The opposition of Mars, 1993

Richard McKim

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

An account of the 1992-93 apparition, in which minor (but significant) albedo changes occurred on the martian surface. *Solis Lacus* remained large and dark, *Phasis* had faded but *Gallinaria Silva* remained visible. The *Aetheria* secular darkening persisted, the *Huygens* crater in *Iapigia* could still be identified, *Nepenthes* continued to be invisible, and the W. (IAU) end of *Mare Sirenum* was still truncated. *Pandorae Fretum* was rather dark. The exceptional *Idaeus Fons-Achillis Fons* development on *Nilokeras* persisted. The *Cerberus-Trivium Charontis* complex continued the fading which had begun in 1990. The northern hemisphere was favourably displayed for the first time since 1984, and the areography of the *Utopia-Boreosyrtis* region was seen to be broadly unaltered. There was little dust activity, but the presently favoured *Chryse* source was again active on at least two occasions, on 1992 August 31 (L_s= 316°) and October 2-3 (L_s= 333-334°). This local activity continued with a minor dust storm in *Elysium-Cebrenia* that began on February 12 (L_s= 39°). White cloud activity was seasonally normal. The observations covered the period of northern hemisphere winter and spring, and much of the regression of the North Polar Cap could be observed. Its behaviour closely followed the Dollfus-Baum historical mean from L_s≈ 25° onwards, but the cap/hood was somewhat smaller than usual before then. This report of the work of 89 observers covers the period 1992 May to 1993 August.

Introduction

At opposition in Gemini on 1993 January 7, Mars rode high in the sky for northern temperate observers, with a reduced disk diameter of 14.9 arcsec. Closest approach occurred on January 3 (14".95), with Mars 93,660,000 km distant from Earth. The apparition was the first in a new series of aphelic apparitions. (The writer counted the 1990-91 apparition as perihelic, but it could equally be regarded as intermediate as opposition had occurred exactly 90° from perihelion, which longitude distinguishes perihelic from aphelic approaches.) The north pole of the planet was tilted towards the Earth for most of the apparition. Physical data are listed below:

Latitude of centre of disk at opposition	... +7°.3	
Declination at opposition	... +26°	
Mars in perihelion	... 1992 May 16	(L_S= 250°)
Summer solstice of S. hemisphere / Winter solstice of N. hemisphere	... 1992 Jun 17	(L_S= 270°)
Autumnal equinox of S. hemisphere / Spring equinox of N. hemisphere	... 1992 Nov 22	(L_S= 0°)
Mars in opposition to the Sun	... 1992 Jan 7	(L_S= 22°)
Mars in aphelion	... 1993 Apr 24	(L_S= 70°)
Winter solstice of S. hemisphere / Summer solstice of N. hemisphere	... 1993 Jun 8	(L_S= 90°)

The martian date at opposition was April 12. The tilt of the martian axis towards Earth was at its southward maximum (-25°.4) in 1992 late April, decreasing to 0° by 1992 late August, then increasing northwards to +12°.7 in mid-November, decreasing through opposition to only +3°.7 in 1993 February, and finally increasing to a maximum of +26°.0 by late 1993 July.

A total of 1,773 observations (1,402 drawings, 102 photographs and 269 CCD images) from 89 observers in 14 countries covered the period 1992 May 5 (Parker, L_s= 243°) to 1993 August 24 (Schmude, L_s= 125°), about two-thirds of the martian year: see Table 1. Long series of observations were made by Devadas, Johnson, P. A. Moore, Parker (including colour filter and colour composite CCD work), Dal Santo, Schmude, Shirreff, Troiani, Warell and the Director. International collaboration was similar to 1990-91. Observational coverage was good from August to May and complete for all longitudes from October to March, the number of days observed per month out of the number possible being as follows: 1992 May 1/31, Jun 0/30, Jul 8/31, Aug 20/31, Sep 24/30, Oct 23/31, Nov 30/30, Dec 31/31, 1993 Jan 31/31, Feb 28/28, Mar 30/31, Apr 20/30, May 14/31, Jun 3/30, Jul 0/31, Aug 1/31.

Since our last report appeared,[1] other organisations and individuals have published accounts of the 1990 apparition.[2-6] Reviews of the current apparition,[7] and various reports,[8-14] have been published. The writer sent a pre-opposition Circular to active Section members, and wrote several interim notes for the *Journal*[15] and *Circulars.*[16] The 1992-93 observations may be compared with the seasonally equivalent apparition of 1977-78, as described by Collinson[17] and Dragesco.[18] It was hoped to correlate members' observations with data from NASA's *Mars Observer* probe. Unfortunately its premature failure made this impossible.

