The opposition of Mars, 2001: Part II

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A report of the Mars Section (Director: R. J. McKim)

Part I of this paper[63] describes the outbreak of a planet-encircling dust storm in 2001 June, together with changes in albedo features on the planet. This paper (Part II) describes short-lived 'flashes' located in *Edom* recorded on 2001 June 7 and 8, when the sub-Earth and subsolar latitudes coincided, due to specular reflection from near-horizontal ground ice/hydrated mineral deposit or other smooth surfaces. These events had been predicted from seasonally similar observations made in 1954. A further flash on June 16 was located further south near *Hellespontus Montes*, another region found to have a historical precursor for such an event. The North and South polar regions are also described.

Editor's note: Numbering of figures and references in this paper continues consecutively from Part I.

Bright 'flashes': 2001 June

Introduction

Section members Dobbins & Sheehan[20,45] noticed that the values of D_e and D_s would coincide near the martian equator a few weeks prior to opposition, with geometry and season resembling 1954 July, when T. Saheki had famously recorded a 'flash' from *Edom* (*Edom Promontorium*) (Figure 13). Their published ephemeris convinced several US observers to travel to a low latitude site on the E. side of the USA (Florida Keys; see Table 1). From there, *Edom* would transit with the planet at a respectable altitude, when observers might possibly witness '...the glint of ice-slopes flashing for a moment earthward as the rotation of the planet turned the slope to the proper angle...' as Percival Lowell had once observed for himself.[46]

2001 June: flashes over Edom

The results of the observing team working from the Florida Keys ('...in the midst of a mangrove-lined and mosquito-infested landscape', Sheehan adds) during Jun 2–9 were communicated by Dobbins & Parker. The mornings of Jun 2–6 produced no events under good conditions, although *Edom* was seen to brighten slightly each martian morning. Melillo also reported negative results for Jun 4. On Jun 7 Parker emailed: '...after two uneventful nights of observing our team ...detected significant brightness fluctuations over *Edom* between 06:40 and 07:30 UT on June 7...' Instruments included two 152mm reflectors, and a 310mm SCT used in conjunction with a monochrome video camera. 'A perceptible brightening of *Edom* was noted around 06:35 UT. By 06:40 UT pronounced pulsations in brightness were evident. These events occurred at roughly 10 to 15 second intervals, with brightness maxima of approximately three seconds duration that could not be attributed to atmospheric turbulence. These dramatic variations in brightness were simultaneously detected by visual observers ...and by those viewing the video monitor. It is notable that they could not be seen with an 85mm refractor.' On Jun 7 Haas[47] began observing at 07:50 UT, but by then the flashes had already ended; the next night for him was cloudy.

On Jun 8, Parker continues: 'We again observed ...from 05:40 UT to 08:36 UT. There appeared to be two peaks in brightening phenomena around *Edom*. The first was a series of short-lived (3–5 second) brightenings observed both visually and via video between 07:00 and 07:20 UT. Mars' altitude was 35°. These were quite pronounced and were similar in frequency to those of June 7... between 07:53 and 08:24 UT (altitude= 26°)... small but frequent brightness variations were detected. In general, the events... displayed the same intensity but less frequency than those of June 7...' 'Observational conditions were very favourable... Seeing was 8 [on a 0–10 scale where 10 is perfect] initially, deteriorating to 4–5 as the planet's altitude fell below 30°. Clouds interfered with observations less than 20% of the time.'

The sightings were immediately reported in an IAU *Circular*[48] and then briefly by Seronik in *Sky & Telescope* and Sheehan in *Mercury*.[49] To Seronik, the flashes were 'subtle but unmistakable.' D. M. Moore analysed the Florida video records to produce the still frames shown in Figure 13, which are compared with the topographic map in Figure 14. This work showed that the reflector was situated in the N. portion of *Edom*.

The Florida Keys group observed the area again for the last time on Jun 9 (07:01–08:00 UT with cloud interference >50% of the time, and in clear conditions 08:00–09:15 UT): although *Edom* brightened a little approaching the CM, no pulsations were seen. S. J. O'Meara (Hawaii, 08:14–09:20 UT) via Parker also recorded a nil result. Nor did Gaskell see anything unusual (07:00–09:30 UT) in intermittent visual monitoring.

Other dates produced no certain result. Haas watched closely on Jun 11. Schumann saw *Edom* brighten as usual in the mornings (Jun 14–19) as did Devadas (Jun 24–27); Massey's Jun 17 images are normal; McKim (Jun 30–Jul 1) watched it approach the CM with no flashes. Gaskell issued further predictions for July and August but the onset of the global dust storm ruled out any further observational test.

