# The great perihelic opposition of Mars, 2003: Part II

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

In concluding the BAA report upon the 2003 perihelic opposition we examine white cloud statistics and both polar regions.The SPC recession curve was very similar to 2001 and 1988 but showed significant differences from earlier decades. *Novus Mons* was detached at the same seasonal date as in 1988.

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

## White clouds

With this report (continued from Part I in the October *Journal*) we complete an unbroken 25-year BAA database (12 apparitions, 1979–1980 to 2003–2004) of water-ice clouds on Mars. Dust activity can encourage crystal cloud activity by nucleation, but as was demonstrated twice during 2003, cloud frequency drops if dust activity continues for long (due to atmospheric warming).

In 2002–2003 telescopic orographic clouds over the volcanoes were as follows:

| | | |
|---|---|---|
| *Olympus Mons* | 2002 Oct 24–2003 Jul 3* | Ls= 85–214° |
| *Arsia Mons* | 2003 May 2–Nov 12** | Ls= 178–297° |

* plus weak, isolated sightings 2003 Aug 13–17

** visibility interrupted in July by dust storm activity

Note the much later start and finish date for *Arsia Mons*, the southernmost of the *Tharsis Montes*, though it might have been observable longer had we been able to continue to view the actual evening terminator. We previously remarked[1] how these features have different Ls limits. For seasonal comparisons we cite classic papers[64] as well as modern *MGS* TES studies by Smith and by Benson *et al.*[65] White clouds are best viewed in blue-violet light: see Figures 13–14.

The ECB was discussed in our 1995–2001 reports. It was detected from 2002 Oct 24 (Ls= 85°), but would have been detected earlier given a larger disk. Its termination about 2003 Feb 2 (at Ls= 132°) was well documented and seasonally normal. Smith[64] found that the ECB showed insignificant variation from 1999 to 2003 according to *MGS* data.

We now list features affected by white crystal clouds (s= slightly; v= very; w= white; *p.*= preceding; *f.*= following). D (apparent diameter of the planet) exceeded 6".0 from 2003 Feb till 2004 Feb; earlier and later data are fragmentary and of low resolution.

### 2002 October

Gray (Oct 24) saw a 'sparkling' *Nix Olympica* (hereinafter the '*Olympus Mons* orographic') at the CM (Part I, Figure 6A). *Chryse* was not very bright to Gray at the *p.* limb.

### 2002 November

a.m. limb: *Hellas*.

p.m. terminator: *Chryse–Xanthe*, *Elysium*.

mid-disk: *Hellas*.

### 2002 December

a.m. limb: *Chryse*, *Hellas*, *Neith Regio*, *Tharsis*.

p.m. terminator: *Chryse–Xanthe*, *Cydonia*, *Elysium*, *Hellas*, *Tharsis*.

mid-disk: *Cebrenia*, *Chryse*, *Elysium* (Figure 15), *Hellas* (also bright in red to Peach, Dec 22).

The SPH was widely seen.

ECB was reported, *e.g.*, by Morita, Dec 2 (Ls= 103°, CML= 330°), and Adachi, Dec 13 (CML= 236°).

### 2003 January

a.m. limb: *Argyre* (Frassati, Jan 18), *Cebrenia*, *Chryse–Xanthe*, *Elysium*, *Hellas* (vw), *Tharsis* (sw).

p.m. terminator: *Chryse–Xanthe*, *Cydonia*, *Elysium*, *Hellas* (vw), *Isidis Regio* (sw), *Olympus Mons* orographic (Peach, CCD, Jan 2, including infrared: Figure 13A).

mid-disk: *Cebrenia*, *Elysium*, *Hellas* (vw across visible spectrum (Figure 15); brighter in red than blue to Morita, Jan 11), *Isidis Regio–Libya*.

**Table 2. Blue-violet filter data, 2003**

| *Observer* | *Filter*** | *Wavelength (nm) of peak transmission* | *BWHM* (nm)* |
|---|---|---|---|
| *Visual* | | | |
| (all) | Wratten 47 | 440 | 70 |
| *CCD* | | | |
| Akutsu | Type 2 (IDAS) blue | – | – |
| Grafton | Edmund blue | – | – |
| Miyazaki | – | 444 | 105 |
| Moore | Blue | 455 | 110 |
| Parker, Clark, Owens | CFW8C blue | 450 | 116 |
| Peach | SBIG Blue | 400 | – |
| Pellier | Astronomik Type II blue | 380 | – |
| HST | F410M | 410 | 15 |

* bandwidth at half maximum

** with CCDs or webcams, blue filters require an infrared rejection filter.

'Blue' images submitted by many ToUcam users were often just 'blue channel' separations, of little scientific value.


**Figure 13A.** Diurnal variation of the *Nix Olympica* and *Tharsis Montes* clouds, 2003 Jan–Sep. Rows 1 and 2 illustrate the 'W' cloud. Row 3 shows diurnally variable orographic cloud over *Arsia Mons*; *Olympus Mons* appears as a dark spot in July throughout the day, and when on the a.m. terminator from 2003 late Aug to Sep (also illustrated). Monochrome images are in blue-violet light. Filter details are given in Table 2.

McKim's drawing of Jan 11 (CML= 90°, Part I, Figure 3A) shows the equatorial zone lighter, due to ECB.

### 2003 February

a.m. limb: *Aeria*, *Elysium* (sw), *Hellas* (vw), *Libya*, *Neith Regio*, *Tempe* (sw), *Tharsis*.

p.m. terminator: *Aeria*, *Arabia*, *Chryse–Xanthe*, *Elysium*, *Hellas* (vw), *Isidis Regio–Libya* (van der Velden, Feb 11), *Olympus Mons* orographic (sw).

mid-disk: *Cebrenia*, *Elysium*, *Hellas* (vw), *Tharsis*.

As in Dec–Jan *Hellas* continued to be bright throughout the martian day; filter reaction points to surface frost.

Morita's Feb 2 images (CML= 79°) clearly show the ECB: our last ground-based record at Ls= 132°. It was imaged at many longitudes – rather fragmentarily – in press-released *MGS* images taken on Feb 14 (Ls=138°).[66]

### 2003 March

a.m. limb: *Amazonis*, *Arcadia* (within which Frassati, Mar 25, drew a small vw cloud N. of *Ascraeus Mons*), *Chryse–Xanthe*, *Isidis Regio–Libya*, *Tempe*, W. *Tharsis*, *Thymiamata*, *Zephyria*.

p.m. terminator: *Candor–Ophir*, *Chryse–Xanthe*, *Eden*, *Elysium* (vw at extreme terminator, late Mar), *Hellas*.

mid-disk: *Chryse–Xanthe* (sw), *Hellas* (sw), *Tempe*.

A bright bluish hood covered the S. pole on most dates (Figures 5E, 15); the SPC began to appear. *Hellas* was not as bright at the CM as last month, and slightly invaded by SPH.

### 2003 April

a.m. limb: *Aeria*, *Chryse–Xanthe*, *Cydonia* (sw), *Hellas*, *Isidis Regio–Libya* (veiling the rising *Syrtis Major*).

p.m. terminator: *Candor–Ophir*, *Chryse–Xanthe*, *Elysium* (sw), *Isidis Regio–Libya*, *Olympus Mons* orographic (Valimberti, Apr 5; Parker, Apr 28 (now only sw)), *Tempe*, *Thymiamata*, *Xanthe*. The *Tharsis Montes* clouds were also seen on Ikemura's Apr 10 image as an unresolved belt (corresponding to the western stroke of the 'W' cloud). *Hellas* again was not bright.

mid-disk: *Elysium* (sometimes sw), *Thymiamata*. *Hellas* was not bright.

A trace of residual SPH was seen over *Argyre*, Apr 21.