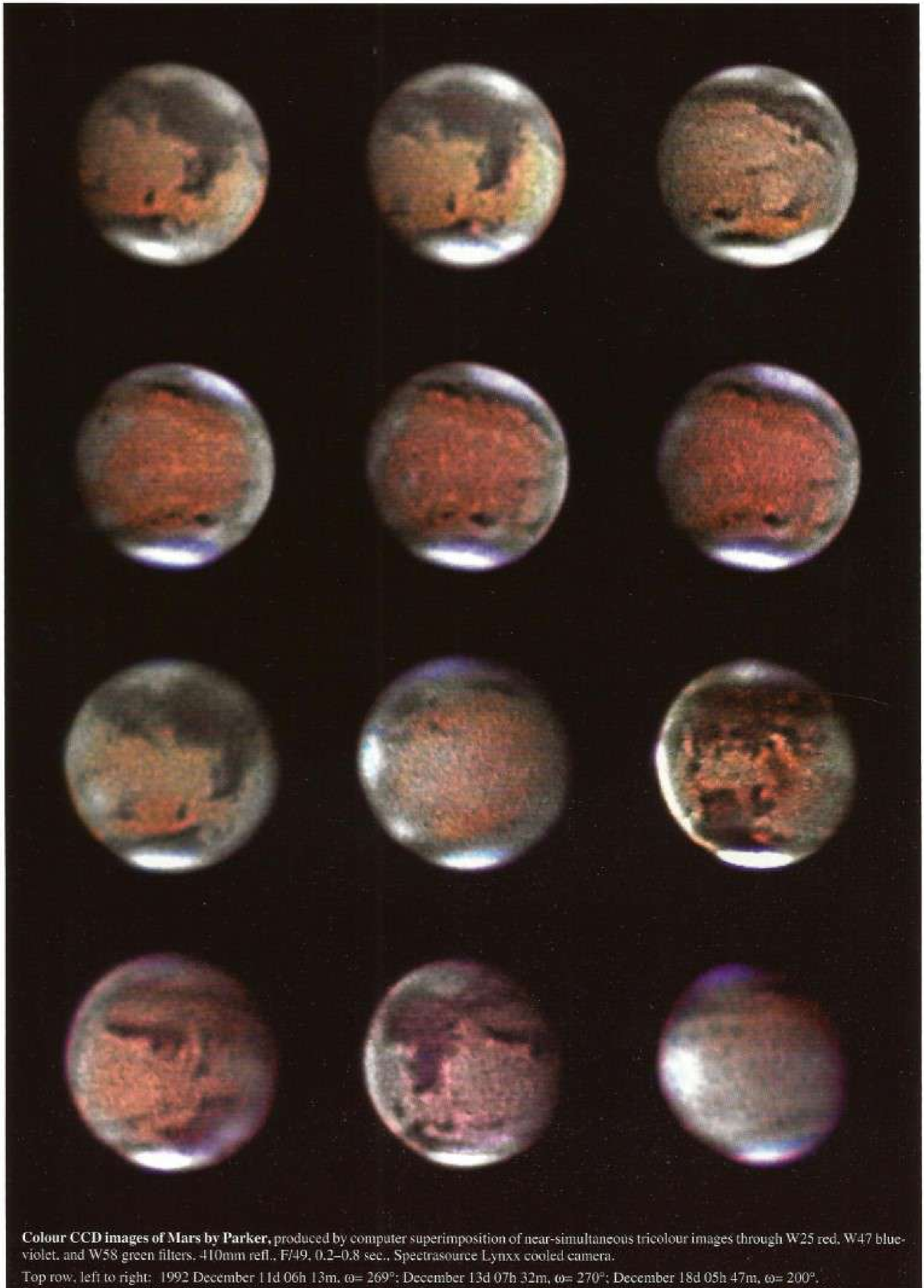
Surface features

Note: nomenclature is after Ebisawa;[19] E. and W. are used areographically *(E.= p;* W.= *f)*.

At the martian season prevailing at opposition, the desert areas generally appeared a beautiful reddish-orange or brick-dust colour, a sign of atmospheric clarity. Selected apparent colour estimates are necessarily subjective.

Apparition map

The chart (Figure 1) was compiled from the best drawings, photographs and CCD images taken around opposition (December to January). No professional data were included. Comparison with 1988[20] and 1990[1] shows real but small-scale changes.



Colour CCD images of Mars by Parker, produced by computer superimposition of near-simultaneous tricolour images through W25 red, W47 blue-violet, and W58 green filters. 410mm refl., F/49, 0.2–0.8 sec., Spectrasource Lynxx cooled camera.