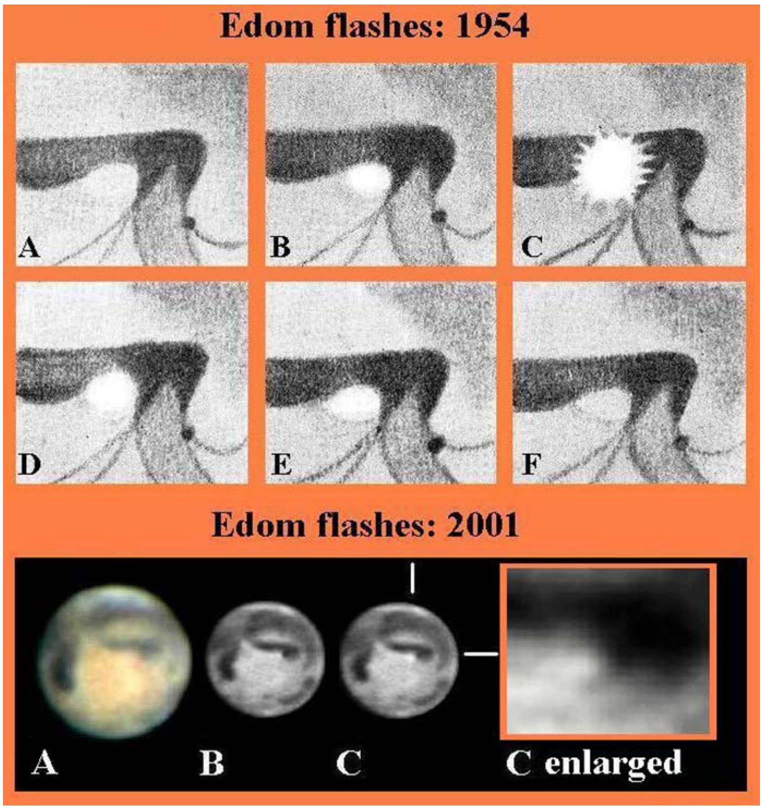

Figure 13. Flashes from *Edom*.

1954. Six aspects of the 'flare' observed by Tsuneo Saheki (scanned from Saheki's book[52]) at Hiroshima, Japan, on 1954 Jul 1d 13h 16m, 200mm refl., ×330, ×400.
A The normal faint yellowish-white aspect of *Edom* (3s before flare).
B A slight brightening (now white) 1s before the event.
C The flare itself, *Edom* enlarged, white and brilliant enough apparently to separate *Meridiani Sinus* from *Sinus Sabaeus*.
D *Edom* remains fairly bright and white, 1s afterwards.
E *Edom* is rather bright, yellowish-white, 3s afterwards.
F *Edom* is merely its normal faint yellowish-white colour, 5s afterwards.

2001
A 2001 Jun 5d 05h 25m, 152mm refl., CML= 330°, *T. J. Parker & D. C. Parker*. *Edom* approaching the critical angle but no flashes observed.
B 2001 Jun 07d 06h 47m 35s Florida Keys expedition video footage (see text), *processed by D. M. Moore*. *Edom* at a brightness minimum. **B** and **C** are composites of 9 frames.
C 2001 Jun 07d 06h 46m 49s, Florida Keys expedition video footage (see text), *processed by D. M. Moore*. Near-stellar bright flash at *Edom* (location indicated) captured at brightness maximum. (Also shown greatly enlarged, right.)

Geometric and geological considerations

Figure 15 is a plan view looking down upon the S. pole of Mars before opposition. A is the subsolar point, and C is the sub-Earth point, which lies on the great circle of the Central Meridian (CM). The phase angle i is the angular separation of these points. It is related to fractional phase by the equation:

$$\text{phase} = 0.5\,(1 + \cos i)$$

Viewed from Earth the terminator will be at E and the shadowed *p*. limb at F. If sunlight striking the ground at B causes a specular reflection off the perfectly horizontal mirror-plane ABC (whose length is exaggerated for clarity and to which BD is the normal), then the reflected ray is deviated by an angle equal to i. However, the reflector will be apparently displaced by $i/2$ west of the CM as seen from Earth. For Jun 7 and 8 the phase angles were calculated to be 6° and 5° respectively, so any specular reflections from a horizontal surface would be visible 3° or 2½° west of the CM. We can calculate when *Schiaparelli* crater (long. 339½–347°) within *Edom* will be this amount west of the CM, and the following predicted times are due to the Director rather than Dobbins & Sheehan:[45]

Date	*UT times, predictions*	*UT times, observed flashes*
Jun 7	07:04–07:35	06:40–07:30
Jun 8	07:43–08:14	07:00–07:20; 07:53–08:24

CCD images clearly show the flashes were limited to the N. part of *Edom*, affecting the whole of its longitudinal span. On Jun 7 the flashes began early but ended close to the predicted time. Their 'early' occurrence implies reflections from terrain sloping upward to the west, at least at the start. Their intermittent nature implies only partly reflective terrain, or terrain of slope other than horizontal (already implied by the early appearance). On Jun 8 the flashes were again ahead of schedule, continuing a few minutes longer than expected, suggesting very similar behaviour, but with slight alteration in the pattern of reflective terrain. MGS images of the site show that dunes exist there. Furthermore, *Mars Odyssey* would later find an unusually

