

fine objects as the canals and lines of demarcation to appear much worse when viewed through an unsteady atmosphere. If the rather sharp lines of demarcation appear clear cut under 385 or 460 diameters on a 16-inch, in the same atmospheric conditions could a power of 1000 on a refractor of twice the diameter be expected to resolve much finer lines so as to make them appear a long mass broken up in structure, as shown in the same volume on p. 418, Figs. 5 and 7? It is the atmosphere mainly that apparently causes the canals, if visible, to be resolvable. In his article on Mars, some pages of which are referred to above, Mr. Antoniadi does not describe the quality of the air through which he observed. It may be clear, but not steady enough to permit the sharpest detail to show as such. In passing from a large refractor to a much larger one, the observer is rather far more deceived by the state of the atmosphere than by the delicate character of the canals themselves. It may be remembered that, under ordinary conditions, a large instrument for visual observations is more affected by atmospheric disturbances than in a smaller one: the larger the instrument and, therefore, the higher the power, so much better must be the conditions of the air at and above the place of observation.

Los Angeles, Hollywood, Cal.

MONTHLY REPORT ON MARS.—No. 4.

WILLIAM H. PICKERING.

During the past month from January 16 to February 15 the northern polar cap ceased to retreat. The mean of six observations made between February 12 and 16 gave a latitude for its southern boundary of $68^{\circ}.5$ or practically the same as that found in the middle of January. This would seem to imply that the remaining area north of this latitude is of considerable thickness and therefore melts slowly. Three of the four polar marshes became much fainter, and apparently dried up, indicating that the water supply was diminishing. Unfortunately our double-image prism did not arrive until February 17, and the places formerly occupied by the marshes, examined since that date, have shown no polarization, but when they were dark blue in color there is no doubt but that the light coming from them was polarized as had been the case at two previous oppositions.

On January 13 Professor Lowell reported that the Martian southern cap was beginning in stippled patches of hoarfrost, between longitudes 30° and 60° . Our own next view of this region was on February 7, when it was occupied by a cloud 1200 miles in length. The cloudy area increased in size the next night to 1800 miles, but two nights later was again smaller, measuring 1500 miles. February 12 it had entirely disappeared. The following night all the south polar regions were recorded as very dark, with no trace of cloud. February 14 a crescent of haze lay along the whole length of the limb and part of the terminator, extending half-way to the center of the disk, entirely concealing the polar regions. After this the area in question passed around to the other side of the planet, and we saw no more of it. We are quite clear however that there was no hoarfrost or permanent snow area there on either February 12 or 13. The writer does not believe that the hoarfrost is ever seen far from the sunrise terminator, and he would suggest that what Professor Lowell interprets as hoarfrost is described here as cloud. The appearance noted here has a white pearly lustre, clearly fainter than the snow at the north pole, but brighter and much whiter than the desert areas of the planet.

White cloud is occasionally seen in the equatorial regions close to the limb, but when it gets nearer the center of the disk it turns yellow owing doubtless, as previously stated, to its thinness, and to the fact that we see the soil between separated small clouds. Our own cumulus clouds often have a bluish tint, even near thin centers, when they are forming or dissolving, and are therefore thin enough for us to see our blue sky through them.

It is the writer's impression that the meteorology of Mars resembles very closely that of the earth, much more closely than has heretofore been supposed. Clouds are numerous on both planets but they are more so in the daytime with us, and possess greater density. It is believed for theoretical reasons that the northerly and southerly components of their winds are more marked than ours, that their daily range of temperature is greater, and that their precipitation usually occurs at night, but except in these respects the meteorology of the two planets is practically identical.

The writer has introduced the custom of entering on his drawings certain numbers, indicating the brightness of the areas observed. He does not know whether this plan has been previously used as a regular custom by others, but recommends it to their attention. It is what has been done by selenographers in their lunar observations for years, and is generally approved. On the writer's scale the polar snows are marked 10, and the very blackest areas 1. Most of the *maria* are about 3, most of the deserts 6 to 7, and the polar clouds usually 8.

