The opposition of Mars, 2014: Part II

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

In Part II we describe the usual seasonal meteorological indicators such as the *Tharsis* orographic clouds and the Equatorial Cloud Band (ECB). The ECB was observed to be complete during *Ls* = 051 to 145° and observations of the *Syrtis* Blue Cloud were frequently made. In 2014 the N. polar spiral clouds at the edge of the summer cap were particularly well observed from *Ls* = 117°. Their morphology was observed to change with time, and those clouds over *Baltia* occurred seasonally earlier than similar features over *Utopia.* The transition from N. polar cap to hood occurred during *Ls* = 153 to 162°. The early stages of the recession of the N. polar cap occurred too close to solar conjunction to be well observed, but the later stages were followed quantitatively and the data compared with previous years.

White clouds & blue-violet light phenomena

We deal briefly with meteorological indicators; much detail was given in the last report.[1] The Director's drawings illustrate the changing meteorology in Figure 12, the N. polar spiral clouds are shown in Figures 13A–C and the Equatorial Cloud Band is shown in Figure 14.

Equatorial Cloud Band (ECB)

The ECB commences near *Ls* = 0°, but the great distance of the planet then (2013 Jul 31) rendered it unobservable. The already partly-formed ECB was first noted on 2013 Sep 19–23 (*Ls* = 024–026°) by Morita and on Oct 6 by Peach, brighter in the evening over *Chryse–Xanthe*. On Nov 18 (*Ls* = 051°) the ECB was probably complete on Parker's blue image, again brighter over the evening *Xanthe–Tharsis*. Visually, Haddon recorded the ECB as a thin, incomplete streak on Sep 27 and Oct 19, which had broadened by Oct 29. At its peak, in blue light the ECB often veiled *Syrtis Major*. For general views see Figures 12A–D, G & H, 13A & C, and 14.

As in 2012, the highest-resolution blue images showed considerable fine, fibrous structures within the ECB at its height, like terrestrial cirrus: see Figure 14B–C. Furthermore, tiny bright patches of cloud were sometimes noticed even in integrated light, over locations which would have been unusual in the absence of the ECB. For

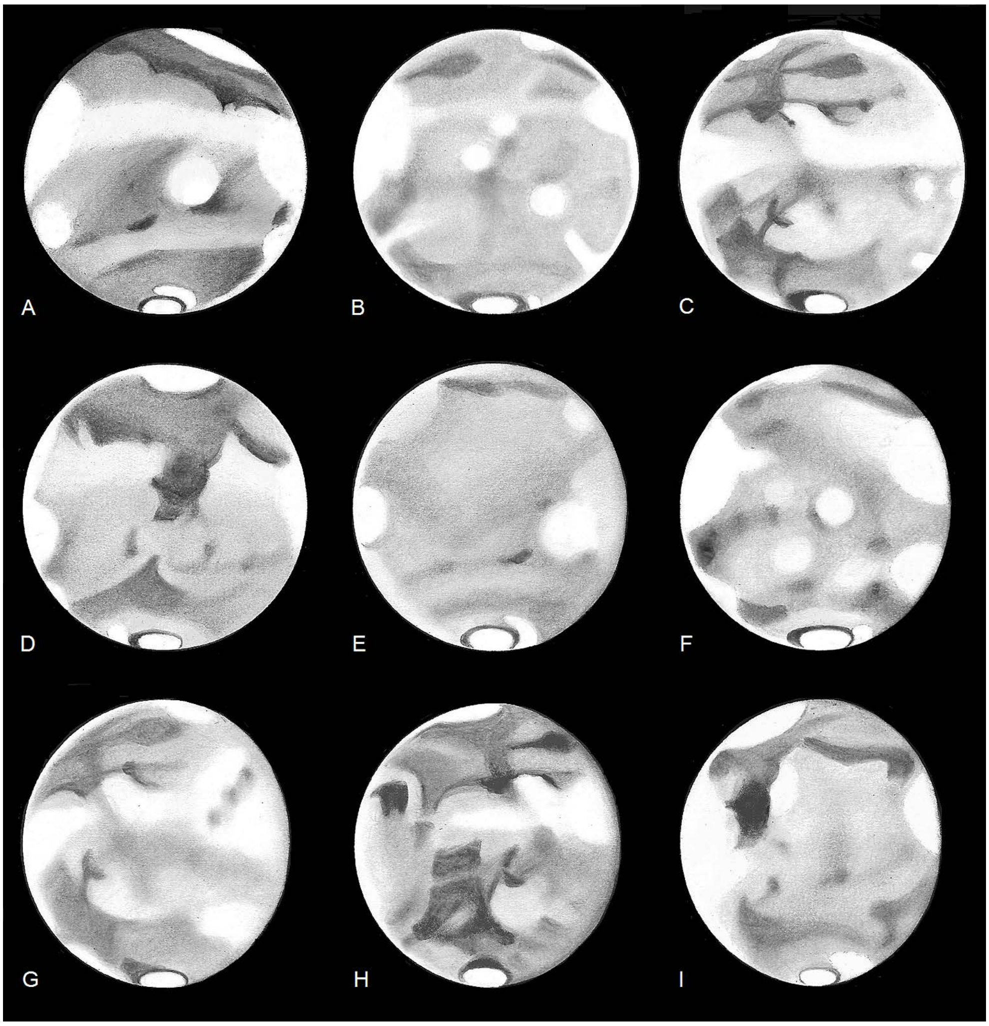


Figure 12. Drawings of Mars in 2014 by R. J. McKim (410mm DK Cass., ×265, ×410, white light (integrated; INT) and with W23A orange filter).

(A) 2014 Mar 22, 23:30 UT, CM = 212°. Orographics: *Olympia*; ECB faint in INT (and in (B) & (C)).
(B) 2014 Mar 31, 21:55 UT, CM = 110°. Orographics: *Ascraeus* and *Pavonis Mons* clouds the brightest of the *Tharsis Montes*; *Solis Lacus* dark.
(C) 2014 Apr 4, 22:10 UT, CM = 078°. In very good seeing even the tiny *Juventae Fons* was seen; slight whiteness at *Argyre*.
(D) 2014 Apr 19, 20:15 UT, CM = 280°. *Hellas* brilliantly white; *Elysium* p.m. cloud; *Olympia*.
(E) 2014 May 2, 20:20 UT, CM = 166°. Large a.m. cloud over *Elysium* and environs.
(F) 2014 May 7, 20:45 UT, CM = 128°. *Olympus Mons* near the CM mostly obscured by its orographic cloud; *Hyperboreus Lacus p.* the NPC.
(G) 2014 May 11, 20:45 UT, CM = 092°. *Tharsis Montes* as dark spots within extensive a.m. cloud.
(H) 2014 May 16, 20:50 UT, CM = 048°. *Argyre* is light; ECB still partly detectable in INT; note detail in and around *Mare Acidalium*.
(I) 2014 May 25, 20:40 UT, CM = 326°. Small *Aeria* p.m. cloud; *Ismenius Lacus* well visible but very small. *Hellas* still bright; polar cyclonic cloud NE of *Mare Acidalium*.

