The opposition of Mars, 2012: Part II

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Part I of this report covered dust storm activity and variations in the albedo markings, along with the remarkable terminator projections seen at high southern latitudes during 2012 March–April. Part II discusses white cloud activity. The appearances of the Equatorial Cloud Band, the *Syrtis* Blue Cloud and the various orographic clouds were all seasonally normal, while the seasonal commencement of the N. polar cyclonic white clouds were recorded from Ls= 116° onwards; they exhibited obvious signs of vorticity only from Ls= 129°. The N. polar cap retreat was in close accord with the average, but there was a small systematic difference from 2010 when the seasonal separation of *Olympia* had been slightly delayed: in 2012 the recession of the cap after Ls~ 35° was a little faster. The onset of the N. polar hood was timed at Ls= 151°. The seasonal brightening of *Hellas*, due to ground frost formation, was well observed in 2012 March–April.

White clouds & blue-violet light phenomena

Part I described atmospheric dust activity and its interaction with albedo features and the N. polar cap, as well as the extraordinary terminator phenomena of 2012 March–April.[54] (Numbering of figures, references and tables runs on consecutively from Part I.)

In Part II we note the seasonal behaviour of the Equatorial Cloud Band (ECB), the orographic clouds and the spiral clouds near the N. polar cap. Drawings and images appear in Figures 15–18. The *Syrtis* Blue Cloud was well seen and, as previously noted, this is a phenomenon associated with the presence of the ECB. We have not specially looked for the 'violet holes' detailed in some recent reports, though we mentioned them in conjunction with dust storm activity in Part I. Neither do we discuss routine diurnal clouds or the so-called (but now known to be non-existent) 'Blue Clearing'.

Equatorial Cloud Band

The ECB can be wholly or partially seen in Figures 15–16 & 18. See also Part I Figures 1, 3C, F, 4G & H.

In 2010, the ECB had first appeared at areocentric longitude Ls= 001°, and was complete about Ls= 43°.[27]

No ECB was seen upon good early images by Jolly on 2011 Aug 21, nor in those by Akutsu from Sep 9–11, but it could be traced – on the *p*. (preceding) side only (Central Meridian CM= 120°) – upon Peach's Sep 15 image (coincidentally at Ls= 001°). This is in keeping with earlier work, which shows that the ECB first forms over *Chryse* or *Xanthe*. Abel on Sep 27, and Akutsu on Oct 15 & Nov 5, confirmed a partial ECB.

The ECB remained patchy and incomplete for several more months. On Dec 12 to Poupeau (CM= 004–015°, Ls= 42°); on Dec 24 to Macsymowicz; on Dec 29 to Buda; and on Dec 30 to Flanagan it finally seemed complete. At some other longitudes the ECB remained patchy or faint (in particular, the *Tharsis Montes* always interrupt it).

Nearly all blue-violet images with the appropriate passband showed a complete ECB from Feb 20 onwards. As ever it was best seen in UV: thus on Mar 10 it was complete to Parker in UV, but in blue light stretched only across *Elysium* to *Isidis Regio*. Pellier mapped the ECB near local noon during Feb 21 – Mar 18.[55] Now at maximum development, it was sometimes apparent in white light: see the author's drawings in Figures 15J–K. Moreover, at that stage the bluish tint of the *Syrtis* Blue Cloud was visible mid-disk; the *Syrtis* looked paler in RGB images and was invisible or nearly so in blue (or UV). This was the case to Pellier, Feb 26–29; Akutsu, Mar 21–25; Peach on Apr 1–2; Parker on Apr 13, *etc*.

High-resolution work by Peach during Mar 11 – May 28 (his final observation) showed intricate filamentary structure within the mature ECB: see Figures 16 & 18.

The ECB was very strong in blue under CM= 123° to Peach on Apr 21 and visually to the author under CM= 104° on Apr 22. Indeed, it was still strong and complex on May 28 in Peach's final blue images in Figure 18. Yunoki found it complete on Jun 1. It was still weakly present in the images by Willems up to Jul 4 at Ls= 134° (with *Syrtis Major* faded by it but no longer totally effaced). However, no later images were good enough.

To summarise, the ECB during 2011–'12 first appeared at Ls= 001°, had become complete about Ls= 042°, and persisted beyond Ls= 134°. These timings agree extremely well with 2009–'10 (and 2007–'08).

The *Syrtis* Blue Cloud

This feature was widely observed; it can be seen in Figure 16 and in Part I Figures 2, 4 & 13.

The *Syrtis* Blue Cloud could be seen at the edge of the disk whenever the ECB was sufficiently strong, and the effect often showed up in images over the extreme range 2012 Jan 15 – Jun 29. Particularly strong sightings were found at the a.m. terminator after opposition, where morning mist enhanced the scattering of the shorter wavelengths. At the height of the ECB, the *Syrtis Major* was occasionally clearly tinted blue upon mid-disk and sometimes

appeared less dark (for example, to the author on May 15). As noted above, at such times the ECB could on occasion be weakly traced in white light.

A seasonally related aspect of the ECB was when one or two small bright white clouds obscured part of *Syrtis Major*, or bisected its mid-latitudes upon the evening limb. This effect was sometimes recorded during Jan 27 – Apr 4 (Figure 15A and Part I, Figures 2H & 13).

Orographic clouds

The evening *Elysium Mons*, *Olympus Mons*, *Tharsis Montes* & *Alba Patera* clouds can be seen in Figures 15–17 and in Part I; Figures 1–4, 8 & 9.

Elysium Mons

In 2010 this orographic cloud was visible on the evening side, from Ls= 20°.[27] In 2011–'12 it was definitely not yet present by Ls= 16°, but after a small gap in the data it was seen as a light spot on the evening side on Oct 24 (Ls= 20°) by Maxson, then on Nov 3 by Morita. It was followed till Jun 10, by which time the evening terminator was well beyond the limb. It brightened considerably during January. The unclouded *Mons* looked tiny when viewed at local noon. *Elysium* as a whole was still bright at the evening limb on Jul 17, though the *Mons* cloud could no longer be separately resolved.

