a small prominence, which surrounds a very minute inland lake, designated on the map Juventae Fons [Font of Youth]. This delicate object was first seen by me on the memorable evening of October 2, 1877, when I enjoyed moments of more perfect telescopic vision than before or since. It seemed for a moment to be an outlet from Mare Erythraeum, but of this I could not be sure, since the air was already beginning to deteriorate when I attempted to settle the point. I do not know how to suggest the dimensions of this lake otherwise than to describe it as apparently a perfectly black point. Certainly in comparison with the proportions of the surrounding objects, its diameter could not exceed 3 Martian degrees, which would make its micrometric measure at the time no more than 0".5. Even so, this comes out to almost 100 Italian miles in actual linear dimensions.

71. On the same evening, I sketched the Aurea Cherso. The dark hairline that bounds it on the west was rather difficult to see: nevertheless, it was recognized as early as September 30 and October 1 in a few good moments, but put beyond all doubt on October 2. It was seen for the last time on November 2. On October 2 I discovered at the same time as the Juventae Fons the other [fons] of Nectaris, a kind of bulge in the Agathodaemon not far from the Aurea Cherso. This bulge has at its center a point, entirely black and almost round, that in appearance and breadth exactly resembles the Juventae Fons. As for the mouth of the Agathodaemon, which I

surmised to be at the Aurea Cherso, I found it to be little evident. Instead, on October 2, I for a moment suspected another mouth of the Agathodaemon beside the base of the Aurea Cherso: a mouth whose existence would reduce the latter to an island. But the air turned poor soon afterwards, so that a definite judgment was impossible.

72. The greater part of these details are new to the observations of Mars, and I record them in the hope that in time they will be confirmed. The Chrysorrhoas appears to have been made out distinctly by Kaiser, and is verified in his chart and his sketch of 1864 December 18, only he fails to carry it leftward to its conjugation with the Agathodaemon but instead interrupts it in its lower part. Regarding my observations of the Chrysorrhoas in October 1877, I must caution that I could not at the time make out that the junction of the more southern part with the Agathodaemon, so that the way that it is shown in figure II, disc xvii is rather conjectural. Only on November 4, and to my very great surprise, I saw all of the Chrysorrhoas as I have delineated it in my chart, very wide and very dark, although diffuse: it was a great deal more prominent than the Agathodaemon, and only a little less so than the Ganges itself. But then a month later, on December 10, while observing the same region, I saw the Ganges conspicuously; nothing however of the Chrysorrhoas. Indeed, subsequently the latter always remained invisible in my searches for it. This variability I believe to be only apparent: it must be due to the movement of clouds over the lands of Ophir and Tharsis.

73. As far as the Agathodaemon is concerned, I was not successful, in my earlier observations along the 65° meridian, in finding any trace of it in that part of its course that skirts the Aurea Cherso. But the west trunk, that follows the parallel from the base of the Aurea Cherso and joins the Chrysorrhoas and the already mentioned expansion at this point, I have made out in many observations. Earlier observers have sometimes figured the Agathodaemon as a wide and readily observable dark strip, with fairly wide embankments; in this form it competes with the Chrysorrohoas for the title of sea (thus the *Dawes Sea* on the chart of Proctor). However, in 1877 I saw nothing in either place that was worthy of such a title: the Agathodaemon was always much more difficult than the Ganges, and also than the Chrysorrhoas, whenever the latter was visible. To the study of these differences and others, an article devoted to this subject alone would be apposite.

Section VI. *Thaumasia, Solis Lacus.*

74. From the inner recesses of the Aurorae Sinus, the boundary of the equatorial lands of Mars follows the diaphragm first to the south, then toward the west, thereby making up a grand and prominent arch, which encloses in its concavity the vast Region of Marvels (*Thaumasia Felix*). The adjoining sea is as dark as the Aurorae Sinus and reaches in an arch along its entire length, where it presents everywhere a sharp contrast with the bordering land. In the concave part of that arch lies a strong blackish spot of around 10 degrees (a little less than 350 miles) in diameter, almost exactly round, called the Solis Lacus [Lake of the Sun] on our chart and *Lockyer's Sea* in that of Proctor. The northern and western sides of Thaumasia are defined by channels, the already mentioned Agathodaemon and the Phasis, proceeding in opposite directions from the oblong Lacus Phoenicis [Lake of the Phoenix], which is not as large or as dark as the Solis Lacus. The region of Thaumasia, then, constitutes a large oval space surrounded on each side by seas and channels in the interior of which, in rather eccentric position, lies the Solis Lacus: all of this contributing to the appearance well known to observers of a human eye, of which the Agathodaemon and the Phasis seem to constitute the lower eyelid, the Solis Lacus forms the iris and the pupil, and the large and dark arch above described forms a thick and ample brow. The vertical course of the Agathodaemon between Thaumasia and the Aurea Cherso is not pronounced enough to interfere with this general impression.

75. The Solis Lacus has stood many times before me and been attentively examined in good conditions of the atmosphere. On September 30, 1877, with the apparent diameter of Mars at 21".79, its diameter was estimated at 2", or twice the size of the comparison threads. This would

make it 10.5 Martian degrees in breadth. It was grossly circular, or perhaps slightly elongated from south to north, though this elongation was by no means obvious to me; its edge is not altogether regular, but probably contains many small indentations. This last, however, I do not state with certainty, but only as a plausible conjecture. The color was by no means completely uniform; the darkness was strongest toward the center, then fell off toward the edges in a discontinuous and irregular way, so that one judged the intensity as here a little more, there a little less. Still, it always remained among the most beautiful objects on the surface of Mars. A channel or thin emissary, less dark, departs to the northwest and travels to Oceanus after passing through Lacus Phoenicis. To the south, where it is poorly terminated, there is another emissary, or at least another streak, rather obscure and wide, which deviates slightly toward the east. This is darkest at its base, where it leaves Solis Lacus. At its southern extremity it seems to reach to the limits of Thaumasia, but as to its actual connection with it my observations are not so compelling. It is not given any name on the chart, not being regarded as a definite object but only as a slight variation in the generally bright tone of this region. Apart from these two channels, there are no others that depart from the Solis Lacus; at least in 1877 I didn't see any traveling in other directions. All the details around the Solis Lacus and the Region of Marvels were repeatedly explored by me on many different evenings: that is, on September 20, 22, 24, 25, October 24, and November 4, 1877. A confirmatory observation was made on December 1, in which I was able to demonstrate no change. On February 21, 1878, I was still able to detect the Agathodaemon, and on this and succeeding days the Eosforos and the Solis Lacus were visible. They remained so even on March 21, when the apparent diameter of the planet had been reduced to a mere 5".16.

76. With respect to the maritime contours of Thaumasia, my chart presents enormous disagreements with that of Proctor, which, following the sketches of Dawes, does not represent Thaumasia as an oval at all but instead extends it indefinitely toward the southwest under the name of *Kepler's Land.* My representation is much more conformable to those of Kaiser and Lockyer in 1862 and of Kaiser in 1864. The great arch or brow of Kaiser corresponds perfectly with the dark tints of the seas surrounding Thaumasia and the Aurea Cherso. But there are other very noticeable differences. The Solis Lacus does not occupy, with Kaiser and Lockyer, that eccentric position that I have allotted it. The bright border that surrounds the lake is shown almost as wide by Kaiser as by me, but Lockyer shows it narrower—narrower, indeed, than the diameter of the lake itself, which appears proportionately much greater. And there are still other differences: in 1862 and 1864, Kaiser, Lockyer and Dawes all represented the Solis Lacus as elongated in a horizontal direction, that is in the sense of the parallel; Dawes and Lockyer give it a form that is rather anomalous, while Kaiser represents it as a perfect ellipse whose diameters are in the ratio of 2:3. I have examined the point diligently, and I repeat: if there is any elongation at all it is rather in the direction of the meridian than of the parallel.

77. Great discordances also exist regarding the channels from the Solis Lacus. That which I have marked as traveling almost due south is not shown by any other observer, with the possible exception of Kaiser, who indicates it with some probability on his disc of December 10, 1864. On that of November 23, 1862, he also shows a slight trace of my other channel, Eosforos, which travels through the Lacus Phoenicis. The Eosforos seems also to be vaguely figured by Lockyer in his sketch of October 18, 1862. But while these features are only faintly indicated, Kaiser, Lockyer and Dawes all agree in giving the Solis Lacus a large and conspicuous outlet to the east toward Mare Erythraeum. Lockyer gives our Solis Lacus the name of *Baltic*, and names this outlet the Kattegat. It is indicated, though less clearly, in the sketches of Rosse (September 16 and October 19, 1862). Lassell seems to have noticed it on September 13 of the same year, but not on October 21, 23, or 25. Maedler evidently indicates it in three of his sketches of 1830, and it is also shown very prominently in his chart. Now I must say that I have studied this part of Thaumasia with all possible care, especially on the evenings on which I have been intent on the Aurea Cherso, and discovered the Nectaris Fons precisely in the place where the mouth of this channel ought to have been seen. Nevertheless, despite having the solution of this problem as one of the main objects of my observations, I have never succeeded in detecting the least trace of

it. In the interval between September 20 and December 9, 1877, the Thaumasia region always appeared equally splendid with those that are coterminus with it: and also in the searches made in February and March 1878 (less decisive, naturally, because of the small disc of the planet) there was no suspicion of any changes having taken place there. I don't dare to express any opinion as to the cause of these discordances. If one wishes, one might attribute them to the diverse distribution of clouds, only one must suppose that they exhibit an extraordinary persistence over a very limited locale. Perhaps instead they are due to immense floods which local obstacles could divert now one way, now another?

Section VII: *Lacus Phoenicis. Esoforos and Phasis.*

78. From the Solis Lacus the short and thin but fairly observable Eosforos extends for a distance of 15° in a northwest direction from the Lacus Phoenicis, through which it passes as it continues in the same direction toward regions to be described later. The Lacus Phoenicis has a maximum diameter about equal to that of the Solis Lacus, but its form is a good deal elongated in the northeast to southwest direction: in extent, it doesn't perhaps reach as far as the other, and also its color is considerably less dark in its central part. That makes it very much less obvious—and even the presence of the Solis Lacus itself competes to divert the observer's attention away from it. However, on September 20, 1877, when I saw for the first time the Solis Lacus, I discovered immediately that of Phoenicis, and I found the latter always visible even in mediocre conditions until November 4. Thereafter, it could not be seen, because its apparent dimensions were too much reduced, and also because of its proximity to the much larger Solis Lacus.

79. The Lacus Phoenicis forms a kind of quadrilateral: this is cut along the diagonal by the course of the Eosforos; at another corner the Agathodaemon emerges and reaches eastward to the Mare Erythraeum, and finally, at still another corner, the Phasis juts out toward the Southern Sea. The Phasis was seen for the first time on September 20, 1877, while still far from the central meridian; the two trunks of the Eosforos were discovered on September 22; the Agathodaemon from the Lacus Phoenicis to the base of the Aurea Cherso on September 24. All of these objects continued to be visible, even in indifferent seeing, as long as the planet was fairly near the Earth: the last time they were delineated was on November 4. The inferior part of the Eosforos, reaching toward Oceanus, grew in width and visibility, so that I was able to make it out at times during 1878 and last of all on March 21.

80. Of these channels, the Agathodaemon divides Thaumasia from the regions of Tharsis and Ophir; it receives the Chrysorrhoas from the north, then bends southward to reach the Aurea Cherso. Perhaps it has two mouths, one at the base, the other at the point of this peninsula or would-be island. At the division with the Chrysorrhoas, there is an expansion, which has been mentioned already; it could also be considered a small lake, though very much inferior in size and visibility to the Lacus Phoenicis. The Phasis is shorter than the Agathodaemon: in 1877, conditions were very favorable for exploring this. It goes straightaway to the south, and ends in a mouth in the form of a trumpet, which flares out into Mare Australe. It gives off a lateral branch, the Araxes to the Mare Sirenum [Sea of Sirens], as will be described later. The gulf formed by the mouth of the Phasis is called the Sinus Aonius.

81. The Agathodaemon and the Phasis were without doubt seen by Maedler in 1830; together they form an arch very dark and observable, which on this astronomer's chart surrounds the Solis Lacus on its northern side. Obstacles of a probably meteorological nature prevented him from recognizing the rest of the perimeter of Thaumasia and the great brow. The only sign of the Sinus Aonius is found in his disc no. 20. Also the widening of the Phasis toward its mouth seems indicated in the chart, but this is not entirely accordant with his discs; perhaps here the evidence is against the unpublished discs. Agathodaemon and Phasis are shown as continuous, which makes it doubtful whether he saw anything of the Lacus Phoenicis, though its width is certainly greater than either of these two channels.

82. During the opposition of 1862 the Agathodaemon and the Phasis were again visible. Kaiser draws both, but seems to have seen the western branch of the Phasis better, that is, the Araxes. He imperfectly hints at the communication of the Phasis proper with the Mare Australe (October 24 and November 23, 1862). Lockyer has distinctly seen the Agathodaemon crossing the land; more doubtfully the mouth of the same, at the isthmus of the Aurea Cherso. He doesn't indicate any trace of the Lacus Phoenicis, nor of the Phasis. Lassell represents the Phasis, the Lacus Phoenicis and the Agathodaemon in the manner of Maedler, that is, as a continuous belt: but his Agathodaemon falls short of the Aurea Cherso (October 21, 23, and 25 1862), and he removes all communications with Mare Erythraeum.

83. At the opposition of 1864 Kaiser saw the Agathodaemon again: in his sketch of December 10, he indicates it lightly as a direct communication with the Mare Sirenum. At this time, as in 1862, he made out the Lacus Phoenicis and the Araxes, though not the Phasis proper. The sketches made by Dawes at this opposition seem in open contradiction to all the others. He indicates the expansion of the Agathodaemon at the place where I show it meeting the Chrysorrhoas; that is, as a lake hardly smaller than the Solis Lacus and having a very obvious outlet into Mare Erythraeum. This Proctor has carried over into his chart, and called the *Dawes Sea*. But the contemporaneous sketches of Kaiser prove that this spot failed to equal the Solis Lacus in visibility or strength (cf. to § 73 above). The way that Dawes in his sketches shades it in the western part would seem to indicate the uncertainty of the author as to the form and extent of this object, which in 1877 one would certainly not have thought deserving of the denomination *mare*.

84. None of the preceding observers seems to have seen the Lacus Phoenicis distinctly. Kaiser on his chart puts in this place a kind of isthmus, which entirely separates the Agathodaemon from the Phasis, or rather from the Araxes, connecting Thaumasia to Ophir. As stated, the Lacus Phoenicis is not to be confused with the *Dawes Sea* on the chart of Proctor, which occupies an entirely different position relative to the Solis Lacus.

Section VIII. *Argyre: Noachis.*

85. The elegant elliptic arch that includes Thaumasia begins at Aurorae Sinus and ends at Sinus Aonius which belongs equally to the polar Mare Australe and the Mare Erythraeum. In fact before Thaumasia in the southeastern part lies the lucid spot of the Island of Argyre, one of the few islands on Mars which is surrounded entirely by vast seas instead of by narrow straits. The wide channel that separates it from Thaumasia is the Bosporus; it winds around Argyre to end in the twin capes which form the well-defined Charitum Promontorium and Horarum Promontorium [the capes of the Hours and the Graces]. When Argyre first presented itself to me on September 24, 1877, it appeared as a dazzling brightness on the left edge of the disk. This appearance immediately inspired its designation of Argyre—silvery. Since that time I have seen it many times—most recently, on February 26, 1878—with complete certainty. It always appears very bright on the western limb, on the side that looks toward Thaumasia. When on the eastern limb it is never as distinct, and generally a dense veil of vapors covers that part of Argyre as well as the nearby land of Noah or Noachis.

86. I believe it to be my duty to report here all the minute observations that might be useful in determining the relation (not entirely clear to me) between the island of Argyre and the land of Noachis. As I have said, on 1877 September 24 I saw the first traces of the great brightness on the west side of Argyre near the right edge of the planet. In the following days, thanks to the diurnal delay that the rotation of Mars has with respect to that of the Earth, Argyre remained bright, and little by little emerged more fully into view. On September 30 it was presented in its entirety, but still I was not able to discern clearly the eastern side, and I have so indicated it on the chart. It appeared to me almost as if the island might be prolonged on that side, though of more restricted width, all the way to the confines of the limb on the east (left). On October 1, I

made out the same thing: but having started my observation earlier, I was able to distinguish the eastern limb from the long bright spot, which seemed to reach as far as the 350° meridian and to lie on or about the 45° parallel. On October 2 I had a view which was even better: although the eastern part appeared well-defined, I began to convince myself of the existence of an impressive and isolated island, bordering all of Mare Erythraeum on its southern side (Fig. II, sketch xx shows well enough what was seen). On October 4 I noted that it was the same in height but appeared somewhat wider, and also was paler and less defined on its left side where it seemed to consist of a great confusion of colors. From October 10 to 14 I devoted my full attention to the eastern extremity of this supposed island and found the same hue and uncertainty of colors and contours, which it is vain to try to reproduce well in a sketch. Finally, on November 4, I saw the real Argyre once more, represented with its western part toward the left edge; it was as clear and as bright as it had seemed a month earlier.