### 2003 May

a.m. limb: *Aeria*, *Aethiopis*, *Amazonis* (sw), *Argyre*, *Candor–Ophir*, *Chryse–Xanthe*, *Elysium* (sw), *Hellas* (extreme E. only, Parker, May 30), *Isidis Regio–Libya* (veiling the rising *Syrtis Major*), *Tharsis*. *Hellas* was dull.

p.m. terminator: *Aeria*, *Candor–Ophir*, *Chryse–Xanthe*, *Cydonia*, *Eden*, *Edom*, *Hellas* (sw; especially on the W. side), *Isidis Regio–Libya* (partly crossing *Syrtis Major*, Parker, May 20 (Figure 14)), *Olympus Mons* orographic (sw), *Tharsis*, *Thymiamata*. The *Tharsis Montes* clouds coalesced in the evening to produce the 'W' cloud (seen from May 2 (Ls= 178°) onwards) with *Arsia Mons* being especially bright. The 'W' cloud was beautifully captured by Parker, May 4 in blue light (Figure 13A). (The condensations are located over *Candor*, W. of *Noctis Lacus* ('*Nox Lux*'), *Arsia Mons* in the south, and *Lunae Lacus* and the

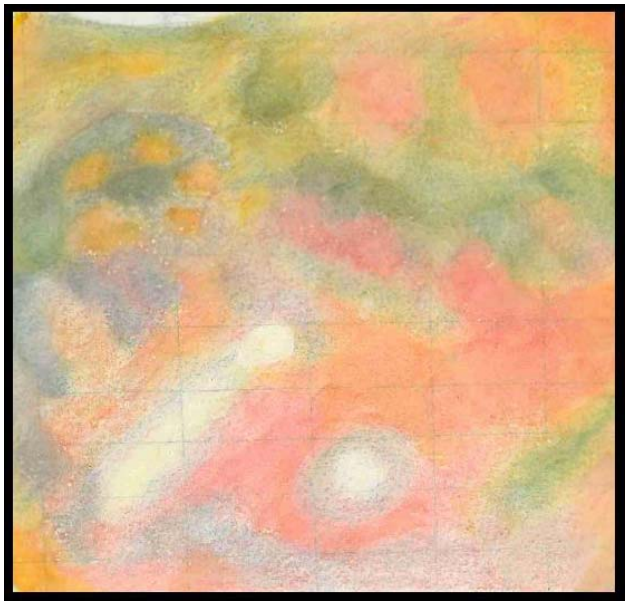

**Figure 13B.** Mercator projection map of the *Tharsis Montes* clouds (sloping diagonally, NE to SW, with *Arsia Mons* brightest at the SW) and *Nix Olympica* (*Olympus Mons*) cloud drawn in natural colours, 2003 Jul 15, 16, 17 and 18, 140mm OG ×125 (Corfu, Seeing I–II), under CML= 41–105°, chart longitudes approx. 60–200°. South is uppermost. *C. J. R. Lord.*

*Ascraeus Mons* orographic in the north. No separate condensate cloud over *Pavonis Mons* was seen, but the western stroke of the 'W' crosses its summit.)

mid-disk: *Aeria* (sw), *Argyre* (sw), *Candor–Ophir* (sw), *Chryse* (sw), *Edom* (sw), *Olympus Mons* orographic (sw), *Thymiamata*. The *Tharsis Montes* clouds formed in early afternoon. Neither *Elysium* nor *Hellas* was bright.

N. polar hood cloud partly covered northern *Mare Acidalium*.

### 2003 June

a.m. limb: *Aeria*, *Aethiopis*, *Argyre*, *Candor–Ophir*, *Chryse–Xanthe*, *Eden*, *Eridania*, *Hellas* (sw), *Isidis Regio–Libya*, *Noachis*, *Phaethontis*, *Tharsis*, *Thaumasia*.

p.m. terminator: *Aeria* (sw), *Aethiopis*, *Arcadia*, *Argyre* (with S. *Argyre* projecting over the terminator to Beish, Jun 11; also shown by some Parker blue images), *Candor–Ophir*, *Chryse–Xanthe*, *Eden*, *Edom*, *Elysium* (sw), *Hellas* (W. side), *Isidis Regio–Libya* (partly extending over S. *Syrtis Major*), *Mare Erythraeum*, *Oympus Mons* orographic, N. border of *Sinus Sabaeus* (sw), and the *Tharsis Montes* including the 'W'cloud (as in May (Figure 13A); seen visually by McKim, Jun 2, *etc*.).

mid-disk: *Candor–Ophir*, *Chryse–Xanthe* (sw), *Edom*, *Elysium* (sw), *Hellas* (sw; W. side). The 'W' cloud was faintly forming at the CM.

N. polar hood cloud partly covered northern *Mare Acidalium*.

### 2003 July

White cloud activity was much reduced by S. hemisphere dust. All the following white cloud activity disappeared/faded by mid-month (the orographics after Jul 3), but some of it reappeared late in the month. The *Arsia Mons* orographic was the only conspicuous cloud in late July.

a.m. limb: *Aeria*, *Aethiopis*, *Candor–Ophir*, *Chryse–Xanthe*, *Edom* (partly cutting off the *f*. end of *Sinus Sabaeus* to McKim, Jul 28), *Electris*, *Hellas* (sw; w in late Jul), *Phaethontis*, *Tharsis*, *Thymiamata*.

p.m. terminator: *Arsia Mons* orographic (sw at first; then absent; again sw to Pace, Jul 24, extreme terminator), *Candor–Ophir*, *Elysium* (sw), *Hellas* (late Jul only), *Olympus Mons* orographic (sw), *Thymiamata*. A projection over the terminator adjacent to the SPC was seen by Beish and Parker on Jul 4 (CML *ca*. 230°).

mid-disk: *Arsia Mons* orographic (initially sw; nearly invisible by Jul 13), *Candor–Ophir* (sw), E. *Deucalionis Regio* (Okša, Teichert, Jul 20–25), *Libya* (sw), *Tharsis*, *Thymiamata* (sw). *Hellas* was again dull at local noon.

The NPH generally remained bright, being marginally affected by the southern regional dust storm.

In white light, *Olympus Mons* in the afternoon appeared as a light oval with a small reddish patch at the summit on the E. (evening) side. This patch was virtually invisible in red light but darkened in green and blue, and enlarged in an eastward direction, darkening as it neared the evening terminator in the best images from Jul 13–27 (Grafton, Kumamori, Morita, Parker (Figure 13A), Van der Velden). A similar appearance was seen, on the afternoon side, during the 2001 global storm.[1] The effect was also noted with *Ascraeus Mons*, and less certainly with the other *Tharsis Montes*.

### 2003 August

White cloud activity was higher, but still inhibited by the July dust. The *Arsia Mons* orographic remained conspicuously bright in blue light. (Figure 13A)

a.m. limb: *Aeria*, *Ausonia* (sw), *Candor–Ophir*, *Electris*, *Eridania*, *Hellas* (sw), *Isidis Regio–Libya* (bluish; veiling the rising *Syrtis Major*), *Neith Regio*, *Phaethontis*, *Tharsis* (sw), *Thaumasia*.

p.m. terminator: *Aeria*, *Argyre* (sw), *Arsia Mons* orographic (compact and again bright, irradiating over terminator to Hill, Aug 9), *Candor–Ophir*, *Chryse–Xanthe*, *Cydonia*, E. *Deucalionis Regio*, *Eden*, *Hellas* (sw), *Isidis Regio–Libya*, E. *Noachis*, *Olympus Mons* orographic (sw; see below). The line of the *Tharsis Montes* was marked by thin evening cloud to McKim, Aug 10, separated from the small cloud over *Arsia Mons*; this was the aspect charted in Figure 13B and imaged by Lau, Aug 30.

mid-disk: *Arsia Mons* orographic, *Candor–Ophir*, *Edom* (sw).

*Olympus Mons* showed as a light spot throughout the day, merely ground-lit, for it was not brighter in blue, except faintly so in Parker's Aug 13 (Figure 13A) and Maxson's Aug 17 images, upon the evening terminator: final sightings of its orographic cloud. Hall's Aug 29 image (Figure 13A) shows *Arsia Mons* as a black spot at the sunrise limb.

The NPH was bright.

A small morning cloud adjacent to the SPC was often seen, especially under CML *approx*. 50–90° and 230–280°: its most rapidly changing periphery. In excellent seeing, McKim on Aug 20 (Figure 3I, Part I) found evening cloud associated with the remnant of *Novus Mons*.

