Mapping the Mars Canal Mania: Cartographic Projection and the Creation of a Popular Icon

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ABSTRACT: At the turn of the twentieth century, a popular mania developed around the idea that Mars was inhabited by intelligent beings. This obsession was originally based in the science of the time, but it outlasted astronomers' certainty regarding the red planet's conditions of habitability. Cartography was vital to the popular construction of Mars as an inhabited world and created a powerful landscape icon that differed significantly from the observations of astronomers. Acceptance of a Martian civilization began to wane only when cartography's status as an objective representational format was weakened by new photographic technology in the early 1900s. Although the processes and formats of cartography are rarely considered primary factors in the Mars mania, they were integral to the origin, development and expiration of the conceptualization of Mars as a world that was possibly inhabited.

KEYWORDS: astronomical cartography, planetary photography, science popularization, Mars, Martian canals, Giovanni Schiaparelli, Nathaniel Green, Percival Lowell, Eugène Antoniadi.

At the turn of the twentieth century, an extraordinary popular mania developed around the idea that Mars was inhabited by intelligent beings. The idea originated in the 1880s, when several astronomers reported observing geometrical patterns on the surface of the planet. Despite disagreement among scientists regarding the accuracy of these observations and reports, a few high-profile astronomers championed the existence of the patterns, inducing widespread interest from popular audiences by the mid-1890s. In both Europe and North America, people gravitated toward the most sensational interpretation of the strangely regimented Martian landscape: namely, that the intersecting lines must indicate a canal system engineered by intelligent beings as a desperate response to increasing aridity. In newspapers, highbrow magazines and penny pulps alike, writers enthusiastically took up the subject, usually accepting without reserve the depiction of a fully managed Martian landscape. Although professional astronomers had largely dismissed this interpretation by 1910, popular audiences maintained strong interest in it for at least another decade, with a muted obsession lingering in some quarters for much longer.[1]

Much of the scholarship addressing the Mars craze has focused on the nature of science popularization, the process of astronomy's professionalization and the influence of astronomers' individual personalities and philosophies. These

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works have deepened our understanding of how Mars science became enmeshed in wider intellectual debates, particularly those concerning the nature of evolution and the uniqueness of man.[2] These studies have not, however, tackled the fundamental role that maps played in shaping the claims and their popular reception. I am arguing here that cartography was a vital element in the popular construction of Mars as an inhabited world, and that it gave rise to a powerful landscape icon that differed significantly from astronomers' reported observations. I also show that acceptance of the Martian civilization began to wane only when the status of cartography as an objective representational format was questioned and weakened by new photographic technology in the early 1900s.

Cartography and Mars

Maps were instrumental in every phase of establishing inhabited-Mars claims as legitimate scientific knowledge. When the Italian astronomer Giovanni Schiaparelli first reported seeing lines, or *canali*, in the Martian landscape in 1878, he conveyed his findings in a map (Plate 6).[3] Although this was not the first map of Mars nor even the only map of Mars produced that year, Schiaparelli shook the astronomical world with his revolutionary depiction of the red planet. Compared with cartographers of the preceding decade, who had applied naturalistic shading and subtle reddish-orange markings to render Earth's imperfectly seen neighbour, Schiaparelli used hard-edged lines and a schematic blue shading to represent a planet neatly divided into what he presumed were innumerable islands and waterways. This depiction was drastically different from another major Mars map produced in 1877, by the English astronomer Nathaniel Green (Plate 7).[4] Not only did Schiaparelli's map display significantly more detail than Green's or any prior map, it demonstrated the new landforms with substantially more clarity and definition. On the basis of this convincing visual authority, Schiaparelli's map quickly thrust its maker into the spotlight, despite the fact that he had never observed Mars before 1877.[5]

Once Schiaparelli's *canali* were inscribed in the map, the hunt for canals was on. No other astronomers had seen any geometric forms on the Martian surface, but the European astronomical establishment reacted to Schiaparelli's depiction by working feverishly over the next decade to confirm it. Although his canals went unconfirmed until 1886, Schiaparelli himself continued to augment his map at every 26-month interval, when Mars passed relatively close to Earth.[6] As Schiaparelli's maps became more detailed, other astronomers' reactions became more intense. Those who failed to see the canals were divided in their reactions: some maintained that Schiaparelli might have been in error, while others merely lamented their own poor luck, eyesight, instruments or location.[7] In 1886, however, other astronomers confirmed Schiaparelli's observations, and it then became more difficult to reject the canals inscribed on the map.[8] Within one decade of the confirmations, an explosion of post-Schiaparelli canal sightings had produced an exceedingly complex map, and attention had turned to interpreting the curious landscape.

Just as the visual certainty and perceived objectivity of the map had helped Schiaparelli to establish the legitimacy of his early claims, later astronomers found that their authority as interpreters of the Martian landscape depended largely on their own cartographic contributions. American amateur astronomer Percival Lowell, who built his own observatory and began mapping Mars in 1894, quickly became one of the foremost authorities on Mars by producing extremely detailed maps of the red planet. Not only did he confirm all of Schiaparelli's original canals, but he also discovered an additional 116 waterways in his first year of observation. He went on to record even more canals two years later, and his second major map became increasingly abstract (Fig. 1). His work attracted the attention of other astronomers, many of whom were initially sceptical of his lack of astronomical training. Despite reservations about Lowell's amateur status, however, several leading astronomers had to acknowledge that he had made a major contribution to Mars science through cartography.[9] Lowell's success, attributed to the superiority of his telescope and his advantageous location in Flagstaff, Arizona, was thus both reflected in and constructed by the vast complexity of his maps.

Immediately upon making his first Mars observations in 1894, Lowell began to publish his theory that the canals were evidence of an advanced Martian civilization. Not only did he target scientific journals, but he also set his sights on popular magazines such as *The Atlantic Monthly*, *Scientific American* and *Century Magazine*. In these periodicals, Lowell argued that Mars must have been undergoing planetary aridification so severe that its