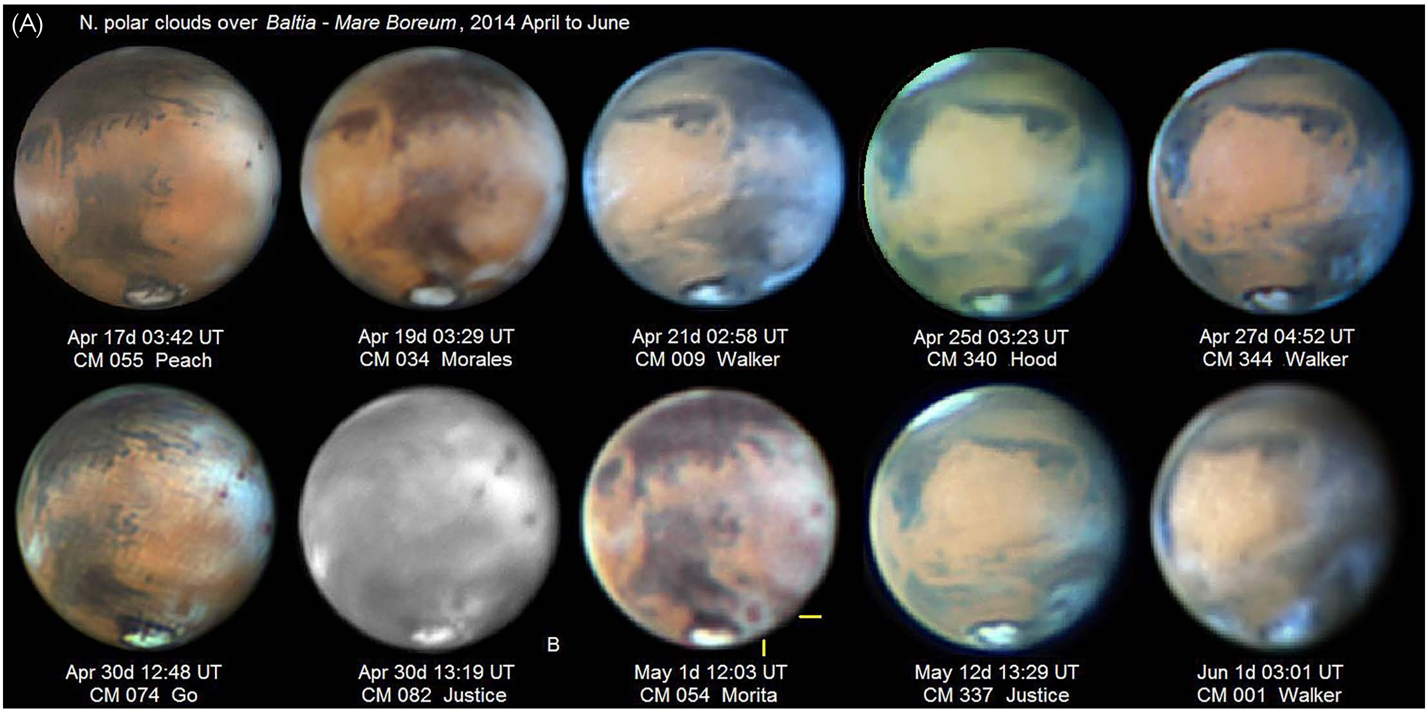
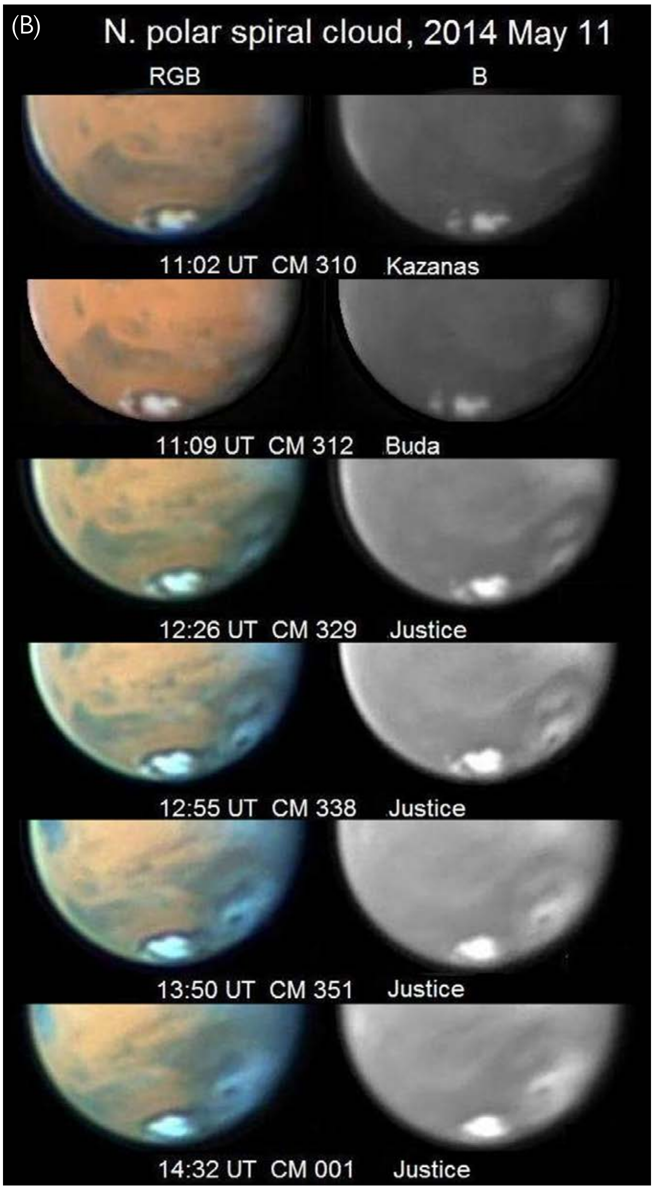


Figure 13. (A) Daily changes in the N. polar spiral clouds over *Baltia*, 2014 April to June, according to C. Go (Skyris 132M camera and 355mm SCT), M. Hood (200mm OG and ASI120MM camera), M. Justice (305mm refl. and DMK21AU618 camera), E. Morales (Flea 3 camera and 310mm SCT), D. A. Peach (355mm SCT with SKYnyx 2-0M camera) and G. Walker (254mm OG and Flea 3 camera). On May 1 the polar cloud (indicated for that date) first revealed a definite spiral character.