Olympus Mons

The orographic cloud had been visible on the evening side from Ls= 19° onwards in 2010, and from Ls= 354° in 2007.[27]

A light patch was visible in the location of *Olympus Mons* as early as 2011 Sep 15 (Ls= 001°), near local noon. Poupeau caught it further brightening in the evening from Oct 17–21, as did Put and Sussenbach on Nov 28, and G. Walker on Dec 2. It was however not yet striking, becoming conspicuously bright in the evening from 2012 Jan 7 till at least Jul 13.

In the evening the orographic cloud seemed to lay over the volcano itself, but earlier it lay more to the west and covered only the W. half of the caldera, trailing to the leeward side in a WNW or NW direction. (This variability was also quite apparent with *Ascraeus Mons* – whose cloud typically streaked away to the WNW or NW – but less so with *Pavonis* and not at all with *Arsia*.)

A diurnal sequence by Peach on Mar 14–15 (Figure 17) is typical, showing how *Olympus Mons* appeared as a dark spot with growing white cloud around it and upon its leeward side in the afternoon. These exceptionally fine images resolve tiny details upon and around the volcano's summit. Equally spectacular images were acquired by Jaeschke during Mar 19–23, and Willems on Apr 2 (Figure 17).

The *Tharsis Montes*

Our 2007 & 2009 data showed that *Arsia Mons* is seasonally the first to exhibit cloud at Ls= 330 ± 4°,[27] but in 2011 the disk was too small at that season for the start to be timed. The other *Tharsis Montes* acquired their orographic clouds at Ls= 004 ± 8°.

A large but weak afternoon cloud was detected at *Arsia Mons* by Maxson on 2011 Aug 15 (Ls= 345°) – 19, and by Jolly on Aug 21. On Sep 15 (Ls= 001°), Peach was the first to find the *Tharsis Montes* in generally weak light in the evening, confirmed by Maxson on Sep 24; the individual clouds were as yet unresolved (merely showing up as the light streak called *Tractus Albus* on the old maps). This is therefore in excellent accord with recent work.

The *Tharsis Montes* evening clouds appeared somewhat stronger to Poupeau on Oct 21 and Tasselli on Oct 26. Data from Nov 28 onwards show they had now become rather bright near the evening terminator. By Jan 2, all three *Tharsis Montes* were cloud-covered and most impressive on the evening side. An additional cloud near *Tithonius Lacus*, combined with those at *Olympus Mons* and *Alba*, gave a nearly complete rendition of the martian 'W' cloud, but the NE spot in *Tempe* was missing so the full 'W' was not seen.

During January–March *Ascraeus Mons* already showed its orographic cloud near local noon, but *Pavonis* and *Arsia* did not. Later in the afternoon *Pavonis* too brightened and finally *Arsia* acquired its cloud, becoming bright at the evening limb. In Figure 17 we show a diurnal sequence of images depicting the development of the clouds.

To the author on Mar 3, the *Arsia* cloud was as bright as *Pavonis* with both at the evening limb. To Jaeschke and Phillips on Mar 19–21 the situation was similar, but on Mar 22–23 the *Arsia* cloud had become extremely faint to Jolly, Majewski, Maxson and Willinghan. From Mar 31 it no longer showed up at all, even right at the limb. By Apr 13, *Pavonis* too was less obvious at the limb (recall that the evening terminator could no longer be viewed, post-opposition). Nevertheless on Jun 4 *Ascraeus* and *Pavonis Mons* still exhibited their orographic clouds at the evening limb, and Willems recorded something of them at low resolution till Jul 21–22.

On Mar 15–21 and on Apr 7 in particular, the densely reddish patch NW of *Ascraeus Lacus* – or just E. of *Olympus Mons* – stood out intensely in blue light. We suppose there is a local reduction in water vapour content in the atmosphere there. The effect, which was described in more detail in 1997 & 1999,[56,57] was also noticeable during Apr 11–14.

Alba Patera

A faint light patch on the evening side over *Alba* first appeared on 2011 Aug 21 (Jolly, Ls= 348°), Sep 15 (Peach) and Sep 28–Oct 1 (Maxson). There were numerous observations of it brightening in the afternoon during October–December. It was large and bright in the afternoon and evening around Jan 8 – Feb 17, and was already conspicuous near local noon as a large light area. In 2007 & 2009 the orographic cloud had appeared at Ls= 355 & 011° respectively.[27]

By Feb 23 *Alba* had become appreciably fainter than the *Tharsis Montes* in the evening. It seemed to weaken from around Apr 26, but was still identifiable in the evening as late as Jun 4.

Opposition brightening of the volcanoes

This year no substantial 'opposition effect' was seen, due to the presence of cloud over the slopes of the volcanoes at opposition.

The morning Montes

The now familiar sight of the Montes poking through a sea of low cloud was observed from 2012 Feb 20 – just prior to opposition – onwards (see Figures 15P, 16, 18 and Part I Figures 3E, F & 11). Following that date, the *Tharsis Montes* and *Olympus Mons* always appeared in morning cloud as darker spots. Contrast between volcanoes and cloud was stronger from March onwards. Poking out of the lower clouds, the volcanoes had a distinct reddish tone.

From Mar 19 – Apr 22 several observers found that the southernmost *Arsia Mons* corresponded to the largest dark spot, in an epoch when its orographic cloud was disappearing. This difference in size was exceptionally marked upon the images of Jaeschke for Mar 28, Kumamori and Morita for Apr 6–8, Kardasis on Apr 21 & 22, Maxson for May 3 and Morita again for May 16–18; all