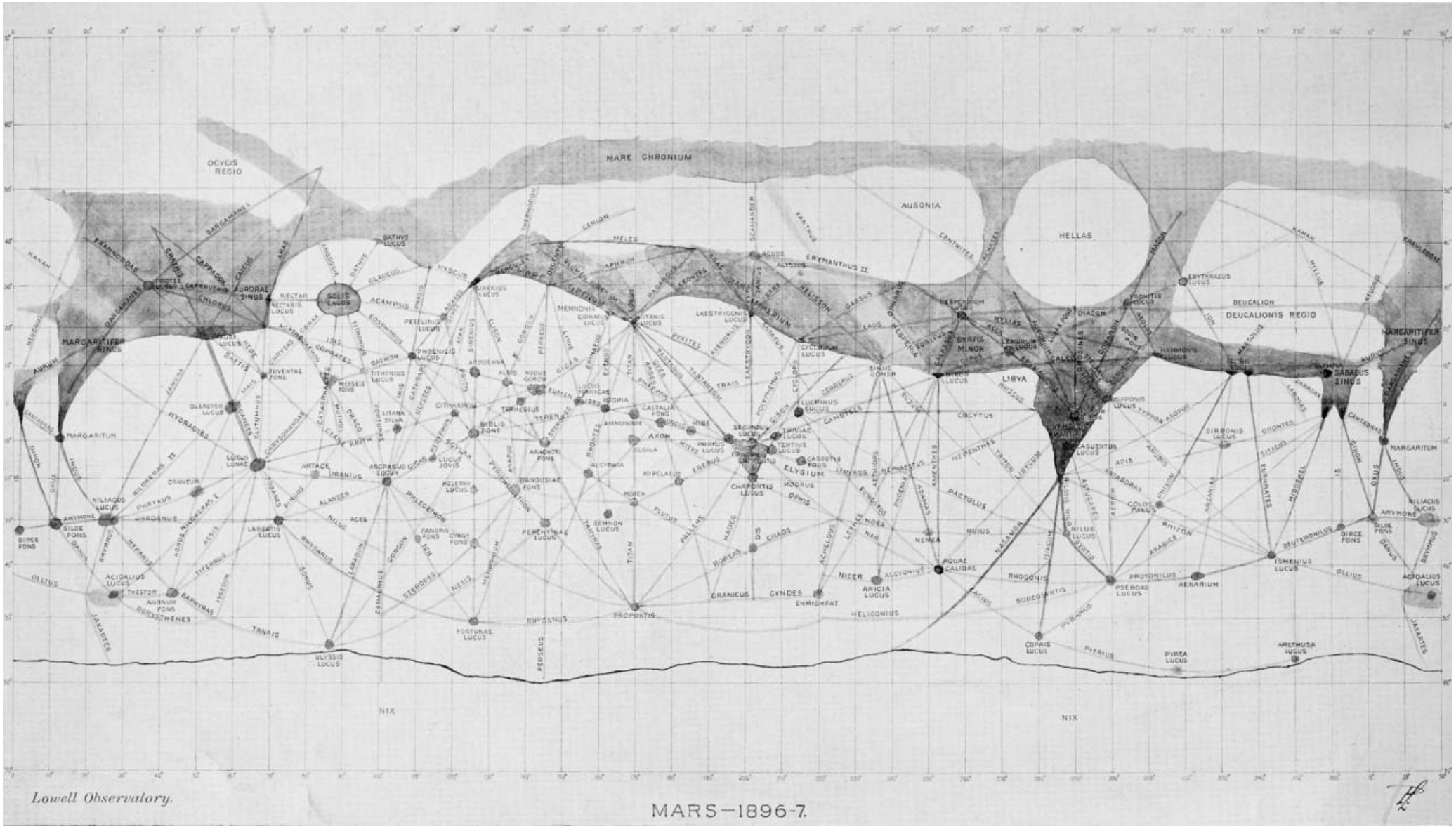


Fig. 1. Map of Mars by Percival Lowell, 1897, published in *Annals of the Lowell Observatory*, 1905. This Mercator-projection map did not appear in published form until 1905, owing to publication delays with the *Annals*, but Lowell had circulated it widely among other astronomers, many of whom referred to it in their own publications. According to Lowell, the dark patches shown in the southern hemisphere of Mars (in the upper part of the map) were likely to indicate seasonal swamps, while the straight lines appeared to indicate artificial waterways that conveyed seasonal snowmelt from the polar caps to the equatorial regions. The dark circles at the intersections of the lines were labelled 'oases', which Lowell also thought were vegetated. (Reproduced with permission from the Lowell Observatory Archives, Flagstaff, Arizona.)

inhabitants had been forced to construct immense canals to bring seasonal snowmelt from the polar caps to the inhabited equatorial regions. When doubtful astronomers balked at the certainty with which Lowell delivered this sensationalist account to popular audiences, he challenged them to come up with a natural explanation for the geometrical appearance of Mars. He also responded by increasing his own publication activities, using maps and other imagery liberally to present his case that the Martian landforms were analogous to Earth's man-made structures, such as rail networks, irrigation systems and street patterns. This cartographic imagery quickly became standard fare in books and articles intended for wide readership (Fig. 2).

By the early 1900s, Lowellian images of Mars had become powerful icons. As his maps became ubiquitous in popular magazines and newspapers, they reinforced the certainty of life and civilization on the red planet by presenting a landscape that had no obvious natural explanation. Popular Sunday newspapers frequently published geometric images of Mars to accompany articles about the most recent astronomical discoveries. Although these images took on the general appearance of the scientific canal maps, they were often unlabelled or did not show any coordinates (Fig. 3). Such generic abstraction indicates that this cartographic imagery was meant to convey legitimacy for the inhabited-Mars view, rather than information. As a simple icon, the geometric image of Mars stood for intelligence, civilization and advancement.

The Creative Power of the Maps

The strength of the Mars icon as a visual symbol rested on more than a map's powers of inscription, authorization and legitimization. It was also supported at a fundamental level by the creative power of the cartographic *process* which had brought into existence a landscape that differed greatly from what astronomers were seeing through their telescopes.

Despite the widespread use of geometrical canal imagery, in fact, no astronomer ever actually saw, or claimed to see, an interlinked canal network while sitting at the telescope. The cartographic authority of the increasingly prominent Mars icon concealed the fact that the canal 'network' was invisible to the eye. From Earth, the surface of Mars was (and still is) notoriously difficult to make out. Even under excellent conditions for 'seeing', Mars shimmered tantalizingly, allowing only fleeting glimpses of its surface.[10] Astronomers constantly complained about their inability to hold an image of Mars steadily in the telescope, and therefore detail could only be glimpsed in flashes. George R. Agassiz, an amateur American astronomer and philanthropist who actively championed Lowell's theory, commented that

> It must not be imagined that any drawing represents what the observer sees the moment he looks through the telescope. Instants of exceptional seeing flash out, here and there, at different spots on the planet. It is not till the same phenomena repeat themselves in the same way, in the same place, a great number of times, that the observer learns to trust these impressions. One has to keep one's mind constantly at the highest pitch to catch and retain what the eye sees.
>
> It is like looking at a Swiss landscape from a high Alp, with the summer clouds sweeping about one. Now the mist rolls away, revealing a bit of the valley, and shuts in again in a moment; while in some other spot the clouds break away, and disclose a jagged summit, or a portion of a shining glacier.[11]

In essence, then, the art of sketching Mars consisted of waiting intently for a moment of still air, then quickly recording an image before the memory could fade. Given this difficulty, several astronomers insisted that a given feature should be seen, sketched and measured multiple times before it could be definitely said to exist. Otherwise, the opportunity for mistakes—of vision, memory or depiction—was too great.

As a result, few of the sketches that astronomers drew in their observation logbooks or on standardized sketchpads depicted more than a few Martian surface details at any given time. Only the process of gathering, compiling and projecting dozens (or even hundreds) of individual sketches onto comprehensive maps gave rise to the view of a geometrical Martian landscape. Schiaparelli's famous chart included details from dozens of sketches recorded in his 1877–1878 logbooks. Other maps published by the Royal Astronomical Society and British Astronomical Association throughout the 1880s and 1890s typically collated the work of at least a dozen observers in London, Edinburgh and many far-flung corners of the British Empire.[12]

Lowell's influential maps of the 1890s and early 1900s were likewise made by plotting the details from hundreds of his own and his colleagues' sketches directly onto a wooden globe, which was then tilted to the proper angle and photographed before tracing the negative into a Mercator projection.[13] Thus, simple sketches blossomed cartographically into complex and interlinked networks that had never been seen by any single individual