For many years Martian observers have been in the habit of reporting marked changes as occasionally occurring upon the planet, but the writer believes that a considerable proportion of these, perhaps a third, were due simply to shifting clouds. Thus the numerous and marked changes in size of the southern polar cap at this opposition are almost certainly due to nothing more complex than the formation and dissolution of cloud areas. The sudden appearance of two lakes and four canals in the Protei Regio on December 31, where on the previous night only a whitish area was visible, was presumably due to the clearing away of clouds. Possibly the fact that certain narrow canals were seen south of the Sabaeus in January, which were not seen on February 14 or 16, though near the center of the disk, with seeing 12 and 10, is due to their having been hidden by invisible, because partially transparent, cloud masses. The writer believes that the disappearance and reappearance of Margaritifer Sinus between February 8 and 14 was due to the same cause. Whether its first appearance in the latter part of November will bear the same explanation is by no means so certain.

On the other hand the formation of the four marshes surrounding the north polar cap, the formation of a dark area bounding it, some 900 miles in width in one place, and its subsequent disappearance, are clearly due to some other cause. The appearance of the whole region about Solis Lacus as of a uniform grey tint in August, and also at the end of November, and the beginning of December, and its subsequent clearing up at the end of the latter month, when the dark areas were surrounded and intermixed with bright areas, so as to give the region its customary aspect, could not possibly be due to the clearing away of clouds,—unless indeed we assume the latter to have been of a dark grey tint, like the *maria* themselves. This seems to have been a case where the vegetation, at first grey, died or turned yellow in certain areas. The Martian date was April 3, which for the southern hemisphere would correspond to October 3 for us, in the northern hemisphere of the earth.

In the last report attention was called to the gradual shifting in latitude of the northern boundary of the dark regions of the planet in certain places. It is thought that some statistics of this change may now be of interest. In Table I three different longitudes 315° , 185° , and 130° are considered. The measures were all made from drawings, and in the first two columns of each section the date and central meridian are given. The last column gives the measured latitude of the boundary line in the longitude indicated at the head of the column.

In the first longitude considered little change occurred in the latitude after October 30, when a slight increase was observed. In the second longitude no obvious change occurred between September 2 and December 23. After that the latitude also increased. A comparison of the figures in these two columns will give one an idea of the accuracy to be

TABLE I.

CHANGE IN LATITUDE OF THE BORDER OF THE DARK AREAS.								
1913-4 Central 315°			1913-4 Central 185°			1913-4 Central 130°		
Aug. 14	4	—6	July 27	180	—15	Aug. 6	92	+12
Sept. 17	0	—5	Sept. 2	183	—25	Oct. 12	160	—33
Oct. 30	346	—16	Oct. 12	160	—28	Dec. 19	162	—47
Nov. 30	0	—20	Nov. 17	187	—23	" 25	125	—44
Dec. 2	4	—25	Dec. 16	192	—22	Feb. 1	150	—60
" 3	346	—15	" 17	185	—25			
Jan. 4	5	—20	" 18	177	—28			
" 6	351	—20	" 19	162	—25			
" 10	342	—18	" 22	168	—23			
Feb. 12	350	—16	" 23	172	—23			
" 14	537	—25	Jan. 21	184	—34			
			" 27	163	—28			
			Feb. 1	158	—31			

expected from this method of measurement. Thus during the interval when no change is thought to have taken place the latitude and average deviation of the nine results in the first section is $-19^{\circ}.4 \pm 2^{\circ}.9$; of the nine results in the second section $-24^{\circ}.7 \pm 1^{\circ}.7$. The latitudes given by Schiaparelli are -12° and -30° respectively. According to the map of Lau referred to in Report No. 3, they are -15° and 22° . The results by both of these authorities were obtained with a micrometer. It does not seem possible to explain the large deviations between them as due merely to accidental errors. The stations selected, especially the first one, Hammonis Cornu, might be supposed to be fairly constant in position. During the January, February presentation, the writer's determination of the mean latitude of the second station 31° , agrees very well with Schiaparelli, but the earlier measures agree better with Lau.