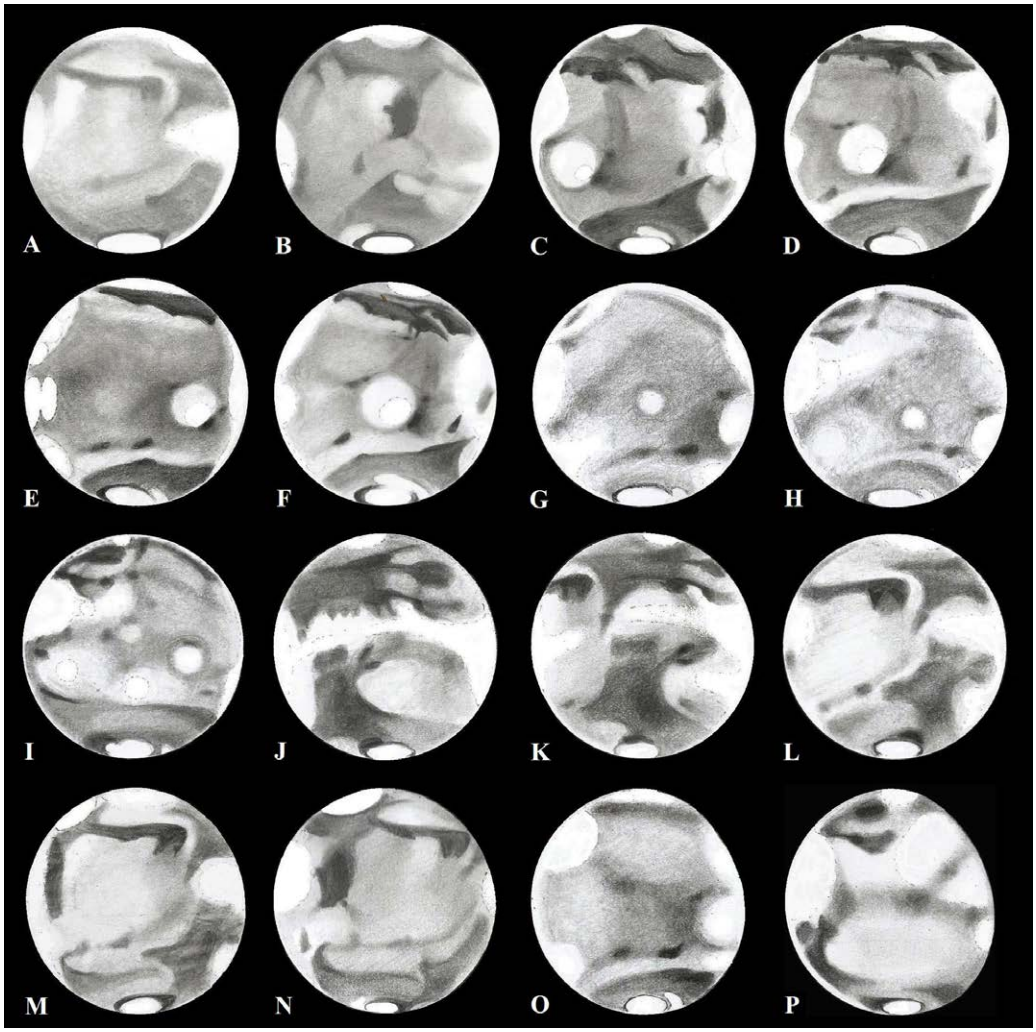

Table 3. NPC latitude measurements, 2011–'12

Mean L_s (°)	*Latitude of S. edge of cap (°) on images*	*No. of measures*
358 (*i.e.*, 356–360°)	57.2	5
003	58.5	9
008	58.3	4
013	60.4	7
018	60.4	15
023	62.3	16
028	63.0	6
033	63.8	13
038	65.2	17
043	65.6	16
048	68.1	13
053	68.8	32
058	70.0	53
063	71.4	65
068	73.2	46
073	77.0	89
078	78.6	104
083	80.3	197
088	79.3	138
093	80.0	85
098	80.7	53
103	81.2	33
108	80.8	39
113	81.3	36
118	82.7	17
123	81.3	7
128	80.2	2
133	81.6	7
138	80.3	2
143	81.0	4
Total:		1,130

Figure 15. Drawings by R. J. McKim (410mm DK Cass., ×265 & 410, INT and/or W21 orange filter) showing aspects of martian meteorology and of the N. polar cap. South is uppermost in all figures.

(A) 2012 Feb 18d 22:20 UT, CM= 328°. Only the S. part of *Syrtis Major* visible at the *p*. limb. The morning *Chyrse–Xanthe* cloud extends some way along the equator. SPH visible.

(B) 2012 Feb 24d 21:20 UT, CM= 276°. Southern *Hellas* is brightened by the SPH. Many details around *Syrtis Major*. *Olympia* on the *p*. side separated from the NPC (also in (C)).

(C) 2012 Feb 29d 22:10 UT, CM= 244°. *Syrtis Major*, with *Nodus Alcyonius* Np. it.

(D) 2012 Mar 1d 21:15 UT, CM= 222°. Many tiny details in near-perfect seeing. *Syrtis Major* is bluish in the morning mist. See also Mar 3d, CM 213°.

(E) 2012 Mar 3d 20:00 UT, CM= 187°. Orographic clouds at the p.m. limb. *Propontis* and *Castorius Lacus* appear as small elongated dark spots *p*. *Elysium*. *Olympia* on *f*. side.

(F) 2012 Mar 3d 21:50 UT, CM= 213°. *Elysium Mons* orographic cloud, with another such cloud over *Olympus Mons* at the *p*. limb. Fine details N. of *Mare Cimmerium*. Secular darkening in *Aetheria* with faint southward streaks across *Aethiopis*. *Syrtis Major* pale and bluish, dimmed by a.m. cloud. *Trivium Charontis* consists of two tiny dots only.

(G) 2012 Mar 9d 20:15 UT, CM= 138°. *Nix Olympica* at the CM. Morning cloud over *Cebrenia* and *Elysium*.

(H) 2012 Mar 11d 20:35 UT, CM= 126°. *Tharsis Montes* weakly visible as albedo features. Small orographic cloud brightening over *Olympus Mons*.

(I) 2012 Mar 14d 20:45 UT, CM= 102°. Disk littered with tiny granular details in near-perfect seeing. *Phasis* follows *Solis Lacus*. The *Tharsis Montes* are seen together with orographic cloud over *Olympus Mons*. NPC irregular.

(J) 2012 Mar 18d 20:55 UT, CM= 070°. See (K).

(K) 2012 Mar 19d 19:10 UT, CM= 035°. Complex a.m. cloud. The ECB is even seen in white light. The S. albedo markings are bluish compared with the reddish-brown northern ones. *Argyre* light, *Hyperboreus Lacus* dark.