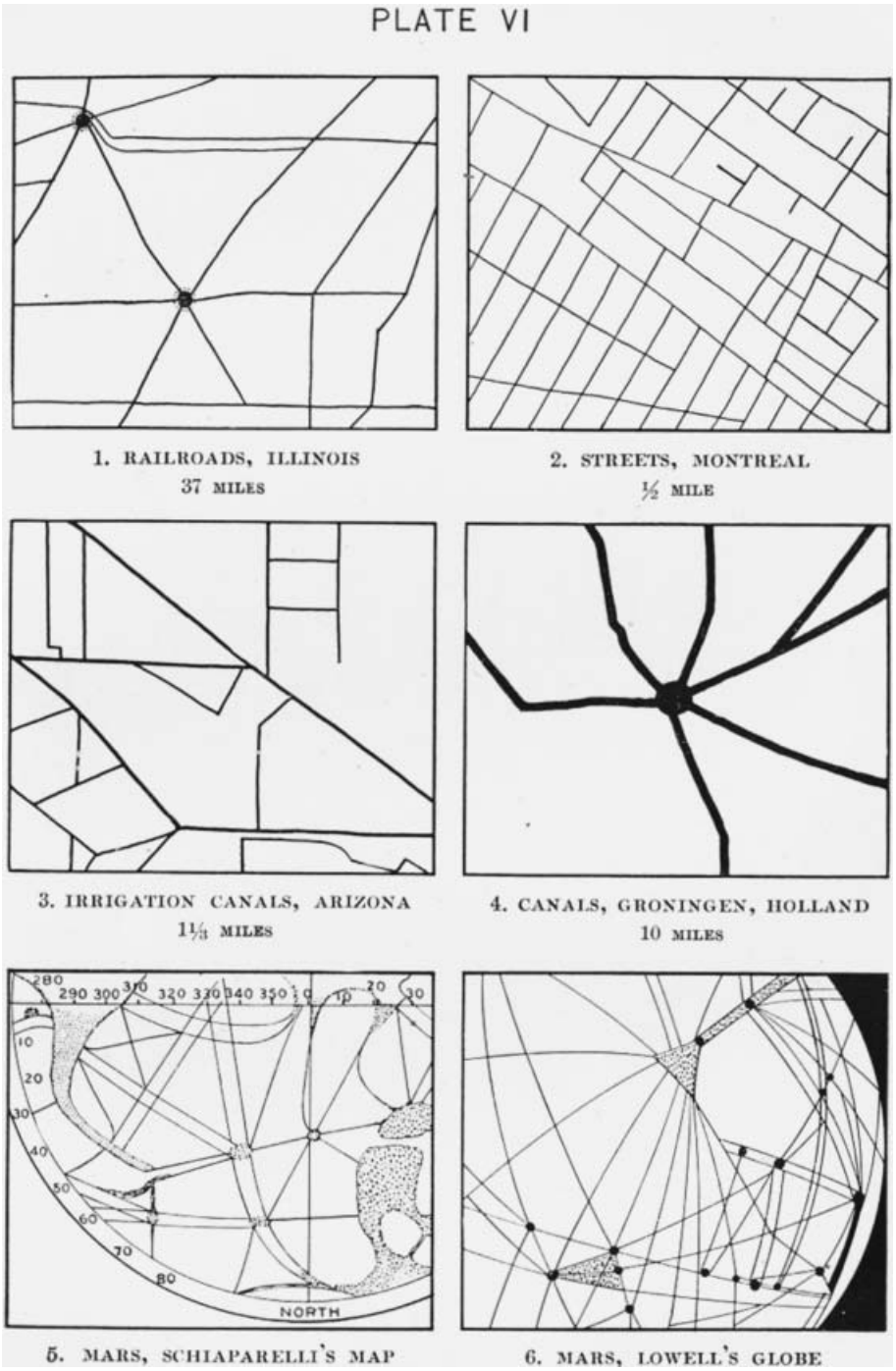


Fig. 2. Illustration for Edward S. Morse, *Mars and Its Mystery* (Boston, Little, Brown, and Company, 1906). The plate was produced for a popular book written by Lowell's close associate, Morse. Details from Schiaparelli's and Lowell's canal maps (nos. 5 and 6) are compared with abstract drawings of several artificial features known to exist on Earth. By placing the cartographers' canal networks alongside familiar man-made patterns at various scales—Illinois railways, Montreal streets, Arizona irrigation canals and Groningen canals (nos. 1 to 4)—Morse intended to demonstrate that the geometry of the canals was likely to have been produced by intelligent beings. These 'artificial' patterns were contrasted with a similar plate showing six patterns of 'natural' landscape patterns, including branching cracks in mud and irregular geological fissures. According to Morse (and Lowell), the overwhelming straightness of the mapped Martian canals simply could not have been produced by natural processes. (Reproduced with permission from the University of Texas.)

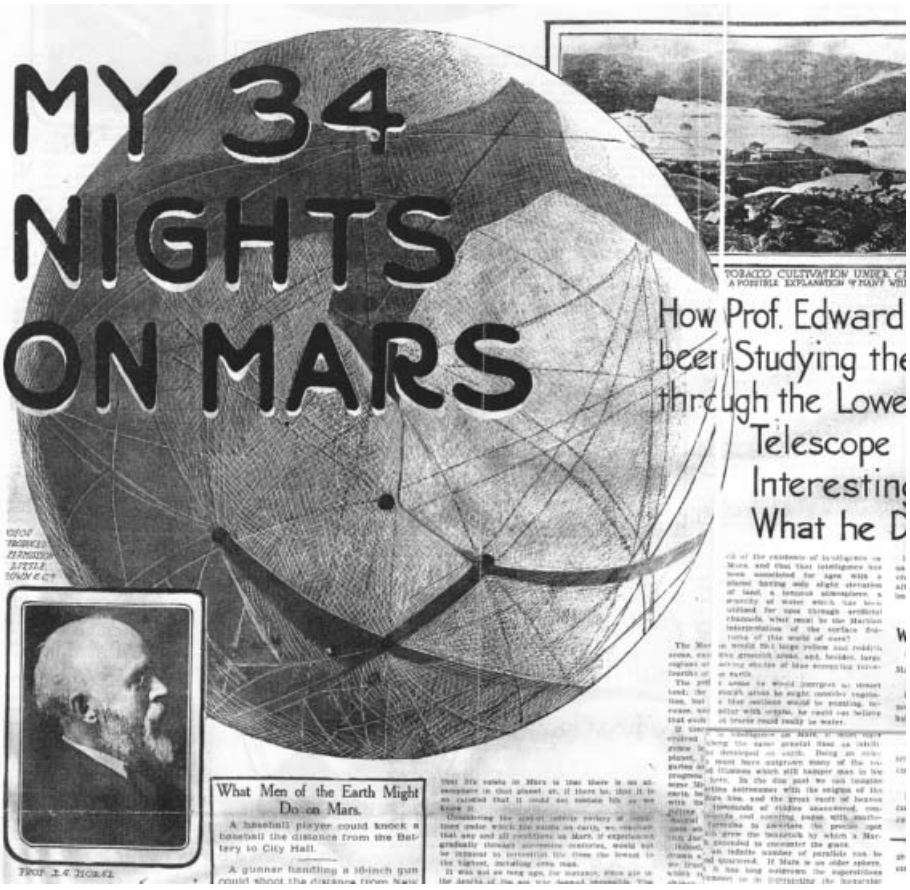
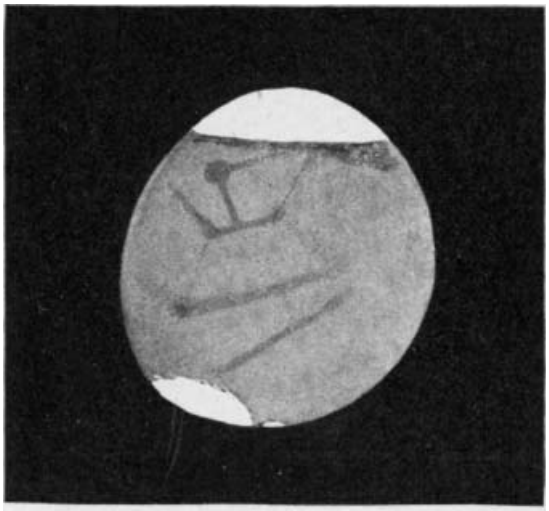


Fig. 3. Detail from Edward S. Morse's article 'My 34 nights on Mars: How Prof. Edward S. Morse has been studying the great planet through the Lowell Observatory telescope and his own interesting account of what he discovered there', published in *The World Magazine*, 7 October 1906, p. 9. The representation of Mars is clearly meant to resemble Lowell's map of the planet, even though major cartographic details, such as the names of places and other features are missing, as are Lowell's coordinates of latitude and longitude. As a graphic accompaniment to Morse's text, which strongly supports Lowell's hypothesis regarding the existence of canals and intelligent life on Mars, the illustration acts as a powerful cartographic icon by using the geometry of the Mars map to reinforce the certainty of Martian civilization. This type of illustration was common in newspapers and magazines that reported scientists' views on the Mars debate. (Reproduced with permission from the Lowell Observatory Archives, Flagstaff, Arizona, USA.)

or on any single night (Fig. 4 and Plate 8). In truth, then, the networked appearance of the canals owed its existence more to the cartographic process than to any reality on the Martian surface.

Although astronomers admitted that the maps showed a landscape invisible to the eye, the authority of the complex scientific map conveyed an objectivity that outweighed the simplistic sketches. Detractors who criticized the inhabited-Mars theory on the basis of the difference between what was seen on the maps and in the drawings seem only to have cast suspicion on the simpler drawings, rather than to have diminished the legitimacy of the detailed maps.[14] Even the theory's great champion, Lowell, acknowledged that the process of cartographic projection created an un-viewable view: 'not a single piece of the chart resembles the actual presentation of any part of the planet at any time'.[15] Although this comment may have been intended primarily to rebuff criticism from those who were unable to confirm the map's canals through their own telescopes, Lowell seems also to have acknowledged the more creative role of cartography in bringing his populated 'oases' to life: '*When they are plotted upon a globe*, they and their connecting canals make a most curious network over all the orange-ochre equatorial parts of the planet, a mass of lines and knots'.[16]

Lowell's one-time associate William Pickering made a similar caveat: 'The maps of Mars look very artificial; but we must remember that they are composites of many drawings. . . . All the canals shown on the maps are not seen at once; on the



DRAWING OF MARS, APRIL 8, 1907, SHOWING THE DARK BELT THAT GIRDLES THE SNOW DURING ITS MELTING

Fig. 4. Sketch of Mars by Percival Lowell, published in *Mars as the Abode of Life* (New York, Macmillan, 1909). The image shows the amount of surface detail that typically could be contained in a single sketch in an astronomer's observation logbook. Depending on atmospheric conditions, an astronomer could record at most a small number of such sketches in a single evening, each of which might show only a few canals. Lowell reproduced this particular sketch in *Mars as the Abode of Life* to show that a dark band sometimes appeared along the edge of the polar cap. He suggested that this 'dark belt' was a shallow, temporary sea that had formed as ice melted along the edge of the polar cap. This effect is now thought to have been an optical illusion. (Reproduced with permission from the University of Texas.)

contrary, only a very few of them are visible on the same night'.[17] The use of a coordinate grid, however, implied exactness and scientific objectivity; the combination of multiple observations to form a composite view conveyed unassailable comprehensiveness. As an artefact of a map projection, therefore, the iconic geometrical image of Mars could not have existed or grown so meaningful except through the format and processes of cartography.