(B) Image sequences to show the diurnal development of a N. polar spiral cloud on 2014 May 11, according to S. Buda (405mm DK Cass. and DMK21AU04 camera), M. Justice (305mm refl. and DMK21AU618 camera) and J. Kazanas (318mm refl. and ASI120MM camera).

(C) ***[p.107, opposite]*** N. polar clouds over *Utopia*, 2014 May to June, according to L. Aerts (355mm SCT and DMK 21AU618 camera), H. Einaga (300mm refl. and ASI120MM & MC cameras), W. Flanagan (355mm SCT and Flea 3 camera), T. Kumamori (279mm SCT and ASI120MC camera), P. W. Maxson (250mm DK Cass. and ASI120MM camera) and T. Olivetti (410mm DK Cass. and Flea 3 camera). These clouds were seen to peak in size in late May and early June.



instance, Pellier on Mar 13, Parker on Mar 17 and Peach during Apr 19–22 saw one such fragment in northern *Aeria*, at the N. edge of the ECB. Peach on Apr 14–18, Milika & Nicholas on May 3 and Pellier on May 14–15 saw small white clouds over SW *Cydonia*, while Parker imaged another in NE *Arabia* on May 29. In Part I we mentioned a small, bright projecting terminator cloud seen on Apr 7–9.[1] All these lay within the latitudes and timespan of the ECB.

The ECB remained complete on Jun 6 (Parker) & 12 (Flanagan). On Jun 18–20 McKim saw a weak remnant under CM ~100°, and Olivetti showed it weak and interrupted on Jun 21 & 28, though still largely obscuring the *Syrtis* in blue light. Thus it was complete until around Jun 12: from Ls = 051 to 145°. The corresponding period in 1999 for complete ECB was from 050 to 145°,[10] with 1997 very similar: a closely defined seasonal event.

The *Syrtis* Blue Cloud

As with the ECB, the planet was too distant to catch the commencement of this feature, but it was very well seen later, and recorded for certain from 2014 Jan 6 to Jun 12 (till *Ls* = 145°): see Part I, Figures 2 & 4. As in 2012, one or more discrete clouds were sometimes seen over the central latitudes of *Syrtis Major*, cutting across it at the evening limb (Figure 13A and Part I, Figures 2G & H).

Orographic clouds

Elysium Mons

See Figures 12 & 13C and Part I, Figures 2, 4 & 6. *Elysium* first appeared whitish on 2013 Sep 18 (*Ls* = 023°) to Gray, on Sep 20 to Peach and on Oct 2 to Maxson, in the evening. Brightening over time, its orographic cloud had become conspicuous by late December, remaining bright through opposition into early June. It was still fairly bright near the evening limb to Olivetti on Jun 28 (*Ls* = 153°). Later observations hardly reveal its presence.

At the last two oppositions it had first become visible as a light spot on the evening side at *Ls* = 020°.[1]

Olympus Mons

Olympus Mons was first seen to be associated with weak orographic cloud in the afternoon, to Kardasis on 2013 Sep 28 (*Ls* = 028°) and Gray on Sep 30 (Part I, Figure 4B). It remained weak throughout October, but was more conspicuous by Nov 19 (Maxson).

The cloud remained very bright in the afternoon and evening for many months into 2014 early May, but by mid-May it was less conspicuous. See Figures 12A–C & F and 13C, and Part I, Figures 4 & 6. It was still conspicuous to Maxson upon the evening limb on Jun 20 (*Ls* = 149°), but was barely recognisable – only vaguely light – to Barry, Kumamori and Olivetti, Jun 30 – Jul 4.

The first sign of orographic cloud here during the past two oppositions was during *Ls* = 016–019°.[1]

The *Tharsis Montes*

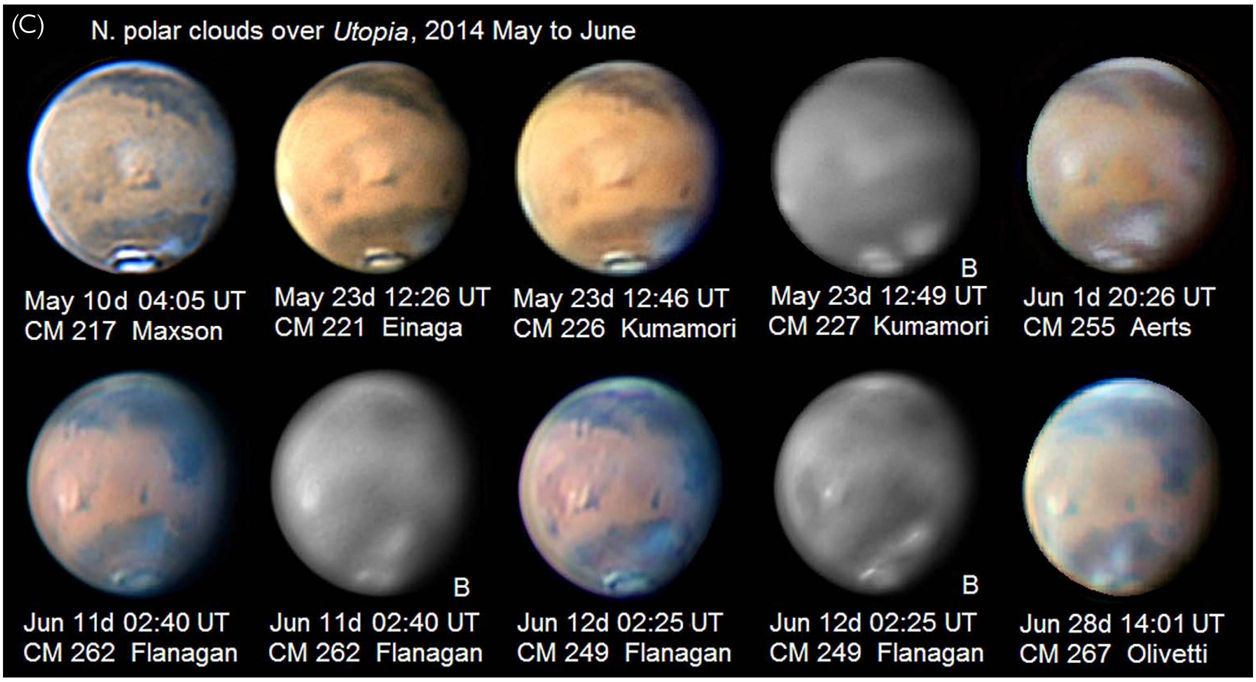
The seasonal start of the *Montes* clouds fell before the first observation in 2013. The clouds were weakly imaged by Morita as early as 2013 Sep 19 (*Ls* = 024°) to 22, and by Kardasis on Sep 28, though not yet separately resolved. Gray sketched a weak evening cloud at *Ascraeus Mons* on Sep 30 (Part I, Figure 4B). The evening clouds remained weak during October, but were considerably brighter to Maxson on Nov 19, who resolved all three. They were very well seen by 2014 February, though by that time the cloud at *Arsia Mons* had weakened relative to the more northerly two. Other views are shown in Figures 12A–C & E–F, and Part I, Figures 4 & 6.