(L) 2012 Mar 23d 19:40 UT, CM= 009°. Evening cloud over *Aeria* largely hides *Syrtis Major*.

(M) 2012 Mar 25d 19:10 UT, CM= 342°. The evening *Syrtis Major* appears blue, contrasting with the reddish brown *Mare Acidalium*. *Ismenius Lacus* remains small.

(N) 2012 Mar 27d 19:00 UT, CM= 322°. *Hellas* outstandingly bright in all visible waveband filters. *Syrtis Major* is deep blue.

(O) 2012 Apr 15d 20:28 UT, CM= 172°. Faint desert halftones are more prominent at this phase angle. Note *Olympia*, *Elysium* light a.m. cloud.

(P) 2012 Apr 22d 19:55 UT, CM= 100°. The belt of the *Tharsis Montes* crosses extensive a.m. cloud. *Solis Lacus* prominent at the CM. With a W44A blue filter, the ECB was complete.

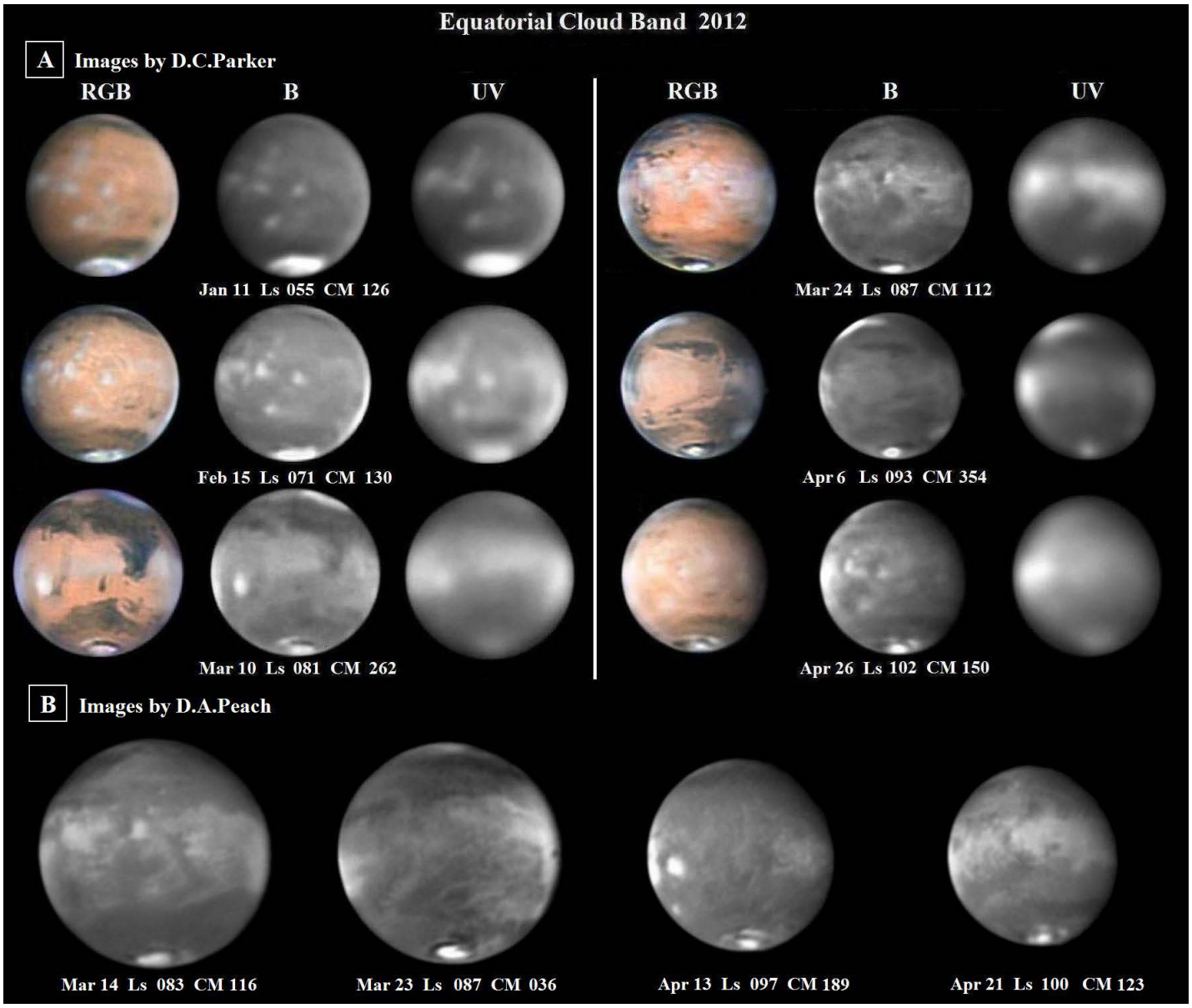

Figure 16. The wavelength dependence of the Equatorial Cloud Band, the *Syrtis* Blue Cloud, and the *Elysium*, *Tharsis* and *Olympus Mons* orographics. In (A) the planet's apparent diameter was kept constant, but in (B) the actual variation is shown.

(A) Taken using a DMK 21AU 618.AS camera with 625nm red (125nm BWHM), 480nm blue (135nm BWHM) and 365mm ultraviolet (60nm BWHM) Astrodon filters. *D. C. Parker*

(B) High-resolution images obtained with SKYnyx 2-0M camera and 470nm blue (90nm BWHM) Astronomik filter, showing filamentary structures within the mature ECB. *D. A. Peach*

found the large dark *Arsia Mons* spot was located at the S. edge of the ECB. The final view of the morning aspect of the Montes was secured on Jun 12.

N. polar spiral clouds

In 1999 (MY 24), BAA data recorded N. polar 'cyclonic' clouds from Ls= 127° onwards, so they were expected in 2012.[11]

On 2012 May 26–28 (Ls= 116°) Akutsu and Morita made the first positive sightings of an object in *Baltia*. Peach on May 27, 28 & 30; and Delcroix on May 28 quickly followed up with images of a second such cloud centred over N. *Arcadia*. The May 28 sequence in Figure 18 shows the cloud rotating with the planet's surface. These clouds were uniform in appearance. However, on Jun 24 (Ls= 129°) Barry obtained evidence of vorticity,[15] when a dark patch was visible in the centre of the *Baltia* cloud. His observation of Jul 3 (Ls= 134°) may confirm this dark area at the terminator.