87. On December 14, 1877, the left extremity of the cloud covering this area dispersed, and a day or two later the peninsula of Noachis emerged. This is a long peninsula of dark color, with poorly defined contours, similar in all respects to those of Deucalion and Pyrrhae, though rather larger than either. Such observations were confirmed on several occasions in February 1878. On February 24 Argyre appeared at the superior edge of the disc like a bright elliptical spot (in consequence of the obliquity of the projection), and one could almost have regarded it as a canopy of snow. Its extension didn't exceed 20° of the maximum circle. On February 25 I saw the part of Noachis adjoining the much brighter Argyre. At last, on February 26, I was able to sketch both of these lands in what I now consider their true form, that is, as reproduced in the chart annexed to this memoir. Considering that the apparent diameter of the planet was reduced to 5".8, one could not expect any exact measures or outlines, above all since these regions at the time were presented under highly oblique viewing conditions. For this region of the planet, then, the form shown on the chart cannot be relied on as more than a gross approximation. Also the nature of the boundary that separates Argyre from Noachis is very uncertain: I am unable to say definitely whether the boundary shown is precise, or whether the splendor of Argyre passes by gradation into the obscurity of Noachis. The existence of a dark channel between the one and the other is also possible. All of these things await the light which future observations will shed upon them.

88. The island of Argyre seems confusedly indicated on a disk by Lockyer, September 23, 1862. In some other sketches by the same astronomer, Noachis is represented under a covering of clouds, which forms a long white streak lying close south of the Mare Erythraeum and in much the same form that I saw in October and November 1877, which is apparently its usual aspect. In fact the same appearance is given by Secchi (October 25, 1862), Lassell (October 25, 1862), Kaiser (December 2, 1862 and December 18, 1864), and above all by Maedler in his discs of 1830, nos. 6, 7, 19, and 21. Secchi in his sketches of 1858 also has the same outline: he identifies the large mass of bright clouds with part of the south polar canopy, making it a great extension thereof.

89. The only observation that I know of that distinctly shows the island of Argyre separated from Noachis and in its true aspect not veiled by clouds is that of Dawes, January 21, 1865, where it is shown as an isolated bright spot, in size equal to the Solis Lacus, with the annotation *glistening white*. The position is in agreement with our Argyre; the size a little smaller; the form roundish. Despite some slight differences, there can hardly be any doubt as to the identity. Dawes in vol. XXV of the *Monthly Notices of the Royal Astronomical Society of London*, p. 226, writes that he observed that bright spot on January 20, 21, and 22, 1865, and that it showed a perfect resemblance to a large mass of snow, being of the same brightness as the polar canopy. Although Argyre has always appeared very bright to me, it has never seemed equal to the polar canopy. On September 30, 1877, I noted: "Its splendor is really extraordinary, perhaps even superior to that of Memnonia (see under § 122 the description of that region), though very much inferior to that of the polar snow." Observations analogous to this of Dawes, by me and others, will be cited hereafter, where meteorological phenomena of the planet will be discussed. On the

chart of Proctor, Argyre is denominated the snowy island (*Dawes' snowy island*). If at times it is snow-covered, it is certainly not so perpetually.

Section IX. *Mare Erythraeum, Deucalion Land.*

90. Mare Erythraeum I call that great expanse on the surface of Mars, almost quadrilateral in shape, which lies between 60° and 310° meridian, and from the equator up to 60° south parallel; it is of somewhat varied color, though generally much darker than that of the zone of equatorial lands. Its basin, in general, is darkest on the north coast along the great diaphragm, and decreases in intensity gradually toward the south; upon it are found various bright stripes and spots, whose configuration relative to each other and to the continents is stable. When examined with insufficient optical power or in turbulent air, these spots are altogether invisible, or appear as fleeting phantasms; to distinguish their form it is necessary to combine a high magnification with a very calm state of the atmosphere.

91. Of all the areas of half-tone, the largest and most conspicuous is Deucalion,[1] although in mere point of size it may be exceeded by Noachis. It separates the Sinus Sabaeus from the rest of Mare Erythraeum, as has been described above. Its form is that of a peninsula partly bent and partly straight: the isthmus, which is attached to the Land of the Incenses [Thymiamata], is bright, and forms a part of that continent. But this isthmus is neatly truncated by a transverse line, beyond which the rest of the peninsula has a very much darker color. In spite of this, there can be no doubt that the bright isthmus and darker peninsula constitute one and the same formation; the difference in color is probably only an accidental circumstance, and due to the fact that beyond the line of shade the peninsula is submerged below the level of Mare Erythraeum. We will see later how much can be explained by the hypothesis that Deucalion land and others similar to it are submarine continents. While the shores of the isthmus are neatly terminated along the Sinus Sabaeus, and also along the Margaritifer Sinus, the two sides of the dark part of the peninsula do not allow precise measurement at any point; their contours are too diffuse. For this reason, such formations are indicated with a dotted line. It is impossible to say whether the peninsula, beyond its bend, proceeds exactly along the parallel. As one proceeds along its course, it becomes ever darker in color, and it is finally indistinguishable from the surrounding sea. It ends or is lost around the 320° meridian, close to the Horn of Ammon.

92. Such seems to be the true aspect of Deucalion, viewed during a favorable state of the atmospheres of both the Earth and Mars. But these appearances do not seem to be entirely enduring. In December 1877 I have seen the part of the peninsula extending along the parallel as more splendid than that adjacent to the bright isthmus. But this is as nothing compared with the varied aspects that the peninsula of Deucalion has presented to other observers. Maedler in his sketches of 1830 invariably shows the peninsula of Deucalion as a bright continent, without hinting at the slightest trace of shade, not even near the Horn of Ammon, where it is truncated.—The sketches of Secchi in 1858 often represent the land of Deucalion in the form of an island along the coast of the continent from the Horn of Ammon to the Aromata Prom. The Sinus Sabaeus is for him one long strait, running between the one and the other of these two points; of the isthmus he gives no trace.—The observations of 1862 in large part corroborate the existence of the peninsula of Deucalion. The sketches of Kaiser and Lockyer provide irrefutable testimony on this point. Lassell, too, indicates it, though less clearly, in his discs of September 24, 25, and 27. Secchi does so (November 25), enclosing the Margaritifer Sinus within a brightish border, which demonstrates that he has seen at least the west bank of the isthmus very well.

93. In 1864 the testimonies diverge greatly. Kaiser's outlines suggest no sensible changes from those of 1862. To him the isthmus is always evident (November 11 and 19, December 18).

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1. The idea that this and all like regions are submerged continents has led me to name them after diluvian heroes, such as Noah, Deucalion, Pyrrha, Ogyges.

Much the same is found in the sketches of Franzenau (November 8 and 10). Dawes alone, whose observations of this region are particularly accurate, doesn't seem to suspect the existence of the isthmus at all (November 12, 14, and 20). Consequently the chart of Proctor shows, instead of the Sinus Sabaeus, a long strait like that shown by Secchi in 1858 (*Herschel II Straits*), going all the way through the area where we have placed the bright isthmus: Deucalion land becomes for him an island, again as Secchi has shown it (*Phillips Island*). All of these testimonials are of value, even where mutually contradictory. I won't prolong the discussion with still other citations, as the point has already been treated diligently by M. Terby in his *Aréographie*, pp. 64-68. Terby seems inclined to conclude that the true configuration is as represented in the sketches of Secchi and Dawes. If so, one must believe that the isthmus of Deucalion seen by Maedler, by Lockyer, by Kaiser, by Franzenau, and indeed for months by myself, is an illusion due to clouds.

94. I judge that the two versions might easily be reconciled on account of the particular facility with which we find that layers of fog form on all these dark lands. Whatever explanation one wishes to give for this tendency, it is a fact founded firmly on the basis of many observations, and is seen to prevail in a most singular and incomparable way in Noachis. This tendency for mists to form is greater as the solar rays fall more obliquely on the region in question. We now observe that the part of the land of Deucalion which stretches along the parallel from latitude about 20°, during the oppositions of 1830, 1862, and 1877, for a long time received the solar rays at an almost perpendicular angle of incidence. By contrast, during the oppositions of 1858 and 1864, the region was more obliquely presented: at an angle of 32° in the first case and of 14° in the second. From these premises it follows that Deucalion land has been covered with a denser fog in these latter cases, and then shines with a more vivid light: the isthmus then appears comparatively dark (but not so much as Kaiser and Franzenau represented). In the years 1830, 1862, and 1877, the isthmus shone more brightly than the peninsula, because it really is brighter, but also because the more oblique angle of the sunlight has allowed the development of a denser fog over it. There is not, then, a single strait, but a peninsula and an isthmus.

Section X. *Pyrrhae Land.*

95. The land of Pyrrhae is almost a copy, though on a somewhat smaller scale, of that of Deucalion. It takes off from the Aromata Prom., which lies exactly on the axis of the isthmus, and proceeds southward and eastward until it attains the 24° parallel; it then bends at an angle of about 120° and fills about half the space which Mare Erythraeum occupies between Deucalion land and the island of Argyre. Its contours are precise only close to the continent from which it departs: thereafter its sides become increasingly diffuse, and seem to converge somewhat, until at last they are merged insensibly into the general background of Mare Erythraeum. It is impossible to determine an exact endpoint. I have never succeeded in discerning it east of the meridian of Aryn, though certain appearances lead me to believe that it is prolonged still further east. Overall it is a good deal darker than Deucalion land, and not easy to make out in the midst of the darkest color of Erythraeum. The maximum brightness is a little beyond the bend. The isthmus is rather darker, and even in the vicinity of the Aromata Prom. difficult to observe, because it participates for the most part in the strong color that distinguishes the Margaritifer Sinus and Aurorae Sinus. It would be easy to imagine that Pyrrhae land is an island, although it is certain that it is not (cf. § 64).

96. The disposition of Pyrrhae land is worthy of further consideration. In fact, given that the dark color of Erythraeum is due to the existence of a true sea, whoever observes the northern coast from Margaritifer Sinus to Aurorae Sinus and notes the contrast of light and shade along that splendid coast can hardly escape the conclusion that it is part of the same sea that forms those two gulfs. This leads quite spontaneously to the idea that the lighter tongue dividing them actually is a submerged expanse, brighter toward the top, because not as deep there. Other facts lend support to this view of things and will be presented in due course.

97. Pyrrhae land has been very well delineated by Lockyer in 1862 (September 23, 11h 55m) in a sketch that clearly shows the Aromata Prom. and also the mouth of the Hydaspes. Another sketch made an hour later shows only the isthmus of that peninsula. Lord Rosse (October 29, 1862) figures it entirely, but connects the point with the knee formed by Deucalion land. Kaiser has seen the extended part of the peninsula, but not the isthmus, on November 9 and 11, 1864; the isthmus but not the extended part on December 18 of that same year. The sketch made by him on the latter date indicates the existence of a third land lying between those of Deucalion and Pyrrhae, but very much shorter. I must confess that I have been able to make out nothing of it, and believe that this appearance is merely an accident of the way that Kaiser has interpreted the Margaritifer Sinus and the mouth of the Hydaspes.

Section XI. *General Observations on the dark land of Mare Erythraeum.*

98. These lands, with their tendency to appear as if covered with layers of mist, strongly illuminated from the sun during the winter of the southern hemisphere of Mars, often look like islands or bright continents, and are so imaged in the chart of Proctor. But because we do not find such a bright veil, meteorologic in origin and subject to continual changes, elsewhere on the surface of Mars, the delineations of the different observers of this part of the planet are accordingly subject to the most glaring inconsistencies. I have already tried to describe the discordant representations of Deucalion land, of its isthmus, and of the Sinus Sabaeus, and by the same principles hope to explain these even more inexplicable appearances.

99. Proctor, in his chart founded (as he has said) chiefly on the sketches of Dawes, places to the south of his *Herschel II Straits* three large lands extending in the direction of the parallel and disposed along a line from south to north. They are in order: *Phillips' Island, Jacob's Island, Kunowski's Land.* Between the vast equatorial lands and Phillips' Island he puts the aforementioned Herschel II Straits; between Phillips' Island and Jacob's Island, *Arago's Straits,* and between Jacob's Island and Kunowski's Land, *Newton's Straits,* Kunowski's Land would then be connected to a polar continent which according to me does not exist.

100. All of these are no more, I believe, than atmospheric metamorphoses of the map of Erythraeum. Because the isthmuses and peninsulas of Pyrrhae and Deucalion are located in the torrid zone of Mars and lie among the darkest lands, bright layers of clouds form more readily here than in higher latitudes. Phillips' Island actually represents a clouded region extending south of Deucalion, Jacob's Island the clouded extremity of Pyrrhae; finally, the third and last, the most important island, is formed from the fogs which cover Noachis and the island of Argyre: in attempting to define the nature of this last (§§ 85-87), I was put to so much trouble that it even prevented me from completing the description of Argyre and Noachis as accurately as I had wished. These islands of vapor result from the to and fro movement of the atmospheric current; they grow together by two and two; sometimes all three are involved. At yet other times they divide or transmute into other forms. These meteorologic contours correspond with those of the dark lands of Mare Erythraeum, and are *meteorologic images* of those lands.

101. The union of these two cloud banks is fairly commonly recorded by various observers. The large island shown in the sketches of Secchi (1858) above the Sinus Sabaeus is probably due to the union of these cloud banks over Pyrrhae and Deucalion. The great clear space which occupies this region in the chart of Maedler (1830) is prolonged as far as the south pole; it is part of a cloudy mass, which in that year enveloped all of the lands of Deucalion and Pyrrhae, also all of Noachis. In his chart this great cloud appears tripartite toward the east, and its origin is clearly indicated. I won't multiply examples here, since one can easily refer directly to the observations, some of which are collected by Terby in his often cited *Aréographie.*

102. A notable example of a bank of cloud formed above a dark land which then moved by some force (wind no doubt) is provided in the drawings of Lockyer made on the evening of September 23, 1862. In the first of them (10h 25m Greenwich) the land of Deucalion has the

same form shown by us up to the bend; beyond this point, it forks into two equal tongues, of which one, the lower, is the true peninsula, the other is nothing more than the meteorologic image produced by the winds blowing toward the southwest but with greater force at its eastern extremity than at its western. In the second sketch (11h 55m Greenwich) the same is exactly reproduced, and one sees that the meteorologic image of Deucalion land touches its eastern point to the land of Pyrrhae, and further on is confused with the veils covering Noachis. In the third sketch (12h 55m Greenwich) that meteorologic image is much diminished in intensity, perhaps because the continued heating of the sun, which is by now three hours past the meridian, has in part reduced these transparent vapors. The other part in the eastern extremity seems also greatly weakened.

103. A similar situation, though less clear, is apparently found in the sketches of Lockyer on September 23 and 25, 1862, in which strips of cloud originate over Deucalion land and then push in a southwest direction in many tongues and parallel filaments. The same appears in the disc of Kaiser of December 23, 1864. A current of clouds seems to issue from the Horn of Ammon (a current which in various forms appears in all the sketches which Kaiser has made of this region), and is driven, as usual over Deucalion and Pyrrhae lands, toward the southwest. The same thing is repeated again on October 31 and December 10, 1862. On November 19, 1864, Kaiser instead has seen two currents of clouds tending directly toward the south pole, the one departing from the Horn of Ammon, the other from the knee of Deucalion.

104. I don't propose to discuss in the same way all the other delineations. But I do greatly regret that I cannot comment on similar phenomena from my own experience. During the period of useful observations in 1877, the southern hemisphere of Mars between the pole and the great diaphragm was singularly free of vapors; with the exception of those that for a long time veiled Noachis and of another case that I will report in the following section, there were no changes that could be attributed to clouds floating over the surface of the planet. This circumstance, while greatly facilitating the topographical mapping, has left very deficient my notions of the meteorology of Mars.

Section XII. *Lands of Ogyges and Proteus.*

105. The Bosporus Straits, which lie between Thaumasia and Argyre, are not of uniform color: along half of their course they take the form of a stripe less dark than the land of Ogyges, which I observed distinctly on the evening of October 2 ($\omega = 45°.2$) and confirmed on November 4 ($\omega = 86°$). I saw it turn in a gentle arch around Thaumasia, but because of the oblique presentation could not follow it leftward as far as its western end. However, it cannot have extended much beyond the Charitas Prom., to judge by the color that at other times I have seen the Mare Australe take in those places. Its eastern terminus, and indeed that of the Mare Erythraeum itself, might be taken as lying close to the parallel in which lies the apex of the Aurea Cherso, and from thence the land of Ogyges points eastward, a fact which the observation in the excellent air of October 2 put beyond doubt. Its color seemed in places even clearer than that of the land of Pyrrhae.