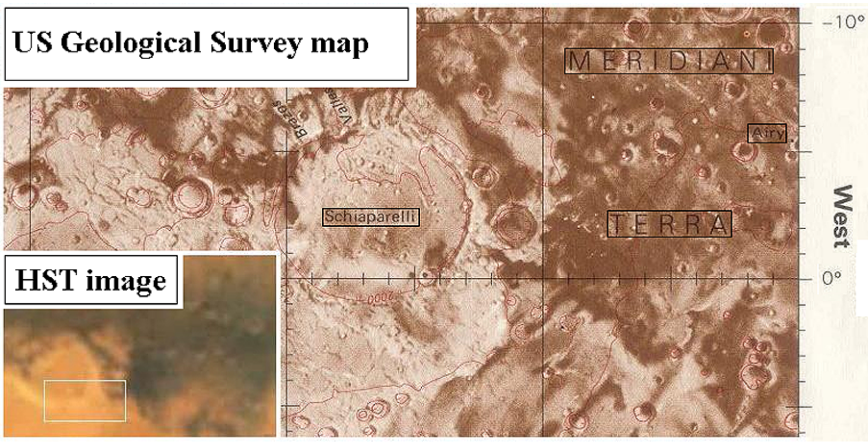

Figure 14. *Edom* flash location.
Schiaparelli crater from the US Geological Survey shaded relief map I-1618 (1985). Classical *Edom* is a little larger than this topographic feature. South is up; vertical lines denote longitudes 330, 340, 350 and 0°. *Inset:* Dobbins' interpretation of the target area (boxed) for the June 7 and 8 flares marked upon an HST image, also south up.

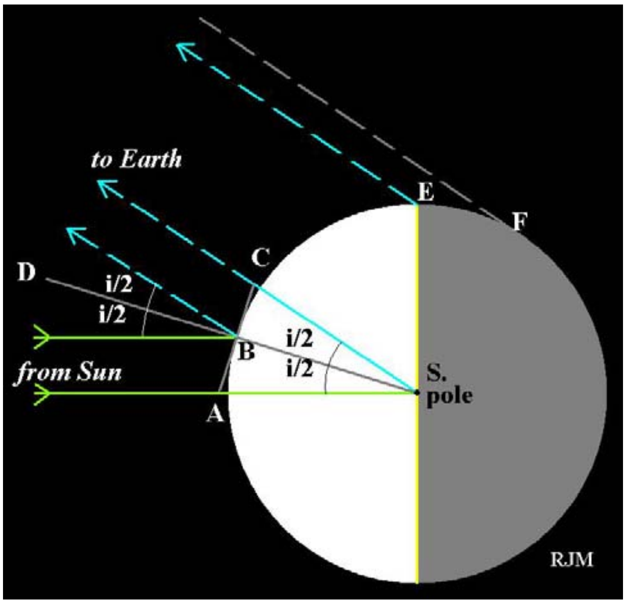

Figure 15. Flash geometry; see text for details. *Graphic by R. J. McKim.*

high amount of subsurface hydrogen at and around that location.[50] It is assumed that this hydrogen is chemically combined as ice or hydrated minerals, and given the proximity to the equator the latter are the more likely upon the surface.

Yet another possibility is raised by the recent mapping (from *Mars Odyssey* data) by Osterloo *et al.*[51] of chloride-bearing mineral deposits. One mineral source was located upon western *Edom*, which turns out to be just one of many such sites. Given that flashes from Mars are so uncommon, the writer prefers a sheet of hydrated minerals for the 'reflector'. Further discussion is beyond the scope of this paper.

Adding the D_e and D_s data we can examine the N–S inclination of the *Schiaparelli* reflectors:

Date	D_e	D_s	*Latitude of horizontal reflector*
Jun 7	+1.7°	+2.5°	+2.1°
Jun 8	+1.9°	+2.3°	+2.1°
Jun 9	+2.1°	+2.1°	+2.1°

Since the flashes were observed to come from latitude 0°, near the N. edge of the crater, and the reflector lay at lat. +2.1°, the ground must slope very slightly in the N–S sense too.

Finally, the martian surface rotates at about 240ms^{-1} at the equator, so a flash lasting 3–5s implies a reflective area *ca*. 1km long: hardly an unreasonable requirement. The 'modulation' of the flashes may be due to the interposition of dunes or other surface unevenness.

2001 June: flashes from southern Hellespontus

Schumann found a very bright spot in SW *Hellas*, somewhat larger than *Edom*, on 2001 Jun 16 (Figure 16A). He first noticed it at 11:43 UT during a longer observing session which had begun at 11:15 UT. It was visible for several minutes, ten at maximum. At 11:53 UT he could '...detect no trace of this incredibly bright feature which has just vanished right before my eyes.'