Later observations of the shrinking disk could no longer resolve these clouds. Schmude obtained a drift rate of 6.1km/h eastwards for a similar feature from 2014 images.[58]

Pellier notes that past N. polar clouds acquired their vorticity around Ls=130°, although they existed earlier without it. He suggests 'spiral cloud' is more apt for a dry planet such as Mars.

North polar region

Activity in the NPC & the NPH/NPC transition

Drawings and images featuring the seasonal recession and fragmentation of the N. polar cap are shown in Figures 15 & 19. Compared with our imaging capability at the same seasons in 1997 or 1999, the images of Figure 19 represent a great improvement in resolution.

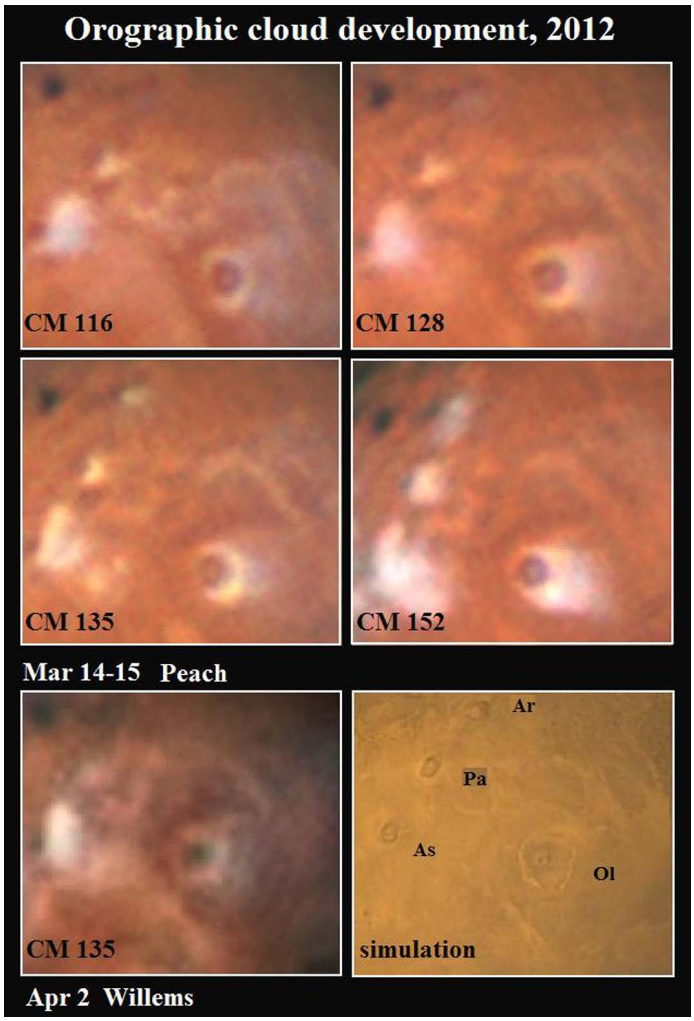

Figure 17. The hourly development of orographic clouds over the *Tharsis Montes* and *Olympus Mons* near opposition, according to D. A. Peach and F. Willems. In the simulation, Ar= *Arsia Mons*, Pa= *Pavonis Mons*, As= *Ascraeus Mons* and Ol= *Olympus Mons*.

N. polar dust storms were reported in Part I.[54]

Akutsu recorded no NPH (North Polar Hood) on 2011 Jun 11, but definite signs of it were detected in his blue image of Jun 26. D_e (the declination of Earth from Mars) became positive in 2011 late-July, and the NPH was confirmed by Ikemura, Jolly, Macsymowicz, Maxson, Morales, Morita and Sussenbach during Jul 16 – Aug 10. During Aug 10 – 31 several observers recorded that the large NPH veered southwards at the longitude of *Mare Acidalium* on the morning side, while Gray's drawing and Kardasis' image of Aug 15 showed the same effect with the evening *Acidalium*.

Akutsu's RGB composites of Aug 29 & Sep 11 show the North Polar Cap Band (NPCB) bisecting the hood: partly so in the first image, and extending right across *Tempe–Arcadia* in the second, so that the first partial sighting of the cap was on Aug 29 (Ls= 352°). On the next day Jolly caught the ground cap in red and infrared, with a large overlying hood in blue. This was a seasonally late appearance of the cap compared with the last two oppositions, but much more in keeping with the historical norm.

The ground cap was unquestionably present in the red and infrared images of Kidd on Sep 2, Willems on Sep 7, Akutsu on Sep 9, Peach on Sep 15, *etc.*; it now showed a dark S. edge. A larger but diminishing hood was always seen in blue, reaching lower latitudes on the a.m. side – especially again when *Mare Acidalium* was near the limb – in many images during Sep 1–29. Jaeschke and Walker on Sep 13 imaged a part of the hood on the a.m. side overlying the dark cap border between *Elysium* and *Utopia*. Biver saw the hood bifurcated there by visual observation on Sep 3.

The overriding impression by late September was of the ground cap having a dark fringe, confirmed visually from Sep 24–27 by Minami. The N. limb of the cap had already appeared darker to Akutsu from Sep 11, to Jolly from Sep 19 and to Peach from Sep 22. The seasonal annular rift (the cause of the darkened N. limb) was suggested by Akutsu's image on Oct 22; it had clearly separated from the limb to Peach on Nov 18 and to Jolly on Nov 28, being constantly visible until the outer part of the cap had evaporated.

Images by Jolly and Maxson on Oct 14 showed another small section of protruding NPH under CM= 314°, while Akutsu on Oct 22 (Ls= 19°) recorded a longer section (it may have had a dusty component according to MRO MARCI daily maps) south of the NPCB under CM= 356°. After that however, the hood was not recorded. This final appearance of the hood accords well with 2009.[27]

North polar fronts ('cascades')

In 2010 there were instances of 'cascades' or polar 'fronts' moving off the cap's outer ring during the recession phase.[27] In 2012 the cap had already lost its peripheral ring south of the annular rift by opposition. Several features around and over the cap were identified as dust storms (see Part I).