When we come to the third station, in longitude 130° , the change in latitude is so marked and so regular, that it is obviously due to a continuous alteration of the boundary line. Indeed this is shown by the most casual examination of the drawings. The Martian dates corresponding to the first and last observations of this region, August 6 and February 1, are January 17 and April 19. Since the course traversed by the station (if station is the proper word to use in speaking of the survey of such a region), lies chiefly in the southern hemisphere of Mars, the corresponding dates for us in the northern hemisphere of the earth, would be from the middle of July to the middle of October. That is the gradual change from green or grey to yellow occurred in their autumn. It would thus appear that the great yellow plains of Mars, which are sometimes red and sometimes yellow, but usually light-colored, may be spoken of as deserts only for purposes of convenience, and because we cannot tell where the boundary line between the yellow sand and the yellow vegetation really lies.

We should note that this gradual change in latitude is quite different from the change in color of Libya. When Libya is light colored the northern boundary of the *mare* in that longitude is in latitude -10° . When Libya is dark colored the latitude is $+10^\circ$, but the whole area which is enclosed by canals, changes color at the same time, the latitude is either $+10^\circ$ or -10° , never any intermediate value.

But it is not merely the vegetation whose boundary lines shift about over the surface of the planet. In Table II are given the latitudes and longitudes of the northern and southern ends of the two marshes which have been previously referred to as the twin bays on the southern boundary of the northern polar cap. In some of the drawings only one bay is shown, for sometimes one and sometimes the other is too near to the limb or terminator. A comparison of the upper and lower line of

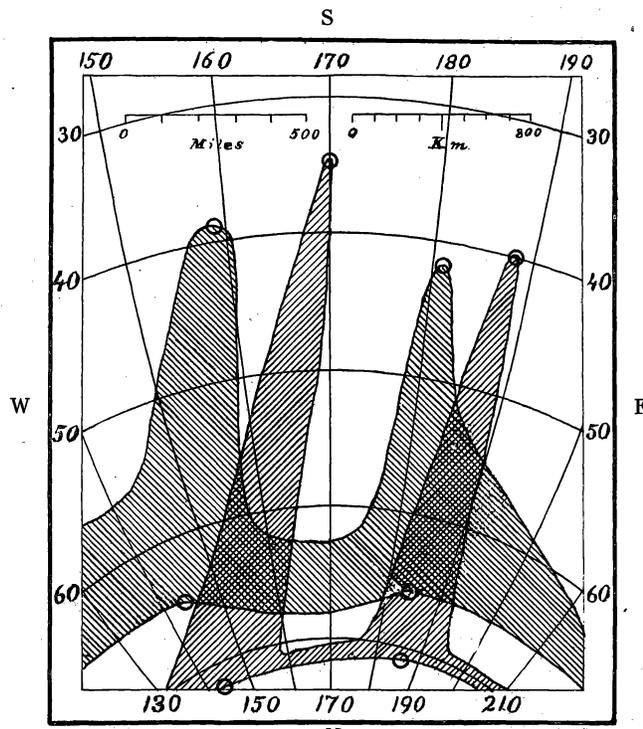


FIGURE 1.

means shows what changes have taken place between the December and January presentations. In both cases it will be noticed that the northern ends have retreated northerly with the retreating snow, while the southern ends have advanced southerly, thus lengthening the bays at both ends. But the most interesting feature consists in the change

Returning from this brief hypothetical digression to the facts of observation, the question may now be asked are we sure that any of the dark markings are fixed features of the planet. The writer believes that the chief canals do not shift laterally, at least to any great extent, and that the lakes are also fairly fixed in location. Fastigium Aryn, the point from which all Martian longitudes are reckoned, is a light colored point lying between two bays. The point is sometimes drawn long and narrow and sometimes short and broad. Its axis is sometimes represented as lying due north and south, and sometimes with a position angle of $-15^\circ \pm$. The latter position is undoubtedly sometimes correct, and the length undoubtedly varies, so it is highly probable that the position of its end or point varies somewhat in longitude. The variation is so small however that it is of little consequence for our present purposes.