Decline of the Martian Map

The inhabited-Mars theory enjoyed widespread support only as long as the cartography itself was accepted as the most scientific representation of the red planet. When doubts were cast on cartography as an objective format, astronomers' patience with increasingly outlandish claims about Mars finally began to dry up. At the same time, popular enthusiasm for Mars began to show the first signs of waning. Although it took much longer for popular interest to die out (it arguably continued with some audiences into the 1950s, if not to the present day), the decreasing power of the map had a marked effect on the confidence of both scientific and popular audiences in the supposed Martian inhabitants.

Having risen to prominence as the most eloquent and active promoter of the inhabited-Mars hypothesis, Lowell suffered most keenly from the decline of the map. After a brief hiatus from his Mars studies between 1898 and 1901 owing to illness, Lowell had returned to work with a renewed vigour. He published several new maps early in the twentieth century, wrote three new books by 1909, conducted extensive lecture tours on the American east coast and in Europe and disseminated his findings to the popular press at every opportunity. As Lowell became more outspoken in his claims about the landscape and civilization of Mars, he also became more vicious toward the doubters, prompting many of the most prominent American astronomers and several professionals and amateurs in Britain to turn against him. To combat what they saw as Lowell's wilful disregard for scientific professionalism and standards of proof, his detractors reacted with a sustained effort to disrupt his popularity and undermine his legitimacy.[18]

In Britain, Edward Maunder, a well-known astronomer from the Royal Observatory, Greenwich, began to write extensively about the likelihood that Lowell's maps were based on nothing more than optical illusion, provoking significant doubt among those astronomers who had never seen the canals clearly in the first place. At a June 1903 meeting of the British Astronomical Association, for instance, a member commented that Maunder 'had really cut away the ground from under the feet of those who thought they had been able to prove that there were canals. The onus of proof now lay upon those who thought the canals were there'.[19] In the United States, the elite academic astronomers acted in concert to isolate Lowell from the scientific community, cast doubt on his claims and minimized his publishing opportunities.[20] Following Maunder, several American astronomers questioned whether Lowell's maps and sketches were not in fact distorted by optical illusion.[21]

Lowell turned to photography to counter the many charges being levelled against him. After Maunder's first attacks in 1903, Lowell helped to

pioneer a new method of planetary photography that could capture a clear image with only a short time exposure.[22] When his assistant Carl O. Lampland succeeded in photographing Mars in 1905, Lowell quickly began publishing and circulating the images to rescue his reputation. For a time, this strategy worked. Despite being small and grainy, the photographs indeed contained some dark markings in areas where Lowell's maps depicted canals, indicating a confirmation. At a June 1906 meeting of the British Astronomical Association, the President A. C. D. Crommelin stated that Lowell's photographs proved the 'objective reality of the canals', reviving belief within the British astronomical community.[23]

In 1907, however, new optical illusion experiments carried out in the United States immediately produced a reverse sway in scientific opinion concerning the reality of the canals.[24] While relentlessly rebutting the illusion research, Lowell clearly determined that he needed to shore up the authority of his claims regarding the objective reality of the canals.[25] In the face of what he perceived as an onslaught, Lowell mounted a high-profile photographic expedition to South America for the 1907 planetary opposition,[26] essentially staking his reputation on the new imaging techniques that Lampland had developed since 1905. As British and American magazines and newspapers hyped the expedition, scientific and popular anticipation mounted.[27] When Lowell's photographer finally returned from the Andes with the negatives, however, the images proved a general disappointment.

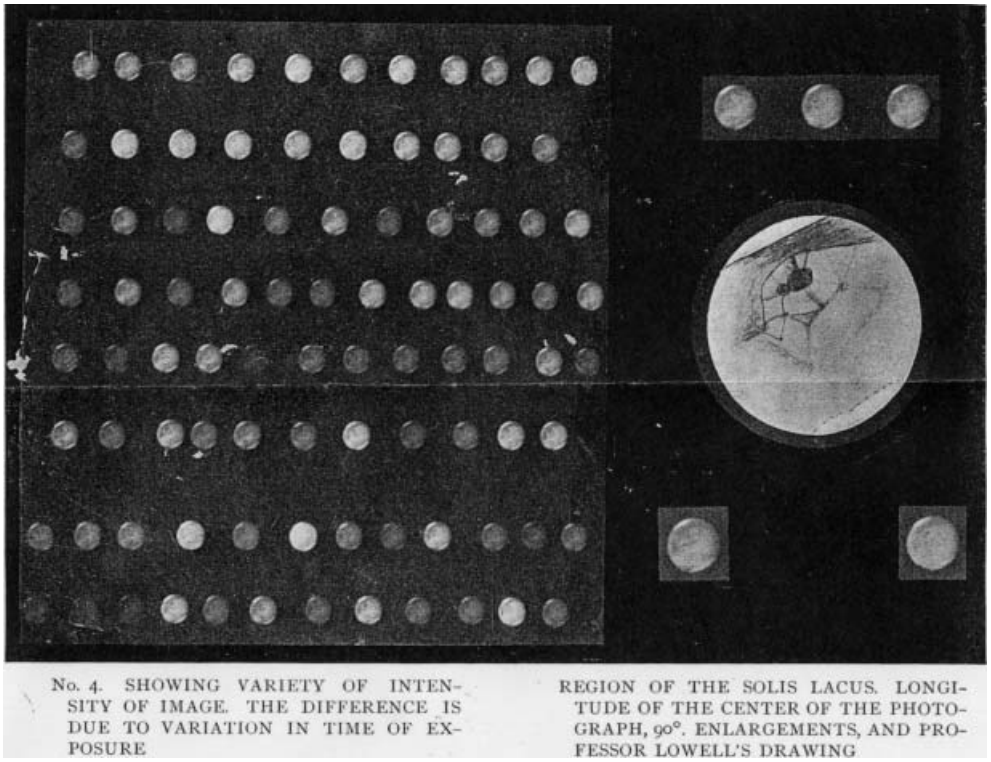
Lowell claimed that the 1907 photographs dispelled all doubt regarding the existence of the Martian canals. Paradoxically, however, they contributed to his further loss of credibility. With each photographic image of Mars typically measuring less than half an inch in diameter on the negatives, the photographs showed far less detail than any of Lowell's elaborate maps (Fig. 5). Although the photographs could be said to confirm Lowell's simple sketches, showing some isolated lines on the on the surface of Mars, they did not show a definitive canal network.

On top of that, the photographs were incredibly difficult to reproduce: their original size was too small to show any significant detail, yet they became excessively grainy when enlarged. Lowell agonized over the proper presentation of his photographs in the *Century Magazine*, even asking that they be 'retouched' to show the canals better.[28] Having paid a substantial sum for the copyright of the images, however, the editor was in no mood to delay publication of the long-promised Martian canal photographs: 'There is no time to retouch the photographic plates and we should consider it a calamity to do so, as it would entirely spoil the autographic value of the photographs themselves. There would always be somebody to say that the results were from the brains of the retoucher'.[29]

To counteract his expectation that the unedited photographs would reproduce poorly, Lowell began sending negatives and prints to select astronomers in Britain in the calculated hope that these men would vouch for the photographed canals in their own publications and presentations.[30] This strategy produced some desirable results. Crommelin reported that when he examined Lowell's images he had seen twenty-two canals.[31] Likewise, the director of the British Astronomical Association's Mars Section commented in his report on the 1907 opposition that, 'Regarding the objectivity of the canals of Mars, there seems no necessity or room for doubt after the truly splendid photographic results obtained by Messrs. Lowell and Lampland'.[32]

Despite such personal opinions, however, the fact remained that Lowell's photographs were not convincing in any of the formats available for mass distribution. They appeared too small, too blurry or too dark to match the certainty levels that had been inscribed in the maps. Wherever the much-vaunted photographs were published, Lowell usually insisted that they were to be accompanied by a disclaimer. In the 1907 *Century Magazine* exclusive, for instance, Lowell alerted readers that the printed images were three steps removed from the original negative as a result of the processes of photographic printing, half-toning and press printing. He also warned that use of a magnifying glass would only increase the grain size without revealing more details. Lowell was thus obliged to make a delicate argument. On the one hand he asserted that 'to the camera no evasion of the fact avails. They [the canals] are there, and the film refuses to report them other than they are', while on the other hand he was forced to qualify the photographs as 'handicapped', claiming the canals' 'straightness is *more* pronounced than appears from the photographic print'.[33]

Perhaps more damaging than the inadequate reproduction of the tiny photographs was the fact that after 1907 photography began to supplant cartography as the proper standard of proof for features discernible on Mars. The build-up of