106. The other land of Proteus was small but notable among the dark lands of Mare Erythraeum. It was also found by me on 1877 October 2 and was figured as a spot a good deal brighter than the sea lying between the land of Ogyges and the apex of the Aurea Cherso, as indicated on the chart. I could not judge to my satisfaction whether or not it was connected to the Aurea Cherso: the sketch that I consider best shows it detached, and this is how I have shown it on the chart. On the eastern side the boundary seemed to be fairly decided, and extended to a point about parallel with that of the left hand side of Ogyges. The color was the same but brighter than that of the peninsula of Pyrrhae. The existence of the land of Proteus was confirmed on November 4.

107. On two occasions I have seen not the land of Proteus itself, but its meteorologic image—that is, a layer of bright clouds filling the place and imitating its form. The first time

was on 1877 September 26 ($\omega = 84°$); that day I saw projecting from the eastern extremity of Thaumasia (or rather of the Aurea Cherso, which I had not yet learned to distinguish from Thaumasia) a white horizontal streak. This clearly interrupted the large dark arch, or great brow, that impends above the eye formed by Thaumasia. This phenomenon is well represented in Fig. II, drawing XVII attached to this memoir. When I drew this bright streak on the 24th, I did not yet suspect that what I was treating would prove to be variable: this was only confirmed from subsequent observations. In fact, on October 2, I found the land of Proteus in the same place, but more obscure, while on October 4 ($\omega = 75°$) the bright streak was again represented. The two objects were almost identical in form and extent, but so unequal in brightness that I wanted further clarification. This was not immediately forthcoming: only on November 4 did I see that only the dark area remained. All these changes led me to name this object the land of Proteus.

108. Now there can be no doubt that the land of Proteus had twice been covered by a bright veil, on September 26 and October 4, and twice uncovered. The region shows successively and rapidly the same changes that in a longer period, and then but once, had been ascertained in Noachis. These are the observations leading me to suppose that in this kind of dark land (or low-lying basin, as I believe it to be) layers of fog are produced, which conform to its actual outline. And we have already seen that this conjecture serves to explain the varying appearances which the lands of Deucalion, of Pyrrhae, and of Noah have offered to so many faithful observers. But this is not the place to enter into a full discussion of the causes that facilitate their production.

Section XIII. *The Araxes: Icaria: The Columns of Hercules*

109. After this excursion among the dark lands of Mare Erythraeum, I return to the great diaphragm, and resume my description of the continental regions that I left off with the Sinus Aonius and the Phasis. As already indicated, the latter channel, upon leaving the Lacus Phoenicis, forks and then throws out a tortuous arm called the Araxes, which empties into the eastern-most extremity of the Mare Sirenum. I first saw the Araxes on September 24, 1877 ($\omega = 98°$) and on many occasions thereafter. To its curvature, which is very evident and constitutes a rather rare case among the channels that cover the whole planet, I have paid particular attention, and made quite a few sketches on the 24th and 25th. The Araxes is broader at its beginning than at any other point along its course. On September 26 ($\omega = 91°$) it even seemed to me that the Araxes was more easily visible than the lower part of the Phasis.

110. Between the Araxes and the Phasis there lies a region which is grossly polygonal, called Icaria. I have noticed here a more subdued color than that in the neighboring regions of Thaumasia, Daedalia, and Electris. Especially noteworthy seemed to be the contrast of brightness between Icaria and Daedalia along the Araxes, which divides them. Along Icaria, from the mouth of the Phasis in the Sinus Aonius to the mouth of the Araxes, runs the Columnae Herculis [Columns of Hercules], a uniform channel of considerable length, one of the most readily visible on the planet, which forms a connection between the Mare Sirenum and the great Mare Australe. The Columns of Hercules was seen for the first time on September 20, 1877, and afterwards on all occasions until January 3, 1878, when the diameter of the disc was reduced to 8".4; then, with great effort, it was recovered as late as March 21, when the diameter was not more than 5".2.

111. The Araxes and the Columns of Hercules, and also the first part of the Mare Sirenum, were well seen by Kaiser on December 10, 1864, and are well represented in his chart, though in a somewhat idiosyncratic fashion. Since Kaiser was ignorant of the wide mouth of the Phasis, he includes it and the polygon of Icaria within the great oval of Thaumasia. The Columns of Hercules represents the right extremity of the great brow or arch that impends above the region, while the Araxes, confused with the first part of the Mare Sirenum, is shown as a long straight uniform ray. Also Kaiser includes the Aurea Cherso on one side of Thaumasia and Icaria on the other—thus in his chart the arch extends for 64° of longitude; in mine, without these appendages, for only 45°. This explains why his Thaumasia, instead of having a graceful elliptical contour, is terminated at the top by a circular arch, and pinched off in the form of an almond at the two

extremities; also why he puts the Solis Lacus, which on my chart is eccentrically located within the oval of Thaumasia, almost in the middle. In fact, I also show the Solis Lacus almost exactly in the middle of the base of the Aurea Cherso and the mouth of the Columns of Hercules in Mare Sirenum, that is, the two points corresponding to the two extremities of the Thaumasia of Kaiser. On the whole, everything agrees well enough, and I believe that the differences between me and the excellent observer of Leyden are in reality not very significant.[8]

112. The Columns of Hercules is clearly indicated by Lockyer (October 18, 1862), Lord Rosse (September 14, 1862), and Lassell (November 17, 1862). Maedler also designates it very well in his 20° disc of 1830, together with the adjoining regions of Sinus Aonius and Mare Sirenum.

Section XIV. *Daedalia: Channel of Sirens: Oceanus.*

113. To the north of Icaria on the other side of the Araxes lies another tract enclosed by channels, which I have designated Daedalia. Its color is similar to that of Thaumasia, so that it belongs among the regions of intermediate brightness on the planet. Separating it from Thaumasia and Tharsis are the southernmost part of Phasis, the Lacus Phoenicis, and the channel Eosforos. The last, on leaving the Solis Lacus, crosses the Lacus Phoenicis and continues due northwest. In the vicinity of the equator, it disgorges into the great channel referred to as Oceanus. The outlet of the Eosforos was seen by me many times, though never very distinctly. However, the same Eosforos during the first months of 1878 grew much wider and more observable: thus it was well distinguished on March 21, when the apparent diameter of the planet was only 5".2.

114. The western limit of Daedalia is formed by the channel or river of the Sirens, which runs nearly in the direction of the meridian and has its southern mouth in the Mare Sirenum, in the vicinity of the Araxes; the northern mouth empties into Oceanus not far from the equator. The southern part of the river of the Sirens is straight and precisely bounded: this part of the channel has been seen many times beginning on September 18, 1877, and was fairly well indicated even near the edge of the disk, although throughout 1877 the inferior wider part was always pale and without well-defined limits. Certainly this must have been due in part to disturbances in the atmosphere of Mars, because on January 6, 1878, when the diameter of Mars was reduced to 8".2 and (contrary to all expectation) the Sirens appeared wider, darker and more observable than it had ever been seen before; and this appearance lasted until March 21, 1878, on which date one could make out not only its northern mouth, but also a good deal of the adjoining shore of Oceanus, which in my earlier views had always appeared confused. I believe that the advance of the sun to the equator of the planet (which occurred on February 22, 1878) dispersed the mists and allowed this feature, despite the great distance, to show more clearly than it had on its doubtful first presentation.

115. The channels of Eosforos and of the Sirens have ample but not very well terminated mouths; and the same phenomenon is also hinted at in various other places on Mars. The cause of this defective visibility may well be that a veil of fog darkens the region, which on the face of it would certainly seem to be the case with the river of the Sirens; yet other observations lead me to think that at least in part the effect may be due to the presence of an actual delta in these channels, in other words, the division of the greater channel into two or more tributaries which are too fine to be discernible. Instead they appear confusedly as a shadow or dark cloud on the bright ground in much the same way that stars, individually invisible, mass together to form the nebulae. I will later give one more noteworthy example of this illusion [§ 121].

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8. I must admit that at first, on finding the Solis Lacus eccentrically situated within the ellipse of Thaumasia, in flagrant contradiction to Kaiser, I suspected that changes had taken place; a suspicion which, on closer examination, proves to be unjustified. This is a beautiful example of why it is necessary to interpret the sketches of observers carefully before reaching any conclusions about possible mutations on the surface of the planet.

116. The Oceanus, into which the Eosforos and the river of the Sirens empty in almost the same mouth, may be a grand channel, perhaps the most notable which exists on the entire surface of Mars, both because of its great width, which almost entitles it to the title of a sea, and its enormous length, which at the opposition of 1877 was followed through some 140°; however, it is probably even longer, since I was unable to make out either its beginning or end. Because of the mists that in September, October, November and December 1877 constantly hung over this whole region, and then because of the increasing distance of the planet in January, February and March 1878, I was not able to say whether it was a shade or a continuous series of shades in the form of a ribbon, not very dark or well defined: but I would be surprised were there not very many notable changes in its course. Its eastern section appears to empty into the Nilus (a point on which I could wish for a more accurate determination) left of the 180° meridian. That it is possible to characterize this even so inexactly is owing chiefly to the views that I was permitted in January and March 1878. Many additional details of Oceanus and especially of its northern course (which remains almost entirely unknown) may be anticipated from the opposition of 1879.

117. It is not possible to identify any obvious trace of the Eosforos or of the channel of the Sirens in any of the observations I have consulted, unless possibly it is the latter that is indicated by the shading on the right side of Kaiser's sketch of October 24, 1862. The presence of Oceanus, in the contiguous region called by me Daedalia, is attested beyond a doubt in his disc of November 23 of the same year. The sketches of this region by Kaiser in 1864 are all poorer than those of 1862, when the planet presented itself less favorably. In his chart, moreover, the region is completely blank. Dawes alone at the opposition of 1864 has, as usual, a greater number of details, but these for the most part are irreconcilable with those of 1877. His disc of November 3, 1864, contains in the center of this region a crowd of dark streaks, which tend predominantly northeast to southwest. He also distinguishes the Solis Lacus and the Mare Sirenum. The long streak, which from the eastern extremity of this region descends into that which I have called Tharsis, Proctor designates with the name Channel of Bessel (*Bessel's Inlet*). On his chart this extends along the 240° meridian, that is, our 120°. Examining closely the original sketch by Dawes, we find that the Channel of Bessel should actually be on the 125° meridian. That being so, we can immediately and exactly compare it to our chart with regard to position and form, and find as follows: first, it corresponds partly with the course of Oceanus in Tharsis and Daedalia; second, with our Channel of the Sirens; third, with the first section of Mare Sirenum, from the mouth of the channel to the Columns of Hercules. This small portion of the Mare Sirenum constitutes a kind of lake, in which Dawes and Proctor terminate the upper end of the Channel of Bessel. All this agrees very well, if we assume that for Dawes the final section of Mare Sirenum appeared separated from the rest, probably owing to strips of cloud. The Channel of the Sirens, and the existence of our Oceanus in the region adjacent to Tharsis and Daedalia, are completely confirmed by the observations of Dawes.

118. This also provides the explanation for why in the chart of Proctor his *Maraldi Sea* (our Mare Sirenum and Mare Cimmerium) is shown shorter than it actually is. Between our fundamental points no. 19 and 41, which are its extremities, are 107°.5 of longitude. According to Kaiser, there are 112°.3, but Proctor has only 80°, or at most 85°. But if we consider the lake that forms the head of his *Bessel's Inlet* as actually a part of his Maraldi Sea, he has 102° for the total length, which is much closer to the truth. In his discs of 1858, Secchi did not have the opportunity to represent this part of the planet very satisfactorily.

Section XV. *Mare Sirenum: Memnonia: Amazonia: channels of the Giants and the Titans.*

119. I have now arrived at the beginning of that long series of inland seas, divided by thin diaphragms, which surround, in a direction rather inclined to the equator, the southern hemisphere of Mars for a good 165° of longitude. This series one could almost regard as a wide

channel on the surface of the planet, interrupted in two places by breaks of little consequence: it is a formation analogous to that of the great channel Oceanus, but known in much greater detail. The two breaks divide it into three principal trunks, which I have named the Mare Sirenum [Sea of Sirens], the Mare Cimmerium [Sea of Cimmerians], and the Mare Tyrrhenum [Tyrrhenian Sea]. A cohort of small channels, most tending in the direction of the meridian and lying nearly parallel to one another, connect the three aforementioned seas on their southern side with the Mare Chronium, which could be regarded as a formation analogous to the other two and a few lesser ones that they parallel. But the Mare Chronium is not enclosed between continents; it has three principal maritime connections with the great southern basin.

120. I will examine first the Mare Sirenum. From the nearly kindred mouths of the Araxes and the river of the Sirens, this sea runs westward; a little after it receives the mouth of the Columns of Hercules (§ 110) it becomes tilted about 30° to the south. Beyond the 145° meridian it changes direction, and becomes tilted 30° to the north. It keeps this direction all the way to where it ends, abruptly truncated almost perpendicularly across its length. Here are found three gulfs: the first and smallest opens upon the river of the Giants; the second and largest forms the southern mouth of the river of the Titans; and the last is located at the point of its most extreme extent, where it comes up against the peninsula of Atlantis; the latter divides it from the Mare Cimmerium. The Mare Sirenum is among the darkest areas on the planet, and equal in color to the Solis Lacus: but I believe it to be less dark than the Sinus Sabaeus and the Margaritifer Sinus. Its color has seemed to me always and everywhere uniform: its shores are clearcut, forming a vivid contrast with the splendid lands that surround it, especially on the northern side.

121. In its eastern extremity the Araxes, the Columns, and the river of the Sirens empty into the Mare Sirenum, as already described: in the western extremity the river of the Giants and that of the Titans do so. The mouths of the last two are very near each other, but well divided, and they go off in very divergent directions. Yet it is not possible to describe them exactly, since as they proceed northward toward Oceanus they become ill-defined. On the date of September 16, 1877, also the following, I saw confusedly one current only, toward the north, in the form of a fan. Only on October 27 did I succeed in discerning that there were two distinct channels with separate mouths in the Mare Sirenum. The land enclosed between the two, which because of its pronounced hue is well defined even from afar, is called Amazonis. By January 3, 1878, the mists that at first had covered this region seemed to have dispersed, and I was still able to see and distinguish from one another the rivers of the Giants and the Titans, which were of a width and darkness which they had not had at first. The river of the Titans was still observable on February 10, and again on March 18. On the last day, I wrote: "The river of the Titans is beautiful, and it seems to me to be very toothed and tortuous." The apparent diameter of the planet was at that moment 5".2.

122. The river of the Giants and that of the Sirens together with the Oceanus forms an ample circuit, which departs at one extremity of the Mare Sirenum and reenters it at the other. The almost circular land which is thereby isolated from the rest is called Memnonia: in it, and especially in the part abutting on the Mare Sirenum, I have noted a degree of splendor truly extraordinary, which is without example on Mars except for that which I have already described on the west shore of Argyre and for one other place of which I will say more below. This effect is sensitive to Memnonia's position on the edge of the disc, but unaffected by the phase. I have recognized it many times, most recently on March 18, 1878. The same observation was made by Dawes, who on his disc of November 3, 1864 makes the comment: "White, almost glistening."

123. Up until the most recent times, Mare Sirenum and Mare Cimmerium were designated together as a single sea, to which Proctor has given the name *Maraldi Sea.* This sea is the most extensive marking that has ever been observed on the surface of Mars, as noted in the *Aréographie* of Terby. Most of the observations show the figure of Mare Sirenum bent like the neck of a bird. In 1864 it had the same form that I have given it in my chart, as is shown by the sketch of Kaiser on December 10: our agreement regarding the Mare Sirenum and the Columns of Hercules is as perfect as one could ever wish. But in making his chart Kaiser has apparently

not taken account of that sketch, and the form of Mare Sirenum given there is less faithful. The bend at the eastern extremity of Mare Sirenum is missing in the chart of Proctor, in consequence of the truncation of that sea that gives rise to the separate *Bessel's Inlet* (see above § 117). I find no certain sign of the river of the Giants or of the Titans by any observer. There is only a hint in the already cited disc of Dawes of November 3, 1864.