Professor Lowell and the writer both independently found from micrometric measurements, that the Martian meridian transited several minutes ahead of time this year. Since Aryn itself was not visible, presumably in both cases points in its immediate vicinity were selected for the observation. The writer used the Edom promontory, longitude 356° . It is quite possible that the longitude of these secondary points may themselves vary somewhat,—hardly enough to vitiate the fact of the deviation, but enough to invalidate its accuracy. It is therefore most desirable that several observers should repeat the observation at the next opposition, if Aryn is then visible. This may well be the case, as the opposition will occur appreciably later in the Martian season then, than it did this year, so that Aryn will have had time to develop. Aryn was certainly not visible February 14, when within 23° of the center of the disk, with seeing 12. $\odot = 35^\circ.2$. Equivalent Martian date April 24.

A notable change in darkness occurred at the northern end of the Syrtis major this year, a region that is often very dark, sometimes blue, and sometimes brown. A dark segment-shaped marking 1100 miles in length was observed January 15, which had been fainter, larger, and more ill-defined at the previous presentation. Two days later a dark bay 500 miles in length was thrown out along the line of Nepenthes. See Fig. 2. The following day this was unchanged, but when next seen, in February, the whole region had faded materially, no trace of the segment or the bay being visible.

It will perhaps be of interest to study the change in color that accompanied this change in darkness. On December 8, 10, and 12 the region concerned is described and painted as green and greenish grey. January 11 it is described as "Grey, neither green nor brown." January 12, Bluish or greenish grey. January 15, "Grey. Neither brown, green,

nor blue, but the region following is greenish". January 17, "Very blue tonight." January 18, Very blue or green. February 14, Grey. February 16, Greyish green.

It will be noticed that January 15 the region is clearly described as grey, but on the addition to its area of the large bay two days later, its color changed to "very blue." It appears to the writer that this blue color can have been due only to water. This same color has been noted in this same region by others, notably by Molesworth in 1903, as well as by the writer on previous occasions. This region is then a marsh, like the ones surrounding the polar cap, but it is the only one to which the water was transported over a great distance, some 2000 miles. Moreover the water did not remain there for any great length of time; less than 30 days. A local darkening December 10 leads us to believe that there may have been an earlier deposit in this region, not observed at this station.

The two dark lines connecting it with the polar cap were, with the possible exception of Cerberus, much the most strongly marked canals that were observed during this opposition. January 15 and 17 they measured some 200 miles in width, January 18 but 100 to 150. On February 24 the following one Nilosyrtris was but a few miles in breadth. It would certainly seem that the great increase in size of the dark spot and its change of color on January 17 had some connection with the narrowing of the canals the next day. It also seems as if these two very marked and sharply bordered canals differed in their functions from the fainter ones, with more hazy borders, found in other parts of the planet.

The phenomenon observed is the exact counterpart of that recorded by Professor Douglass and the writer July 17, 1892, when the water from the southern polar cap discharged through Pandora's Fretum and the Mare Australe into this very same region (*Astronomy and Astrophysics* 1892 11, 668.) The two canals concerned on that occasion were recorded as of 150 miles in width, and sharply defined. Immediately after the temporary enlargement of the swamp, along Nepenthes, see Fig. 3, which is described as blue in color, the canals faded, one narrowed and the other, the following one, disappeared. In the present instance the two canals joined the bluish marsh known as Boreosyrtris with the marsh in the Syrtis Major. In 1892 they connected a long dark narrow cleft in the polar cap with this marsh. The heliocentric longitude of Mars at the time of the first event was 301° , at the second 110° ; difference 191° . That is they occurred at very nearly opposite seasons of the year, the corresponding Martian dates being October 22, and April 12. The two canals which faded and narrowed in each case are marked by arrows, indicating the course of the vapor which it is