### 2003 September

Atmospheric activity had further increased: by late Sep considerable a.m. terminator cloud was visible.

a.m. terminator: *Aeria*, *Aethiopis*, *Amazonis*, *Arcadia*, *Arsia Mons* orographic, N. *Ausonia*, *Candor–Ophir*, *Chryse–Xanthe*, *Dia–Mare Australe* (McKim, Sep 21, adjacent to the SPC, as in Aug), *Edom* (sw), *Eridania*, *Hellas*, *Hesperia–Mare Tyrrhenum*, *Isidis Regio–Libya* (bluish; veiling *Syrtis Major*), *Mare Acidalium* (partly veiled by NPH), *Memnonia*, *Tharsis*, *Thaumasia*, *Thymiamata*, *Zephyria*.

p.m. limb: *Aeria*, *Argyre* (sw), *Arsia Mons* orographic cloud, *Candor–Ophir*, *Chryse–Xanthe*, *Edom* (sw), *Elysium* (sw) (*e.g.*, McKim, Sep 3, Figure 3, Part I), N. *Hellas*, *Isidis Regio–Libya*, *Memnonia* (sw), *Tharsis* (including the unresolved *Tharsis Montes*), *Thymiamata*.

mid-disk: *Aeria*, *Arsia Mons* orographic (sw), N. *Ausonia* (small w patch, Hill, S.Moore, Teichert, Sep 1–3), *Candor–Ophir*, *Edom*, *Elysium* (vsw to McKim, Sep 6), N. border *Sinus Sabaeus*, S. and SW of *Solis Lacus* (Adachi, Sep 2–8, variable positions), *Symplegades Insulae* (S. *Zephyria*; Rogers and Topping, Sep 10–11), *Tharsis*, *Thymiamata*.

*Olympus Mons* was again a light area all day, ground-lit. Ng's Sep 11 image shows (as in late August) *Arsia Mons* as a black spot right upon the sunrise terminator, surrounded by light cloud (Figure 13A).

Anomalous dark features in (particularly) *Memnonia–Zephyria* were observed in blue-violet light in the early morning (Figure 14).

The NPH deviated to lower latitude at *Mare Acidalium* and *Utopia*. Ng's Sep 17 images show an E–W 'slit' through which part of *Acidalium* was visible (also Biver, Sep 26, Morita, Sep 17, *etc*.).

### 2003 October

a.m. terminator: *Aeria*, *Aethiopis*, *Amazonis* (rotating with the planet), *Ausonia*, *Chryse–Xanthe* (sw), *Elysium*, *Hellas*, *Hesperia–Mare Tyrrhenum*, *Isidis Regio–Libya* (*Syrtis* Blue Cloud), *Memnonia*, *Tharsis*, *Thaumasia* (large, as in Sep; in late Oct it hid *Solis Lacus* in white light even till CML= 70° (Siegel and others)), *Thymiamata*, *Zephyria*.

p.m. limb: *Amazonis*, *Argyre*, *Arsia Mons* orographic (extreme limb), *Candor–Ophir*, *Chryse–Xanthe* (sw), *Cydonia*, *Hellas*, *Isidis Regio–Libya* (*Syrtis* Blue Cloud), N. border *Sinus Sabaeus*, *Tempe*, *Tharsis*, *Thymiamata*, *Zephyria*.

mid-disk: NW *Hellas* (sw), *Tharsis*, *Thymiamata*.

The region adjacent to the SPC at the terminator often showed a white cloud, as in September.

*Olympus Mons* remained a lightish, ground-lit spot. The summit was reddish (Kumamori, Oct 8; Valimberti, Oct 3).

Anomalous dark features in (particularly) *Memnonia–Zephyria* were observed in blue-violet light in the early morning.

The NPH veered north at *Mare Acidalium* to hide its northern parts, but sometimes with a small E–W gap: the cloud also occupied *Tempe* (*e.g*., to Ikemura, Oct 19). Several image series show this cloud rotating with the planet.

### 2003 November

a.m. terminator: *Aeolis*, *Aeria*, *Aethiopis*, *Amazonis*, *Arcadia*, *Ausonia*, *Chryse*, *Cydonia*, E. *Deucalionis Regio*, *Elysium* (small bright point to Siegel only, Nov 19), *Eridania*, *Hellas*, *Hesperia–Mare Tyrrhenum*, *Isidis Regio–Libya* (bluish; again extending over the *Syrtis Major* to *Aeria*), *Memnonia*, *Noachis*, *Ogygis Regio*, *Phaethontis*, *Tharsis* (within which Siegel (Nov 28) spotted a brighter point near *Ascraeus Mons*), *Thaumasia*, *Thymiamata*.

p.m. limb: *Aeria*, *Amazonis*, *Argyre*, *Arsia Mons* orographic (weak to Akutsu, Minami and Valimberti Nov 6–12), *Candor–Ophir*, *Chryse–Xanthe*, *Eridania*, *Hellas*, *Isidis Regio–Libya*, *Tharsis*, *Thymiamata*, *Zephyria* (sw).

mid-disk: N. border *Sinus Sabaeus*, *Thymiamata*.

Diminution in brightness of *Arsia Mons* is probably due to observational selection: due to changing phase angle it gradually became impossible to see at the evening terminator.

*Olympus Mons* was once again ground-lit. Likewise in our 1988 Report,[9] covering a similar seasonal range, we noted without conclusion how it was once bright in white light, but not blue.

Geometry dictates that Siegel's Nov 19 and 28 small clouds must have been on the east-facing slopes of *Elysium Mons* and *Ascraeus Mons*.

*Mare Acidalium* and the NPH behaved as in October.

### 2003 December

Diurnal cloud frequency was again reduced by a large S. hemisphere storm.

a.m. terminator: *Aeria*, *Amazonis*, *Argyre*, *Hellas*, *Isidis Regio–Libya* (bluish; extending over the *Syrtis Major*), *Noachis*, *Tharsis* ((the E. edge clearly demarcating the E. of the line of the *Tharsis Montes*), *Thymiamata*, *Zephyria*.

p.m. limb: *Aeria*, *Elysium* (sw), *Eridania*, *Hellas*, *Isidis Regio–Libya* (weak *Syrtis* Blue cloud), *Tempe*, *Zephyria* (sw).

The southern hemisphere regional dust storm soon tinted the evening limb strongly yellowish.

Up till mid-month *Hellas* showed normal diurnal cloud, then became dusty. *Argyre* was affected by dust, but showed a white cloud component on the morning side. *Aeria–Iapigia–Mare Serpentis* exhibited a large a.m. cloud that preceded the rise of the E. *Deucalionis Regio* dust core on Dec 16.

The ground-lit *Olympus Mons* was observed.

The NPH weakened slightly, due to the southern storm, but was again bright by Dec 27.

### 2004 January

a.m. terminator: *Amazonis*, *Argyre*, *Chryse*, *Dia–Mare Australe*, *Hellas*, *Memnonia*, *Noachis*, *Tharsis* (Parker, Jan 15–16), *Zephyria*.

p.m. limb: *Candor–Ophir*, *Chryse–Xanthe*, *Eridania*, *Hellas*, *Isidis Regio–Libya*, *Memnonia*, *Zephyria*.

mid-disk: *Chryse–Xanthe*.

On Parker's Jan 13–14 images the three *Tharsis Montes* form a chain of dark spots in red light; in blue there was a neighbouring belt of diurnal cloud. *Olympus Mons* was a dusky spot in Parker's Jan 6 images, especially in green and blue.

In the south the SPC gave way to a polar hood.

The NPH regained its brightness, but the high northern tilt much foreshortened it.

### 2004 February

a.m. terminator: *Aeria*, *Hellas*, *Isidis Regio–Libya* (and *Syrtis* Blue Cloud; early Feb), SW *Thaumasia*.

p.m. limb: *Argyre*, *Elysium*, *Hellas*, *Isidis Regio–Libya*, *Zephyria*.

The SPH hood was visible throughout Feb–Mar.

### 2004 March

a.m. terminator: *Arcadia*, *Phaethontis*.

p.m. limb: *Chryse–Xanthe*, *Hellas*.

### 2004 April

a.m. limb: *Mare Acidalium–Tempe*.

p.m. limb: *Chryse–Xanthe*, *Hellas*.

mid-disk: *Hellas*.

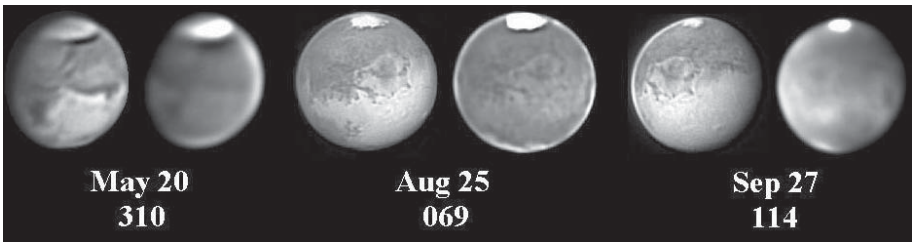


**Figure 14.** Atmospheric transparency (2003 May, Aug) and anomalous markings in blue-violet light (Sep): 400mm refl., ST9XE CCD camera with CFW8C blue-violet filter (peak transmission 450nm, BWHM 116mm), *D. C. Parker*. The left hand image of each pair is with a red filter.