Section XVI. *Atlantis I and II: The Gulf and Channel of Laestrygonum.*

124. I designate by Atlantis I that long and narrow tongue of land that divides Mare Sirenum from the Mare Cimmerium. Its width is almost uniform, and measures around 3 or 4° of the maximum circle (100 miles or somewhat more). It is seen somewhat better in its northern part, where it attaches to Zephyria. It is easily discernible even in mediocre air, and I have been able to distinguish it with complete certainty on the evening of December 30, 1877, the apparent diameter of the disc then being reduced to 8".75, and yet again on February 7, 1878, when the apparent diameter was 6".54. On the last evening I have written: "Atlantis I is strangely evident." On March 18, the air being fairly good, one could hardly have seen it more decidedly, though the diameter of the disk was then a mere 5".2. In the first observation that I made of Atlantis I on September 14, 1877 ($\omega = 205°$), I believed that the color of the peninsula in the lower isthmus or northern lowland was darker than the rest, but remained doubtful whether there was a definite connection with the continent of Zephyria. I was never able to resolve this doubt at other times, even in much more favorable atmospheric conditions. I also noticed that the eastern part of that isthmus and the adjoining gulf, forming from the Mare Sirenum our fundamental point at 26°, never appeared with complete distinctness and in a way that satisfied me fully. There certainly are in this place details reserved for other observers to discover.

125. I noticed on the same date, September 14, 1877, the atmosphere then being very tremulous, that the part of the Mare Cimmerium bordering Atlantis I seemed very much less dark than the remainder of that sea: the same observation was repeated on October 20. Finally, on October 21 ($\omega = 199°$), I discovered the true cause of this appearance, when I recognized that long and straight peninsula almost parallel and equal to Atlantis I, only somewhat narrower, which in the map is designated Atlantis II. The same day, the longitude of the central meridian being 218°, I noticed that it was not completely regular; it was narrower at the top than at the bottom, and its upper end consisted of a blunt and confused area. I also saw that, though it had a color rather brighter than that of Mare Cimmerium, it was darker than Atlantis I, so that this peninsula must be considered similar to those of Deucalion and Pyrrhae. Atlantis II is a rather difficult object: on December 30, 1877, when the disc diameter was reduced to 8".75, it was no longer to be recognized, though Atlantis I remained steadily visible.

126. The area of Mare Cimmerium lying between the two Atlantidi, which appeared very dark on October 21, I have named the Sinus Laestrygonum. In its intimate recesses between the northern isthmuses of Atlantis I and II, the river of the Laestrygons has its mouth, on the western side of Zephyria. It follows a course along the meridian, and I have been able to follow it, on the dates of October 20, 21, and 27, also December 30, 1877, all the way to the great Oceanus. The river of the Laestrygons is a great deal less observable than those of the Sirens, the Titans, and the Cyclops. Nevertheless, it could still be recognized on February 7, 1878, when the apparent diameter of the disc was only 6".54.

127. Atlantis I, like a diaphragm dividing Mare Cimmerium and Mare Sirenum, is already recognizable in the sketches of Maedler made in 1837 (see especially his discs 7, 14, 15, 16, and 17 in figure V of the *Beiträge*, but in a form that is very rudimentary). After him various observers saw and sketched it, especially Lockyer and Kaiser in 1862, whose discs agree sufficiently well with our tracing. On October 9 and 11, 1862, Lockyer even succeeded in glimpsing something of our Atlantis II, and his descriptions of Atlantis I are the basis of those given by Terby in his *Aréographie*, p. 90. Mr. Terby deserves the credit of calling attention to this peninsula, for which he proposed the name *Webb's Land.*

128. As for the river of the Laestrygons, it is apparently shown for the first time on our chart, unless we wish to identify it with the light cloud occupying the inferior left hand part of Kaiser's sketch of January 3, 1865. The mouth of the river of the Laestrygons is more definitely shown in the sketches of Phillips of October 15 and 16, 1862; at least I am inclined to identify it with the small indentation that follows the lower isthmus of Atlantis I, which is fairly well, if not exactly, represented in the same sketches.

Section XVII. *Mare Cimmerium: River of the Cyclops.*

129. That part of the ancient Mare Maraldi which is cut off by the two Atlantidi from Mare Sirenum I have designated by the name of Mare Cimmerium. Its color is fairly uniform, and equal to that of Mare Sirenum and Solis Lacus; but its shores are not at all as well-defined, especially the southern, so that I have represented it by a simple straight line along the parallel without indicating other notable indentations than the mouths of the channels Simois and Scamander. Much more marked is the western shore along the peninsula called Hesperia.

130. The Mare Cimmerium has communications with the great river Oceanus by means of two emissaries: the river of the Laestrygons and the river of the Cyclops. The first has already been described. Very much more important than this seems to be the river of The Cyclops, which I have been able to see at all times whenever this part of the planet has been presented to view. In September, October and November 1877, it really appeared more like a blurry and indistinct shade than as a continuous line, no doubt because of the vapors that lay over this part of the equatorial continent at the time. But these eventually dissipated with the sun's crossing the equator, and on the dates of December 25, 28 and 30, 1877, when the disc was less than 9" of arc, I saw it as an apparently long dark strip descending for perhaps 18-20° in the direction of the meridian, then bending to the northeast to join with the river of Oceanus, thereby confirming the prior sketches which had been made by me with such effort. This appearance it maintained throughout the observations of 1878, and up to March 17, when the diameter of the disc was hardly more than 5". I could hardly believe that the width of the river of the Cyclops is less than 3 or 4° of the maximum circle (100 miles at least), even in the more narrow parts. The region that lies between the river of the Cyclops and that of the Laestrygons I have named Aeolis.

131. For the earlier observations of Mare Cimmerium, refer to the *Aréographie* of Terby. Here I will note only that the large and easily visible river of the Cyclops must be represented by the mouth of the vast inland sea indicated on the chart of Proctor with the name *Huggins Inlet*: an inland sea that perhaps in places is identical with our Oceanus. The chart of Proctor in this part has been based on a sketch by Dawes on 1864 December 1. The position of the mouth of the Mare Cimmerium agrees to a hair. In the observations of December 28 and 30, 1877, I have given much attention to verifying whether the course of the river of the Cyclops could be reduced exactly to the beginning of the *Huggins Inlet*; but I was unable to convince myself. The river of the Cyclops leaves Mare Cimmerium and travels for about 20° in the direction of the meridian, and then curves lower and eastward, while according to Dawes and Proctor the direction of the *Huggins Inlet* makes an angle of around 45° shortly after leaving Mare Cimmerium; beyond it an even greater angle.

132. M. Terby has collected the accounts of all the observations which could refer to the *Huggins Inlet* (*Aréographie*, pp. 93-96). Taken as a whole, they confirm my tracing of Mare Cimmerium. The left part of Secchi's sketch of 1858 June 20 shows two channels following the direction of the meridian, one of which is apparently the river of the Cyclops. The other two sketches of June 17 and 18 are not useful because the region is too close to the edge of the disc. The sketch of June 24 would have been decisive, had it not unfortunately been made in bad air. In the right part of his disc of October 11, 1862, Kaiser has a streak running along the meridian which indicates a vague perception of the Cyclops. The same streak is shown in his chart, probably inadvertently, running obliquely to the meridian in the direction of the Huggins Inlet of Proctor. Perhaps of greater weight are the sketches of Kaiser of January 7, 1865, which contain

an indistinct shadow in this place, and of Terby, made after Mr. Gledhill's of April 6, 1871, which shows a streak in the direction of the meridian in the same way that Secchi and I have it. Franzenau in his disc (November 22, 1864) also concurs with us, and the 16° sketch of Knobel (May 31, 1873), if one allows for the obliqueness of the orthographic projection, seems to agree sufficiently well, at least the part near Mare Cimmerium. I hope that at the opposition of 1879 some of these uncertainties will be dispelled.

Section XVIII. *Phaetontis, Electris, Eridania.*

133. These three regions form a brightish zone limited on the north by Mare Sirenum and Mare Cimmerium, and on the south by Mare Chronium; this zone stretches along the parallel with a fairly uniform width between the Columns of Hercules and the great peninsula of Ausonia, where it connects with the equatorial lands by means of Atlantis I and Hesperia. The splendor of this zone is inferior to that of the lands lying below the great diaphragm, but is clear enough relative to the dark seas that bound it on both sides. In general it seems brighter in the western part by Ausonia than in the eastern part next to the Columns.

134. Extending from the Columns is the tract called Phaetontis, which is attached to, and continuous with, the southern isthmus of Atlantis I. Immediately after it comes the channel of the Simois, which follows an arc-like course, and is indeed one of the most strongly curved features on Mars. The Simois is certainly among the most difficult things to make out: it escaped me throughout the first series of observations I made of this region, September 16-22, 1877, and I failed to see it until October 21 (197°), on which date I delineated its form with certainty. Its existence was entirely confirmed on October 27 (147°).

135. The land called Electris is trapezoidal in form, and featureless: it is bounded by the strait or channel of Scamander. This goes straightaway from south to north, and is very much easier to detect than the Simois. I saw it for the first time on September 16, 1877, and on many occasions until December 30, when it was still discernible on a disc of only 9" diameter. On February 7 1878 it was not recognized, though perhaps in part on account of the bad state of the air.

136. Eridania properly speaking is no more than the southern head of the great peninsula of Hesperia. It has always seemed to me bright in comparison with the neighboring regions, especially when it lies near the edge of the disc; and I continued to verify this observation as late as December 24, 1877. It is divided from Ausonia by the channel of the Xanthus, which again is easily observable; the first observation of it was made on September 13, 1877, and the last on February 1, 1878. It has a mouth on the inferior part of Mare Tyrrhenum, and ends in another ample gulf in Mare Australe known as the Sinus Promethei [Bay of Prometheus]. The Xanthus like the Scamander seemed to be visible more on account of its width than its darkness: I believe that I have also seen that they are both terminated by two banks.

137. The northern limits of the lands described here have necessarily been recorded by all who have seen Mare Cimmerium and Mare Sirenum, the southern limits only by those who have seen the Mare Chronium with certainty (see Section XIX). The channel of Scamander and its companion were here noticed for the first time. But the Xanthus is clearly indicated by Lockyer (October 3 and 9, 1862), again more confusedly by Kaiser. Also the dotted line that forms the southern part of Ausonia in Maedler's chart of 1830 may indicate an uncertain and fugitive observation of the Xanthus. The second disc of the 1832 series published by Maedler in the *Beiträge* contains a less certain record of this feature.

Section XIX. *Mare Chronium, Thyle I and II.*

138. From the Sinus Aonius and the mouth of the Phasis the shore of Mare Australe stretches to the right or westward for some 180° of longitude, climbing gradually from the 45° to

58° south parallel, and forming various bays of which few are well defined apart from that coinciding with the southern mouth of the Simois and another coinciding with that of the Xanthes. The latter presented itself well on October 14, 1877 (275°) in excellent conditions of atmosphere, and was very evident and well defined; but the first was sensible only as a slight pinching off of the bright zone of land described in the previous section. The lands of Thyle I and Thyle II, like true islands, here emerge from a kind of long Mediterranean, having many openings, to which I have given the name Mare Chronium. The latter generally presents as a stripe a little less dark than Mare Sirenum and Mare Cimmerium, occupying, when the central meridian is at 190°, all the observable disc along the parallel from right to left; it then seems like a dark chord stretched across the disc. In excellent air one begins to recognize that the width of Mare Chronium is not at all uniform throughout, because of indentations on the northern side; also because of the Ulysses Fretum [Strait of Ulysses], which passes between the two islands of Thyle and accounts for the rounded contours of these. Such inequalities, and also the width of Mare Chronium itself, appear much foreshortened because of the obliquity with which they are projected: during the observations in question the visual ray had an average tilt of 55° to this part of the surface. At all the times that I have observed it, Mare Chronium has been free of fog. I saw it perfectly well on January 3 and February 10, 1878, when the apparent disc was reduced to 8".5 and 6".4, respectively.

139. The real condition of the two islands of Thyle did not become apparent to me except by successive stages. On the date September 13, 1877, and the next night I recognized that Mare Chronium in its western part was separated by a bright cape from the sea surrounding the snowy canopy. The western edge of this cape seemed to me to lie near the river Xanthus. Later, on September 20 (ω = 152°), when Phaetontis was on the central meridian, I saw another bright round cape south of the Columns of Hercules. I supposed then that these two capes belonged to one and the same island, elongated in the direction of the parallel, which I named Thyle. But I was undeceived on October 20 (219°), when I discovered a strait which divided this supposed island into two lesser ones. This strait, which on the chart bears the name Ulysses Fretum, was evident, despite the fact that its meridian was already well past the center and indeed nearing the left edge of the disc. I then saw no less decidedly the southern limits of the two islands, which seemed to me like ovals lengthened in the sense of the parallel because of the indirectness of the projection, though in reality they must be nearly round. On October 21, I succeeded in observing the passage of the Ulysses Fretum across the central meridian. Its axis runs almost due north-south. Under these circumstances I noticed that the westernmost of the two islands (Thyle II) seemed to be somewhat larger and more southern than the other, or Thyle I. I made other observations of the two islands on October 27, which confirmed the preceding depictions.

140. A singular splendor is exhibited by these islands when they lie close to the edge of the disc. Thyle II has appeared many times in this aspect, whenever its western extremity lay on the left edge, that is, at the time when the central meridian is at 280°. The last observation of this kind was made on November 16, 1877, when the disc was reduced to 13".3. I have also noted the existence near the edge of the disc of bright spots little different in appearance from the snowy polar spot, and as already mentioned, the Ulysses Fretum was first recognized when it lay very far from the central meridian. These phenomena are analogous to those I have already narrated in connection with Argyre.

141. The Mare Chronium is exactly rendered by Maedler as early as 1830. It is also very well shown on the disc of Secchi on June 18, 1858. Lockyer has also seen it on October 3, 9, and 11, 1862. I will say nothing of other observations. Kaiser not only indicates Mare Chronium indefinitely and diffusely in his chart, but he also shows above it a fairly bright spot, which undoubtedly is our island of Thyle I. The longitudes assigned to its limits are 258° and 305°, or according to our way of reckoning, 134° and 180°. The difference is partly due to the fact that Kaiser has taken as the pole of his chart the snowy patch, and this explains also other imperfections of his representation. The latitude, however, agrees very well with ours. Kaiser seems to have confused Thyle II with Eridania, and has not represented the strait denominated on our

chart as Tiphys Fretum [Strait of Typhon]. Anything of Thyle allegedly seen by Lockyer is in the sketches already described, although it is shown too large for us to say so confidently. The representation of these regions in Proctor's chart is completely inadequate, the Mare Chronium being identifiable, but by no means certainly, with his *Phillips Sea.* Also the liberal disposition of his seas of Maraldi and of Hooke put his tracings at great variance with the truth.

Section XX. *Hesperia, River of the Ethiopians.*

142. Between Mare Cimmerium and Mare Tyrrhenum stretches the great peninsula of Hesperia. It lies in a general direction of northwest to southeast, connecting the zone of the equatorial continent with that of the lands described in Section XVIII. It follows a bent course, and is not constant in width, but the northern part is at least twice as wide as the southern; beyond a latitude of around 30°S it pinches off to less than 8° of the maximum circle.

143. What is most striking about this peninsula is the strong shading that is found in its narrow part, and covers about a third of its entire length. The southern boundary of this shade is rather well defined, and reaches from the last bay of Mare Tyrrhenum northeast across the peninsula to Mare Cimmerium: here the shade has its maximum intensity, which is little less than that of Mare Tyrrhenum itself. As one goes further from this boundary the shading decreases and appears less dense, until in the remaining half of the peninsula there is no trace of it whatever. I have never succeeded in affirming with any precision the exact northern limit, but judge that the shading must pass by gradual degrees into insensibility. These phenomena seem to me to be permanent, inasmuch as each time I have been able to see Hesperia well near the center of the disc; the shade has always looked the same: the last time I could distinguish it with any certainty was on February 4, 1878, when the apparent diameter of Mars was 6".67.

144. I have also observed consistently that whenever the rotation of the planet brought Hesperia to the edge of the disc, the shade invariably appeared intensified, and then resembled an extension of the seas it lay between. Then Hesperia appeared truncated in its upper part and looked like a single oblique prominence or peninsular extension of the equatorial continent. I first noticed this on September 10, 1877 (240°), the shade being already 55° in longitude from the central meridian. At first I took this to be the normal appearance, and noted in place of the shade a channel communicating between Mare Tyrrhenum and Mare Cimmerium. I will set down later the reasons that lead me to believe that one half of Hesperia really does have a lower level relative to that of Mare Cimmerium and Tyrrhenum, and that it can be inundated by them, thereby affording an actual communication between the two basins. The fact that the shade is precisely at the narrowest neck of the peninsula to me increases the probability of this; at least it receives, from the preceding hypothesis, a perfectly natural explanation.