thought condensed to produce the marsh and its extension. In 1892 both canals started at the right hand end of the snow cap. By July 23, the shape of the marsh was very like that shown in Fig. 2, but in August its size was again further reduced. Why two canals should be

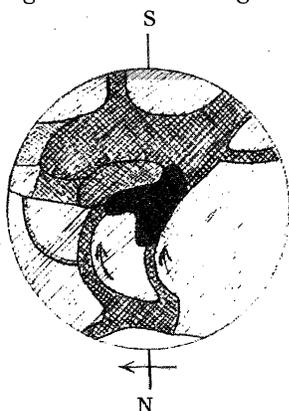


FIGURE 2.

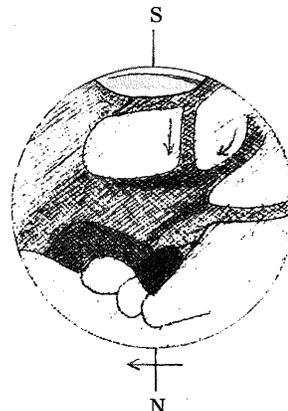


FIGURE 3.

involved in both cases seems a little surprising, but possibly vapor coming along the two routes met and produced an especially heavy downpour at their junction. It is believed, although it is by no means certain, that the Syrtis marsh is filled twice every Martian year. Whether two canals are always concerned in the filling is yet to be determined.

Sabaeus like the Syrtis Major has sometimes been observed to be of a deep blue color. This has not been recorded this year however. When it first developed upon November 30, and again on December 3, it was described as grey. At its next return January 6 its color was a chocolate brown, and this color it retained through February 13, when it is recorded as "clearly brown". February 14 it is described as having "a trace of brown," but February 16 the record reads "Sabaeus grey, not brown." This is our last note concerning it. Cerberus has constantly been recorded as brown this year, and was so at last accounts, these being the only two areas on the planet where this color has been observed at this opposition. The greens of the southern *maria* which have hitherto been so conspicuous, are now gradually fading into greys with the approach of winter, in those portions of the planet where they have not already turned yellow. Indeed we see that on Mars as on the earth different kinds of vegetation act differently with the advance of the seasons, and it is possible that some future astronomer may even develop a botany of Mars, as we are now trying to develop its meteorology.

Turning now to the observational side of our work, Professor Lowell has long claimed that there were advantages in using a reduced aperture on Mars, when the seeing was not at its best, and I believe in practice he seldom uses over 18 inches, and often less. Many years ago the

writer found that with the quality of seeing usually prevailing at Cambridge, better photographs of the moon could be obtained with a 4-inch aperture than with either a larger or smaller size. On one occasion recently, in January, when the seeing here was exceptionally bad, about 3, the planet being at an altitude of 30°, it was found that just as much could be seen with the 3-inch finder, and a magnification of 180, as was visible with the 11-inch, and powers of either 330 or 660. As a result of experiment we find that when the seeing here gets as bad as 6, which is about the best we have in Cambridge, that better results are obtained if we stop our aperture down to 8 inches. Certainly nothing could be done with a 30 or 40-inch lens under the circumstances.

In practice however when the seeing gets as bad as that, unless something of especial interest is happening, we seldom observe at all, as it is a mere waste of time.

The following canals have been recorded here this past month:

Jan. 17. 5 Nilosyrtis, Nepenthes, Thoth, Boreosyrtis, Triton, Pactolus, Achelous (L).