Top row, left to right: 1992 December 11d 06h 13m, ω= 269°; December 13d 07h 32m, ω= 270°; December 18d 05h 47m, ω= 200°.
Second row, left to right: 1992 December 21d 04h 10m, ω= 150°; December 21d 05h 04m, ω= 163°; December 21d 05h 15m, ω= 166°.
Third row, left to right: 1993 January 19d 04h 17m, ω= 257°; January 30d 01h 57m, ω= 125°; February 7d 02h 20m, ω= 60°.
Bottom row, left to right: 1993 February 11d 00h 58m, ω= 3°; February 17d 01h 16m, ω= 313°; March 11d 02h 49m, ω= 133°.

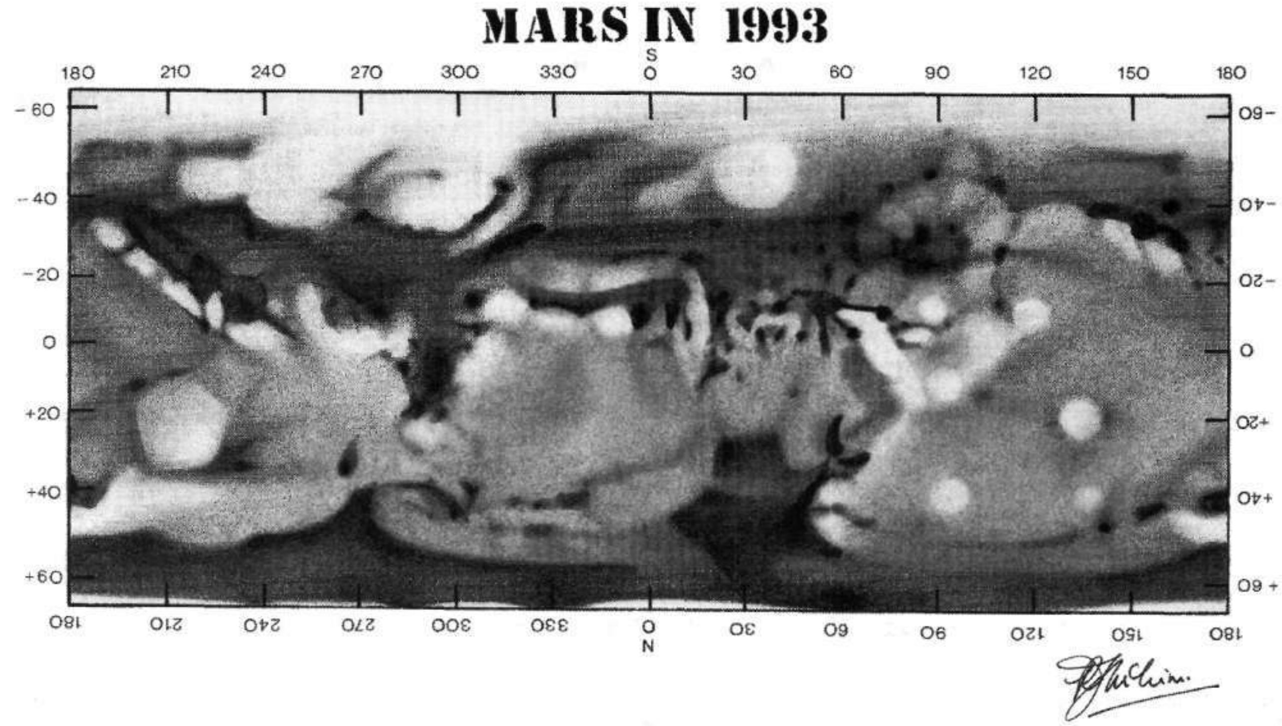


Figure 1. Martian albedo features in 1993, from images taken about opposition time. The S. edge of the NPC is drawn for the epoch L_s= 16-35°. More details are given in the text. *R. J. McKim.*

Region I: *ω= 250-010°*

Refer to Figure 5 for images specifically of this Region of Mars.