No. 4. SHOWING VARIETY OF INTENSITY OF IMAGE. THE DIFFERENCE IS DUE TO VARIATION IN TIME OF EXPOSURE

REGION OF THE SOLIS LACUS. LONGITUDE OF THE CENTER OF THE PHOTOGRAPH, 90°. ENLARGEMENTS, AND PROFESSOR LOWELL'S DRAWING

Fig. 5. Mars photographs as reproduced in Percival Lowell, 'New photographs of Mars: taken by the astronomical expedition to the Andes and now first published', *Century Magazine*, 75 (1907): 303–11. The advent of photographical reproduction presented Lowell with difficulties. The small circles in the array at the left—produced directly from a sheet of negatives at original size—are each hardly larger than a few letters of the text. Lowell and his associate Lampland had not found a way to produce larger negative images of Mars without requiring long time-exposures that would introduce blur. To a magazine reader, unfortunately, original-size images such as those arrayed on the left were thus nearly unintelligible, showing little more than variations of light and dark, depending on the exposure time for each photograph. The intermediate-sized circles on the right are enlargements of selected photographic originals centred on the 90 degree meridian. The largest circle (centre right) is a sketch of the same region from Lowell's 1907 observation logbook, which he included for comparison and as a guide to the enlarged photographs to help readers pick out the canals and the conspicuous dark spot known as the 'Solis Lacus'. Lowell's text warns the reader, however, that the process of enlargement is of minimal use, as it enlarges also the grain of the photograph and 'must not be overdone'. Despite being hailed as more objective images than maps, then, photographs were of little use for confirming the existence of the canals, especially in the public eye. (Reproduced with permission from the University of Texas.)

expectations regarding Lowell's 1905 and 1907 photographs focused on their objective quality and ability to resolve long-standing disputes among astronomers over the existence of the canals. Once the early grainy photographs had become available, Lowell's elaborate maps—the basis of his reputation, credibility and hypothesis—became essentially obsolete as scientific images. In 1907, Hugh Chisholm, the editor of the tenth edition of the *Encyclopaedia Britannica*, wrote to Simon Newcomb saying that that he did not want to publish Lowell's hand-drawn maps as illustrations for Newcomb's article on Mars:

> I think that only a half-tone reproduction of Lowell's *photographs* would be scientific. . . . The whole thing in fact is so much bound up with the Lowell photographs that I shrink from showing anything but the originals (which are decidedly difficult for us to reproduce, and had better be therefore referred to only in their source). . . . I don't in any case like the idea of mere drawings, which must inevitably 'fake' to some extent the 'canals'.[34]

In the end, Chisholm decided he would publish the Mars entry without any image at all, rather than use maps instead of 'scientific' photographs.

Many editors seem to have come to similar conclusions after the 1907 expedition, since Lowell's maps rarely appeared in scientific publications after that year. Photography had provided a new standard of objective representation that made the diverse maps of astronomers appear positively subjective in comparison. The fact that the photographs were blurry and grainy did not

diminish their perceived objectivity. It did, however, diminish the certainty of the canals that had been inscribed in the maps by Lowell and others.

A Scientific End for the Canals

The final blow to Lowell's scientific credibility came in 1909–1910, when he became embroiled in a debate with the French astronomer Eugène Antoniadi over the best way to represent Mars. With the authority of his map weakened by the new photographs, Lowell's personal credibility also became vulnerable. Whereas he had earlier been able to maintain a spirited defence against all criticisms, he was left after 1907 to argue from a much weaker position. Those astronomers who had long wanted to dismiss his theories and speculations regarding Martian life suddenly found the proposition much easier.

During the planetary opposition in 1909, Antoniadi observed Mars at the celebrated 33-inch Meudon Observatory telescope, the largest in Europe.[35] Although he observed for only nine nights during a month-long stay in Paris, he reported seeing Mars so clearly at times that the linear appearance of the canals dissolved into an intricate mess of smaller, irregular details, and he noted that 'the geometrical ''canal'' network is an optical illusion; and in its place the great refractor shows myriads of marbled and chequered objective fields, which no artist could ever think of drawing'.[36]

Antoniadi, an accomplished draftsman, attempted to represent the complex markings he had seen. He sent five sketches to Lowell with a letter describing his perfect certainty that they represented an objective view of Mars' surface. Lowell had cautioned Antoniadi in an earlier letter about the danger that such a large telescope as Meudon's might actually show diminished detail (by allowing excess light to overwhelm subtle features),[37] but Antoniadi reported,

> the tremendous difficulty was not to *see* the detail, but accurately to *represent* it. Here, my experience in drawing proved of immense assistance, as, after my excitement, at the bewildering amount of detail visible, was over, I sat down and drew correctly, both with regard to form and intensity, all the markings visible.[38]

Lowell tried to discredit Antoniadi's claims but to no avail. Upon the occasion of Schiaparelli's death in 1910, Lowell wrote an eloquent obituary praising the Italian's canal discoveries, while also blasting his own opponents for not accepting the reality of the canals.[39] It was, however, to be the last time he actively defended the inhabited-Mars hypothesis in a scientific publication, showing that the tide had finally turned. Antoniadi, on the other hand, wrote more than a dozen well-received scientific articles in 1909 and 1910, most of them directly refuting Lowell's hypotheses. In his official reports for the British Astronomical Association, Antoniadi wrote with confidence and finality of the artificial canals' demise:

> We thus see in the so-called 'canals' a work of Nature, not of Intellect; the spots relieving the gloom of a wilderness, and not the Titanic productions of supernatural beings. To account for their various phenomena, we need only invoke the natural agencies of vegetation, water, cloud, and inevitable differences of colour in a desert region.[40]

To understand how Antoniadi's nine nights of Mars observations succeeded in discrediting Lowell, who had a fifteen-year record of continuous observation and publication, we must consider the visual authority of Antoniadi's new claims in 1909. Upon completion of his stay at the Meudon Observatory, Antoniadi immediately began circulating his sketches to colleagues within the British astronomical community. At the same time, he wrote a series of articles about his and others' Mars observations in the *Journal of the British Astronomical Association*. In most of these publications and letters, he emphasized the fact that his drawings showed more detail than Lowell's maps by revealing intricate features in places where Lowell showed mere lines. He referred to a 'vast and incredible amount of detail',[41] claiming that 'the fact that *no straight lines could be held steadily when much more delicate detail was continually visible* constitutes a fatal objection to their crumbling existence'.[42] Antoniadi and his ally Maunder (still an active critic of Lowell) also pointed out that the new naturalistic, shaded sketches bore a striking resemblance to the latest photographs of Mars.[43] Antoniadi's 1909 sketches thus appeared more objective than Lowell's in their similarity with the new photographic imagery.

Finally, it must be noted that Antoniadi's personal authority as a long-standing Lowell supporter made him an especially effective critic. Antoniadi himself had reported seeing canals on numerous occasions and had drawn dozens of them on maps he compiled for the British Astronomical Association in his capacity as the Mars Section director since 1896.[44] Furthermore, Antoniadi had championed the evidentiary quality of Lowell's 1905 and 1907 photographs. In an

analysis published for the Royal Astronomical Society in 1908, for instance, Antoniadi commented that 'the amount of detail shown on [Lowell's] photographs is very considerable' and noted that he could count seventeen canals as 'more or less discernible on the images'.[45] Antoniadi thus could not be dismissed as a feeble observer who rejected the canals because he could not see them himself.

In the end, Antoniadi brought about a complete reversal of the 1877–1878 verdict, since his subtle, naturalistic shading more closely resembled the appearance of Green's 1877 map than anything that had been produced in the intervening thirty years, yet it won substantial approval from the astronomical communities in Europe and North America, relegating Lowell's hard-edged Schiaparellian-style maps to a weakened status as 'startling theories'.[46] Maunder claimed at a meeting of the British Astronomical Association that the canals had been irrevocably put to rest:

> There never was any real ground for supposing that in the markings observed upon Mars they had any evidence of artificial action. Had it not been a sensational idea which lent itself to sensational writing in the daily press he [Maunder] did not believe they would ever have heard of it. He considered it was all the better for science that the idea was now completely disposed of. They need not occupy their minds with the idea that there were miraculous engineers at work on Mars, and they might sleep quietly in their beds without fear of invasion by the Martians after the fashion that Mr. H. G. Wells had so vividly described.[47]

Although his pronouncement was somewhat premature, given that the public did not let go of the canals as quickly as the scientists, Maunder accurately recorded a definitive reversal in scientific considerations of the geography of Mars.