Jan. 18. 5 Nilosyrtis, Nepenthes, Thoth, Boreosyrtis, Triton, Pactolus, Achelous, Cerberus, Hyblaeus, Styx.

Jan. 20. 4 Nepenthes, Thoth, Boreosyrtis, Triton, Pactolus, Achelous, Cerberus, Hyblaeus, Styx, Aesacus, Anian, Hades, Orcus.

Jan. 21. 3 Cerberus, Hades, Pallene (L).

Jan. 27. 3 Cerberus.

Feb. 1. 3 Cerberus, Hades, Pallene, Trais (L) (?), Gigas (?).

Feb. 5. 2 Agathodaemon, Daemon, Nectar, Hyscus (L), Eumenides, Chrysorrhoeas, Phlegethon.

Feb. 7. 2 Agathodaemon, Daemon, Nectar.

Feb. 8. 1 Ganges.

Feb. 12. 1 Ganges.

Feb. 14. 6 Protonilus.

The following Table of Data is arranged like those published in the preceding reports.

TABLE OF DATA.								
No.	1914.	☉	M.D.	Long.	Lat.	Sun	Diam.	Seeing
55	Jan. 17	22.7	Apr. 12	284	+3	+9	14.3	11
56	"	"	"	306	"	"	"	7
57	18	23.1	"	240	+2	"	"	10
58	"	"	"	302	"	"	"	6
59	20	24.1	13	222	"	"	14.1	8-10
60	21	24.6	"	184	"	+10	14.0	4
61	27	27.3	16	163	"	+11	13.5	6
62	Feb. 1	29.6	19	150	+1	+12	12.8	12
63	"	"	"	158	"	"	"	10
64	5	31.4	20	104	"	"	12.4	8
65	7	32.3	21	74	"	"	12.2	10
66	8	32.8	22	42	"	+13	12.0	10-6
67	10	33.7	23	50	"	"	11.8	6
68	12	34.6	24	350	"	"	11.6	6-9
69	"	"	"	38	"	"	"	6
70	14	35.2	"	337	"	+14	11.4	12-10
71	"	"	"	29	"	"	"	7-9

Referring to the twin bays at the edge of the northern polar cap, one of our European correspondents, M. Jarry Desloges has kindly furnished the following information:—

They were first seen in November. On November 5 and 8 they appeared rounded, but on November 9 vaguely triangular. November 10 they were again rounded, but November 15 large and triangular. November 17 they were pale and on the limb. December 9 and 12 they were triangular. December 13 they were measured, and were observed every night until December 18. They were observed again on the nights of January 16 and 21, when they were still triangular, and their southern ends were now united with Titan. The writer would remark that the change from the rounded to the triangular form must not necessarily be attributed to a change in the quality of the seeing, for sometimes he has noted that one bay is fainter, and sometimes the other, and that they change from night to night. M. Desloges further states that something unusual was observed between them at both of his observatories, but does not mention what it was. Nothing but a small cloud was noticed here, on December 19 to 23, but possibly some of our readers can supply this deficiency, and thus corroborate his observation.

NOTE ON THREE NEW BINARIES.

STORRS B. BARRETT.

In his paper on "The Radial Velocities of Twenty-six Stars", Jordan* published measures of two stars which had been under my observation also, at Yerkes Observatory. These are *21 Lyncis* and *6 Comae*. The spectrum of the former contains some excellent lines and a variation of 15 km. on eight plates indicates clearly a binary. The range is from +23 km. to +38 km. The four plates taken at Allegheny gave values between +20.8 and +28.4 km.

The lines of *6 Comae* appear poor on many plates, but on the best ones it is possible, under low powers, to measure fine lines, often in pairs. The Allegheny values from six plates range from -3 km. to +15 km., with an average +5 km. which probably represents the center of gravity of the components, the stronger of which gives a range of from -50 km. to +150 km. on my plates taken in the years 1909-1911.

* *Pub. Allegheny Observatory*, 2, 121, 1911.