As in 2010 and 2012, the orographic cloud over *Arsia Mons* was seen to be the first to seasonally disappear, while *Pavonis Mons* and *Ascraeus Mons* (and *Olympus Mons*) remained cloud-covered. For example, Buda on Mar 19 (Part I, Figure 4F) showed the *Arsia* cloud faint, though the streak of cloud running south towards it from *Pavonis Mons* remained conspicuous. To the Director on Mar 22, cloud covered all three *Montes* upon the evening terminator (Figure 12A), but during local mid-afternoon on Mar 31 he could only see the cloud streak running towards *Pavonis*, though the other *Montes* were already covered by bright orographic clouds (Figure 12B). In April, the *Arsia* cloud could only be seen very close to the evening limb. The last sightings of it there were by Bosman, Pellier and Tyler on May 2–4: the cloud was extremely small by then.

The inaccessibility of the evening terminator meant that the *Montes* could be observed only till local early afternoon: under these circumstances the *Ascraeus* and *Pavonis* clouds remained visible until May 29 (Justice), with the *Ascraeus* cloud then still the larger and brighter.

Alba Patera

The seasonal start of the *Alba* cloud would have occurred too early for observation in 2013. *Alba* was first seen to be covered by



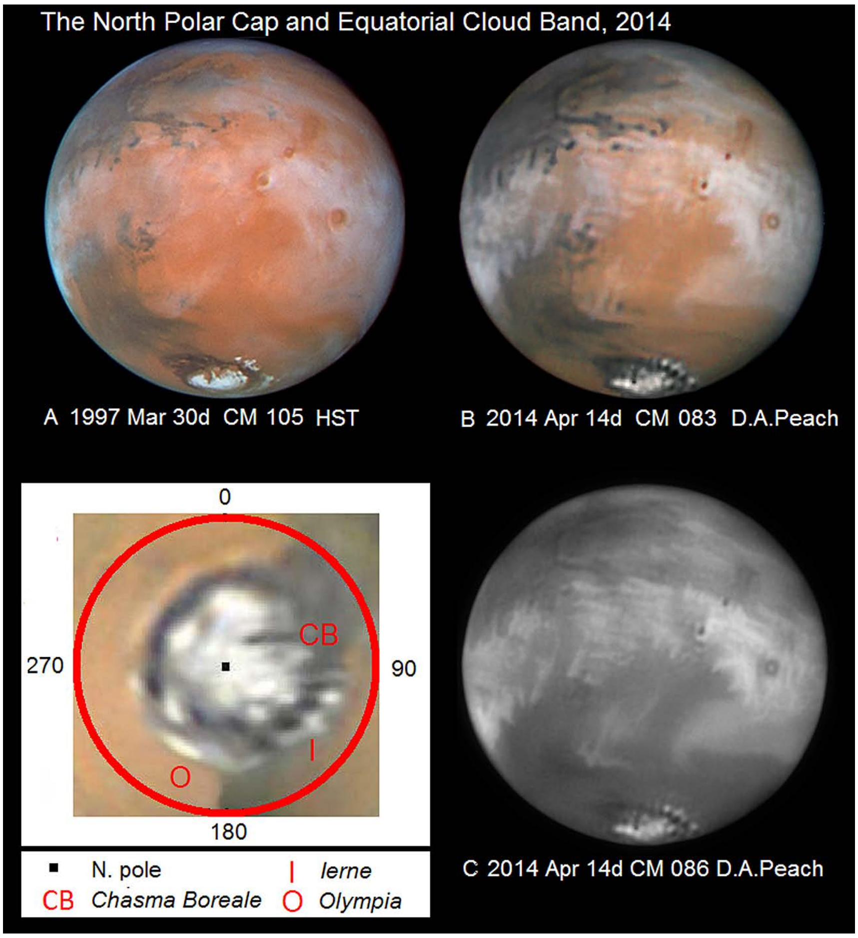


Figure 14. The N. polar cap and the Equatorial Cloud Band, 2014.

(A) 1997 Mar 30, CM = 105°, *Ls* = 97° *(HST image).* (A) and (B) compare ground-based and HST images at similar CML and seasonal date; the fragmented appearance of the outlier *Ierne* is just one point of interest.

(B) 2014 Apr 14, 03:51 UT, CM = 083°, *Ls* = 116°. 355mm SCT with SKYnyx 2-0M camera. *(D. A. Peach)*

(C) 2014 Apr 14, 04:04 UT, CM = 086°, *Ls* as (B). Also shown is a N. polar projection map, 2014 Apr 15–28. *(D. A. Peach)*

weak orographic evening cloud on 2013 Sep 28 (*Ls* = 028°). By mid-November it had brightened enough to be visible from early afternoon, and it was large and bright in the evening. It was still comparable in size and brightness with the *Olympus Mons* cloud to Maxson on Dec 28–31.

Alba weakens at an earlier season than the other orographics, and it was already much fainter by early February of 2014 (see Part I, Figure 6), remaining small and faint throughout March (Part I, Figure 4F). It again appeared bright, but small, after mid-April (Part I, Figure 4E), and in May – especially during May 14–16 (Maxson, Morales, Walker) – when it seemed to recover somewhat to rival the *Montes* clouds, and even sported a double cloud on May 16. It was still quite bright – but small – in June, and was last imaged on Jun 19–20 by Maxson and Walker. No later image showed it bright.

Opposition brightening of the volcanoes

As in 2012, the volcanoes were cloud-covered around opposition and so no special brightening of their slopes was seen.