145. The boundary between Hesperia and Eridania is not entirely definite: I mark it somewhat arbitrarily along the 40° parallel south. Not so for the northern boundary. Its furthest part is in the western bay formed where Mare Cimmerium receives the mouth of the river of the Ethiopians, a channel that follows at first a straight course leading north to south, before settling into a more deviant course across the equatorial continent. The mouth where the channel of the Ethiopians empties into Mare Cimmerium could be followed, when discovered by me on September 14, 1877 (219°), for a length of 5 or 6°: further the clouds did not allow me to trace it, on that or the following day. On October 20 I was able to trace it for about 10° in the same direction. On the evening of October 21 I saw its further prolongation, up to its meeting with the Eunostos, and I also discovered the channel of the Lethes, which unites the river of the Ethiopians with the Syrtis Minor and the Mare Tyrrhenum and completely bounds Hesperia on that side. I will describe more carefully later the network of channels that furrow this region.

146. Hesperia was well observed by Maedler in 1830, the drawings that he made coinciding very nearly with my own. Actually, in his published map, the shade of which I have spoken is not shown, but it is well represented in his discs no. 11, 13, 14 and 17 when its position was just

right to show it to advantage. The agreement does not get any better! Also the disc of Lassell made on November 5, 1862, is in close agreement. Kaiser and Lockyer in 1862 and Dawes in 1864 represent Hesperia as a strip of almost uniform width and brightness, and Dawes also shows it pinched in the northern or lower isthmus in a fashion that is unusual and contrary to all other observations; this configuration is adopted also in the chart of Proctor, where the peninsula is given the name *Burckhardt's Land.* None of these observations has any sign of the shade that covers the narrower part of Hesperia.

147. Other observers saw the shade very well, but thought that it indicated an expanse of sea—thus they drew Hesperia like a much shortened peninsula attached only in its lower part to the equatorial land. Such a representation is given by Secchi (June 17 and 18, 1858); Franzenau (November 20, 1864); and Green (nos. 43 and 49 of the *Aréographie* of Terby, May 16 and 28, 1873). To all of them the shade appeared in a position high on the disc and close to the limb. This, then, must be an effect similar to that noted by me under § 144, and is certainly due to the same cause, which is the indirectness of the visual ray relative to the surface of that region. Of the probable nature of the manner in which this comes about, I will have more to say later.

Section XXI. *Mare Tyrrhenum, Syrtis Minor, the River Lethes.*

148. In the great zone of inland seas which I have been describing, the Tyrrhenum forms the most complete and largest section. It stretches slantwise in a northwest to southeast direction, and has a nearly uniform width of 8 or 10° and a length of not less than 80°. It communicates with the Mare Chronium by means of the Xanthus; with the Oceanus and Eunostos by means of the river Lethes, and perhaps, by means of the Nilus, with the northern polar sea. It also seems that, through the inundations of its basin, it mixes with Mare Cimmerium and Mare Erythraeum. In its southern parts its color is similar to that of Mare Sirenum, but in its northern it is darker and not inferior to the Margaritifer Sinus. On its western limit lies the great land of Ausonia, which straddles it on that side; to the east and north project two great gulfs into the zone of the great equatorial continent, called on the map Syrtis Major and Minor.

149. Syrtis Minor, pointing a sharp wedge northeastward into the land, is bounded on the west by the lower part of Hesperia. In its inner recesses converge two channels, the river Lethes[9] and the river Triton. Of the latter, which is the principal, we shall say more below. As for the river Lethes, it consists of a short trunk 12 or 15° in length, which continues in the direction of the wedge of Syrtis Minor until it meets the river of the Ethiopians in an acute angle, thus isolating Hesperia from the rest of the equatorial lands. The river Lethes is one of the most difficult objects that I have thus far encountered in the exploration of Mars. Time and time again I have examined the Syrtis Minor and the mouth of the river Triton, and what was marvelous to me was the most unnatural manner in which they joined together. A similar elbow or right angle has never been formed by any of the other channels that have been seen by me on Mars. On October 20 (234°) the air being very fine, and having already discovered in these places various novelties, I examined attentively the gap between the Syrtis Minor and the river of the Ethiopians: I saw nothing, so that I was able to convince myself that Hesperia was not divided in any way from the equatorial lands. But then on October 21 (216°), I had an interval of seeing that was truly superb, during which I ascertained the existence of the Lethes and its connection with the river of the Ethiopians; also the connection, almost equally delicate, of this with the Eunostos. The sketch made rapidly in that moment has served as the basis of the chart.

150. The Mare Tyrrhenum is called *Hooke's Sea* in the chart of Proctor, and is among the best known objects on the surface of Mars. Also the gulf of the Syrtis Major is indicated more

9. The course here denominated Lethes was seen in 1890, but is different from that denominated Lethes in 1879-82-84-86-88. To the latter I will give, after 1888, the name of Lethes: the first, in 1890, should be denominated Vulture. Vulture, then, was observed in 1877 and 1890 (and eventually thereafter), Lethes in 1879-82-84-86-88. [Schiaparelli's note, posthumously published]

or less prominently by almost all of the observers, and clearly by the principal ones, Maedler, Secchi, Kaiser, Lockyer and Dawes.

Section XXII. *Subsequent observations of the river Oceanus. Eunostos, the Elysium Fields.*

151. The really unfavorable condition of the atmosphere of Mars which prevailed during the last months of 1877, affecting the whole region north of the great diaphragm between the meridians 90° and 200°, prevented me from making very exact observations on the great channel Oceanus. All the mouths of the many channels coming to it from the south, from the Eosforos to the river of the Cyclops, showed scarcely a trace even during the best apparitions of the planet, and were shown on the sketches in impressions more or less fugitive. Some observations in December 1877 and in January, February and March 1878 manifest a more intense coloration in all of these lines, and more definite courses. But the dimensions of the disc were by then too greatly reduced to allow very certain delineations from these observations.

152. As I have stated earlier, I have not been able to detect the beginning and end of Oceanus. It was present, beyond a shadow of a doubt, in the regions of Tharsis and Daedalia, as far as the channel of the Sirens, and this agrees also with the observations of Dawes (§ 117). It was seen without undue difficulty in the region between the river of the Sirens and that of the Titans, though appearing exactly like a diffuse and ill-defined shade. The best observations I have made were on October 27, 1877, and confirmed on later occasions, most recently on March 21, 1878, though then with the planet at an excessive distance. From the mouth of the river of the Titans to that of the river of the Cyclops, I made many observations, and also many attempts at determining positions (like those of our fundamental points 28, 29, and 33), but they were anything but precise. On parting from the mouth of the river of the Cyclops, Oceanus winds north and follows along the 200° meridian. This area was sketched on October 27 and 28, 1877, and again in much revised form on December 30. Its existence is sure, but not its exact course, since it presented under greatly foreshortened perspective. Also unsure is the existence of the branch to the north which is indicated opposite the river of the Titans. I believe I have established yet another channel or sea to the north of Oceanus, between meridians 130 and 150°; possibly, however, it is only a circumvolution or branching of Oceanus itself, but its position, at any rate, is very doubtful. All of these observations were made on October 27 and 28, 1877, in the neighborhood of the inferior limb and with much interference owing to the poor transparency of the atmosphere of the planet. My previous observations of this region do not, unfortunately, add much to the certainty of these tracings.

153. As far as the width of Oceanus is concerned, it is probably not as uniform as it is represented on the chart. It is, however, clearly impossible to assign measures to things whose very existence has scarcely been established beyond doubt. The same is true regarding the gradations of color, where the color itself is hardly discernible. Of the lands north of Oceanus it is not possible to affirm more than their existence; the rest is left to the examination of future oppositions.

154. Before the river of the Cyclops enters Oceanus via its large northern mouth, it encounters a branch thereof running northwestward, the Eunostos, which in turn picks up the rivers of the Ethiopians and the Lethes conjoined to it, thus completing a communication between Oceanus and Mare Tyrrhenum. At this point in its course the Eunostos does not appear very ample, but further to the northwest it may become as wide as Oceanus, and it follows a direct course to the great bend in the Nilus in the west: along the way it picks up the mouth of the river Thoth, which comes from the Triton Lacus to the south. The Eunostos was discovered in its more eastern part on October 20, 1877: its prolongation up to the Nilus, and its conjugation with the Triton Lacus in the middle of the Thoth, was ascertained, not without a little doubt, on March 9, 10, and 12, 1878, on which dates I also was able to make out all of the river of the Ethiopians again. In these last observations, the Eunostos was very black and easily visible, despite the fact that the apparent diameter of the disc at the time was not more than 5".45. The western part of

Oceanus, the river of the Cyclops, and the Eunostos form a great arch; the land contained therein has been designated the Elysium Fields.

155. For observations as uncertain as the preceding, it is not very useful to attempt comparisons with the results of earlier observers. Already one sees, however, evidence of the existence of Oceanus below Tharsis and Daedalia from Dawes. The following part between the river of the Sirens and that of the Titans may be indicated in the sketches of Maedler (see *Beiträge*, 1832, nos 1 and 2; 1837, nos. 6, 7, 15, 16, and 17), but this is by no means certain. The chart published in the *Beiträge* does not agree very acceptably with our tracing. But certainly all of Oceanus from the river of the Sirens to that of the Cyclops was seen by Harkness at Washington on September 6, 1862.[10] And Secchi has the same part of Oceanus on his disc of November 16, 1862. Kaiser doesn't put any diffuse shadings here, and Lockyer also shows nothing. That the trunk of Oceanus proceeds further north beyond the 200° meridian is very clear from what Maedler shows in his chart in the *Beiträge*. The coincidence in position, direction and inclination are all as perfect as could be desired. It also seems that this turn of Oceanus is indicated in the 49° sketch of the *Aréographie* of Terby, which is based on that by Mr. Green on May 13, 1873, showing a curved marking near the center of the disc.

156. The same north-west trunk of Oceanus, together with the rivers of The Cyclops and Eunostos, form a great arch, which seems to me to be recognizable in part in the *Oudeman's Inlet* of Proctor's chart. The accordance is fairly satisfactory as to form and position. *Oudeman's Inlet* is also encountered in various sketches of Mr. Knobel (1873), according to which it forms a closed circuit, and the Elysium Fields (Fontana's Land) occupies the center in the form of an island.

157. The Eunostos is certainly shown by Secchi in his disc of June 20, 1858, which has been described already in connection with the river of the Cyclops. However, everything has a rather different form from that which we have given it. Kaiser has undoubted, though indefinite, traces of the Eunostos, in his discs of November 29 and December 28, 1864. In the latter the river of the Ethiopians even seems to be indicated; also in the 43° sketch published by Terby in the *Aréographie*. And Franzenau seems to give hints of it in his discs of November 20 and 22, 1864. I have every confidence that Secchi has delineated it in his disc of June 20, 1858 despite the fact that this hypothesis is not without difficulties.

158. I have failed to recognize, in any form, the eastern part of the *Huggins Inlet* of Dawes and Proctor. As I have already described, the western part also is not identifiable, unless with our Cyclops (see § 131). If this supposition is correct, it would be necessary to assume a connection between *Huggins Inlet* and *Oudeman's Inlet*, since this is distinctly shown in the chart of Proctor. But having arrived, by this rather violent identification, at the mouth of the river Cyclops where it empties into Oceanus, which of the two trunks of the latter channel do we take as the continuation of the *Huggins Inlet*? Here the disagreements are so great that we are forced to abandon the discussion. We can only hope that the next opposition will shed more light on this region which is now known so imperfectly.

Section XXIII. *Libya: the Syrtis Major and Nilus: the river and lake of Triton: the rivers of Nepenthes and Thoth: Lacus Moeris.*

159. We arrive now at the Syrtis Major, styled the *Kaiser Sea* on the chart of Proctor, which reaches from the Syrtis Minor along an elegant and regular curve skirting the beaches of Libya. From thence takes off the Nilus, which runs in a north-south direction through the northern hemisphere and among all the channels that furrow the surface of Mars is the widest and best known from earlier times. Around the 45° parallel the Nilus separates into two branches, of which one is the Eunostos already described: the other curves west and travels almost halfway

10. *Washington Observations*, 1862, p. 512.

around the planet's circumference, forming the northern limit of the lands of Aeria, Arabia, Eden, Chryse, Ophir, and Tharsis, and meeting up with a good many of the channels southward of which we have already given the description, before it joins up at last with Oceanus. This part of the Nilus I was not able to examine until very late, in the interval between March 7 and 18, 1878, and thus its representation on the chart cannot be trusted as more than a first approximation. During this interval, the Nilus appeared like a black chord stretched across the inferior part of the disc, separating off only a small bright segment beyond it. This chord appeared longer when its western part near Oceanus lay on the central meridian, and shorter when the eastern part near Syrtis Major did so. This demonstrates that the course of the Nilus from the point of its bend does not follow precisely along the parallel, but rather approaches toward Mare Erythraeum in its western part. The remarkable fact is that the three great channels, the Nilus, the Oceanus, and the Eunostos, form a continuous band around the girth of the entire planet, along the zone of the equatorial lands.

160. The configuration of the Nilus described above is in almost entire agreement with the sketch made by Dawes on November 20, 1864; and other sketches of that year, despite discordances in minute particulars, also agree on the whole with our description, in that the Nilus is shown to reach as far as the Solis Lacus. In the chart of Proctor the Nilus seems to be indicated partly by the Channel of Nasmyth (*Nasmyth Inlet*) and partly by the *Tycho Sea*. There are nevertheless many disagreements among Dawes, Proctor and me, of which for now it is useless to attempt the reconciliation; this is only to be achieved from new and accurate research under favorable presentations of the planet, since at the opposition of 1877 these regions were presented at too great an obliquity. A part of the Nilus between the 10° and 40° meridians had already been seen by Maedler in 1830 and is the marking labeled on his chart with the letter *v*. It also appears in the sketches of Secchi of 1858, of Kaiser and Franzenau of 1864, of Knobel of 1873, and in the 15° sketch in the *Aréographie* of Terby, made by Green on May 25, 1873. The latter is noteworthy, in that it offers all the available evidence of the joining up of the Nilus with the northern part of the Phison.

161. The Triton Lacus is a fairly easy object: I was already able to recognize it on September 12, 1877, and again saw it on December 24, when the diameter of the disc had been reduced to 9".2. The best observations of it and the surrounding region were made on October 14. The Triton Lacus is oblong in the direction of south to north, its dimensions being estimated at 6° and 3°; its color is very dark, like that of its two southern emissaries, the river Triton and the river Nepenthes. The northern emissary, which goes by the name of Thoth, was not seen by me until March 1878; I hardly dare to give an exact description of it, and the only fact of which I am certain is that it is much enlarged in its mouth where it joins with the Eunostos. The river Triton is a very easy channel to distinguish; it was first seen by me on September 12, 1877, and last on March 13, 1878. It leaves the southern point of the Triton Lacus, and forms a graceful arc which connects to the Syrtis Minor, making at that point an almost perfect right angle to the river Lethes. The river Nepenthes also goes out from the southern part of the Triton Lacus, and describes nearly a parabola, its wide dark mouth emptying into the Nilus and forming, with it, the Osirides Promontorium [cape of Osiris]. This is a long peninsula, whose color becomes increasingly dark toward its endpoint, as if this part of the land consisted of darkened (or submerged) land. At the summit of the parabola and attached to the side of the Nepenthes is the Lacus Moeris, which is somewhat quadrilateral in shape, with two angles adjoining the Nepenthes itself. Its diameter is perhaps 4°, its color is dark. The Lacus Moeris is one of the more difficult things to be seen on Mars: the observations concerning it were made on October 13 and (chiefly) 14, 1877. Also the Nepenthes is difficult to see well: nevertheless, it has been easy enough to be assured of its existence, from the contrast of color that the land of Libya has along its border with the very much brighter region of Isidis that makes up the inland lying south of the parabola, between the Nilus and the Thoth. As early as September 13 I find I have written: "Between the Triton Lacus and the point of Syrtis Major runs an arcuate line, not a distinct feature but rather a boundary, of the Isidis region, which is much brighter than the adjoining part of Libya." On October 14, however, the Nepenthes appeared as a beautiful dark and observable line. Where its

mouth empties into the Nilus, the Nepenthes widens greatly, and forms a kind of dark lake, which is easily confused with the point of the Syrtis Major; the Nilus, coming from the north, runs directly into this mouth and into the Nepenthes, which are its natural prolongations; its opening into the Syrtis Major is like a lateral arm, producing the striking asymmetry that is notable in the chart. The land of Isidis is of distinctive brilliance, similar to that which has already been described in the case of Memnonia. But a bit of the Isidis region (marked with a contour at a point immediately west of Triton Lacus on the chart) appeared on September 14, 1877, more brilliant than any other part of the planet, and I would almost liken its appearance to that of the polar snow. This white spot was seen again, very distinctly, on October 14, when it seemed to me to form a quadrant of about 1".5 on a side (around 8° of the maximum circle). If this be snow, we should be obliged to infer the existence of a group of tall mountains on the western side of Triton Lacus.