Flanagan on 2012 Jan 3 & 7 (especially) showed a lighter strip of cloud S. of the still-not-separated *Olympia*: the cap was evaporating more strongly around it. This is analogous to the clouds that followed the evaporating *Novus Mons* in the S. polar cap (SPC) in 2003 & 2005.[59, 60]

In February (*e.g.* Feb 16 to McKim, and Feb 24 to Peach [Part I, Figure 6]) there was a sharp projection at the cap edge around λ= 350°, and a thin stream of material crossing the NPCB from it was visible in red, green and blue images during Feb 19–28.

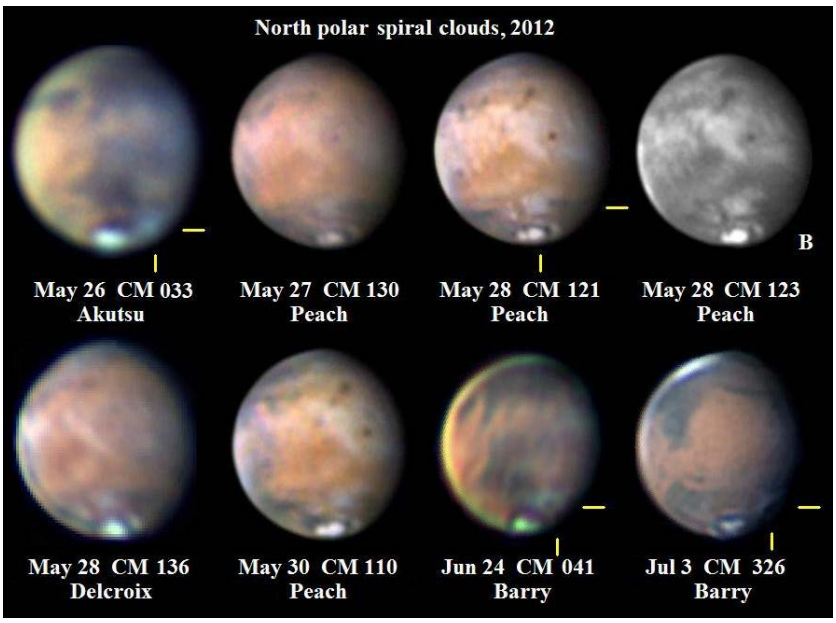

Figure 18. N. polar cyclones, 2012.

NPC fragmentation

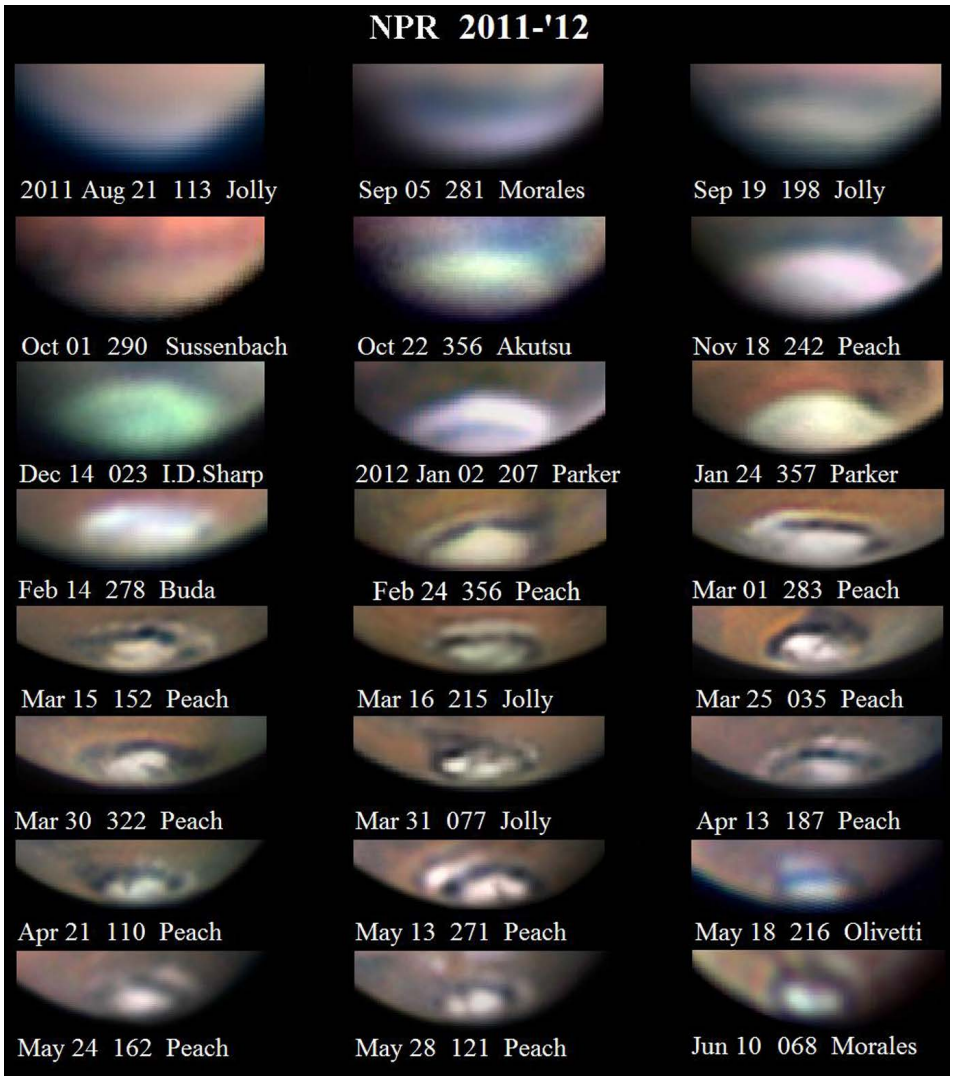

Figure 19. RGB images showing the formation, retreat and fragmentation of the NPC, 2011 August – 2012 June. Date, CM and observer indicated. Same scale within each row; some images show the dust activity described in Part I.