The morning Montes

The *Tharsis Montes* and *Olympus Mons* were seen as conspicuous dark patches amidst a sea of morning white cloud from 2014 Mar 6 (Pellier) till Jun 29 (Parker), though only weakly by the latter date. See Figures 12G, 13A & 14, and Part I, Figures 3 & 7. Naturally, once the ECB had decayed after mid-June they were never again conspicuous, though they could still be detected as smaller, lower-contrast spots.

N. polar clouds

Spacecraft data tell us that in northern summer the winds at the S. edge of the north polar cap (NPC) blow to the west, but further south the wind direction is to the east. Warmer air to the south of the polar cap is lifted above the colder, denser air to the north, and white cloud forms as it cools; over a certain narrow range in *Ls*, the velocity difference leads to the formation of spiral-shaped clouds. In 2012, the season for the spiral clouds came right at the end of the apparition.[1] 2014 was therefore highly favourable.[13] These clouds are only well observed in the early morning, and rotate with the planet, fading by local noon as they are disrupted by solar heating. They can become strikingly bright in blue-violet images and appeared bluish-white (like the north polar hood or NPH) visually. Such clouds are best observed over the longitude range λ ~ 0–100°, but *Utopia* in the opposite hemisphere is also favoured by the same type of feature. Over 200 sets of images showed these features. See Figure 12I, 13A–C and Part I, Figures 2A & C.

First detected in 2014 April over *Baltia – Mare Boreum*, these polar clouds initially looked simple. Peach on Apr 16–18 recorded a mere curved wisp of cloud *f. Mare Acidalium*, which appeared at the same longitude each day. It extended into a long, bright streak each morning, and was strikingly bright on Apr 19–21 to Morales (Figure 13A), Peach, Walker (Figure 13A) and Willinghan. Next the cloud became more complex, with several bright fragments, sometimes curved. On Apr 27–30 Buda, Curcic, Einaga, Go, Justice, Kumamori and Valimberti showed a partially complete circle with a darker centre. Then on May 1–4 Akutsu, Go (Figure 13A), Morita and Weldrake showed the complete circle. These critical moments were observable only by those in Australia and Japan.

Schmude studied the motion of this cloud from MGS images during Apr 29 – May 6 and obtained an eastward drift rate of 6.1km/h.[15]

By May the spiral clouds were fully developed. On May 11, Konnai at the eyepiece saw an apparent indent at the morning terminator that marked the dark centre of such a cloud (as imaged by Barry in 2012):[1] see Part I, Figure 2C. We show the diurnal change in this cloud for the same date in Figure 13B.

Most unusually, a small cloud over *Baltia – Mare Boreum* was observed near local noon (near the *p.* limb) on Apr 22–23 by

Kumamori and Morita, and on May 2–4 by Bosman, Kardasis, M. R. Lewis, Pellier, Sussenbach and Tyler.

The observed date range for the clouds at these longitudes was Apr 16 to Jun 1 (*Ls* = 117–139°), with Walker showing a very bright but highly condensed feature at the E. side of *Baltia* on the last date (Figure 13A). Clear evidence of spiral structure was shown only during May 1–14 (*Ls* = 124–130°), though it did not always involve an absolutely complete circle. In 2012 the polar clouds here were observed from *Ls* = 116°,[1] but they only exhibited spirality from *Ls* = 129°.

Pellier on May 14 & 15, in his R and RGB images, captured a striking anomalous darkening in *Tempe*. It took the form of a round, reddish spot, like the calderae of the *Tharsis Montes*, then visible in the morning. Blue light work showed it was the core of a cloud, fading during the morning. He wrote that the May 14 images showed two to three successive cloud fronts with a cloud-free area (a darkening in blue light) preceding the advancing fronts, and the second of these dark areas was the anomaly mentioned. The leading cloud was observed to be advancing from *Tempe* into W. *Mare Acidalium* over several hours: Pellier has an animation online.[31] The anomalous dark spot was seen by others between May 10 and Jun 3, including visually by the author on May 16 (Figure 12H).

Large polar clouds at about the same latitude, but rarely of an obviously spiral form, were widely seen at a slightly later time period over *Utopia* (Figure 13C and Part I, Figure 2A) during May 6 to Jun 28 (*Ls* = 126–153°). They were often large and very bright near the morning terminator, particularly so in late May and early June, but rarely persisted for long into the day. However, on Jun 4 & 5 Maxson and Walker showed them at the *p.* limb, near local noon.

On May 23, Einaga, Kumamori and Iwamasa clearly recorded a dark centre in a *Utopia* cloud, and on a few occasions after mid-June an arc of white cloud was noticed. On Jun 15–20, Maxson's images showed a very bright arc-shaped polar cloud interacting with (or commencing at?) the W. end of the polar outlier *Olympia*. On Jun 21 Olivetti imaged a polar cloud over *Cecropia*, further west than *Utopia.* Odd-shaped N–S elongated streaks were recorded by Flanagan on Jun 11 & 12 and by Olivetti on Jun 28 (Figure 13C). But they marked the finale for, on the latter date, the formation of the polar hood was beginning and any later cloud features could only have been part of that hood.

Polar regions

North polar region

The behaviour of the NPC could be studied during MY 32, including its seasonal retreat and the development of surrounding and overlying clouds. Polar dust storms have already been discussed in Part I.[1]

Table 3. NPC latitude measurements, 2013–'14

Mean Ls (°)	*Latitude of S. edge of cap (°) on images**	*No. of measures*
013 *(i.e.,* 011–015°)	61.9	2
018	60.6	3
023	64.1	9
028	66.7	9
033	67.6	9
038	68.0	6
043	68.3	8
048	70.3	4
053	73.1	6
058	73.0	4
063	73.7	5
070.5**	75.8	7
078	80.5	5
083	81.1	35
088	80.8	21
093	79.4	22
098	80.9	51
103	80.9	48
108	80.6	49
113	80.0	84
118	80.6	140
123	81.5	89
128	80.4	80
133	83.4	42
138	82.8	33
143	83.4	20
148	81.6	10
153	81.1	14
158	84.1	9
163	82.1	4
Total:		*828*

* As usual, we do not include cap outliers in our measurements once fully detached.
** Averaged over *Ls* = 66–75°.

Activity in the NPH & the NPH/NPC transition

The closing stages of MY 31 fell too close to solar conjunction for any useful record of NPH dispersal. Gray on 2013 Aug 13 (*Ls* = 006°), Maxson on Aug 16 and Abel on Sep 5 recorded the freshly uncovered cap with its darker border. None of these early observations showed any sign of a lingering NPH, even in the longitude of *Mare Acidalium*.