### 2004 May to June

Limb brightening was visible, but few discrete clouds with certainty. Morita's Jun 5 image (Figure 15) shows extensive p.m. cloud over *Isidis Regio–Libya*.

## Atmospheric transparency in blue-violet light

We continue to use the misnomer 'Blue Clearing' (BC) for historical continuity. The scale:

| *Appearance in blue-violet light* | *order of BC* |
|---|---|
| No detail whatsoever visible | 0 |
| Some detail visible | 1 |
| Recognisable surface features visible | 2 |
| Dark markings nearly as strong as in white light | 3 |

Some 'personal equation' is involved in assessment: for images the Director often preferred his own estimates to those of the original observers. We list appropriate filter/bandpass details in Table 2, updating our 1997 data.[6,7]

Visual data covered 2003 Apr 6–Dec 23, with W47 blue-violet filter work from Adachi, Colombo, Crandall, Haas, Heath, McKim, Parker and Siegel. A moderate BC order 2 existed over the extreme range 2003 Jul 12–Nov 24, but there were many discontinuities of BC 0 or 1. McKim saw his strongest BC at and just after opposition, but never rated it above 2 visually (perhaps partly due to the planet's modest altitude), but on Sep 4 his blue-violet video images showed BC 3. Outside this period the BC was rated 0 or 1. Very strong BC was rare, but Haas rated it as order 3 on Sep 4, like McKim, days after opposition.

CCD data covered a longer span: reporting only those data with D above 6 arcsec, these in general accord with visual data, though – as simultaneous visual/CCD work by Parker often shows – they often reveal subtleties missed visually upon the dim W47 filtered image. For the opposition-centred period BC order 2 was detected over 2003 Jun 24–Nov 17, with several periods of BC 1+ (but never 0). A very strong BC of 2+ or 3 was recorded during *approx*. Aug 25–Sep 8 (Figure 14), and again on October 13–14 (and also visually).

There was also a short BC (order 2+) from 2003 Apr 14–16 (Parker; *Syrtis Major–Sinus Sabaeus* longitudes, confirmed visually) and on May 20 (similarly; Figure 14).

Throughout Sep and Oct, many observers saw a diffuse, anomalous dark patch in blue light (or webcam blue channel) over *Memnonia–Zephyria*. It was particularly noticeable when close to the morning terminator, with image sets such as Akutsu's of Sep 2 showing that it faded out as morning advanced. McKim on Sep 6 (W47) visually observed a similar darkening; other sightings over *Amazonis* were obtained by Ikemura and Lau, Sep 9, and by Parker (in both green and blue light) on Sep 27 (Figure 14; near +10°, 165°). On Oct 3–5 Parker and Warell imaged anomalous albedo features in green and blue N. of *Solis Lacus* and in E. *Memnonia*. On Oct 4 and 6 Minami noticed that *Amazonis* (deficient in blue-violet light) showed a red-brown dusky area through the eyepiece. As in previous apparitions we assume these anomalies represented especially transparent regions of the atmosphere.

Figure 14 illustrates some of these features.

## 'Flashes'

Following the remarkable observations made in 2001,[1] observers were again on the alert around the times when $D_e$ and $D_s$ coincided, as they did on 2003 Aug 1 and Nov 2.

Minami[15] had the following experience on Jul 29 about 15h30m UT, but regards it as a dubious candidate for a true flash given the hazy martian atmosphere: 'The area of *Claritas* is usually light, and at this period because of the yellow-whitish overall haze it was yellowish light... seeing was moderate to good.' The observer was watching the *Solis Lacus* region when ' ...an area inside *Claritas* became very bright and then turned dull. This looked rather usual, and possibly a trick played by the air fluctuation, but a few seconds later it flashed again ... The repeat was a rare experience.' If longer-lived it would have been classified as a real flare, '...but as far as we considered, it must have been a mere flicker caused by a sharp air disturbance under good seeing...'

The OAA organised systematic patrols from Jul 30–Aug 3, typically from *ca.*13–19h UT, mostly with 15–31cm apertures. On August 15 ($D_e$= –18.8°; $D_s$= –21.6°) about 15h 30m UT (CML= 311°) their observer T. Matsumoto (28cm SCT) detected a white flare near *Huygens*. The published drawing[15] shows the spot some 3° S. of the disk centre and 5° E. of the CM. The phase angle was then 13°. The flare was a little brighter than the SPC, its diameter about 0.5 arcsec, and it twinkled due to seeing conditions. Mars was hidden by cloud after 4–5 min. At around 16h UT, Mars reappeared, seeing was poor, and no trace of the flare was found. BAA records contain no data for precisely the moment of the flare, but Kumamori's 15h 04m image is normal; neither do Valimberti's 15h 26m image nor Yunoki's 15h 28m image show the flare.

## The polar regions

### North polar region

We could watch only the closing stages of the NPC recession in late 2002, but the cap's reappearance was well seen over a year later: see Figure 15. Frassati saw a bright NPR on 2002 Oct 18, and Gray detected a small NPC on Oct 19 to Nov 18 (Figure 6A), but with D< 6", no fine detail. On 2004 Jan 7, 11 (Figure 3A) and 31 McKim saw a lightish NPR. Peach's image on 2003 Jan 28 (Ls= 129°; Figure 15) barely shows the small summer remnant, the last to do so. According to OAA visual data[15] the NPC was almost constantly visible till 2003 Feb 13, though Peach could not see it in good conditions on Feb 5.

BAA 1982–'84 data (for example) show that the polar hood masked the NPC from about Ls= 152–161° onwards, initially intermittently and CML-dependent. Such was the case in 2003. On Apr 11, Parker captured a tiny NPC under CML= 351° (Ls= 168°). Polar hazes were hard to see in 2003 Mar–Apr

owing to the low value of $D_e$, but occasional southward projections were caught as bright spots at the limb. Parker imaged tiny ones on Mar 8 and Apr 14 (Figure 15); their position angles are inconsistent with their being the NPC itself. Biver drew a hood on Mar 9 (Ls= 149°) and Mar 11, as shown on images by Van der Velden on Mar 14 and 29, as well as on Parker's of Apr 22–28. Thus by May there was a continuous, rarely symmetrical hood, often bluish, which during May–Oct was regularly displaced towards lower latitude over *Mare Acidalium*, particularly when this feature was near the morning limb/terminator. By November, *Acidalium* was hidden up to *Niliacus Lacus* in blue light. The hood was slightly effaced during the Jul and Dec regional dust storms.