The reasons for this reversal include both the rise of photography as a standard of proof and Antoniadi's claim that his few sketches showed more detail than Lowell's many maps. Visually supported by the photographs—the new scientific imagery of truth—Antoniadi's sketches trumped Lowell's maps. After a long assault on the logic of Lowell's theory and the authority of his methods, it was the dismantling of his maps that finally diminished the scientific community's willingness to seriously entertain further talk of Mars' inhabitants.

Throughout the period of the popular Mars mania, maps were the principal means of disseminating scientific information regarding the geography of the planet. The present-day analyst can see that little value can be gained by assessing which maps were 'right' or 'wrong' in terms of their faithfulness to modern-day imagery of the Martian surface. Maps produced at the turn of the twentieth century are much more valuable for what they reveal about the processes of conferring authority for a knowledge claim and legitimization of certain landscape views.

The sharp rise of the inhabited-Mars theory in the late nineteenth century was intimately tied to the perceived objectivity of scientific cartography, the visual authority of specific maps and the personal authority of various mapmakers. The competition to add more and more canals to the map of Mars eventually produced a powerful iconic image that transcended the boundary between science and popular culture. This icon—showing a geometrical canal network on the planet—came to represent an advanced intelligence and civilization on Mars. In the process, the image of Mars assumed a mantle of scientific objectivity despite admissions that no one had ever actually seen the canal network as a whole. As the functions of the cartographic process were erased in the visual aspect of the map, the geometrical map of Mars became a convincing piece of evidence for advocates of the inhabited-Mars theory.

Because this theory was so keenly linked with the visual authority of the map, it was dependent on the map's legitimacy. When the perceived objectivity of cartography faltered in the early 1900s in comparison with new photographic technologies, belief in the supposed inhabitants of Mars lost considerable ground as well. The waning credibility of the maps further weakened the position of astronomers like Lowell, whose stature as advocates of the inhabited-Mars theory was built on the foundation of their maps. By 1910, the astronomical communities of Europe and North America had largely abandoned their thirty-year flirtation with the idea of an inhabited Mars and returned to a naturalistic mapping style that closely resembled the pre-1877–1878 maps. Cartography was thus integral to the origin, development and expiration of the scientific conceptualization of Mars as a world possibly inhabited.

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NOTES AND REFERENCES

1. The reportedly geometrical appearance of the surface of Mars is now thought to have been an illusory effect of optical perception (Thomas A. Dobbins and William Sheehan, 'The canals of Mars revisited', *Sky & Telescope* 107:3 (2004): 114–17). For a succinct overview of the turn-of-the-century Mars mania, see William Sheehan, *The Planet Mars: A History of Observation and Discovery* (Tucson, University of Arizona Press, 1996).

2. See especially David Strauss, *Percival Lowell: The Culture and Science of a Boston Brahmin* (Cambridge, Mass., Harvard University Press, 2001), for a thorough contextualization of the work of Percival Lowell, who was the most influential advocate of the inhabited-Mars hypothesis. For comprehensive treatments of the place of the Mars mania in intellectual history, see Steven J. Dick, *The Biological Universe: The Twentieth-Century Extraterrestrial Life Debate and the Limits of Science* (Cambridge, Cambridge University Press, 1996); Michael J. Crowe, *The Extraterrestrial Life Debate 1750–1900: The Idea of a Plurality of Worlds from Kant to Lowell* (Cambridge, Cambridge University Press, 1986); and Karl S. Guthke, *The Last Frontier: Imagining Other Worlds, from the Copernican Revolution to Modern Science Fiction* (Ithaca and London, Cornell University Press, 1983). For discussions of the popularization of Mars science, see William Sheehan, *Planets and Perception* (Tucson, University of Arizona Press, 1988); and William Graves Hoyt, *Lowell and Mars* (Tucson, University of Arizona Press, 1976). Regarding the fraught professionalization of astronomy, see Noriss S. Hetherington, 'Percival Lowell: scientist or interloper?' *Journal of the History of Ideas* 42:1 (1981): 159–61; and Noriss S. Hetherington, 'Amateur versus professional: the British Astronomical Association and the controversy over canals on Mars', *Journal of the British Astronomical Association* 86 (1976): 303–8.

3. Giovanni Virginio Schiaparelli, 'Osservazioni astronomiche e fisiche sull'asse di rotazione e sulla topografia del pianeta Marte fatte nella reale specola di Brera in Milano coll'equatoreale di Merz durante l'opposizione del 1877: memoria del socio G. V. Schiaparelli', *Atti della Reale Accademia dei Lincei: Memorie della Classe di scienze fisiche, matematiche e naturali* 3:2 (1877–1878): 3–136. Schiaparelli's term *canali* was widely translated in English as 'canals'.

4. Nathaniel E. Green, 'Observations of Mars, at Madeira, in August and September 1877', *Memoirs of the Royal Astronomical Society* 44 (1879): 123–40.

5. For a detailed discussion of the early Mars maps and their role in establishing the authority of individual astronomers, see K. Maria D. Lane, 'Geographers of Mars: cartographic inscription and exploration narrative in late Victorian representations of the red planet', *Isis* 96 (2005): 477–506.

6. See the increasingly detailed maps in G. V. Schiaparelli, 'Osservazioni astronomiche e fisiche sull'asse di rotazione e sulla topografia del pianeta Marte fatte nella reale specola di Brera in Milano coll'equatoreale di Merz: memoria seconda del socio G. V. Schiaparelli', *Atti della Reale Accademia dei Lincei: Memorie della classe di scienze fisiche, matematiche e naturali* 3 (1880–1881): 3–109; G. V. Schiaparelli, 'Osservazioni astronomiche e fisiche sull'asse di rotazione e sulla topografia del pianeta Marte fatte nella reale specola di Brera in Milano coll'equatoreale di Merz: memoria terza del socio G. V. Schiaparelli (opposizione 1881–1882)', ibid. 4 (1886): 281–373; G. V. Schiaparelli, 'Osservazioni astronomiche e fisiche sull'asse di rotazione e sulla topografia del pianeta Marte fatte nella reale specola di Brera in Milano coll'equatoreale di Merz: memoria quarta del socio G. V. Schiaparelli (opposizione 1883–84)', ibid. 5 (1895–1896): 183–240.

7. See, for example, C. E. Burton 'Notes on the aspects of Mars in 1882', *Scientific Transactions of the Royal Dublin Society* 1 (1883): 301–5. Burton regularly lamented the 'unfortunate climate' of the British Isles, which he felt prevented British and Irish astronomers from making meaningful contributions to the study of Mars.

8. The Belgian astronomer François Terby and the French astronomer Joseph Perrotin both reported seeing canals in 1886: 'The canals on Mars', *Astronomical Register* 24 (1886): 268, reported Terby's findings; J. Perrotin, 'Observation des canaux de Mars faite a l'Observatoire de Nice', *Observatory* 9 (1886): 364–65. The sketches by these astronomers, however, were less detailed than Schiaparelli's maps, which showed more and more canals with every iteration after 1877.

9. Simon Newcomb, director of the United States Nautical Almanac and a noted Lowell antagonist, wrote to Lowell in 1905 to request a map for an encyclopedia article he was then preparing: 'I would like a good map of Mars to accompany the article. For this I know no better source than the publication of your observatory' (Simon Newcomb to Percival Lowell, 30 October 1905, in Washington, D.C., Library of Congress, Manuscript Division, Simon Newcomb Papers). The editor of *Popular Astronomy*, W. W. Payne, likewise commented in 1904 that Lowell's maps were 'pieces of astronomical work that are now classical in astronomy . . . because they were made by the very best means and methods now known to that science' (W. W. Payne, 'The ''canals'' of Mars', *Popular Astronomy* 12:6 (1904): 365–75).

10. In astronomical terms, 'seeing' is a measure of the stillness and clarity of Earth's atmosphere. Fred W. Price, 'The atmosphere and seeing', in *The Planet Observer's Handbook*, 2nd ed. (Cambridge, Cambridge University Press, 2000).

11. G. R. Agassiz, 'Mars as seen in the Lowell refractor', *Popular Science Monthly* 71 (1907): 275–82, reference on 281.

12. See, for example, Nathaniel E. Green, 'The northern hemisphere of Mars', *Monthly Notices of the Royal Astronomical Society* 46:8 (1886): 445–47; E. Walter Maunder, 'Section for the observation of Mars: report of the Section, 1892', *Memoirs of the British Astronomical Association* 2 (1895): 157–98; Eugène M. Antoniadi, 'Section for the observation of Mars: report of the Section, 1896', ibid. 6 (1898): 55–102.

13. Percival Lowell, *Mars* (Boston and New York, Houghton, Mifflin, 1895).

14. For a typical critique, see Edwin Holmes, 'Notes re Mars', *Journal of the British Astronomical Association* 1:5 (1891): 256–59.