Images by Hood, Morita and Peach on Sep 19–20 already showed the cap slightly darker along the north limb. Then Peach on Oct 6, Aerts on Oct 20 and Dec 3, and Walker on Dec 11 resolved the NPC annular rift, with Hood producing the clearest rendition on Dec 19.

North polar fronts ('cascades')

We mentioned in the 'Dust storms' section of Part I that streaky clouds had run far to the southwest from the freshly detached *Olympia* in 2014 January and February. These features seem to have involved both dust and white cloud, so they also might be included under the heading of 'banner clouds', or 'cascades' as we have designated them in the past. In 2003, for example, streaks of white cloud blowing off sharper-edged features near the S. polar region – such as *Novus Mons* – were visible at times upon the best images.[32]

We also mentioned in Part I how a southward surge of activity from the N. polar region around May 31 – Jun 2 had apparently triggered a dust storm at *Valles Marineris.*

NPC fragmentation

The cap south of the annular rift (see earlier) evaporates to leave the usual outliers *Olympia* and *Ierne*. The *Chasma Boreale* rift was easy to observe. See Peach's polar projection map in Figure 14C.

To Hood on 2013 Dec 19, *Olympia* was a brighter, slightly protruding area within the outer ring of the cap. Parker on Jan 6 (*Ls* = 072°) & 14, and Hood on Jan 15, were the first to see it fully separated. Compare 2012 (*Ls* = 70°),[1] 2010 (*Ls* = 74°), 2008 (*Ls* = 72°) and 1995 (*Ls* = 70°). As in 2012, separation was marked by local dust activity, and the new outlier showed a tapering W. end. From around Apr 13 there was a fading towards its W. end, cutting off that part, which then dissolved into one or more fragments, observed till late May. *Olympia* was still visible when the area began to be covered by the polar hood. The Director's drawings also show it (Figure 12).

Opposition time was ideal for spotting *Ierne*, a smaller and more elusive fragment from the seasonal cap ring, and narrow in terms of latitude. It was seen detached during Feb 4 – Jun 20 (Part I, Figure 3E–G and 4E–H), and in March–May it was often resolved into a string of fragments. Peach on Apr 14–20, in several very high-resolution images, showed about half a dozen components (see Figure 14, with a *Hubble Space Telescope* (HST) comparison at a similar central meridian longitude and season).

In 2014 April, high-resolution images also showed the formation of a rift that cut off a small section of the edge of the cap from λ ~ 270–340°. The rift was complete by Apr 24, and is shown in Peach's polar map (Figure 14C): the area of this detached part was observed to diminish during May. At low resolution this ground-coloured rift gave the misleading impression of dust obscuration over the cap. Comparison with a seasonally slightly later HST polar map (in the 2012 report;[1] Part I, Figure 5) shows that area largely sublimed away.

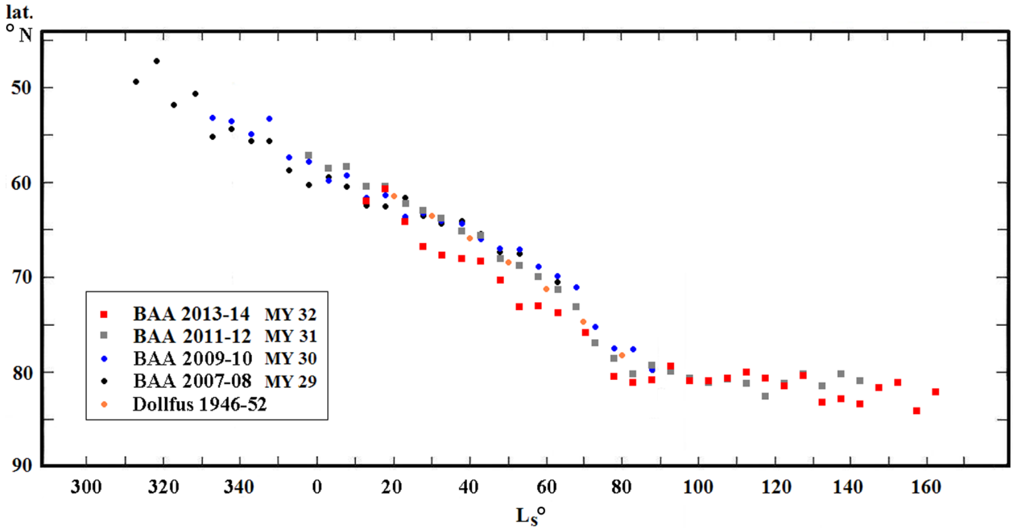


Figure 15. The recession curve of the N. polar cap during 2013–'14 compared with selected earlier work. Plotted points are 5° means in *Ls*. *(R. J. McKim)*

NPC recession

The very early recession curve for MY 32 could not be accessed. 828 images by 51 observers could be satisfactorily measured for the latitude of the S. edge of the cap at the CM during 2013 Aug 28 – 2014 Jul 15 (*Ls* = 013–162°). Averages in 5° intervals of *Ls* feature in Table 3 and Figure 15. (In contrast to 1999,[10] we have not illustrated the subsequent increase in size of the bright area due to the formation and southward expansion of the NPH.) The cap recessions in 2007–'08 (MY 29), 2009–'10 (MY 30) and 2011–'12 (MY 31),[1] together with older work by Dollfus,[33] are also plotted in Figure 15.

During *Ls* ~ 020–070° the early spring cap recessed faster than usual, reaching the summer remnant stage ahead of schedule to leave a small asymmetric fragment. The 2014 summer remnant cap was close to its latitude in 2012. Successive averages reveal some scatter due to bias in longitudinal sampling, but demonstrate a slow retreat continuing right up to the commencement of the polar hood at *Ls* = 153°:

Ls range (°)	*Average lat. (°) ± std. dev. (°)*
076–105	80.6 ± 0.7
106–135	81.1 ± 1.2
136–165	82.5 ± 1.2

Spacecraft data for MY 29–31 have also been published.[34]

The return of the NPH

The NPC was crisply defined at all longitudes up to 2014 Jun 27, though sometimes the polar cloud activity caused its dark surrounding to be fainter from late May. The first loss of sharpness was signalled by Barry under CM ~ 170° on Jun 28 – Jul 2, when a long E–W strip of polar cloud (not the spiral type), brighter and bluer than the cap, bordered it on the south. From a similar terrestrial longitude, Olivetti found the cap well defined on Jul 2–4 (Part I, Figure 8), although there were some bright, high-latitude clouds bordering it. On Jun 30 – Jul 1 McKim (CM ~350°) found the cap border all but invisible, and the polar region paler and enlarged, with clouds bordering its S. edge. Foster from South Africa recorded the cap slowly fading and losing definition until Jul 14 (Part I, Figure 8). On the side visible from the Americas at sunset (around *Syrtis Major*), a well-defined cap persisted up till Jul 12, observed by Morales and Parker. To the latter observers, the cap lost its sharpness and brilliance on Jul 13, to be covered by a larger hood days later. Einaga and Kumamori were the last to image the cap on Jul 15 (under CM ~ 060°), though its boundary was weak, with light cloud to the south. The hood became conspicuously bright and sometimes was seen to consist of a complex pattern of clouds, for example to Olivetti on Jul 17 and to Parker on Aug 7 & 12. (See also Part I, Figure 9A.)