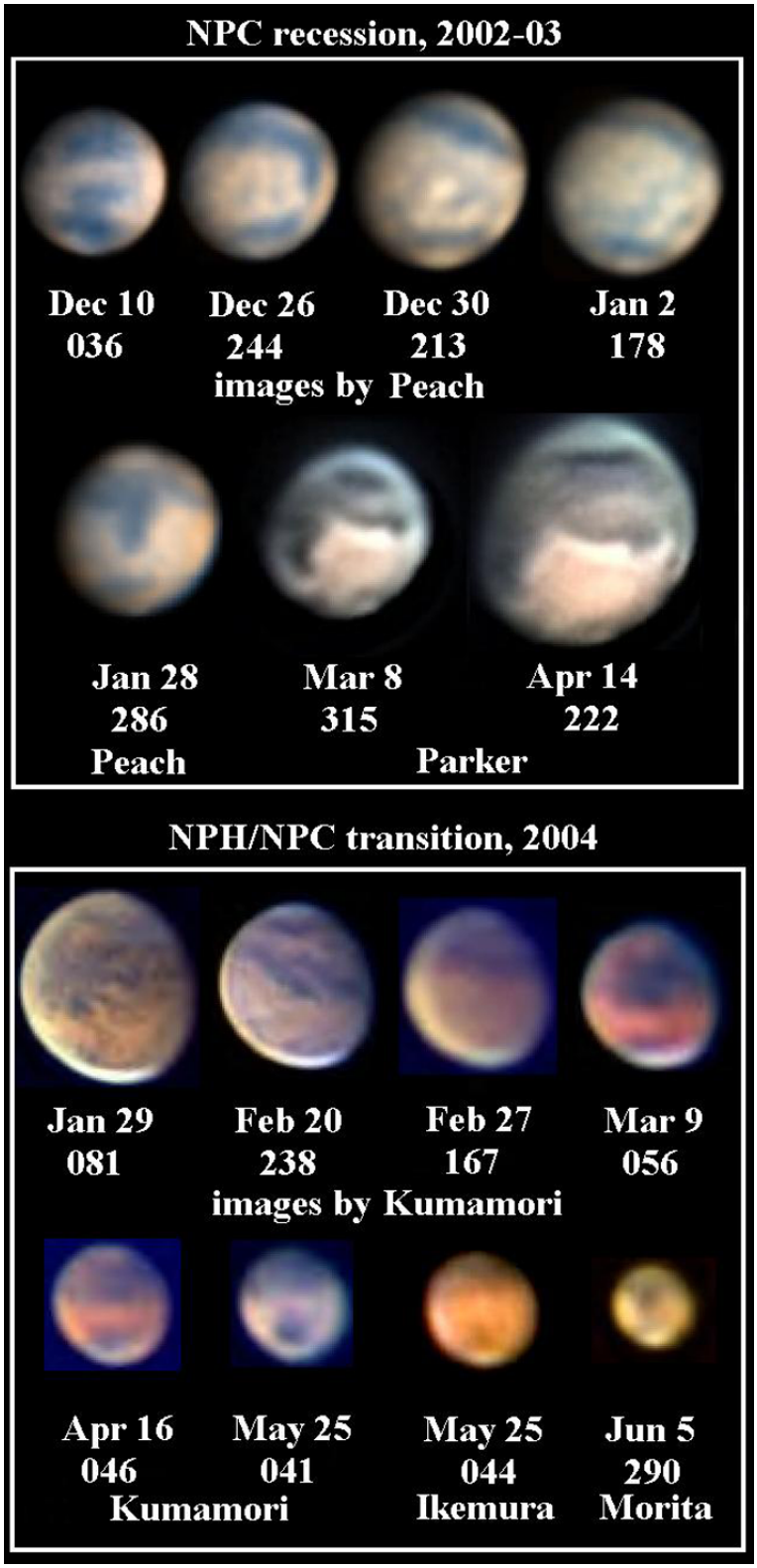


**Figure 15.** Images illustrating the N. polar cap recession in 2002–'03, and the transition of the NPH to the NPC, 2004.

The new N. polar cap began to appear from 2004 Feb 23 (Ls= 354°) onwards, when Parker and Warell (CML= 76–100°) imaged the cap bright in red light, and smaller than the overlying hood still visible in blue. Only a polar hood had been imaged by Parker on Feb 10, and sketched by McKim on Feb 22. From Feb 29 McKim's filter work confirmed its presence, up till his final view on May 13. Kumamori (from Feb 27 onwards) also took numerous images of the new NPC: see Figure 15. Morita obtained a sharp infrared image on Mar 9.

We have given several estimates of the seasonal transitions for NPC/NPH and NPH/NPC in past reports.[62] Quantitative work on the NPC recession in 2002 or 2004 from ground-based work was not possible, but Benson & James[71] compared *MGS* data from 2000 and 2002.

## South polar region

### SPC/SPH transition

A light SPH was apparent even on 2002 Oct 18, visible on and off into 2003 Feb despite unfavourable $D_e$. Not all times and longitudes showed it: for instance, to McKim on 2003 Jan 7 or 11 (CML= 140, 90°) it was not evident, but on Jan 31 (CML= 253°) it was light. By 2003 Mar the SPH was brighter and structured (with complex patches and northward projections to Biver, Mar 9; deviating N. on the *p*. side to Minami, Mar 13 and to Biver, Mar 25 (Figure 5E)).

On Mar 14 (Ls= 152°) Biver drew a sharply defined SPC. Parker imaged a hood on Mar 16. On Mar 20 Minami also saw the SPC, which by Mar 22 (Adachi, Minami) had acquired (by retreat of peripheral hood and martian wind action) a dark N. border. On Parker's images of Apr 14–Jun 5 (Figures 13A, 14) this border was exceptionally intense. (The dark surroundings of the cap, though less intense, persisted through June and August, fading to invisibility by mid-September, but by late September new dark areas, uncovered by the retreating cap, provided a patchy substitute.) Hood continued to haunt the new cap during March and April, sometimes penetrating *Argyre*. Biver on Apr 11 shows the SPH separated from *Hellas*, but obscure to the west; he saw a cap on Apr 16. Parker's images from Mar 29 confirmed the cap in red light, and from Apr 12 (Schmude) there was a dark border, even though a larger hood was visible in blue till Apr 21 (Ls= 172°). Adachi found cap and hood visible, Mar 22–Apr 6; from Apr 15, SPC only. To

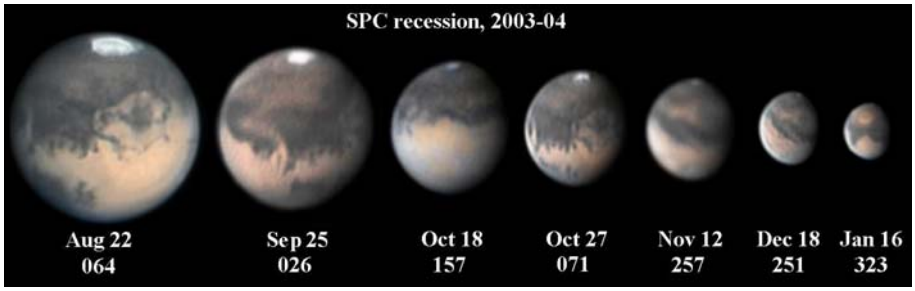


**Figure 16.** The recession of the S. polar cap after opposition. Images from 2003 Aug (56 million km; D= 25") to 2004 Jan (188 million km; D= 7"): 2003 Aug 22, 254mm SCT (f/55), La Palma; others 279mm SCT (f/31), UK. ToUcam Pro webcam. *D. A. Peach.*

summarise: hood only till Mar 13; then alternating cap and hood; then SPC only, Apr 12 onwards, with hood lingering in blue. A few isolated appearances of a partial SPH in blue were notable, particularly Jun 11–16 (Parker, over the NW part, CML *ca*. 50–100°). BAA 1988 data[9] showed the SPC also to have become hood-free by *circa* Ls= 172°. From late 2003 Jun the dark patches or rifts within the cap could also be imaged in blue-violet light (Figure 13A), proving a complete absence of hood.

### SPC recession and fragmentation

The S. part of the SPC was darker to Parker from Apr 16 and to Minami from Apr 17; the dusky area was distinctly orange to Adachi on Jun 7 and showed a warm tint in the images.

The diminution of the SPC with time was a striking feature of the apparition, and its decay following opposition is illustrated in Figure 16.

In Figure 17A we reproduce Antoniadi's general map of the SPC.[68] The main projections or outliers are *Argenteus Mons* (near long. 30°), *Novissima Thyle* (which includes the brighter *Novus Mons* (long. *ca*. 320°)) and *Thyles Mons* (long. 150°). The usual seasonal rift-pattern gradually emerged from the low/bright albedo interface, and Parker's May 4–15 images revealed *Rima Australis–Rima Angusta* as a diffusely darker rift, and on May 4 and 15 respectively the first signs of lighter, barely detectable patches within the cap periphery at *Thyles Mons* and the 'silvery mountain' *Argenteus Mons*. Collages of rifts and outliers feature in Figure 17B.

By late May the cap periphery was considerably brighter than the centre, its contour indented in places. Parker's Jun 1 images showed *Thyle I* and *II* as brighter areas. McKim saw *Rima Australis* well visually on May 26, *Dia* as a bright patch on Jun 2, and *Argenteus Mons* (already very bright) from Jun 13 (see Part I, Figure 3). By mid-Jun *Argenteus Mons* and *Thyles Mons* projected slightly at the edge, an effect later shown by *Thyle I* and *II*. The the *p*. end of the darker part of the *Rima Australis* (brownish in the best CCD images) seemed to begin at long. *ca*.160°: a very dark patch, *Depressio Parva*, was visible there from June 17 (Ng) onwards. *Depressio Parva* is shown in Valimberti's Jun 22 image (Figure 13A): it was very striking near CML= 170°, when it looked like a dark hole in the cap centre, and the same impression was given by *Depressio Magna* around CM= 270°. (Hence the ALPO's nickname for this SPC aspect: the 'lifesaver effect'.)