For Jun 16, three days after opposition, the phase was 0.999 and thus $i = 3.6°$, so a flash observed at CML= 324.7–327.1° would be located at a horizontal reflector at $i/2$ east of the CM at long. 323–325°. Measurement of the drawing yields lat. –44°, and confirms the flash was located a few degrees east of the CM. This would place it just W. of *Hellespontus Montes*, partially over the crater *Rabe*; here the entire terrain slopes down towards the *Hellas* basin.

Historical notes

On 1951 Dec 9, the experienced Japanese observer Tsuneo Saheki observed a long-lived (five-minute) intense brightening of *Tithonius Lacus* as it appeared on the morning limb.[52,53] There had been earlier observations of flashes by Japanese observers, but this was the first to receive worldwide attention. As we saw earlier, Saheki also observed another short-lived and somewhat less bright 'flash' lasting about 8 seconds over *Edom* on 1954 Jul 1 (Figure 13).[52,54,55] These observations became the object of intense speculation. At the moment of Saheki's observation, D_e and D_s (the latitudes of the sub-Earth and subsolar points, respectively) were small and fairly similar, the data implying a reflector at lat. –0.6°. A further *Edom* 'flash' was recorded by C. C. McClelland on 1954 Jul 23.[52] Corliss[56] most usefully reprints some of the contemporary papers *in extenso* and discusses other observations both earlier and later.

Specular reflections do not require D_e and D_s

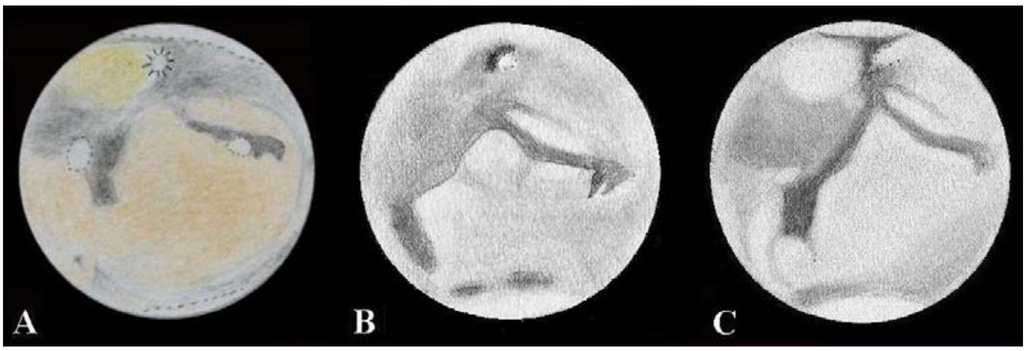

Figure 16. Flashes over S. *Hellespontus*.
A 2001 Jun 16d 11h 43m, 229mm OG, ×275, CML= 324°, *K. Schumann,* Siding Spring, Australia. Incredibly bright patch in S. *Hellas/Hellespontus*. *Edom* is also light.
B 1922 Jul 7d 23h 00m (approx.), 254mm refl., ×310, ×400, CML= 320°, *P. M. Ryves,* Tenerife. Bright 'flash' in S. *Hellespontus*.
C 1922 Jul 9d 24h 00m, 254mm refl., CML= 315°, *P. M. Ryves,* Tenerife. Bright patch, but fainter than on Jul 7, approaches the CM. (**B** and **C** from BAA Mars Section Archives; Ryves remarked that he drew *Syrtis Major* too far north in **B**.)

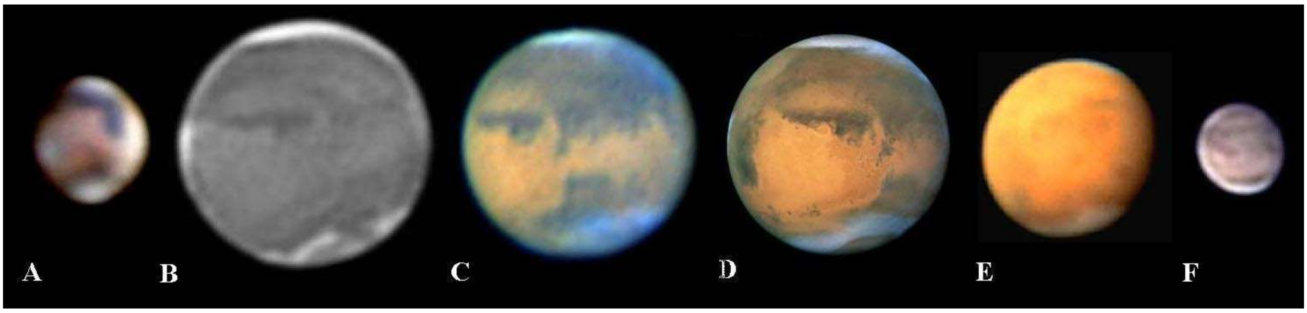

Figure 17. North polar region images, 2000–'02.