162. To the region enclosed between the Eunostos and the river Triton I have given the name Amenthes. The color of this part is brighter than that of Libya and Hesperia, but rather less than that of either Memnonia or Isidis. Libya and Hesperia are of a yellowish color, which becomes more apparent in Libya the further one proceeds toward the Osiridis Prom.

163. So much, then, for the eastern shore of Syrtis Major. The west forms a curve that is almost perfectly even and symmetrical to the other side, but whereas the one ends in a gulf (Syrtis Minor), the other does so in a cape (the Horn of Ammon). The western shore of Syrtis Major is elegantly curved, and not without signs of minute indentations; it encloses a bright land, in which it is impossible to discern anything other than the Phison. This is the land we have called Aeria. I hereby conclude the survey of the great diaphragm which I began in Section II.

164. Although the Syrtis Major is one of the first things that was seen on Mars by the ancient observers, the descriptions thereof are not in complete accord. Many of the discrepancies can possibly be attributed to the presence of clouds and to the projecting shades which ramify throughout this region from the inferior part of Ausonia, of which more will be said presently. Some also derive no doubt from the diverse forms that this great gulf presents under different conditions of obliquity. The chart of Proctor, in this point at least, agrees very well with mine, and here I will say no more about the subject, since as detailed a discussion as one could wish is found in the *Aréographie* of Terby. Any additional points I have to make I will reserve to my depiction of the great peninsula of Ausonia. Instead, I am more interested at the moment in the comparison of what different observers have seen in the inland of Libya and its vicinity.

165. The Lacus Triton was very well seen in 1830 by Maedler, who has marked it with the letter *g* on his chart. In 1873 Knobel figured it at times in the position that I have assigned to it. Refer to his sketches of April 23 and May 23. Maedler, and also Knobel, show it isolated, without any communication with either the Nilus or the Syrtis Major. But the Lacus Triton did not escape the lynx-eye of Kaiser in 1862; neither did the river Triton, nor the Nepenthes. They even seem to be delineated in his bizarre sketch of December 2, 1862,[11] which he has not cared to take into account in compiling his chart. If I am correct about what is shown here, apparently the Lacus Triton, together with the eastern part of the Nepenthes and the river Triton, produce the outline of a curvilinear form exactly resembling the Syrtis Major. The interior of this consists of a region somewhat darker than that of the spaces around it, as earlier described. Kaiser has regarded this configuration as a kind of shadow or duplication of the Syrtis Major, and as such has rendered it in the rest of his faithful sketch. He also states that having repeated this sketch on the following night, he found exactly the same thing.[12] This is a remarkable example of the acuteness and fidelity of that observer, but also of the unusual way that he sometimes interpreted what he has seen. There can be no doubt at all that of the two angles of the shaded region shown in his sketch, the one to the left of center represents Lacus Triton with its vertex, that

11. This sketch represents the Mare Erythraeum and not the Syrtis Major! [Schiaparelli's note, posthumously published]

12. *Annalen der Sternwarte in Leiden*, vol. III, page 30.

still further to the left the river Triton, while on the right hand appears that part of the Nepenthes which lies between Lacus Triton and Lacus Moeris.

166. The river Nepenthes was also well delineated by Green on May 28, 1874 (no. 44 of the sketches of the *Aréographie* of Terby); and one can even recognize, as an elongated swelling thereon, a hint of the Lacus Moeris. For Green the Lacus Triton doesn't exist; but an eastern branch of the Nepenthes drops down along the meridian to join a transverse shade. That branch is certainly none other than my own river Thoth, and the shade is without doubt the westernmost part of the Eunostos.

167. If the eastern part of the river Nepenthes has been seen by but few observers, the western part, with its wide and dark mouth where it enters the Nilus, has been seen by many. To say truthfully, however, the observations don't agree very well among themselves, and my own differ from all others except those of Kaiser and Green. Proctor, from the delineations of Dawes, widens the mouth in such a way as to make it and the Lacus Moeris into another much wider lake, which he calls the *Main Sea;* the promontory included between this and the Syrtis Major forms his *Peninsula of Hind,* which corresponds with our Osiridis Prom. I could very well believe that on November 20 and 24, 1864, when Dawes shows the region in this form, it was indeed very much different from what it was in September and October 1877. But it is strange that on November 20 and 22, 1864 (contemporaneously, then, with the observations of Dawes) no trace of the Main Sea was seen by Franzenau. Maedler in 1830, and Knobel in 1873, also exhibit, with respect to the Main Sea, the same silence. As I have related, Secchi in 1858 and Kaiser in 1864 both have recorded the swollen and more visible mouth into which the Nepenthes widens before it reaches the Nilus. The two discs drawn by Lockyer on October 3, 1862 are precious for the meteorological changes which I have related in my historical note on this region; but Lockyer has not seen anything of the Nepenthes, the Lacus Moeris, or the Lacus Triton. The marking he designates *g* must be a hole in the clouds, through which part of the Syrtis Major itself is seen. Otherwise how would one account for the exceptionally narrow form which the Syrtis Major is given in those sketches? On the whole, it seems to me that the Main Sea still requires confirmation, unless one wishes to reduce it to the almost invisible Lacus Moeris or, more plausibly, with the wide and more evident mouth of the Nepenthes, as I have seen and sketched it and as Secchi, too, has seen and sketched it in 1858. In the second and more northern projection to the left of his "Scorpion" one faithfully locates what we have represented as the Osiridis Prom.; all differences in shape and height being entirely effects of the different perspective.

Section XXIV. *Ausonia, Mare Hadriaticum, Chersonesus, Euripus.*

168. The immense region which has received the name Ausonia extends a quarter of the way around the planet's globe, and shows in form and disposition a great likeness to the terrestrial land of Ausonia;[13] from this likeness is derived its name and also those of Eridania, Hellas, and lastly Libya, which forms the other land bordering the Tyrrhenian Sea. Ausonia is almost uniform up to the bend of the peninsula where the Syrtis Minor and Circaeum Promontorium [Cape of Circes] are indicated. Its first part is lightly shaded, after which it becomes darker below 282° longitude, then it bifurcates, thrusting a thin short branch, the Oenotria, from the border of the Mare Tyrrhenum to the shore of Aeria. The other branch, a good deal wider and longer, is called Iapygia, and pushes west as far almost as Mare Erythraeum and the extreme limit of Deucalion. The colors of these two branches, beyond the bifurcation, are equally as dark as the areas described in areography as seas. The truth is that these two branches of Ausonia have the same character as the dark (or, if you will, submerged) lands of Mare Erythraeum, and belong to the same class of features.

169. This great region is easy to see because of its wide extent; nevertheless, it belongs among the more difficult features to depict exactly, because of the great variety of the shades

13. That is, the poetic name of the Appenine peninsula or Italy itself. [translator's note]

within its confines. In the first observations which I made of it, it seemed that the peninsula terminated in a short shaded area below about longitude 290°, as I find figured in my sketches of September 10 and 11, 1877. But already on September 12 (271°) I find I have written: "It seems in some moments that Ausonia doesn't end at the point first marked, but traverses the sea in a prolongation to join Aeria by an increasingly dark region of halftone; where it contacts Aeria it is little different from Mare Tyrrhenum.... This much is certain, that the prolongation of the Tyrrhenian coast of Ausonia toward Aeria attains in the limit the same dusky color of Mare Tyrrhenum." But the conviction of these observations was later canceled out by the doubts of others, and I remained completely uncertain of the constitution of this part of the planet up to October 10 (301°), on which date I wrote, "Ausonia seems to arrive at Aeria through a lower part, whose southern side winds around Hellas." A little later (314°): "Certainly Ausonia widens in the form of a trumpet to reach Aeria." These observations were confirmed on October 12 (280°). "The foot of Ausonia on the coast of Aeria no longer seems as it did at first." The same day I began to suspect the bifurcation. Also on October 13 (289°): "The connection with Aeria could not be more certain."

170. The true state of things was not revealed until October 14, 1877, when I experienced an interval of really superlative air, which also allowed me to make other important observations. With the center of the disk at 281° longitude, I wrote: "Finally the enigma that the lower part of Ausonia has presented is resolved. It divides into two tails or feet, as is indicated in the sketch" (Fig. II, drawing xxv). The branches are both halftones. The area between them is two-thirds their brightness, that is, a darker halftone. At the point of division between the branches there is a black point, or at least a strong intensification of the darkness. This is our fundamental point 49. The black point in question was close to the shore of Mare Tyrrhenum, but it remained doubtful whether the branch of Oenotria divided from the principal land at that point. As I sharpened my eye, I remained unable either to dispel or confirm my doubts, and after October 14, I never had another opportunity to examine the place when the disc was of sufficiently great dimensions. On November 9, I wrote: "The attachment of Ausonia to Aeria is observable, but not its particular features." On November 16: "The bifurcation of Ausonia is visible, but all is again as at first, and there is nothing to correct in the sketches. An exquisite image, but its small size prevents me from searching for novelties." Observations of December 21, 1877, January 28 and March 5, 1878, did nothing to confirm any of these observations, owing to the limits imposed by the small size of the disc.

171. On the sketch of October 14, note that the black point lying at the bifurcation is bounded on three sides, but in the direction of Aeria there departs from it a kind of tail or diffuse streak, which proceeds westward, and forms (with ever decreasing intensity and definition) the northern side of the branch of Iapygia. In the dark triangle (*Sinus Deltoton* on the chart) the darkness and length of this tail decrease in measure as one proceeds northward. The color loses itself, without any abrupt change, in the brightness of Oenotria, which is greatest at the end by Mare Tyrrhenum but shows throughout its confines a marked contrast with that sea's dark and even color. Here the Oenotria forms an elegant curve which runs exactly parallel to the opposite shore of Libya. Its junction with Aeria is conspicuous, and forms our 55th fundamental point; its color, though bright in comparison with Mare Tyrrhenum, appears very dark next to the bright region of Aeria, especially near this 55th point. The shore of Aeria forms with Oenotria a very vivid contrast; the point where they meet is shaped like the vertex of a triangle, and the boundary between them is very well marked. Indeed wherever the dependent parts of Ausonia encounter Aeria, their apparent darkness is increased, and they appear hardly less black than Mare Tyrrhenum itself. The case is similar to that which was noted earlier at the isthmus of the dark peninsula of Pyrrhae (§ 95).

172. Iapygia is not as clearly bounded as Oenotria. After a short distance its contours become diffuse, and near the Horn of Ammon it dwindles to a scarcely perceptible trace. At its limit it is similar in appearance to the land of Deucalion, which faces opposite to it. Both insensibly lose themselves in the strait of Scylla and Charybdis, where the Mare Erythraeum appears

nearly as dark as the Sinus Sabaeus. The dark ribbon which forms the Sinus Sabaeus has seemed to some observers to curve opposite the Horn of Ammon, to climb southward to form the strait of Scylla and Charybdis, and then to curve back around the peninsula of Deucalion again. This has given rise to that serpentine and hooked form which in Kaiser (and also some of Lockyer's sketches) is so pronounced, and which has been denominated "the Serpentine sea." Kaiser has given this marking a curious and highly unnatural form; it is better indicated by Lockyer on his disc of September 25, 1862, 10h 50m. I should relate, however, that the eastern part of this marking or tract of sea, that is the hook, which surrounds the extremity of the peninsula of Deucalion, is shown so dark that the only thing with any resemblance to it is the very dark ribbon forming the northern side of the Sinus Sabaeus itself. In my figure II, sketch xxv, I have represented accurately the depth of shade of these tints as they seem to appear when the atmosphere of Mars is undisturbed by vapors. But I don't deny that if at other moments the peninsula of Deucalion were covered with a white fog, the contrast with the surrounding sea could easily give rise to the idea of the serpentine form seen by Kaiser and Lockyer and which I also find represented in a sketch by Knott on September 23, 1862 (no. 26 of the *Aréographie* of Terby).

173. But to return to Iapygia. I must add that its southern side curves concentrically to Hellas and shows a hint of prolongation of Ausonia toward the part of Mare Erythraeum between Hellas and Noachis. In fact, in the place named Hellespontus on the map, I debated in vain for many evenings, being unable to discern anything definite there (Noachis itself being covered entirely with vapors; also, in part, the regions contiguous to it). Then, on October 14, 1877, I seemed to detect to the right of Hellas another stretch of dark land, but only vaguely, as sketched in figure II, disk xxv. In some moments I seemed also to make out a connection between this dark land and Iapygia to the right of the Mare Hadriaticum [Adriatic Sea]. Subsequent observations will tell if this be only illusion. Certainly this is one of the places on the planet that is hardest to decipher because of the imperceptible gradations of color and the want of definite contours, and the difficulty was all the greater in the autumn of 1877 due to the presence of atmospheric precipitations in that part of the planet. In the chart I have put down what I have deemed the most reliable outlines, but at the same time it is my duty to relate as correctly as possible the rest of my uncertain observations of what lies between longitudes 315 and 30° and between southern latitudes 30 and 55° (Hellespontus, Noachis, and eastern Argyre), which may with diligence be seen again at future oppositions.

174. In completing the description of Ausonia, I have yet to speak of its eastern meridional part. From the Circaeum Prom., which marks a bend in the long axis of the peninsula, it climbs with almost uniform width to latitude 40°. On its eastern side it hugs the Tyrrhenum basin; it is separated from Eridania by the Xanthus, and from the southern mouth of the latter it stretches diagonally toward the pole along the vast Sinus Promethei. In all this ample zone of land, which I should have observed very well on October 14, 1877, I met with no channel, lake, or interruption of any kind.

175. To the west, the Mare Hadriaticum follows in curvature, length, and uniform tint the course of Ausonia. Its color is paler than that of Mare Tyrrhenum, and rather resembles that of Mare Chronium. Near its end it cuts through Ausonia at an angle that might almost be called a gulf of Venice in the land of Ausonia, beginning as a channel wide and observable, then narrowing rapidly to the south and becoming gossamer-like and difficult to see beyond latitude 52°. Up to October 10 I had always called this part the isthmus of Hellas, believing there to be a connection between the two lands, but on that date (305°) I began to suspect a division, and on October 12 discovered the strait called Euripus; finally, on October 14 (271°) I made an accurate sketch of the Euripus and the long sharp peninsula called Chersonesus, which is shaped like a bent horn, the point of which loses little by little its brightness and finally vanishes without a trace into the basin of Mare Australe. It is, then, another example of the dark or submerged lands. The Euripus was still well articulated by me on November 9, 1877, when the disc was reduced to 14".3 in diameter.

176. In its brighter part, before the division into two branches, Ausonia has been seen by many observers. In his chart of 1830 Maedler noted it distinctly, and indicated the boundaries called by me the Xanthus, Sinus Promethei, and Euripus. He seems to interrupt it in the vicinity of the Circeum Prom. Dawes conducts it farther than Maedler, and ends it in a wide, pudgy and roundish form, as is seen in the *Cassini Land* of Proctor; also his *Sea of Zöllner* is much shorter than our Hadriaticum. In four of his discs, Lockyer lengthens Ausonia to the Circeum Prom. and gives a trace of the Xanthus, and the Euripus as well: but in these sketches the figuring is so varied, that it seems that what he observed was not the true Ausonia but its meteorological image. Three of those sketches were made in an interval of an hour and a half on October 3, 1862, and it is hardly possible to account for the differences in form and indistinctness of contour which Ausonia presents in all three by changes of perspective alone. The same may be said of the sketches of Rosse, July 22, October 6, and November 6, 1862, and of those of Lassell, September 29 and November 4 and 5, 1862.

177. The same cause—the frequency with which the clouds of Mars seem to affect the dark lands and seas—makes it difficult to judge what these observers have seen and figured with respect to the tints of Ausonia and Aeria. Kaiser has seen Ausonia clear of clouds on October 5, 1862, and his sketch (save for the prolongation of the Hadriaticum up to the southern pole) agrees very well with a good many things in our chart and that of Maedler. This sketch carries Ausonia only as far as the Circeum Prom., although perhaps a part of the Iapygia branch is also indicated. Kaiser has shown with perfect distinctness the branch of Oenotria on November 22, 1864; he has also figured the junction with Aeria, and has described the shadow that fills the triangular gulf (Sinus Deltoton). No more telling coincidence could be imagined. The Circeum Prom., a part of the inferior trunk, and also the Oenotria and its conjunction with Aeria, are shown on his disc of December 28, 1864, which Kaiser has relied upon as the basis of this portion of his chart. Other sketches by him present no more than featureless cloud banks.

178. Also Franzenau seems to indicate all of Ausonia and Oenotria in his two sketches of November 20, 1864, but with such differences between the one and other as to suggest meteorologic disturbances. The width assigned to Mare Tyrrhenum appears disproportionate. Secchi does not show the Oenotria, but between June 13 to 16, 1858, he portrays in four sketches the Iapygia branch; also the strait of Scylla and Charybdis is perfectly shown, and the opposite extremity of the land of Deucalion. There is also a part of Mare Hadriaticum, and the sketches of June 14 and 15 bring out strongly the Circeum Prom.