McKim on Jun 13 (Part I, Figure 3D) and 15 identified the location of *Novissima Thyle* at the SPC periphery, clearly outlined by *Rima Australis* curving towards – but not reaching – the edge, but at that time it was no brighter than the rest. To McKim on Jun 24 (Part I, Figure 3E) and 28 it showed up as a bright patch, which Parker (Jun 24) confirmed. On Jun 28 Grafton's image showed *Depressio Magna* as a small dark intensification in the centre of *Rima Australis*, which to McKim visually on Jul 28 (Part I, Figure 3F) had become large. By Jul 19–20 the *Rima Australis* rift (according to Hill, Meredith and others) had become visibly closer to detaching *Novus Mons* (the bright patch on the W. end of *Novissima Thyle*) from the cap, at least on the following side. McKim on Jul 28–Aug 2 found separation incomplete; however, at the start of the next UK presentation, from Aug 18 (Ls= 243°) onwards with *Novus Mons* at the *p*. limb he saw complete separation. Precise dating is always hard, and only the best observations, with the feature at the *p*. limb, are relevant. On this occasion the exact moment could not be observed from Europe. The first observers included Akutsu, Buda, Ikemura, Minami, Valimberti and Warell, during Aug 9–10 (Ls= 238°). BAA 1988 data[9] gave separation by Ls= 239°: an insignificant difference. Separation was beautifully seen by McKim on Aug 20, when *Novus Mons* seemed slightly veiled at the evening terminator. (Part I, Figure 3I) It seems (see 'Condensate clouds at the SPC edge') that the rapid sublimation of *Novus Mons* creates local evening condensate cloud. Further fragmentation of *Novus Mons* would soon produce the so-called *Mountains of Mitchell*.

The two ends of *Novus Mons* showed up as brighter to Minami, Aug 11, and on Aug 19 Yunoki found it split into a smaller *p*. component and longer *f*. one. On Aug 27 Zanotti caught a tiny fragment split off the *f*. end of the latter (Figure

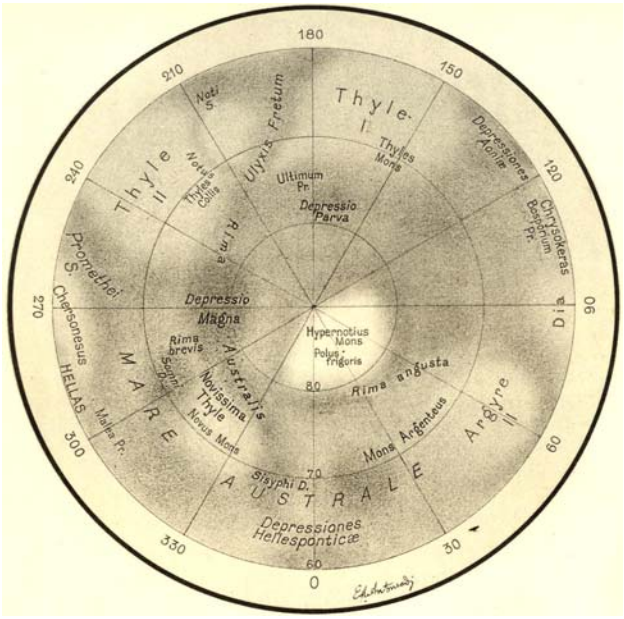


**Figure 17A.** E. M. Antoniadi's general chart of the S. polar regions, for nomenclature, based mostly upon his 1924 observations. (Ref. 68, Plate V.)

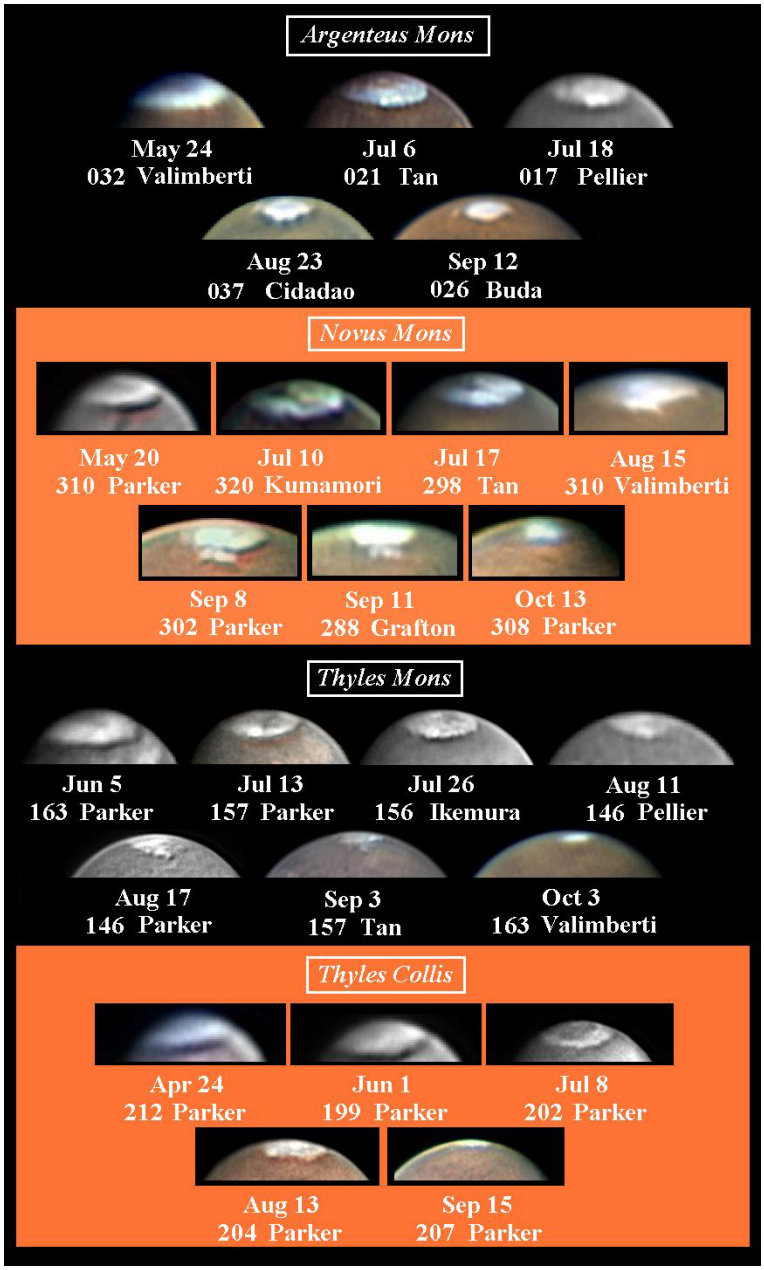


**Figure 17B.** The seasonal development of *Argenteus Mons, Novus Mons, Thyles Mons* and *Thyles Collis* at the edge of the SPC.

1A, Part I). The longer *f*. component looked very ragged with the Lick refractor to Sheehan in early Sep. Images by Grafton and Hatton on Sep 9–13 resolved three parts, owing to the division of the *f*. one (Figure 17B). By Sep 13 the *p*. component was tiny and about to disappear, probably last caught by van der Velden on Sep 22. The more obvious *f*. component persisted, shrinking daily, and was last seen on Sep 29 by McKim (Ls= 270°), who could not see it next day. Remarkably, in the highest resolution images of Oct–Nov (*e.g.*, Parker, Oct 13 (Figure 17B)), the location of these vanished snows showed up as a small albedo increase.

Returning to other longitudes, by mid-Aug, recession had brought *Rima Australis* closer to the cap edge, with *Depressio Parva* no longer distinguishable. Parker's image of Aug 13 shows *Thyle I* and *II* broken into a series of several small patches between the cap edge and the rift: Antoniadi's chart names their last remants *Thyles Mons* and *Thyles Collis*, respectively. (See Figure 17B.) The cap W. of *Thyles Mons* retreated quite suddenly as the receding cap edge reached the rift, leaving a progressively sharper inflexion (Aug 13–19). By Aug 25 (Parker) *Thyles Mons* (long. 150°) had become a small outlier, accompanied by *Thyles Collis* (long. 220°) by Sep 7. By Sep 15 (Ls= 261°, Parker) only the tiniest fragment of *Thyles Mons* could be seen, with the SPC north edge there displaced to higher latitude, and the whole cap eccentric with respect to the pole. The rapidly recessed part showed a warm colouration.