Conditions were ideal for timing the seasonal detachment of *Olympia* from the cap (Figure 20). It was initially part of the outer annulus of the cap, in contact with the annular dark rift (see above). High-resolution work this year enabled us to watch how the annulus thins and finally splits into tiny patches which quickly disappear, leaving the major outliers *Olympia* and *Ierne* to evaporate more slowly against the dark polar collar of the summer cap remnant. See the collage of Figure 19 (and the key map in Part I, Figure 5C).

In 2010 *Olympia* had not fully separated until Ls=74°,[27] suggesting a slightly delayed cap recession.

Brighter patches in the outer annulus were also imaged E. and W. of *Mare Acidalium* in 2011 from Dec 9–16 by I. D. Sharp, and the location of *Olympia* was already marked by a brightening at its longitude. During this opposition local polar dust storms interfered with the timing of the separation of the latter, but the first sign of the E. end of *Olympia* was spotted by Jan 19 (Willems). The author considered that separation at both ends was definitely not finalised by Feb 9, but it was complete to Barry and Buda on Feb 12 (Ls= 70°) and both to them and Willems on Feb 14 (Figure 19). This represents a small but significant seasonal difference.

This opposition was the first when the seasonal cap annulus west of the detached *Olympia* was imaged at high resolution, and it was observed to narrow and fragment over a few weeks. The Feb 12 & 14 images of Barry and Buda showed a white 'tail' streaking away west near the western extremity of *Olympia* (λ~ 270°). There was also a thicker patch upon the tail at λ~ 320°. The thick part quickly thinned, but the 'tail' remained, visibly narrowing to Peach, Pellier and Sussenbach on Feb 19–23, and stretching as far as λ~ 025°. It was visible to Flanagan, Jaeschke, Jolly, Peach and Morales from Feb 24 ~ Mar 5, now paler than the polar ices and still giving *Olympia* an extended appearance. (Compare the Feb 14 & Mar 1 images of Figure 19, and Part I, Figures 1–2.) A small branch of this streak joined the NPC across the NPCB at λ~ 355° upon R, G and B images during Feb 19–28, but this was a 'cascade' from the cap associated with a sharp protrusion at its edge. (See the Feb 23 image in Figure 19.) At the next UK presentation of the area, Peach found the E–W 'tail' all but invisible on Mar 23.

The detached *Olympia* was a conspicuous feature during February–June, and was detected as late as Jul 13 (Willems).

From Mar 1 (Ls= 77°) to May 22 *Ierne*, the much smaller isolated fragment of the peripheral seasonal ring, was caught at CM~ 140° only in the very best images and appeared resolved into tiny patches to Barry, Go, Jaeschke and Jolly.

A notch in the NPC S. edge at *Chasma Boreale* was first seen on Jan 11. *Hyperboreus Lacus* became prominent as a dark patch at the cap edge in February. From Mar 21–30 to Akutsu and Peach and from Apr 7–12 to Morales, *Chasma Boreale* (starting inwards from the opposite side of the cap) gave the classic illusion of a rift cutting the cap remnant nearly in half. In Part I, however, we showed how at one stage the rift was actually apparently prolonged by the presence of a dust storm upon the cap. We wrote more about polar rifts and illusions in our 1995, 1997 & 1999 reports.[61]

From May 28–30 the rift again appeared to Peach to cut the cap in two, but now image processing coupled with the tiny diameter may have been the cause. This was also the impression gained from the May 4 & Jun 10 images of Morales.

NPC recession

1,130 measurements of latitude covering Ls= 351–145° (2011 Aug 26 – 2012 Jul 27), made upon the sharpest images from 50 observers, are summarised in Table 3 and Figure 20. Typical recessional behaviour comparable to 2007–'08 & 2009–'10,[62,27] and the older work of Dollfus (1973),[63] can be seen.

Close inspection reveals that up till Ls~ 35° the cap was systematically a fraction larger than in 2009–'10, and after that a fraction smaller; this implies a faster recession after Ls~ 35° until the summer remnant was reached at Ls~ 80°. The earlier separation

of *Olympia* is consistent with a faster recession. It is a matter for speculation whether the dust deposited upon the cap, particularly around Ls~ 45° in 2010,[27] may have accelerated the recession during the following spring. The results of Calvin *et al*. (2015),[64] based upon MRO data, agree with ours in showing that the 2007–'08 recession was seasonally advanced compared with 2009–'10 & 2011–'12, due to less ice having been deposited during the global storm. Hansen *et al*. (2013) discussed the fine details of the spring sublimation processes in the NPC.[65]

The return of the NPH

The NPC-to-NPH transition could not be closely observed. Willems found the residual cap sharp-edged, with no overlying hood as late as Jul 28. Konnai on Aug 1 & 5 (Ls= 150°) also obtained late drawings of the NPC. However, Willems found the cap indistinct and probably hooded on Aug 6, and Melillo's Aug 16 work suggests a fainter hood had replaced the cap. Adamoli, with his 125mm Maksutov-Cassegrain telescope, could no longer visually resolve the NPC from July onwards, but it is clear that he viewed a large hood during Aug 14 – Sep 6. On Sep 11 (235mm Schmidt-Cassegrain) he found the NPH 'pure white' but no brighter than the equatorial deserts.

Tentatively, the transition did not begin before Aug 6 and was completed no later than Aug 14 (Ls= 151–155°). This is typical of many past years.

South polar region

SPH

Conditions were not favourable for seeing the SPC in MY 30. Akutsu showed a definite lightish area (poorly resolved) on 2011 Jun 11 & 26 (Ls= 309–318°), and Sussenbach's Jul 5 image indicates the small SPC (CM= 078°, Ls= 323°). Kivits definitely resolved the small SPC on Jul 10. The value of D_e became positive after late July, making later sightings impossible. In very good images on Aug 7 & 21 Jolly showed no light area at the S. limb; likewise with Maxson's work from Jul 20 onwards.

No observations during formation and early recession of the SPC in MY 31 were secured, except that Adamoli from 2013 Jan 18–26 (perihelion: Jan 24) saw a small light area – the SPC – at the S. limb.