The hood often extended southwards on the morning side at the longitude of *Mare Acidalium*. It remained conspicuous in August–October, but gradually became foreshortened as the value of the sub-Earth latitude D_e became increasingly negative after Oct 22. Figure 16, and Part I, Figures 10–11 show this phase of the NPH. The hood was still obvious upon Barry's Oct 28 image, bluer and more striking than the thin white strip of the south polar cap (SPC).

Thus the transition from cap to hood was accomplished as usual in a longitude-dependent manner between Jun 28 and Jul 15. The seasonal range (*Ls* = 153–162°) was typical.

South polar region

The SPH/SPC transition

The SPC tends to be free from hood somewhat before the southern spring equinox, but at that time (on 2014 Aug 17) D_e was +18°, unfavourable for watching the transformation. On 2014 Aug 4–12, Barry, Parker and Valimberti imaged a bright SPH, significantly larger and brighter in blue, and on Aug 14 Foster (CM = 218°) still recorded a marginally larger hood in blue. But a very foreshortened, hood-free ground cap was definitely visible

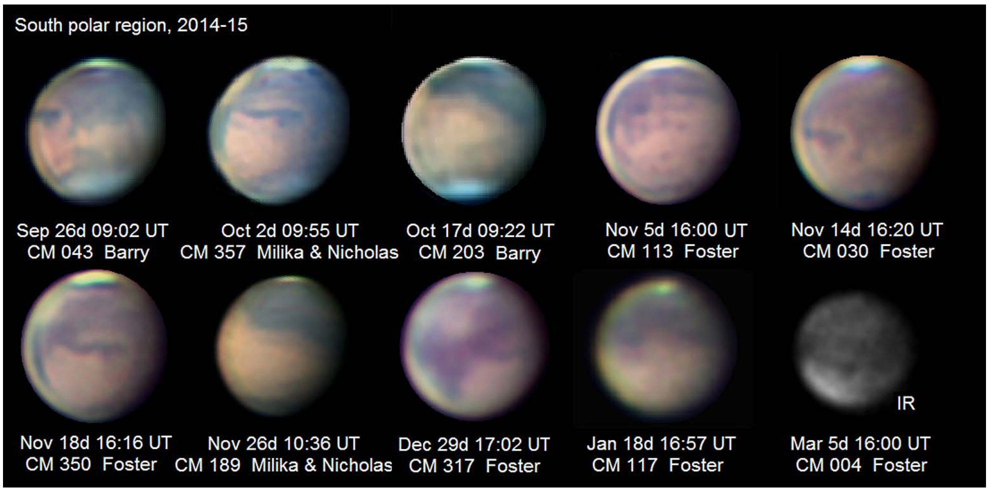


Figure 16. The south polar region, 2014 Sep 26 (*D* = 6.2″) to 2015 Mar 5 (D = 4.2″) according to T. Barry (410mm refl. and ASI120MM camera), C. Foster (355mm SCT and ASI120MC camera) and D. Milika & P. Nicholas (355mm SCT and ASI120MM-S camera).

to Valimberti on Aug 14 at a different longitude (CM ~ 100°) – at all visible wavelengths – and to Foster and Morita on Aug 17 and later. The cap was recorded before Aug 14 in some red images – even in the Jul 24 & 30 images of Morales, and Morita's of Jul 21 & 23 which revealed a well-defined light area along the S. limb – though the hood was constantly present in blue light. Thus the SPC freed itself of the hood during Jul 21 to Aug 14 (*Ls* = 165–178°), the process being longitude-dependent. (See Figure 16 and Part I, Figures 10–11.)

On Oct 2 Milika & Nicholas were the first to reveal an uneven contour to the SPC N. edge. The value of D_e became negative from Oct 22. Aspects of the SPH and SPC are shown in Figure 16. Latitude measurements upon the tiny disc were not attempted.

Argenteus Mons was seen as a brighter spot and northward protrusion by Foster on Nov 14–18. Foster's Nov 14 (*Ls* = 234°) images hint at *Novus Mons* being close to its seasonal detachment. Historically, this has been fully separated from the cap by *Ls* = 237–238°.[31] By November, the asymmetry of the SPC was obvious (Figure 16), so that by 2014 late January the tiny cap remnant was no longer visible at all longitudes. Foster's images resolved it until Mar 5 (*D* = 4.2″).

Hellas

From 2013 September to 2014 January the *Hellas* basin (Figures 13A, C and Part I, Figure 2), showed little meteorological activity. During 2014 January–February several observers recorded diurnal cloud there, which sometimes lasted through local noon. As in previous years we were interested in timing when it became very bright even in red light, and ground frost replaced white cloud.

Parker on Feb 12 found *Hellas* not especially bright on the evening terminator at visible wavelengths, but on Feb 18 (*Ls* = 092°) it was very bright to him near local noon, even somewhat so in red; this marked the beginning of the frost covering. The N. and S. halves were divided by a dark band crossing the latitude of *Zea Lacus*. The images of Miles and Valimberti on Feb 27–28 also showed *Hellas* significantly bright at all wavelengths, and it continued to brighten into March.

Another seasonal phenomenon was the banner cloud (brighter in blue light) which ran west from the basin across *Hellespontus*, Feb 24 – Mar 25 (*Ls* = 094–107°). In 2012,[1] the limits had been *Ls* = 088–093°: a similar, but imprecise, repetition.

By Mar 2 *Hellas* was extremely bright, and the best observations showed a non-uniform distribution of the ground frost that could not have been resolved by imaging during the 1990s. The basin was brightest in the north and particularly in the NE. At high resolution from around Mar 17 a number of icy filaments were seen to extend beyond the edge of the basin on the E. and NE sides: but for their unchanging appearance over several weeks they might have been mistaken for cloud. They looked exactly the same at all visible wavelengths, with a constant appearance till mid-May.