A 2000 Dec 12d 10h 40m, 410mm refl., CML= 258°, *Parker*. NPC at advanced recession stage. (D = 4.7")

B 2001 Jun 21d 15h 21m, 279mm SCT, CML= 3°, blue light image, *Tan*. Images **B–D** show progressive development of polar clouds.

C 2001 Jun 24d 20h 49m, 203mm SCT, CML= 28°, *Csadek & Schulz*.

D 2001 Jun 26, HST image. *(Credit: NASA/STScI)*

E 2001 Jul 13d 13h 02m, 310mm refl., CML= 104°, *Ikemura*. Large and active NPH during global dust storm.

F 2002 Apr 2d 09h 12m, 600mm Cass., CML= 12°, *Kumamori*. Compact NPH about to dissipate to reveal NPC. (D = 4.3")

to be identical. A sloping ice-face or reflective surface at very different latitude may also cause a Sun-glint, such as from the 'Mountains of Mitchell' in the S. polar cap.[57] P. M. Ryves found an intensely bright spot at the SW corner of the *Hellas* basin near lat. −50° on 1922 Jul 7 (Ls= 190°): see Figure 16B. Nothing was seen earlier. A contemporary note of the latter observation (but not the drawing) was published by W. H. Pickering.[58] (Ryves' notebook (BAA Mars Section Archives) also records *Edom* 'small and brilliantly white' on Jun 30 (21h UT) but no flash is mentioned; it was also drawn bright without remark on Jul 1−7.) D_e and D_s had coincided on Jun 12. The season was similar to 2001. The brilliant July 7 *Hellespontus* spot was sketched a trifle E. of the CM, as would be expected from a post-opposition glint (opposition was on 1922 Jun 10 (Ls = 175°)); *i*= 22.9°. Specular reflection from a surface inclined to the south, but horizontal in the E–W sense would be expected 11.4° E. of the CM; Ryves' drawing indicates 1 or 2° E, say long. 319°. The location, given the positional uncertainty at high latitude, is tolerably close Schumann's 2001 observation. Ryves shows the feature again on Jul 9, but less bright, approaching the CM (Figure 16C).

A partial list of flashes can now be given, to include the 2001 data and many reputable cases listed in the literature (Table 3). Flashes were seen near the CM except where stated. It is regretted that a rigorous search through the BAA Mars Section Archives is beyond the scope of this paper.

We do not include observations of variable bright areas in N. *Hellas* and *Edom* by Tasaka, 1958 Nov 21[52] as these were not flares as such.

Table 3. Flashes on Mars, 1894–2001

Date	*Observer(s)*	*Location*	*Ref(s)*
1894 Jun 8	P. Lowell	Mts. of Mitchell (*Novus Mons*) (two bright points, lat.–76°, longs. 280, 290°)	46
1896 Dec 11	J. Milton Offord	NE *Hellas*	59
1922 Jul 7	P. M. Ryves	S. *Hellespontus*	58
1937 May 30	Wilson	N. *Thyle I* and *Thyle II*	47
1937 Jun 4	S. Mayeda	*Sithonius Lacus* (limb)	52
1951 Dec 9	T. Saheki	*Tithonius Lacus* (limb)	52,53
1954 Jul 1	T. Saheki	*Edom* (*Schiaparelli* crater)	52,54,55
1954 Jul 24	C. C.McClelland	*Edom*	52
1958 Nov 5	S. Murayama	*Tempe* (limb)	52
1958 Nov 6	S. Tanabé	*Tithonius Lacus*	52
1958 Nov 10	S. Fukui	N. of *Solis Lacus*	52
1960 Oct 8	T. Saheki	*Utopia*	52
1988 Aug 25	T. R. Cave	Mts. of Mitchell (*Novus Mons*)	57
2001 Jun 7, 8	Florida Keys grp	*Edom*	48
2001 Jun 16	K. Schumann	S. *Hellespontus*	24; this paper

North Polar region

General description

Early observations in 2000 mid-Sep and early Oct by Gray showed the N. polar cap as the only obvious feature. The planet was too distant for fine detail or for latitude measures upon the ground-based images, but James & Cantor[7] measured a normal NPC recession from MGS data during 2000 Apr–Dec (Ls= 330–90°). Benson & James[10] also found the 2000 recession typical, but the following martian year, 2002, was very slightly different. From 2000 Oct to 2001 Feb, BAA data show the dark band at the cap edge as prominent (Figure 17A): the cap was very foreshortened by February. In 2001 Feb–Mar there were still frequent records of the NPC, but as early as Feb 14 (Ls= 117°) Parker described arctic clouds over the N. pole, and Adachi on Feb 26 reported a pale and thin N. polar cloud in addition to the ground cap. In March and April, the arctic haze (bluish to Adachi) was more apparent, but the cap remained visible. On Apr 5, for instance, Minami still saw it clearly.