*Argenteus Mons* was a brilliant patch by late July; July/August data show it consisted of two parts (*e.g.*, McKim, Aug 20 (Part I, Figure 3I)). It had a deep rift on its *f*. side, initially a tiny indentation. *Argenteus Mons* was clearly recorded visually till Sep 1, its location identifiable as an SPC inflexion in Sheehan's Sep 4 sketch. It always retreats with the cap but is apparently not detached from the main body. *Rima Angusta* was still visible in early September. Eventually all the peripheral bright areas faded away. The general appearance of multiple bright spots at the periphery of the cap strongly reminds the writer of the drawings of Green (Madeira, 1877),[69] Graff (Berlin, 1924) and Fournier (Setif, 1924).[70] With the exception of *Novus Mons*, until 2003 these features had never been well captured in ground-based photographs or images.

A rift indented the shrinking summer cap at the 80–90° meridian from about Aug 13 to Oct 28, (as described in our 1988 Report[9] and, for instance, by Dollfus in 1956,[73] *etc*.). (See Figures 13A, 14, 16, *etc*.) By November it was reduced to a small indentation as the cap edge retreated on that side. The cap on the E. side of the rift was darker, and this part disappeared completely to leave only the brighter part, which Antoniadi (Figure 16) named *Hypernotius Mons*. Thus by November the SPC had been reduced to a single tiny summer remnant, eccentric to the rotational pole.

### Water-ice clouds at the SPC edge

Several images revealed short bright streaks of white cloud apparently blowing off the subliming SPC – especially whenever there was a sharp corner – during the period of fastest recession. These required highest resolution and represent, for ground-based imaging, a new phenomenon. An excellent example is the streak following the tip of *Novus Mons* on Valimberti's Aug 15 image (Figure 17B). We give the following list:

| *Date* | *Location* |
|---|---|
| Jul 4 | edge of SPC (Minami) |
| Jul 20 | from *Thyles Collis* (Minami) |
| Jul 24 | edge of SPC at CML =169° (Minami) |
| Jul 25 | from *Thyles Mons* (Minami) |
| Aug 3 | from *Argenteus Mons* (weak) (Akutsu) |
| Aug 4 | from *Argenteus Mons* (weak) (Minami) |
| Aug 12,14 | from *Novus Mons* (Minami) |
| Aug 13 | south of *Noachis* (Minami) |

Aug 15,19 from *Novus Mons* (Buda, Valimberti)
Aug 20 from *Novus Mons* (McKim)
Oct 19 south of *Noachis* (Minami, Van der Velden)

The drawn-out tip of the *f*. end of *Novus Mons* often appeared to produce the effect, but as with polar dust storms (see Part I), one had to be careful to distinguish a real phenomenon from the effects of poor image processing/compositing.

### SPC/SPH transition

Southern polar clouds north of the cap were detected by Haas on 2003 Nov 2, and Siegel on Nov 3, Dec 9. Gray on Dec 27 saw a bright cloudy streak N*p*. the cap under CML= 166°. The southern regional dust storm intervened just before the expected seasonal return of the hood. After Dec 28, settled dust from that event made the summer cap remnant impossible to see, and Parker captured only a diffuse glow on Dec 30. To Bowen the pole was intensity 0 on Dec 28 and 30, but no longer sharp or conspicuous. The 'SPR' was larger and less bright or sharp to McKim on five nights during Dec 28–Jan 24: apparently an impression of the cap blurred and faded by the storm. The true cap was again glimpsed visually by Adachi (2004 Jan 5, 6), Haas (Jan 2, 13), Minami (Jan 5, 9) and Parker (Jan 17–18 (confirmed by images)), Van der Velden just caught it on Jan 1, while Peach imaged it on Jan 24 and 27 (Ls= 340°) as a nearly dimensionless point.

From Jan 13 (Haas) a small, lightish SPH was seen to *cover* the polar region. This hood was confirmed by the work of Adachi (Feb 8), Adamoli (Feb 4), Kumamori (Jan 29 onwards; Figure 15), McKim (Feb 5, 19, 22), Minami (Jan 31, Feb 10), Morita (Jan 31), Parker (Feb 2–3, 10), Pellier (Jan 29) and Siegel (Feb 11), *etc.*, remaining visible through March. (After 2004 Mar, $D_e$ was positive.) Summarising: SPC before Dec 28; obscured by regional storm, visible only in the best seeing, Dec 28–Jan 13; hood and cap, Jan 13–27; hood only after Jan 27.

### Quantitative recession and mapping

The cap recession was measured from 1,081 of the very sharpest (mostly red) images over the range Ls= 156–340° (2003 Mar 23–2004 Jan 27). Up till Jul 20 (due to significant phase defect) the latitude of the N. edge of the cap was measured at the CM, and the E–W angular diameter thereafter. Fully detached parts of the cap were not included in the measurements. The resulting data, averaged in 5° Ls intervals, are shown in Table 3 and in Figure 18 where they are also compared with previous years. BAA 1988,[9] 2001 and 2003 results agree very well. Close inspection reveals some marginal, probably real, differences exceeding the standard errors in the points: thus the 1988 cap was very marginally smaller before Ls= 240°. *MGS* MOC data for 2001 and 2003 are also in good accord: the 2001 global storm having had virtually no effect upon overall cap recession,[71] though Cantor[43] adds that those parts of the cap that had been obscured by dust receded faster in 2001, and that the Mitchell Mountains were more extensively defrosted at Ls= 262° in 2001 than neighbouring years. Historical enquiries suggest that the cap in 2001 and 2003 was rather larger than in some previous decades.[21] Classical results of Antoniadi,[72] Dollfus,[73] Slipher[74] and others invite comparison. McKim's 'Fournier polar spiral' for 2003 was published earlier.[34]

The 2003 apparition was the first in which amateur images captured SPC rifts in intricate detail, as shown in Figure 17B. Good stereographic polar plots were constructed from similar datasets by Nakakushi *et al.*,[18] and Tanga.[20]

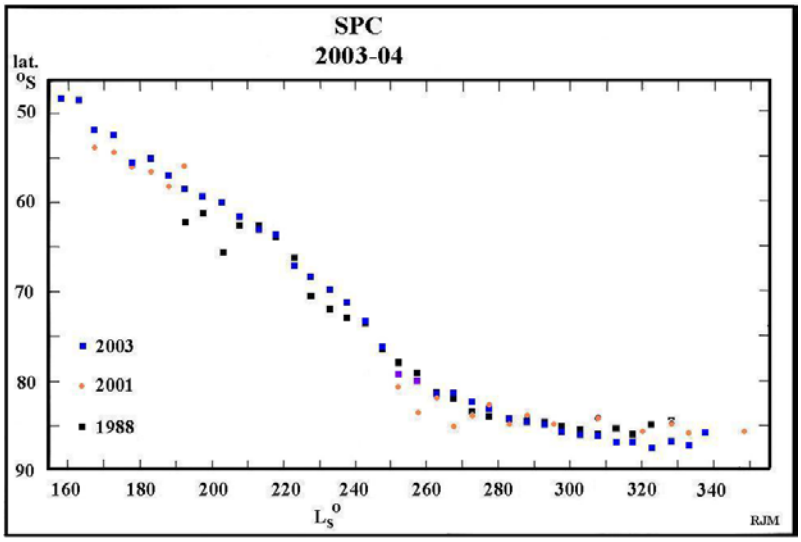


**Figure 18.** SPC recession 2003–'04 compared with previous BAA results for 1988 and 2001.

**Table 3. SPC latitude measurements, 2003–'04**

| *Mean Ls (°) on images* | *Mean latitude of N. edge of cap (°)* | *No. of measures* |
|---|---|---|
| 158 (*e.g.*,156–160°) | 48.2 | 3 |
| 163 | 48.4 | 2 |
| 168 | 51.8 | 8 |
| 173 | 52.4 | 13 |
| 178 | 55.6 | 20 |
| 183 | 55.2 | 11 |
| 188 | 57.0 | 25 |
| 193 | 57.7 | 41 |
| 198 | 59.0 | 45 |
| 203 | 59.8 | 40 |
| 208 | 61.6 | 50 |
| 213 | 62.8 | 43 |
| 218 | 63.7 | 66 |
| 223 | 67.1 | 58 |
| 228 | 68.2 | 48 |
| 233 | 69.6 | 64 |
| 238 | 71.1 | 48 |
| 243 | 73.3 | 57 |
| 248 | 76.2 | 74 |
| 253 | 79.4 | 36 |
| 258 | 79.9 | 52 |
| 263 | 81.1 | 53 |
| 268 | 81.1 | 29 |
| 273 | 82.3 | 24 |
| 278 | 82.9 | 38 |
| 283 | 84.2 | 22 |
| 288 | 84.5 | 12 |
| 293 | 85.0 | 24 |
| 298 | 85.8 | 9 |
| 303 | 86.1 | 18 |
| 308 | 86.4 | 8 |
| 313 | 86.9 | 13 |
| 318 | 86.8 | 22 |
| 321 | 87.3 | 1 |
| 328 | 87.0 | 1 |
| 333 | 87.5 | 1 |
| 338 | 86.0 | 2 |
| | *Total* | 1,081 |