Konnai and Pellier pointed out that images by Go and Wesley on Apr 4–5 distinctly showed *Terby* (–28°, 286°) as a frosted crater marking the NE extremity of one of the icy filaments, and hence the N. limit of the frost deposition. (Konnai cited HST and MGS images showing this phenomenon at the same season in 1999 and 2006.) Buda also caught the frosted *Terby* on Apr 6, but thickening ice deposition seems to have made the crater contiguous with the filament, and they were not separated later. Some gaps on the basin floor indicated relatively ice-free areas, perhaps related to local topography. Part I, Figure 2F shows the icy filaments well.

The basin remained bright, as the S. polar hood brightened to the south. Walker still found the N. part of *Hellas* bright on Jun 4. But now the frost began to sublime there, causing that part to fade, and N. *Hellas* became less bright in red light, though the basin would still be subject to diurnal cloud. Already to Boudreau on Jun 8 the N. basin was notably less bright than the SPH, and by Jun 19–21 Einaga, Iwamasa and Olivetti found the whole basin dull. The hood remained over the S. limb in July, and during Jul 21 to Aug 14 retreated to reveal the SPC. Our observations showed no further brightening in *Hellas* that was not due to cloud.

Argyre

Argyre showed little meteorological activity until 2014 March. (See in particular Figures 12C & H, and Part I, Figures 2, 3 & 7.) Part of it at times exhibited a small but well-defined brightening between Feb 9 and May 28: compare 2012.[1] Later it was part of a wider S. polar hood covering the limb, though in some later images it formed a brighter spot within the hood, particularly to Miles on Jun 4 and Olivetti on Jul 17. As we have seen, the hood persisted till Aug 14. From around Oct 4 the basin was fairly light for some time, containing white cloud; in November it was invaded by dust from the *Hellas* event as described earlier (see Part I, Figures 10–11).

Phobos & Deimos

Wesley imaged Phobos on 2014 Feb 22–23, and both moons on Mar 2.

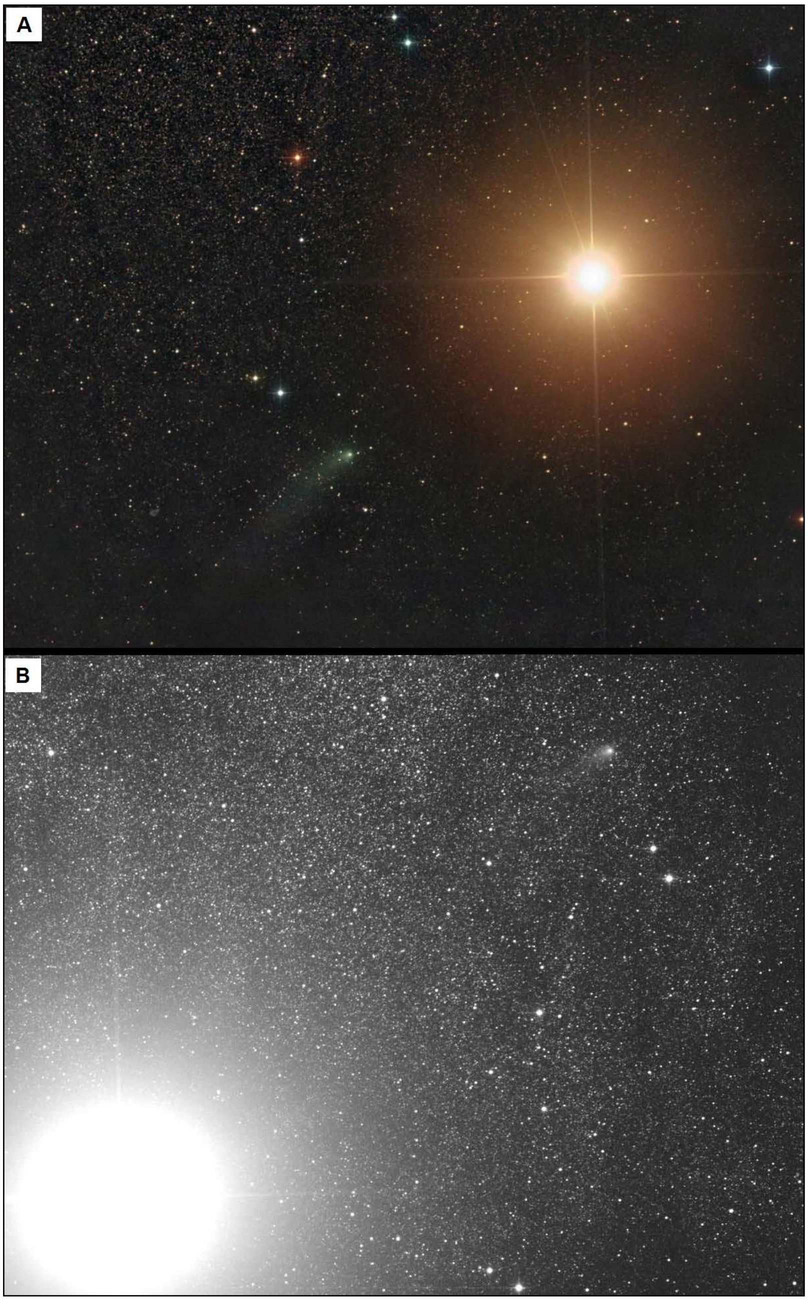


Figure 17. Comet 2013 A1 (Siding Spring) imaged during its close approach to Mars with remote-controlled 0.51m DK Cass. *iTel* at Siding Spring Observatory. **(A)** 2014 Oct 19, 11:07 UT. *(D. A. Peach)* **(B)** 2014 Oct 20, 09:32 UT. *(M. P. Mobberley)*

Encounter with comet 2013 A1 (Siding Spring)

Comet 2013 A1 passed very close to Mars (139,500km, the closest known approach of a comet) on 2014 Oct 19–20, and several contributors attempted to image it in the same field as the planet with their own telescopes. None succeeded, but using the Siding Spring remote-controlled 0.43m and 0.51m DK *iTel* telescopes, Willinghan on Oct 18 (32h before closest approach) as well as Mobberley and Peach on Oct 19 (less than 8h before) recorded it approaching the planet, while on Oct 20 Mobberley caught it receding: see Figure 17. Some of the spacecraft at Mars also obtained images: the coma interacted strongly with the planet's atmosphere, much increasing the charged particle flux at the surface. Abundant metal ions were also detected in the atmosphere, from the cometary dust coma.[35]

Peach obtained further images of the comet at different times using remote-controlled instruments.[36]

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