From Apr 7 till May 27 D_e was slightly negative: on Apr 15 Minami could still see the cap as a narrow bright core to the NPH, but by Apr 25 the NPH had largely covered the NPR. On May 11 (Ls= 159°) Minami saw a thick polar hood, which extended over the a.m. *Mare Acidalium* on May 12 and 19. (In 1999 a hood had been constantly present from Ls= 161°.) In May and June the polar haze was not always continuous, consisting of smaller isolated patches. Peach (Figure 3F, Part I), Biver (Figures 3E, H) and Hernandez during May and

June sometimes drew a small bright patch at the pole, which must on the whole have been polar haze: it was larger in blue light. Local thinning of the hood also occurred: on Jun 11 (Ls= 176°) Minami could again see the northern end of *Mare Acidalium* and a bright NPC-like core through a thin NPH, whilst Parker on Jun 25 reported the NPC to be visible in red light and a strip of polar haze in blue. Otherwise a variable hood covered the NPR.

The NPH became brighter and larger in the second half of June. Tan on Jun 21 (Figure 17B) showed the arctic hazes developing further, with streaks and patches around *Mare Acidalium* and the morning *Baltia*. After Jun 23 Biver's drawings show great expansion of the hood. Csadek's images of Jun 24 (Figure 17C) show a broad, bright asymmetric bright band of NPH covering *Baltia*, etc., pointing to a sudden southward expansion of the hood. It was also large at these longitudes on Jun 25–26, etc., and was imaged by HST (Figure 17D) on the latter date. By Jun 30 to Parker also (with *Solis Lacus* at the CM), the hood had also become larger, brighter and continuous. The hood did not retreat as the dust storm that commenced on Jun 26 became global: instead, activity within the NPH, particularly at its S. edge, increased considerably (Figures 2 & 9–11 in Part I; 17E). This we have already discussed in the dust storm section.

After the storm, the hood weakened throughout 2001 Sep–Oct, becoming lighter again (but foreshortened) during November despite the increasing southward D_e, and expanding and becoming bright (and often inclined towards lower latitude on the evening side) in December. In 2002 Jan–Mar it was more foreshortened but remained as a bright strip at the N. limb. The more favourable tilt revealed the hood as a more compact bright area in Kumamori's fine images of 2002 Mar 28, 30 and Apr 2 (Figure 17E), with *Mare Acidalium* indenting it in the latter (at Ls= 352°). In his final view of May 13 (Ls= 12°) Minami suspected the bright area to be surface cap, but an exact date for the transition was not obtained.

South Polar region

SPH/SPC transition

In an early view at Ls= 56° (2000 late Sep) Ebisawa saw the S. pre-polar hood. Its behaviour up to 2001 May has been described in the white cloud section (Part I). The SPH had already largely cleared from *Hellas* by May, as the SPC began to be visible.

From the side visible from the USA, Grafton's red image of May 14 (Ls= 161°, CML= 225°) definitely showed the ground cap (at higher latitude than the large overlying hood imaged in blue), and Valimberti's work (for instance) on May 19–31 (Figures 5E, 6A in Part I) is identical. By Jun 7 the hood was no larger in blue light to Di Sciullo, and Kumamori (Figure 5D) imaged a sharp edge to the cap from Jun 8 onwards. On May 19 and later Minami had found the cap partly visible on the side accessible from the Far East, as had Adachi, May 25. But much depended upon the CM: on the latter date Adachi saw a hood at CML= 201°, but