179. That the inner ramifications of Ausonia are a frequent theater of changes is already well established from the observations of Lockyer, supplemented by others by Mr. Terby, who has devoted an important chapter of his *Aréographie* to them (pp. 51-56). In the subsequent study of this subject it will be desirable to distinguish between the bright streaks or chiaroscuro described above, which are appendages of the permanent Ausonia, from streaks of a more variable character; the periodic character of the latter will facilitate observations of their passages across the dark basins of the Syrtis Major, the Sinus Deltoton, and the Mare Erythraeum, and will shed much light on the meteorology of the planet. I regret that in my own observations of 1877-78, I have failed to detect any signs of impermanent streaks or spots.

Section XXV. *Hellas, the river Alpheus, Hellespontus.*

180. To the west of the concavity formed by the curved course of Ausonia and Mare Hadriaticum lies Hellas, one of the most curious and remarkable formations on the planet. It is a roundish island, slightly elongated in the southeast-northwest direction, and completely regular around its perimeter; its diameter measures not less than 30° of the circumference of Mars (not less than a thousand Italian miles). It is girt almost entirely around by Mare Hadriaticum, Erythraeum, and Australe: but except for a slight tract (the Euripus) it would adhere to Ausonia, so that it does not share the extreme insularity of Argyre or the twin islands of Thyle. Its color is ordinarily yellow, and it shows up brighter when near the edge of the disc than when located on

the central meridian. Sometimes I have found it as bright as Aeria, at other times a good deal less so. On one occasion, however, I have seen it as white and brilliant as the polar canopy itself. This was on December 16, 1877, at 21h 55m Sidereal Time, and my notes on this occasion read: "Hellas extraordinarily white: cover of snow? or of fog? Polar spot itself easily visible. Arabia and Aeria yellow, much less bright than Hellas." On December 21 it had regained its former color, and also on the following days I failed to notice anything unusual again. However, on March 4, 1878, I have written: "Hellas is intensely white, like snow, much whiter than Aeria and Arabia."

181. Despite a diligent examination, I for a long time found in the interior of Hellas only a uniform brightness, which was perhaps a shade more intense toward the edges. Then on October 12 (285°) I glimpsed a division in the north-south direction, a gossamer longitudinal line passing almost exactly through the center. On the chart this is called the river Alpheus. During the observation I estimated that this line formed an angle of about 10° with the center of Hellas and the snowy canopy, but on reducing the direction to the meridian of Mars, I was able to show that it followed exactly along this line. Its course is not geometrically rectilinear, but slightly wavy: but the waves are much too small to produce a noticeable deviation from the predominant direction along the meridian. All these observations were confirmed on October 13 and 14, 1877. Apparently this is a channel similar to the many others that cross the planet in a meridional direction, but its position is really strange and unexpected. In some moments I seemed to conjecture another much thinner channel, that traveled from the first across the interior of Hellas toward Hadriaticum in an east-northeast direction, but I was unable to assure myself sufficiently of its existence.

182. That part of Mare Erythraeum which lies between Hellas and Noachis, I denominated Hellespontus, when I still believed that Noachis was a bright land similar to Hellas. However, if it is actually a dark (or submerged?) land, as now seems to be the case, it is no longer necessary to posit for Hellespontus a separate existence between Hellas and Noachis. I also seemed to see on October 14, 1877, yet another tract of dark land, but the observation was more uncertain, and I am unable even to say whether there are such tracts or not along the banks of Hellas. The possible relationship with Ausonia has already been discussed in § 173.

183. Hellas comes into contact with that region of Mare Erythraeum which is most frequently veiled by clouds. For this reason it has seldom been sketched in its full integrity or amplitude. It seems that for some reason which is not easy to determine, the atmosphere surrounding it has a tendency to disport itself in a series of concentric zones. Sometimes there appears in the center a bright kernel, which is a great deal smaller than itself; thus it is shown by Kaiser (November 22 and December 23, 1864), Lockyer (October 3, 1862), Schmidt (September 26, 1862, disc no. 8 of the *Aréographie* of Terby), Schroeter (November 20, 1798, disc no. 7 of the *Aréographie* aforementioned). Sometimes there is shown around this brighter kernel a concentric zone, which entirely, or almost entirely, surrounds it, as is the case in the only sketch of Mars that I myself made in 1862; this is shown also by Lockyer in his last sketch of October 3 that same year, but above all by Dawes in his disc of November 26, 1864. Secchi in 1858 didn't see Hellas well, apart from the southern edge, because of the less favorable position of the planet that year. However, it is shown in its entirety by Lassell (November 5, 1862) and Knott (November 3, 1861, no . 9 of the *Aréographie* of Terby). Schmidt at Athens represents it under optimum conditions on September 26, 1862; see the sketch published by Klein in the first volume of his *Descrizione del Cielo*:[14] Perhaps the diffuse edge shown here is attributable to a fog filling the whole interior, though in this sketch one seems to see the Iapygia branch of Ausonia and Ausonia itself, or more probably their meteorological images. Maedler in 1830 did not see Hellas clearly in its inferior portion, but I conjecture from the first edition of his chart that the form was exactly as I have seen it. In the chart of Proctor the figure of Hellas (*Lockyer's Land*) seems to have been derived from the aforementioned sketch of Dawes, but is shown too small.

14. *Handbuch der allgemeinen Himmelsbeschreibung*. Braunschweig, 1869.

Also because of the unfavorable position of Hellas in 1864, its southern part is only conjectured and attached to a polar continent which Proctor imagines surrounding the southern pole.

184. Of the existence of the Alpheus, I can find no sure confirmation by any other observer. Only Knott, in his aforementioned disc of November 3, 1862, draws across Hellas two dark parallel streaks, inclined by an angle of about 45° to the meridian. But only one permits even a remote comparison with the river Alpheus.

Section XXVI. *The South Polar Sea.*

185. If we except the two islands of Thyle, the polar canopy of Mars is confined within the 60° parallel of southern latitude, and lies entirely in a sea, which in some directions extends farther than in others away from the south pole of the planet. The opposition of 1877 was exceptionally favorable for the examination of this region, since it was inclined, in October, by only 65° to the visual ray, so that all the mass of snows remained continuously in view, and in certain configurations appeared strikingly eccentric on the disc and surrounded on each side by dark spaces. From the beginning of October, those places had an uncommonly serene appearance, and on some occasions (especially October 2, October 21, November 17, and December 11) I have been able to trace the sea all the way to the snowy patch, where it appeared a little darker; possibly this was an effect of contrast. If there existed in this tract any islands, they must be very minor in comparison with Argyre and the two islands of Thyle, since otherwise they would have appeared as brilliant protuberances when on the edge of the disc, as those three islands, and also Hellas, have always done. But could not more extensive lands lie within these tracts, buried under polar snows (?) or existing as dark lands (their deep basins?) similar to Noachis; or perhaps something similar (say a shallow sea?) inhabits the region between Thyle I, Argyre, and Thaumasia, since there the Mare Australe as far as the Gulf of Aonius, at a certain distance from the coastline, has always seemed to be of a color less dark than that which I have seen in all the other seas of Mars, without exception. (One might also convince oneself that this dark color is determined by latitude, as I will discuss later.) But whenever I have examined that place, I have been unable to recognize any hint of actual contours, however sparely indicated, which would suggest lands of a different hue; I have only seen the shades surrounding the coastline becoming paler in measure as they are distant from it. The rest of Mare Australe has always seemed to me of a color between red brick and olive,[15] little different from that of Hadriaticum.

186. These observations of mine are borne out by the almost contemporaneous results of Mr. John Brett, who with a 9-inch reflector has particularly examined the point, and concludes thus: "The south polar patch now in view is surrounded with a dark stain, and this darkness is on one side continuous with the so-called sea, and of equal darkness with it. There is no breach or barrier in the straits which join the polar dark patch to the equatorial dark patch. Therefore, if there be snow, it is lying on the sea, or on a polar island."[16] Having abandoned his observations on October 8, 1877, Brett did not see the islands of Thyle separated from the snowy canopy: a separation which did not become apparent to me until October 20 and 21, when I recognized on its southern shore the two islands of Thyle standing out conspicuously, with a strait of polar sea between them.

187. At preceding oppositions it has looked as if this part of the planet has always been more or less veiled in clouds or fogs, as would be expected in such latitudes. Maedler in 1830 seems only to have seen uncovered the three divergent stripes from the pole, which he designates with the letters *x*, *y*, and *t*. They coincide sufficiently well with the mouth of the Sinus Promethei, Hellespontus, and the Bosporus emptying into the polar sea. Also the area of Sinus Aonius, with the corresponding channels of Phasis and the Columns of Hercules, was clear. But the rest of

15. This description of the colors of these regions is rather peculiar, but one must remember that Schiaparelli was color blind and was unable to distinguish reds and greens, both of which appeared to him greyish. [Trans.]

16. *Monthly Notices of the Royal Astronomical Society*, December 1877, vol. XXXVIII, p. 60.

this region in Maedler's chart is blank, that is, covered with clouds. And yet the opposition of 1830 occurred during astronomic and climatologic conditions (I refer here to the climate of Mars) which almost exactly counterparted those of the opposition of 1877. Two other oppositions, those of 1845 and 1847, would have been very favorable for repeating such observations: however, whatever sketches were made in that year apparently have remained unpublished.

188. In 1862 the polar region of Mars was again presented to view under favorable conditions similar to those of 1830 and 1877. Around the polar snow almost all observers agree in putting a dark rim, which Proctor represents on his chart as the *Phillips Sea.* This shaded region Kaiser opens in four places, corresponding to the Sinus Promethei, the Hellespontus, the Straits of Bosphorus, and the Sinus Aonius: at least this is what one sees from his sketches, though they are not identical with his chart. Of these the second and the third are shown precisely in the sketches of Lockyer (especially in those of September 23, 1862) and in those of Lassell (September 22, 24, 25, 27, 1862). The second and fourth have been well indicated by Phillips, especially the second, which corresponds to the Hellespontus. This is also indicated by Knott in the aforementioned disc of November 3, 1862, and by Schmidt in the sketch of September 19, published by Klein.[17]

189. As for the strip of land that in the chart of Proctor surrounds the *Phillips Sea*, I believe that I can affirm that it does not exist, at least not in the form of a continuous zone. The belief in it in this form is based entirely on Proctor's representation of his *Lockyer Land*, *Cassini*, *Burckhardt, Kepler*, and *Kunowski*; but in contrast to his chart, it is certain that none of these tracts reaches as far as 75° parallel. The *De la Rue Ocean* (part of Eyrthraeum) is not closed toward the south by the lands that form the *snowy island of Dawes* (Argyre) and Noachis. Also the *Sea of Lambert* (Hellespontus?) is surely open toward the pole.

Section XXVII. General Considerations on the Results Obtained in the Preceding Comparative Study.

190. The comparison with the works of earlier astronomers which has been the subject of this chapter has been useful not only in illuminating many of their and my own observations; it has also proved of inestimable advantage in furnishing partial verifications of many results not hitherto known with certainty. Many configurations, which judging superficially by my chart might appear as new, are found to have been described at earlier times, with greater or lesser evidence; while many details of the previous sketches, of which it has been difficult or impossible to be certain, are confirmed from my observations in this way. It is this mutual confirmation of results, more than the discovery of new details, which in my judgment provides the utility of our essay in areography.

17. See above, § 183.

Part IV: Physical Description of the Planet and its Constitution

The first thing to be observed on Mars is that it has two white and shining spots like snow, which occupy positions close to the two poles of rotation of the planet. On the chart a wedge of the snowy southern deposit is shown, which in October 1877 was of roughly triangular shape. The similarity of position and color to the snows of the terrestrial poles is perfect, and the supposition that they are in reality masses of frozen and crystallized substance is more than probable.

The fact that the changes in the spots depend more or less on the intensity of the solar irradiation on those regions makes this supposition all but certain. In fact each spot, with the approach of the hot season of the corresponding hemisphere, begins to retreat along its contour; it progressively reduces its area up to around 2 or 2-1/2 months after the solstice. Afterwards it begins gradually to increase again, and this continues until the end of the winter season of that hemisphere, when, with another circuit of the seasons of Mars, it again begins its retreat. For the other pole the same events take place, but in alternate epochs, the one deposit of snow attaining its maximum around the time in which the other attains its minimum. Again we have a clear analogy with the Earth. On the Earth, the snowy masses are proportionately a good deal larger than those of Mars. Though with us the arctic snows can, and indeed do, retreat as far as the 84° parallel in the summer, as the latest English, American and Austrian explorations have demonstrated, in other directions they remain unaffected throughout the summer as far as the 62° parallel, as is the case in the southernmost parts of Greenland. In the winter, a vast area of the Earth is covered with snow, to below the 45° parallel. On Mars, the area of the winter snows would be judged small in comparison with the Earth, though precise observations are lacking on this point; but it is certain that in summer the polar snow dwindles to a very small area indeed, and the diameter is only around 300 miles. The southern snows during the 1877 epoch were eccentric with respect to the planet's pole, and were more extensive in one part than in the opposite. In November they contracted so far as to leave exposed the pole of the planet, something which probably never happens on the Earth.

I have spoken of summer and winter on the surface of Mars. In this respect, in fact, the conditions of the planet are almost entirely similar to those of the Earth. It is known that with us the seasons depend on the inclination of some 23-1/2° that the plane of our equator makes with respect to the orbit that the Earth describes around the Sun. If the inclination were more or less, obviously this would affect the degree of difference in temperature in summer and winter. Now the equator of Mars is also tilted to the plane of its orbit, and this inclination, at 28°, is not very much different from that of the Earth, so that one would expect that its seasons would be rather similar to ours.

This would also seem to be the case regarding the difference between the diurnal and nocturnal temperatures. In fact the duration of the rotation of Mars upon its axis is not very dissimilar to that of the Earth: 24 hrs 38 mins compared with 24 hrs. But what could cause a difference in the climate of Mars relative to that of the Earth is the length of its year—686 terrestrial days. The seasons, then, are almost twice as long, and because of this the summers and winters will be more intense than is the case with us. But however important these differences, the observations of the polar snows demonstrate that the climate of Mars cannot be very much colder than our own. Indeed, the spectroscopic observations indicate that these snows really are made up of water; if so, the limited extent of the polar ices, and the fact that they never approach anywhere near the equator even in winter, suggests that the greater part of the surface, during most of the year, is at a temperature above the freezing point of water.

But of the meteorology of Mars we know still more. Various observations and deductions make certain that its surface is enveloped in an atmosphere. About the density of this atmosphere little can as yet be said; about its chemical composition, too, more decisive observations are needed. The only fact concerning which the spectroscope has testified with any certainty is

that the atmosphere contains a significant amount of water vapor. As it condenses over the colder regions, this vapor should produce fogs and clouds similar to our own. These fogs and clouds are in fact observed frequently and easily. Above the dark areas of the planet, which as we shall see represent seas, bright spots of rather indefinite form develop more or less rapidly; they are clouds, strongly illuminated by the Sun, of which we see their upper parts. They move, they transform their shape, they lengthen in various ways and sometimes dissolve into thin wisps; all of which leads us to conclude for the existence there of *winds*. They are usually formed above specific regions and certain islands, covering them entirely and hiding them from sight, so that new discoveries have been reserved for later. At other times they lie recumbent above the continents in layers of vast extent; and this happens especially when those regions are in their winter season. On those occasions many details in the continents, such as the many channels that furrow them, are rendered invisible. Gradually the Sun rises upon those regions and brings summer to them once again, and these veils little by little lose their opacity; they become more transparent, and eventually disappear, and as they do so unmask the underlying regions. On Mars, the cold season is the season of fogs and clouds, no less than with us. And on Mars as on the Earth, the principal location of the fogs are the polar regions, which seldom reveal themselves completely. In 1877, however, the south polar region was for months entirely free from obscurations.

Between the meteorology of Mars and that of the Earth the similarity is, then, striking. Nevertheless, there are also differences. On Mars the season of greatest calm (drawing upon the observations that have been made up to the present) corresponds to the time when the Sun achieves the greatest elevation upon the meridian, that is summer. The same does not hold true on Earth, or at least in the torrid zone of Earth, where between the southern and northern trade winds exists *a zone of calm, almost parallel to the equator*, which is celebrated for the frequency of its rains and its perpetual canopy of clouds. This zone of calm follows the annual motion of the Sun, and occupies higher latitudes, as the Sun shines higher and more vertically at mid-day. On Mars everything seems to be otherwise, and though many observations are still necessary to clarify the atmospheric phenomena of the planet, I already believe that it is sufficiently certain that such a zone of calm does not exist there.