Hellas

The post-opposition brightening of *Hellas* has been seen to recur at a similar seasonal date in the past, and coincides with frost formation. This time the sequence of events could be followed in greater detail.

During 2011 Jul 30 – 2012 Mar 1 *Hellas* was not very conspicuous at the CM, nor was it so in the evening or morning. Morita from Aug 10–13 showed it light in the evening, as did Morales on Aug 31 and Sep 5. It was whitish in the evening to Maxson, Sep 7, and light around local noon to Ghomizadeh, Sep 30 – Oct 2. Evening cloud was present on Oct 1–2 (Poupeau, Put, Sussenbach) & 14–15 (Jolly, Maxson), but *Hellas* was dull at the CM. However, the far southern part was bright even at the CM to Maxson from Oct 17–19 and to Kumamori, Minami and Morita, Oct 26–31. Gray saw some whiteness in the evening on Nov 7 (Part I, Figure 2D), while Jolly, Peach and Sussenbach found it whitish at the a.m. limb till noon, Nov 16–28. Konnai drew it light, 2012 Jan 7–9. Melillo and Phillips showed the southern part to be light on Jan 29.

The basin began to appear lighter, especially in the south, upon the CM during February; late that month white cloud invaded the northern part. The south part was bright to the author on Feb 24 (Figure 15B).

Another change occurred on Feb 26–27 when Pellier showed the north part also being light at the CM, particularly in the NW. Morales saw *Hellas* light on the *p*. limb, at the CM and on the *f*. side during 2012 Mar 2–10, but it remained much less bright than the NPC. The cloud in the basin was not complete: around *Zea Lacus* in the southern half of the basin there was a darker region (Part I; Figures 1, 2F & G). G. Walker on Mar 8 and Yunoki on Mar 21 showed *Hellas* still brighter in the NE corner.

To Akutsu and Parker on Mar 10–16 it now looked very bright at the *p*. limb. From Mar 17–25 it was bright even at the CM (though less so in red light), but its N. edge was not completely sharp, signifying cloud. Indeed, on Mar 25 – Apr 6 on the *p*. side a short banner of white cloud stretched W. from the basin across *Hellespontus* into *Noachis*: see Figure 16 (Mar 30) and Part I, Figure 13. This is another seasonal event, occurring at the S. winter solstice.

By Mar 30 – Apr 2 *Hellas* was very bright and its boundaries had become sharply defined even in red light, though a central southern dark patch around *Zea Lacus* still interrupted the whiteness. Now it must have been covered by ground frost. Images on Apr 5 showed that in the morning *Hellas* was covered by cloud, less reflective than the frost beneath. Many observers from Apr 4 onwards found *Hellas* dazzling throughout the day (Part I, Figure 2B). The basin was brighter in the NE corner than in the NW. From May 6–13 the dark S. patch remained, and the basin was still bright throughout the day. Infrared images taken in April–May agree.

Hellas remained brilliant to Willems on Jul 1–4 (Figure 18), and visually to Konnai from Jul 10–11 and Adamoli on Jul 23. A July–August dust storm has been described in Part I. Adamoli found *Hellas* bright again on Aug 27. No later observations had adequate resolution.

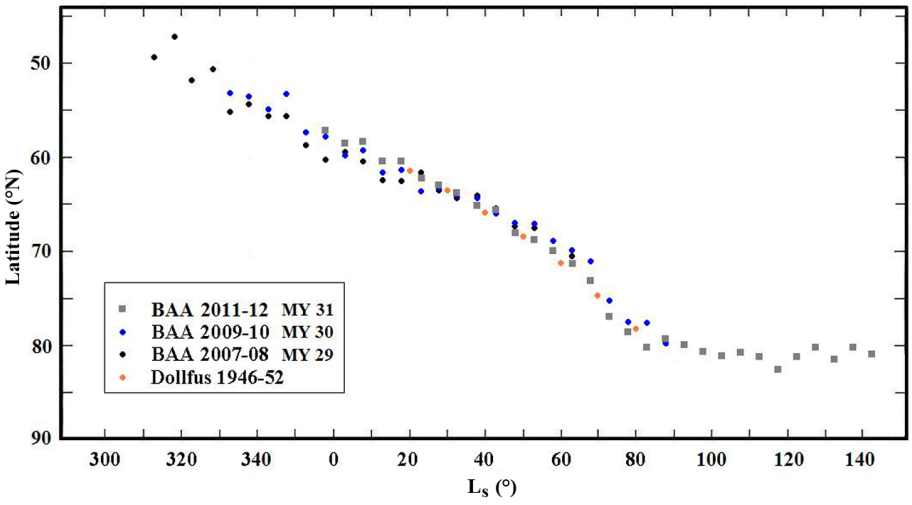

Figure 20. The recession curve of the N. polar cap during 2011–'12 compared with earlier work; plotted points are 5° means in Ls. *R. J. McKim*

Argyre

Argyre occasionally showed thin white cloud, but was not really bright till late in the apparition. *Argyre* was often slightly white in 2011 September, became quite bright during Oct 15–22 (especially on the last date), and was again sometimes slightly white in Nov–Dec. The value of D_e reached a maximum of +24° in December–January. Slight whiteness was again often seen over *Argyre* during 2012 January–March, with a tendency to be slightly brighter around Feb 16–20. (D_e had fallen to +22° at opposition, Mar 3.) In Apr–May it often looked fairly bright, but was never outstandingly so; as D_e rose to +26° in June it was again slightly white at best. Finally, on Jul 28 to Willems and Aug 1–5 to Konnai, despite the high value of D_e the region was bright and conspicuously large at the CM.

On Feb 22 at very high resolution a well-defined small bright patch was imaged by Peach within the *f.* part of *Argyre* – was this a frosted crater? Likewise was observed by Jolly on Feb 25 and M. R. Lewis on Mar 24.

Phobos & Deimos

Both moons were successfully imaged by Maxson, 2012 Feb 27 – Mar 27.

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Dedication

I dedicate this report to the memory of Richard M. Baum (1930–2017): historian, artist, planetary observer, past Director of the Terrestrial Planets and Mercury & Venus Sections, mentor and very good friend.

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