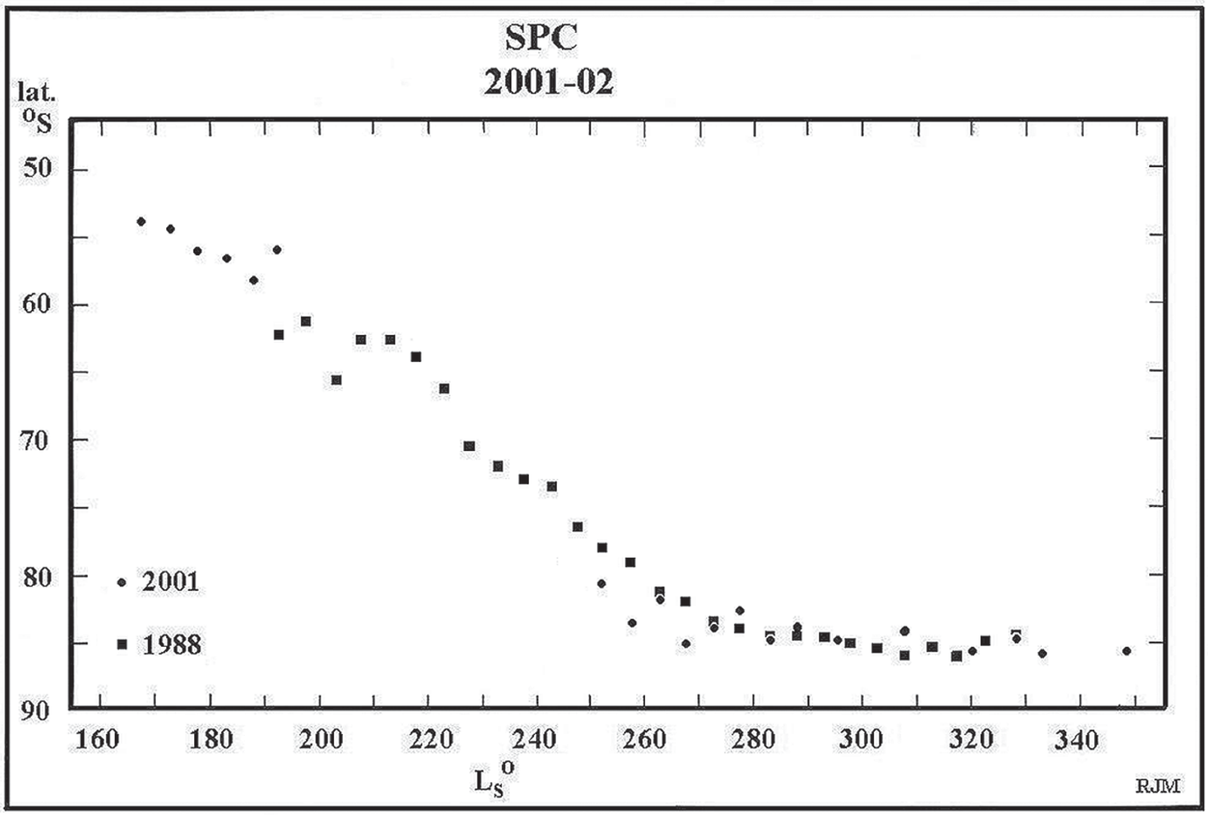

Figure 18. SPC recession, 2001–'02. The SPC recession in 2001–'02 was measured from CCD images; that of 1988 from drawings (photographs provide close confirmation of the 1988 BAA data over a smaller range in Ls).

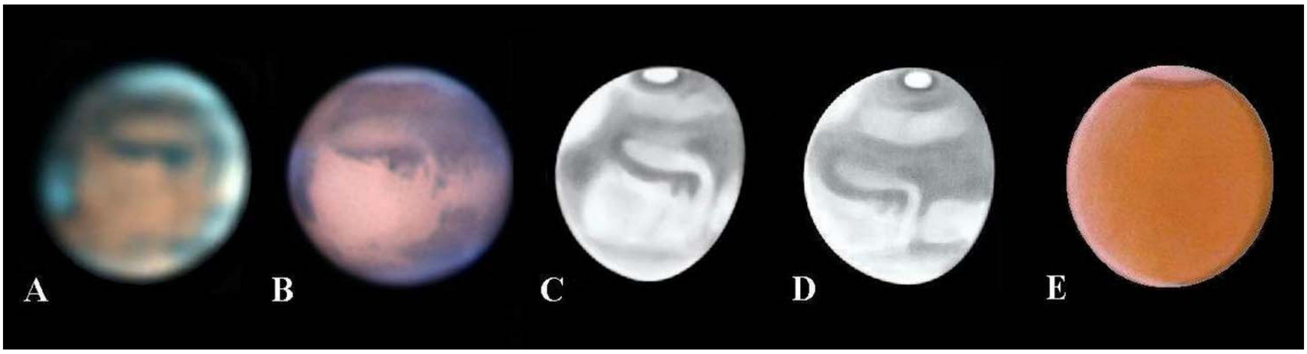

Figure 19. Aspects of the South Polar region, 2001–'02.

A. 2001 Apr 12d 21h 02m, C11, CML= 331°, R(G)B image, *Tan*. The south polar hood is present, covering all of the south limb.

B. 2001 Jun 17d 14h 28m, 600mm Cass., CML= 358°, RVB image, *Massey*. The south polar cap is imaged together with some morning haze (residual polar hood) over *Argyre*.

C. 2001 Oct 18d 18h 30m, 415mm DK Cass., ×415, various filters, CML= 345°, *Gray*. A small SPC is clearly visible as the global storm decays to allow normal surface features to be viewed.

D. 2001 Dec 25d 16h 50m, 415mm DK Cass., ×348–×663, W15, W25, CML= 12°, *Gray*. The SPC has become even smaller. Note that D_e has become rather more southerly since drawing C. (D= 6".5)

E. 2002 May 13d 13h 54m, 203mm SCT, ×250, W23A, CML= 69°, *Frassati*. Daylight observation showing the new, bright, S. polar hood. The disk diameter was too tiny to resolve any of the dark markings. (D= 3".9)

this had given way to a ground cap (Figure 3G) by CML= 233°. Red and infrared images by Akutsu, Morita and Tan on May 20–29 also showed the ground cap well. From Australia on Jun 10 (Figure 5B) observers found a very sharp N. edge to the SPR, which was no longer larger in blue light.