SEAS AND CONTINENTS

The clouds of Mars are unstable formations, which cover one or another part of the surface, and make more difficult and time-consuming, but not impossible, the study of the fixed markings of the planet, which constitute the topography proper and which is the subject of our chart. All the surface of the planet, with the exception of the areas that are occupied by the snowy patches, can be arranged into two principal categories. One of these consists of the clearer and brighter spaces, which on our chart are designated as lands or continents; the other class consists of those darker regions which are designated seas. With some exceptions that are considered separately, the distinction between these two classes is clear, and the boundaries are well-defined and precise.

In searching out the cause of this difference of color, suffice it to say that if the Earth were seen from a similar distance, it would present much the same appearance as Mars does to us. The continents, illuminated by the Sun, would reflect the greater part of the light they receive from the great day-star, and would appear bright; the seas, by contrast, consisting of transparent liquid, would absorb much of the light and reflect very little back to the observer. In general, this difference is not so obvious to the terrestrial observer, because the luminous atmosphere diffuses much of the light, and also because the solar rays strike distant objects at too oblique an angle to the Earth's surface for this to be apparent.

Based on the data of experience, then, we can readily accept the supposition that the bright areas on Mars are its continents, and the dark parts its seas. This probability is further enhanced from the appearance on our chart, where all appears to be disposed in a manner that suggests the

expansion of a liquid mass above an uneven surface. Thus all those streaks, which form furrows between the so-called seas and whose ample mouths have the shape of a trumpet, appear as expected if the large dark regions are indeed seas, and the streaks channels of communication between one sea and another.

The remaining parts of the surface of Mars must also be covered with larger or smaller masses of liquid, as may be deduced from what has been said about the meteorology of the planet. Could we imagine vapors, clouds, and polar ices above a wholly dry planet? The alternating waxing and waning of the two masses of polar ices presupposes the transport of a great quantity of substance from one hemisphere to the other. Transport on this scale must take place in the form of vapor, but some part must also take place in the form of liquid currents, as happens on the Earth.

During the course of my observations of Mars, I have noticed another fact, which tightens still more the knot of analogy between Mars and the Earth. Studying the colors of the different seas of the planet, I have found that, generally speaking, the color of the seas in the equatorial part of the planet is darker than elsewhere, and becomes less dark as one ascends in latitude. Now the same observation has been made by sailors in terrestrial seas, many of whom are convinced of the difference of color between the Mediterranean and the Baltic or North Sea. This fact, the celebrated meteorologist Maury[1] explains by the differing degree of salinity of our seas, which depends chiefly on the differing rates of evaporation; as the darker the sea, the greater quantity of salt, and as the greater quantity of salt is exposed to the irradiation of the Sun, the less water vapor is produced, because of the salt dissolved in it. Now, from all this, I would not dare to conclude that the seas of Mars are salted with sodium chloride, that is with table salt. But this does not affect the main analogy, or the probability of the hypothesis that Mars is covered with seas and continents similar to ours.

One of the most singular features of the surface of Mars, and for us also among the most difficult to understand, is the fact that some regions, according to their color, belong definitely neither to the seas nor to the lands, but apparently participate both in one and the other. Among these, the chief are the various islands and peninsulas in Mare Erythraeum, which are indicated with a less dark color on our chart. Other similar regions are located between the lands, and above all in the isthmus of the region called *Hesperia*. Some observations lead me to believe that these are really lands, but submerged at a shallow depth below the level of the ambient sea. These lands seem to have a distinctive effect on the state of the atmosphere above them, because of the special frequency with which layers of fog are found covering them for longer or shorter periods. At three different times in September and October 1877, the land that has the name *Proteus* was alternately covered and exposed; while that of *Noachis*, after being hidden by veils for months, finally appeared in its true guise only in December 1877. The meteorological influence of these regions on the atmosphere is perfectly analogous to that which they exert in certain banks and depths of our own seas.

Of all these regions of halftones, one is especially worthy of consideration: it occupies one half of the long peninsula called *Hesperia*. When this peninsula is situated toward the center of the apparent disc of Mars and the viewing angle is perpendicular, it appears continuous, and forms a definite separation between the two collateral seas, Cimmerium and Tyrrhenum. Only its middle part, instead of being bright like the two ends and like the surrounding regions, is made up of that color which I have described as a halftone. But if we wait for the planet's rotation on its axis to carry the region to the edge of disc where it is seen under oblique vision, the appearance changes little by little. This central part grows more obscure, and becomes harder to distinguish from the adjacent seas. Under these conditions this part of the peninsula at

1. "The color that is derived from the salt of the sea is what determines the richness of color of the water: the more greenish the color, the less salty the water; and this fact is sufficient to explain the contrast between the waters of the Gulf Stream and those of the Atlantic, and also the clear green of the North Sea and the polar sea, compared with the dark azure of the tropical seas, and especially of the Indian Ocean, whose waters according to some poets have been called black." Matthew Fontaine Maury, *The Physical Geography of the Sea* (1855), § 71.

last disappears without a trace, and its boundaries with the seas on the right and left hand become invisible; it is as if it has been converted to a strait of the sea, and leaves the two remaining bright extremities of the peninsula like two trunks entirely separated from one another. This observation I have verified many times. It is also confirmed by a sketch of Father Secchi in 1858, as well as by other observers.

The fact is very well accounted for if we admit that the regions of halftone are submarine regions, like lagoons. For *Hesperia* this appears likely from the appearance on the chart alone. And it is almost impossible to resist the impression that the peninsula sinks inward at the middle, leaving a delicate communication between the two seas. Any other hypothesis seems in comparison forced and unnatural. We admit, then, that the depth of the water is fairly shallow, for we don't lose the view of the surface of the peninsula when looking down upon it perpendicularly. But with increasing obliquity of the visual ray the path length increases, and the solar rays (supposing that they come from the same direction as us, which is actually the case at opposition) must pass through a greater part of the liquid mass, before being reflected from the bottom. The effect is the same as if the sea in that place became deeper; the absorption of light increases, the color darkens and at last becomes indistinguishable from that of the coterminous seas. This tract of the peninsula seems, then, like an actual strait of the sea.

We will now consider some particulars concerning the different regions of Mars which are indicated on our chart. This examination will lead to some general facts regarding the structure of the surface and the configurations that are found there.

I. *The first fundamental fact is that the greater part of the lands are concentrated within an equatorial zone which surrounds the planet without being interrupted by any considerable seas.* This zone is limited on the south by the line that leaves the Syrtis Major and proceeds along the coasts of Aeria, of Arabia, and of Chryse; it skirts the northern shore of Mare Erythraeum as far as the Ganges, fringes the Aurea Cherso and Thaumasia, and enters by the Columns of Hercules into the Mare Sirenum; then it finally returns, by the northern shore of this sea, and also of those of Cimmerium and Tyrrhenum, back to the Syrtis Major. The boundary of the equatorial zone to the north could not be traced with sufficient distinctness at the 1877 opposition; but from observations by previous astronomers, it appears that it is confined by the 50° north parallel. The zone of equatorial lands is not symmetric with respect to the equator, but the greater part of it lies north of the equator, and the two maritime basins which divide it are very unequal.

II. *In the southern hemisphere exist other lands alternating with isolated tracts of sea, and disposed in two zones parallel to the preceding.* The first zone runs below the mid-southern latitudes, and is formed of the regions of Icaria, Phaetontis, Electris, Eridania, Ausonia (southern part), Hellas, Noachis, Argyre, and the land of Ogyges; it lies between the 30° and 60° parallels, with the only major break occurring at 40° longitude, near the region of Thamasia, which can equally well be included as part of this zone or of the equatorial zone just described.

The second zone of the southern latitudes occupies less than 120° of longitude between the 60° and 80° parallels, and is formed by the two islands of Thyle, with an interruption in the strait of Ulysses. It is separated from the preceding by a vast channel called Mare Chronium.

III. *Between the equatorial zone and that of the mid-southern latitudes runs a series of inland seas, interrupted by long continental or submarine peninsulas all of which are inclined in a generally north-west to south-east direction.* This is the most singular feature to strike us on the chart of Mars. The inland seas are the Hadriaticum, Tyrrhenum, Cimmerium, Sirenum, the lakes of the Sun and of the Phoenix, then the three basins of Erythraeum, that is, the Sinuses Aurorae, Margaritifer, and Sabaeus; to which as a complement could be added the Deltoton or triangular gulf. The peninsulas, all oriented in the same general direction, are: the middle and northern part of Ausonia, with its two branches, Oenotria and Iapygia; then Hesperia, Atlantis I, and Atlantis II. Then (leaving aside the irregularly distributed Thaumasia region) we again have the Aurea Cherso, and the land of Proteus, which may be submerged appendages, and the peninsulas of Pyrrhae and Deucalion. All of these tongues of land must be entirely or partly submarine; the only exception, and then only a partial one, is Atlantis I. It is notable that the direction

in which all of these peninsulas lie would be that of the trade winds and marine currents of this region, which depend on the rotation of the planet. Nor is it impossible that all of these markings are the work performed on the solid surface of Mars by the influences of the two fluid envelopes that surround it.

IV. *Where the antecedent peninsulas adhere to the two continental zones, they are flanked by mouths of large channels which cross the same continental zones.* If we consider their relation to the equatorial zone, we find that the peninsula of Deucalion is flanked by the channels called the Gehon and the Indus; that of Pyrrhae, by the Hydaspes and the Ganges; the Aurea Cherso, by the Ganges and the Agathodaemon; Atlantis I by the river of the Titans and that of the Laestrygons; Atlantis II by the river of the Laestrygons and that of the Cyclops; Hesperia, by the rivers of the Ethiopians and the Lethes. The same is true of the connections between these peninsulas and the zone of the mid-southern latitudes in those cases where connections exist. Thus Atlantis I is flanked by the Columns of Hercules and the Simois; Atlantis II by the Simois and the Scamander; Hesperia by the Scamander and the Xanthus; southern Ausonia between the Xanthus and the Euripus.

V. *The channels which traverse the two zones (equatorial and mid-southern) for the most part follow in the direction of the meridian*; from which it follows that the fundamental plan of the topography of Mars resembles that of a chessboard, composed essentially of zones which with few exceptions tend along the parallel, intersected by channels whose courses follow along the meridian. The most unusual of all, in direction exactly along that of the meridian, is the channel of Alpheus, which bisects the great round island called Hellas.

VI. *The equatorial zone is subdivided into two other zones by long channels running in the direction of the parallel.* These channels, which are the Nilus, the Oceanus, and the Eunostos, form a complete girdle around the globe of Mars, in general nearer to the northern pole than to the southern pole of the planet. This disposition is connected to the chessboard distribution just described.

VII. *Large continuous continental masses don't exist on Mars, but all of the surface of the planet is divided by numerous channels into various smaller islands.* This unusual and completely unexpected arrangement of the seas and continents of Mars is apparent immediately from the chart.[2] The widths of the channels in question are very variable; the thinnest and most difficult to make out don't exceed 100 kilometers from one bank to the other, and are comparable to the Strait of Malacca, the very oblong lakes of Tanganyka and Nyassa, and the Gulf of California. But there must be many others, much narrower, whose existence one suspects during moments of optimal telescopic vision, but cannot completely affirm.

In fact, during the course of the observations, in October 1877, I happened two or three times to have brief moments of absolute atmospheric calm, or nearly so. Under these conditions it seemed as if a dense veil were drawn away from the surface of the planet, which appeared as a complex embroidery of colors.

But such is the number of the details, and so fugitive the duration of this state of things, that it was impossible to form a clear and coherent idea of the things seen, so that what remained was only the confused impression of a dense network of thin lines and minute spots. A similar observation was also made by Secchi on June 29, 1858: "Mars is all red, and only lightly spread here and there with yellow, red and dark characters, which form a kind of variegated pattern difficult to detect and impossible even for the imagination to grasp." These observations lead me to believe that the channels of Mars are like the rilles of the Moon, whose number grows in direct proportion to the increased optic power and attentiveness of the observer. In Mars, then, the separation of the liquid and solid parts is not as great or as complete as on Earth. Are his islands

2. The existence of these channels some will dispute, because they have not yet seen them. Yet a good many of them are not new, having already been recorded by such excellent observers as Kaiser, Lockyer, Secchi, Green, etc. Of these, at least, it is hoped that there will be no doubts; for the others, they await the future confirmation of other observers armed with sufficient optical power.

banks emerging slowly from a vast lagoon, or did reefs develop amid a system of fractures in the crust? One or the other guess is at the moment equally plausible, but perhaps in the not too remote future it will become possible to answer such questions which are now hidden.

The great elevations and depressions on the surface of the Earth are explained by geologists as due to the internal forces of its bulk, which don't seem entirely exhausted even now, and are chiefly an effect of the transformation of the internal heat of our planet. If we admit with Laplace that the planets were formed by condensation or agglomeration of material, then it is easy, from the principles of the mechanical theory of heat, to calculate the temperature which this material must have reached from this condensation. The heat of condensation was calculated by Helmholtz in the case of the Sun as 28,000°C. For the Earth I find, from the same principles, 8,988° and for Mars 1,995°. Everything else being equal, the internal heat of Mars should be very small relative to that of the Earth. If we add to this that, according to the hypothesis of formation, Mars should be more ancient than the Earth, and have suffered a longer period of cooling; that its volume being so small, it ought also to have cooled more rapidly; then it does not seem to me absurd to conjecture that it is further along toward the period of absolute senescence of its internal forces, and that now the leveling forces of its atmosphere and seas hold exclusive dominion there.

However much weight one may wish to give to these speculations, the physical constitution of Mars, in some respects like, in others unlike, that of the Earth, is a subject deserving the attention not only of astronomers but of geologists and meteorologists. In fact the Moon and Mars are the only celestial bodies of whose surfaces it is possible to draw up a chart. But the constitution of the Moon has so greatly diverged from that of the Earth that one has up until now tried in vain to illuminate, through studies of its surface, the history of the formation of our own globe. Mars on the other hand is a small version of the Earth, with seas, an atmosphere, clouds and winds, and polar caps; and it promises, in this regard, a good deal more. When one reflects on how much effort is expended annually by all the nations in the study of the large movements of the terrestrial atmosphere, through countless observations on all the lands and seas of the globe, it does not seem without practical utility to examine closely the analogous phenomena on this planet which is our neighbor and almost brother, on which we are able to take in at a glance the meteorology of a whole hemisphere.

But the accurate study of Mars requires an optical power a good deal superior to that which has been employed until now. The chart annexed to this memoir, although more copious of details and more exact than any published hitherto, has been made with an excellent instrument, but one of only modest dimensions. I have been able to achieve what I have with it chiefly as a consequence of the quiet layers of the atmosphere and tranquil images which are distinctive of the astronomical climate of our lower Lombardy. But in this same climate with another more powerful instrument a chart still more exact and rich in detail could have been produced, since with our Milan equatorial an object would not be observable on Mars unless it were at least as large as Sicily, and one would be unable to make out its form, unless it were at least of the dimensions of the island of Ceylon.

Such limits of visibility are those of our objective of 21.8-cm aperture. Apparently the invincible obstacle here is the diffusion of contours that arises as a result of diffraction. This diffusion results in the thinner lines being widened into strips of gradually decreased intensity on both sides, so that the contrast with the background becomes greatly attenuated: the eye is unable to grasp such weak tones, and the vision becomes doubtful and uncertain. The only remedy for this, as is well known, is to increase the aperture of the objective. The limits mentioned are, then, only an inferior limit for what is possible to achieve in the examination of Mars, and there is no doubt that this limit will soon be surpassed when the examination is carried out with one of the giant refractors, which in recent years opticians have learned how to build.

I have often wondered whether there might be some way of removing, or at least of decreasing, the great inferiority in the instruments that we Italian observers have in comparison with observers of other nations. The lenses of Rome and Palermo have apertures of 25 cm in diameter, while the Amici of Florence is 30 cm; compare this to 38 cm for Pulkowa and Cambridge [Harvard]. Alvan Clark has built for the observatory at Washington that gigantic instrument, of

which the lens is until now the largest ever constructed, and has an aperture of 66 cm and a focal length of 13 meters. With this instrument they have been able to observe and measure with ease luminaries that had previously been the *non plus ultra* of difficulty, and with it this past August Professor Hall discovered the two satellites of Mars, which have been seen from few other observatories, and which in Italy none of the present instruments has rendered visible. The government of Austria, which has organized the splendid observatory of Vienna, intends to equip it with an even larger instrument. In comparison with these colossi, our refractors are very little. Not that they should be considered valueless for science! As infinite as astronomical science is, and as various as are the observations to be made, there remains much work for which smaller instruments will serve as well as great ones. But it is not from these instruments that we can expect the greatest novelties and most splendid discoveries of the future.