15. Percival Lowell, 'Mars', *Popular Astronomy* 2:1 (1894): 1–8, reference on 8.

16. Percival Lowell, 'Mars: oases', *Popular Astronomy* 2:8 (1895): 343–48, reference on 346, emphasis added.

17. William H. Pickering, 'The planet Mars', *Technical World Magazine* (1906): 459–71, reference on 469–70.

18. Strauss, *Percival Lowell* (see note 2), provides the most comprehensive analysis of the manoeuvring

between Lowell and his opponents in the astronomical establishment.

19. 'Report of the meeting of the association, held on June 24 1903, at Sion College, Victoria Embankment', *Journal of the British Astronomical Association* 13:9 (1903): 331–40, reference on 338.

20. See, again, Strauss, *Percival Lowell* (note 2), for a detailed discussion of this effort.

21. See, for example, a series of letters which Simon Newcomb wrote to Percival Lowell in March 1903 (Simon Newcomb Papers (note 9)).

22. For a detailed discussion of how Lowell manoeuvred to validate this method and cultivate supporters, see Jennifer Tucker, 'Science Illustrated: Photographic Evidence and Social Practice in England, 1870–1920' (doctoral dissertation, The Johns Hopkins University, Baltimore, MD, 1996).

23. 'Report of the meeting of the association, held on June 20, 1906, at Sion College, Victoria Embankment', *Journal of the British Astronomical Association* 16:9 (1906): 333.

24. Simon Newcomb, 'The optical and psychological principles involved in the interpretation of the so-called canals of Mars', *Astrophysical Journal* 26:1 (1907): 1–17.

25. For his animated rebuttals, see especially Lowell's personal correspondence with Simon Newcomb and Walter Maunder, for example, letter from Lowell to Simon Newcomb, 15 March 1903; Lowell to Newcomb, 15 May 1907 (Simon Newcomb Papers (note 9)). See also Lowell to E. Walter Maunder, 28 November 1903 (Percival Lowell Correspondence, Lowell Observatory Archive, Flagstaff, Arizona).

26. An 'opposition' occurs when two planets pass one another in their respective orbits, forming a line as seen from the sun. During such an event (which occurs every 26 months in the case of Earth and Mars), the planets are not only relatively closer to one another than at any other time, but the disk of the outer planet (in this case, Mars) is also fully illuminated by the sun, as seen from the inner planet.

27. See Tucker, 'Science Illustrated' (note 22), for a discussion of the media's coverage of the expedition.

28. Lowell asked an associate in New York, George R. Agassiz, to intercede with *Century's* editor, R.U. Johnson, on his behalf. Letter from R. U. Johnson to Lowell, 24 September 1907, from George R. Agassiz to Lowell, 27 September 1907, and from George R. Agassiz to Lowell, 14 October 1907 (Percival Lowell Correspondence (see note 25)).

29. Letter from R. U. Johnson to Lowell, 8 October 1907 (Percival Lowell Correspondence (see note 25)).

30. See Tucker, 'Science Illustrated' (note 22), for a detailed treatment of this episode.

31. A. C. D. Crommelin, 'Martian photography', *The Observatory* 30:387 (1907): 365.

32. E. M. Antoniadi, 'Mars Section interim report on the Australian observations, 1907', *Journal of the British Astronomical Association* 18:10 (1908): 398–401, reference on 401.

33. Percival Lowell, 'New photographs of Mars: taken by the astronomical expedition to the Andes and now first published', *Century Magazine* 75 (1907): 303–11, reference on 309–10, emphasis added.

34. Letter from Hugh Chisholm to Simon Newcomb, 5 February 1907 (Simon Newcomb Papers (see note 9), emphasis in original).

35. See Richard McKim, 'The life and times of E. M. Antoniadi, 1870–1944. Part 1: an astronomer in the making', *Journal of the British Astronomical Association* 103:4 (1993): 164–70; Richard McKim, 'The life and times of E. M. Antoniadi, 1870–1944. Part 2: the Meudon years', ibid., 103:5 (1993): 219–27, for a detailed discussion of Antoniadi's long involvement in the Mars debate.

36. E. M. Antoniadi, 'Mars Section third interim report for 1909, dealing with the nature of the so-called ''canals'' of Mars', *Journal of the British Astronomical Association* 20:1 (1909): 25–28, reference on 28.

37. Letter from Lowell to E. M. Antoniadi, 26 September 1909 (Percival Lowell Correspondence (see note 25)).

38. Letter from E. M. Antoniadi to Lowell, 9 October 1909 (Percival Lowell Correspondence (see note 25), emphasis in original).

39. Percival Lowell, 'Schiaparelli', *Popular Astronomy* 18:8 (1910): 456–67.

40. E. M. Antoniadi, 'On the possibility of explaining on a geomorphic basis the phenomena presented by the planet Mars', *Journal of the British Astronomical Association* 20:2 (1909): 89–94, reference on 93.

41. E. M. Antoniadi, 'Mars Section fourth interim report for the apparition of 1909, dealing with the appearance of the planet Mars between September 20 and October 23 in the great refractor of the Meudon Observatory', *Journal of the British Astronomical Association* 20:2 (1909): 78–81, reference on 79.

42. E. M. Antoniadi, 'Mars Section fifth interim report for 1909, dealing with the fact revealed by observation that Prof. Schiaparelli's ''canal'' network is the optical product of the irregular minor details diversifying the Martian surface', *Journal of the British Astronomical Association* 20:3 (1909–1910): 136–41, reference on 141, emphasis in original.

43. The staff of the Mount Wilson Observatory in California, using the world's largest telescope (with a 60-inch refractor), had taken a series of photographs in 1909 that far exceeded Lowell's 1907 images in clarity and detail. Once again, however, the celebrated photographs failed to show any of the hard-edged features that commonly appeared in Lowell's drawings and maps. 'Report of the meeting of the association, held on Wednesday, December 29, 1909, at Sion College, Victoria Embankment, E.C.', *Journal of the British Astronomical Association* 20:3 (1909–1910): 119–28.

44. See, for example, Eugène Antoniadi, 'Mars Section, second interim report for 1898–99', *Journal of the British Astronomical Association* 9:8 (1899): 367–71.

45. E. M. Antoniadi, 'Note on some photographic images of Mars taken in 1907 by Professor Lowell', *Monthly Notices of the Royal Astronomical Society* 69:2 (1908): 110–14, references on 110 and 112.

46. Antoniadi, 'Mars Section fifth interim report for 1909' (see note 42), 141.

47. 'Report of the meeting of the association, held on Wednesday, December 29, 1909' (see note 43), 123.

L'engouement pour la cartographie des canaux de Mars: projection cartographique et création d'une image populair

Au tournant du 20e siècle se répandit une lubie populaire qui voulait que Mars fût habitée par des êtres intelligents. Cette obsession se fondait au départ sur la science de l'époque, mais elle survécut aux certitudes des astronomes en ce qui concernait les conditions d'habitabilité de la planète rouge. La cartographie était essentielle dans cette construction populaire de la planète Mars comme monde habité et elle créait une puissante icône paysagère qui s'écartait sensiblement des observations faites par les astronomes. La croyance en une civilisation martienne commença à décliner lorsque le statut de la carte comme forme de représentation objective s'affaiblit en raison des nouvelles techniques photographiques du début des années 1900. Bien que les processus et les formes cartographiques aient été rarement considérés comme des facteurs essentiels dans la manie martienne, ils furent constitutifs de l'origine, du développement et de l'effacement du concept de Mars comme un monde éventuellement habité.

Karten zur Marskanäle-Manie: Kartographische Projektion und die Entstehung eines populären Bildes

An der Wende zum 20. Jahrhundert entwickelte sich eine weit verbreitete Manie um die Idee, der Mars sei von intelligenten Lebewesen bewohnt. Diese überzogenen Vorstellungen entstanden zwar im Rahmen der zeitgenössischen naturwissenschaftlichen Forschung, hielten sich aber deutlich länger als die Erkenntnisse der Astronomen über die Bewohnbarkeit des Roten Planeten bei diesen selbst. Die Kartographie war bei der Herausbildung populärer Konstruktionen des Mars als bewohnter Welt von zentraler Bedeutung und sie erzeugte machtvolle Landschaftsvorstellungen, die deutlich von den Beobachtungen der Astronomen abwichen. Die Akzeptanz der Mars-Zivilisation geriet erst ins Wanken, als in den frühen Jahren des 20. Jahrhunderts der Status der Kartographie als objektive Wiedergabetechnik durch das Aufkommen moderner photographischer Verfahren geschwächt wurde. Obwohl die Methoden und Ausdrucksformen der Kartographie selten als zentrale Faktoren der Mars-Manie gesehen werden, waren sie doch eng mit der Entstehung, der Entwicklung und dem Ende des Konzepts der möglicherweise bewohnten Mars-Welt verbunden.