## Lunar occultations

A lunar occultation on 2003 July 17 was not visible from the UK. Observations came from Beish[31] and

Parker, who joined an IOTA/ALPO expedition located at 27° 17'.92 N, 81° 03'.19 W in eastern Highlands County, Florida, USA, where the event was grazing, and also from Phillips. Another event on Oct 6, observable from Australasia, was reported by Valimberti. Both events involved the same part of the lunar limb (Figure 19).

## The martian satellites

2003 provided exceptional opportunity for catching Phobos and Deimos. They were relatively easy to see with 0.4m (*e.g.*, to Biver (Figure 20A), Minami, Miyazaki and Storey) near elongation, and obvious at first glance with the Lick refractor. Akutsu, Gavin,[75] Ikemura, Melillo, Seip, Sussenbach and Violat Bordonau (Figure 20B) captured the satellites with 20–32cm apertures.

### *Brightness*

From his favourable low latitude, Henshaw recorded visual magnitudes from 2003 Mar to 2004 Jun in very close accord with the *Handbook*.

## Remembering 2003

We celebrate this great opposition of 2003 with a collage (Figure 21) showing many observers and their telescopes.

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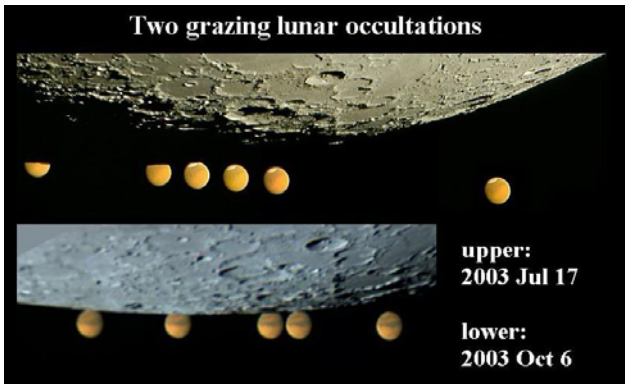


**Figure 19.** Two grazing lunar occultations of Mars. *Top row*: 2003 Jul 17d 08h 17m to 08h 33m, 152mm refl., ToUcam Pro. *J. D. Beish & D. C. Parker*. (See text for details.) *Lower row*: 2003 Oct 6d 16h 32m to 16h 39m, 356mm SCT (f/11), ToUcam Pro. *M. P. Valimberti*. (Melbourne, Australia.)

**Figure 20A.** Deimos (far left) and Phobos on 2003 Aug 24d 00h 17m, CML= 009°, 407mm refl. ×700. *N. D. Biver*.

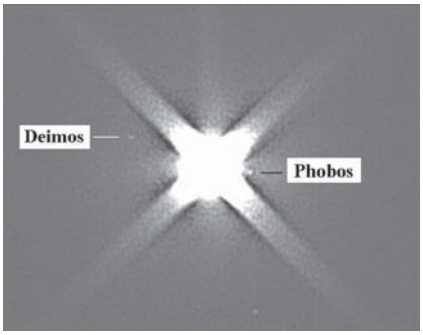


**Figure 20B.** Martian satellites imaged on 2003 Aug 27d 04h 05m, 203mm SCT (f/10), Starlight Xpress MX5 camera & Johnson V filter, 20s. *F. A. Violat Bordonau*.


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*Received 2009 July 5; accepted 2009 October 28*

### Erratum – Part I

In Part I of this paper (2010 October *Journal*), J. Melka observed from Chesterfield, Missouri, USA and not as stated in Table 1.

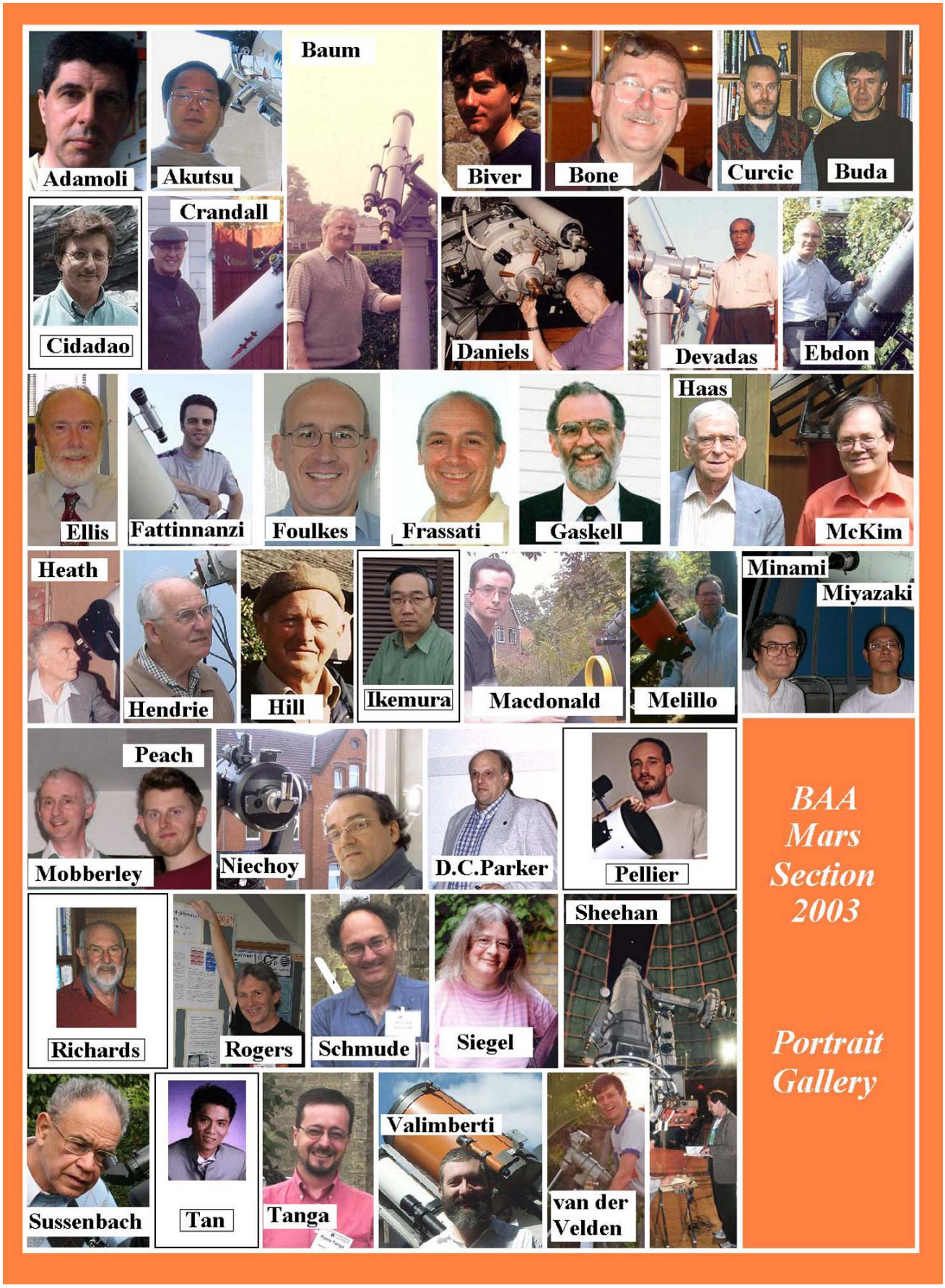


**Figure 21.** Gallery of Mars observers and telescopes, 2003.