In June, traces of hood remained over *Ausonia* and *Argyre*, regions well-placed for European scrutiny. Thus on Jun 9 the Director noted an unmistakable hood remaining over *Eridania–Ausonia* in white light (Figure 2D), which Cidadão's blue images confirmed. But his next view on Jun 17 showed a foreshortened ground cap, concave to the N. pole (Figures 2E–F) in accordance with the positive value of D_e, and Cidadão's images of Jun 16 also no longer showed the SPH larger than the ground cap. In summary, only the hood was visible before May 14, after which there was mixed behaviour, and subsequently only the ground cap was seen from Jun 10 (Ls= 176°).

Grafton (Figure 4B) and Minami on Jun 11, Buda on Jun 17 (Figure 4C), Beish on Jun 26 and others found the far southern part of the new cap already showed the customary traces of interior albedo markings. The southern spring had hardly begun when the global dust storm erupted. The behaviour of the cap during the storm has already been reported.

Table 4. SPC latitude measurements, 2001–'02

Mean Ls (°)	*Latitude on images of N. edge of cap (°)*	*No. of measures*
168	53.8	17
173	54.2	15
178	55.8	33
183	56.6	51
188	58.0	35
193	55.8	8
198–248	–	0
253	80.6	3
258	83.4	13
263	81.4	10
268	82.5	5
273	84.0	3
278	82.6	12
283	84.7	13
288	83.8	24
293**	84.4	4
298**	85.5	2
303	–	0
308	84.2	4
313	–	0
318***	86.4	1
323***	85.2	2
328	84.9	9
333	85.8	8
338	–	0
343	–	0
348	85.6	5
	Total	277

* 5° means (*e.g.*, Ls= 166–170° etc.), plotted in Figure 18 when 3 or more measures were available
** averaged over Ls= 291–300° for plotting in Figure 18
*** ditto, over Ls= 316–325°

Quantitative recession

The decay of the SPC was well observed, although obscuration by the dust storm led to a critical gap in our measurements after mid-July. An SPC could again apparently be measured on a few of the Aug–Sep images, but it is clear that its N. part was still obscured, so useful data do not recommence until mid-October, when the dark N. surround of the cap was again well visible. As described (for instance) in our 1988 report,[57] we have normally measured the cap's E–W diameter, but due to the foreshortening imposed by the positive value of D_e between late May and Sep 8, we were obliged to measure the latitude of the N. edge at the CM for the early part of the apparition. Upon images taken after Sep 8, the E–W diameter was measured. Results of 277 measures from adequately sharp CCD images by 17 observers, averaged in 5-degree intervals in Ls, are presented in Table 4 and Figure 18. The best previous BAA recession curves are for 1986[31] and 1988.[57] (See Figure 18 for the 1988 data.) Antoniadi,[60] Slipher[61] and others published historical averages.

The spring cap was very nearly the same size in 1988 and 2001. Re-observed in October after the storm, the cap was normal in diameter, though for a short time a little smaller than in 1988. After Ls *ca.* 270° (November) the recession curves converge, by which time the surface features (and SPC) were sharp and clear. The summer cap diameter in 2001 was very close to that in 1988. Cantor[2] found that certain parts of the SPC recessed slightly faster in 2001 owing to local albedo decreases resulting from dust fall-out, but both he and Benson & James[10] stated that there was almost no observable overall difference between the 1999 and 2001 recession curves.

Fragmentation

The usual fragmentation of the SPC could not be well observed, as the early phases took place both during the storm and at unfavourable tilt, and for the later phases the disk was too small. HST images for Jun 26 (Figure 17D) and Sep 4[10,19] show *Novus Mons* as a bright patch entirely within the cap boundary. However, the seasonal separation of *Novus Mons* (the 'Mountains of Mitchell') was just caught by Parker on Oct 24 and recorded by Minami on Nov 7 and 10 (a period spanning Ls= 258–267°), and it was imaged in detail by MGS/HST.

The return of the SPH

A small amount of haze followed the shrinking cap in November and December, as the OAA[21] pointed out. McKim had noticed this already on Oct 31. Haas noticed this haze apparently surrounding the cap, Nov 13–21.

The final visual record of a definite SPC was by McKim on 2002 Mar 26 (D= 4".4) and the last electronic record was by Peach on 2002 Mar 28. The SPR was just vaguely light at very lo-res in April, and Kumamori's Apr 2 image (Figure 17E) shows no cap. Frassati on May 13 shows a bright SPR. We conclude a SPH intervened in early 2002 Apr.

Figure 19 illustrates the appearance of the SPR in 2001–'02.

Conjunctions

By 2002 late March, Mars occupied the same low-power binocular field as Comet Ikeya–Zhang. In 2002 Mars was in conjunction first with Saturn (May 4) and then with Venus (May 10). This 'triple conjunction' was witnessed over Stonehenge, as beautifully illustrated in *The Observatory* magazine.[62] On May 4 Heath viewed telescopically all five naked-eye planets from Mercury to Saturn, but the disk of Mars was too small to show detail. On May 9 Frassati had an impressive view of Mars and Venus in the same low-power field.

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