Mapas de la 'Marte manía': La proyección cartográfica y la creación de un icono popular

Al inicio del siglo XX una moda popular extendió la idea de que Marte estaba habitado por seres inteligentes. Esta obsesión estaba originalmente basada en la ciencia del momento pero fundamentada en la certeza de los astrónomos sobre las condiciones de habitabilidad del planeta rojo. La cartografía fue vital para la construcción popular de Marte como un mundo habitado y creó un poderoso icono que difería significativamente de las observaciones de los astrónomos. La aceptación de una civilización marciana sólo comenzó a disminuir cuando, en los primeros años del siglo, el estatus cartográfico como formato de representación, fue debilitado por una nueva tecnología fotográfica. Aunque los procesos y formas de la cartografía son pocas veces considerados factores primarios en la 'Marte manía', fueron parte integral en el origen, desarrollo y ocaso de la conceptualización de Marte como un mundo probablemente habitado.

Plate 6. Map of Mars by Giovanni Virginio Schiaparelli, 1878. Published with his 'Osservazioni astronomiche e fisiche sull'asse di rotazione e sulla topografia del pianeta Marte fatte nella reale specola di Brera in Milano coll'equatoreale di Merz durante l'opposizione del 1877: memoria del socio G. V. Schiaparelli', *Atti della Reale Accademia dei Lincei: Memorie della Classe di scienze fisiche, matematiche e naturali* 3:2 (1877–1878): 3–136. The map is drawn on the Mercator projection. The northern hemisphere (shown in the lower half of the map following the standard convention of mapping celestial bodies as they appear through the telescope, which inverts the image) is depicted as a detailed landscape of islands and peninsulas divided by narrow blue waterways. (Reproduced with permission from l'Osservatorio Astronomico di Brera, Milan.) See p. 199.

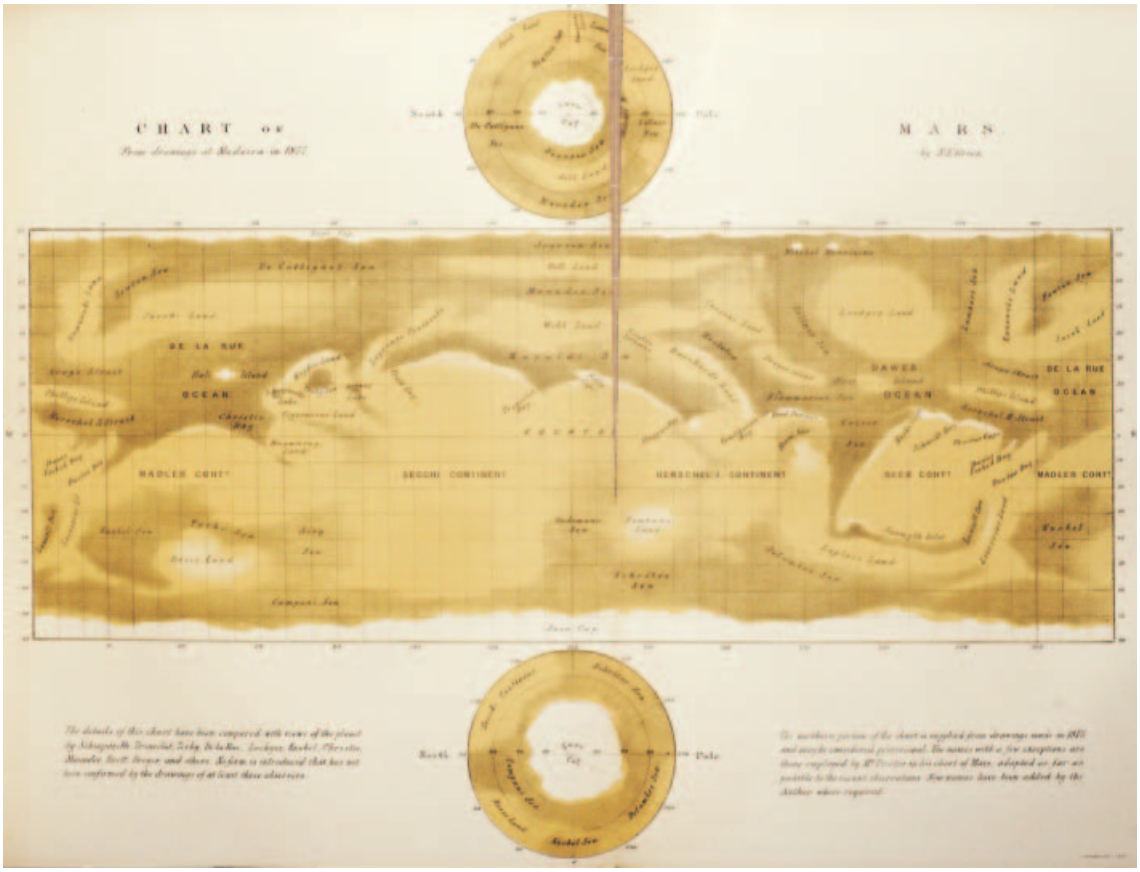

Plate 7. Map of Mars by Nathaniel E. Green, 1877. Published with his 'Observations of Mars, at Madeira, in August and September 1877', *Memoirs of the Royal Astronomical Society* 44 (1879): 123–40. The map is drawn on the Mercator projection. Insets above and below show the Martian north and south poles on planar polar projections. Unlike Schiaparelli, who had opted for definitive dark lines and blue colour tones to indicate his certainty that the planet was largely covered with water (see Plate 6), Green used reddish-orange colour tones and a naturalistic shading style to represent the planet as he observed it through the telescope. Green followed the standard convention of bestowing astronomers' surnames on Martian features, while Schiaparelli created an entirely new system of place-names based on the classical and mythological geography of the ancient Mediterranean world. (Reproduced with permission from the University of Texas.) See p. 199.

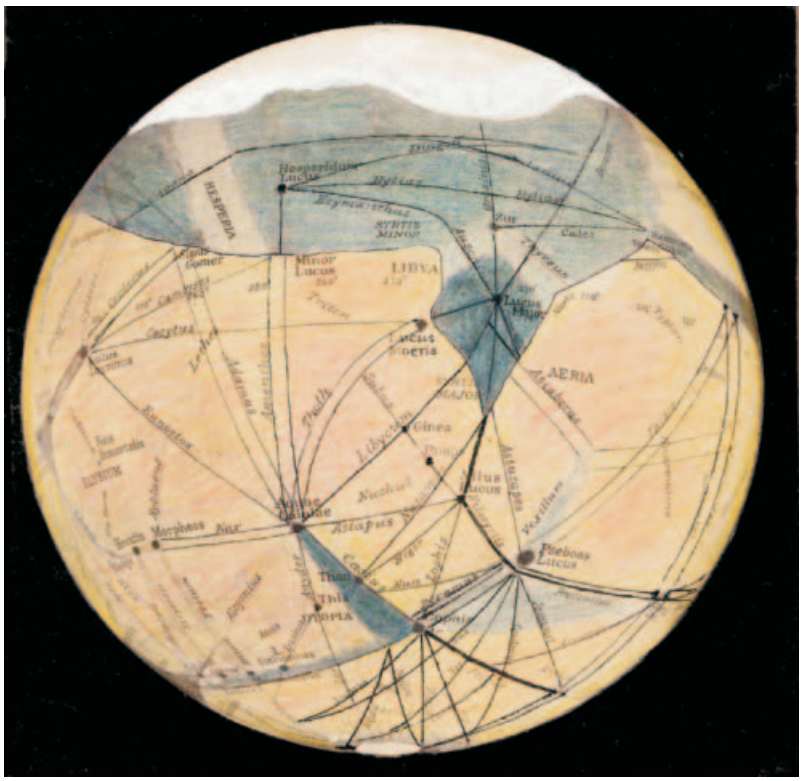

Plate 8. Colour rendering of Mars by Percival Lowell, prepared for possible publication and circulated to other astronomers in 1905. This pencil and ink sketch, which apparently copies a photograph of a globe Lowell made in 1905, shows the planet centred on the 270 degree meridian. The reddish areas were supposedly deserts, while the grey regions were thought to be vegetation. The lines indicate canals and the dark circles indicate oases. Note that Lowell used place-names derived from Schiaparelli's Mediterranean nomenclature, which had become standard by the turn of the century. (Reproduced with permission from the Lowell Observatory Archives, Flagstaff, Arizona.) See p. 203.