Syrtis Major was dark, especially to the N. and NW, and much the same as in 1990 apart from minor differences in detail. It appeared bluish-grey to the writer (Jan 3) and bluish-green to Marchand (Jan 4), but Devadas (Dec 27) found it had brownish edges. Parker's reconstructed colour CCD images suggest a cold grey or bluish grey tone. A surprising amount of fine detail in and around this marking was shown by the CCD images. To the east, *Moeris Lacus* remained small: there was no hint of *Nepenthes* this apparition, apart from a short E. elongation of *Moeris Lacus* (Figures 2G, 5B, D, 7H). *Libya* was often brightened by cloud (Figures 4D, 5C, 7F, G). To the north the *Syrtis* was blunt, with *Nili S.* forming a pointed NE corner. *Antigones Fons* was seen to be just separated from the NW side, *Astusapis Sinus* appeared as a small projection, *Astaboras* was faint *and Astaborae Fons* just visible (Figures 2L, 5B). *Nilosyrtis* was extremely faint. *Deltoton Sinus* was visible in its N. half. *Iapigia* was a half-tone, and the *Huygens* crater continued to be visible as a lighter circle with a dark central spot (Figures 2L, 5D). *Syrtis Major* and *Mare Tyrrhenum* were normal, appearing greenish to Marchand (Jan 8) and bluish-grey to McKim (Dec 2, Jan 3). *Mare Hadriacum* was dark, its S. tip curving west and running into the *Peneus* canal which terminated in the small faint spot, *Zea Lacus.* The latter two features were only shown on Parker's red light CCD images. *Hellas,* much foreshortened, was often light, especially in the NW. The basin was bordered by a dark *Yaonis Fretum* (which included *Nerei D.* as a dark spot) and *Hellespontus. Mare Serpentis* was very dark, as were *Sinus Sabaeus* and *Sinus Meridiani,* and their surroundings looked like they did in 1988 and 1990. *Sinus Meridiani* appeared greenish grey to Hill (Dec). The E. end of *Sinus Sabaeus* was fainter (Figures 2L, 4D, 5D), as in 1990: perhaps it is fading again, in the absence of *Hellas* dust activity which is known to 'rejuvenate' this feature. *Pandorae Fretum* was complete and rather dark, at least from August to March, as in 1990-91. *Deucalionis Regio* and *Noachis* were normal, while *MareAustrale* was too far south to be studied.

The equatorial deserts showed few features of note; *Gehon (I)* and *Cantabras* were dusky streaks (Figures 2F, 4A, 5F), and there were some indications of *Phison.* It was possible to study the northern deserts in some detail; our chart could best be compared with 1981-82[21] and 1990-91,[1] revealing more the improved imaging techniques of the 1990s rather than any major change since the previous decade. *Nodus Alcyonius* remained an isolated spot, elongated a little to the south (Figures 2G, L-O, 3A, 5A, B, 7G). Its position (+33°, 265°) was very similar to the previous decade, continuing to differ from both the IAU map (on which it is called *Thoth)* and the Ebisawa map. There was no sign of a separate *Nubis Lacus. Casius* ran as far south as about +40°, and was darkened to the north by the intense shading of *Utopia:* the region appeared brownish to Marchand, Jan 8. *Boreosyrtis* (Ebisawa map; Figures 2G, 5A, D) was connected to *S. Casius-Utopia,* and *Coloe Palus* (Figures 2G, L, 5B) on its W. side was conspicuous. Comparison with 1990 CCD images reveals genuine minor differences in this area, of which the largest was a fading of W. *Utopia,* causing *Umbra* to appear enlarged to the E. and NE. A faint *Protonilus* ran west into the conspicuous *Ismenius Lacus* (Figures 2K, L, 4D, 5E, H), and *Deuteronilus*. *Dioscuria* was more shaded than *Cydonia.* From December, as the N. polar region (NPR) became hood-free, *Arethusa Lacus* (longitude 330°) formed a dark spot that slightly indented the N. polar cap (NPC) (Figure 5E). The shaded regions to the north, namely *Cecropia* and *Ortygia,* were only visible later in the apparition.

Region II: ω = 010-130°

This Region of the planet is specifically illustrated in Figure 6.

Mare Acidalium formed an intensely dark landmark at the eastern boundary of Region II, and its extensions *Callirrhoe* and *Tanais* were quite dusky. *Niliacus Lacus* was rather large, and well separated from *Mare Acidalium* by the lighter *A chillis Pons* (Figures 2F, I, 4A, 5F, G, 6A). Devadas, Ishadoh and Minami found the dark complex of

Table 1. Observers of the 1992-93 apparition

Name	*Location(s)*	*Instruments)*
G. Adamoli	Padua, Italy	250mm refl.
L. Aerts	Heist-op-den-berg, Belgium	305mm refl.
R. W. Arbour**	South Wonston, Hants.	400mm refl.
T. M. Back	Seven Hills, Ohio, USA	152mm OG
	Mansfield, Ohio, USA	787mm refl.
R. M. Baum	Chester	115mm OG
S. Beaumont	Windermere, Cumbria	235mm & 305mm refls.
M. Bosselaers	Berchem, Belgium	250mm refl.
A. G. Bowyer	Epsom Downs, Surrey	216mm refl.
L. M. Carlino	Lockport, New York, USA	152mm OG
J. Carroll**	Florida Keys, USA	457mm refl.
T. R. Cave	Long Beach, California, USA	320mm refl.
R. Cerreta	Teramo, Italy	203mm Schmidt--Cass.
F. Daerden	Bilzen, Belgium	250mm refl.
	Genk, Belgium	200mm OG
D. Darling	Brooklyn, Wisconsin, USA	279mm Schmidt--Cass.
H. J. Davies	Swansea	220mm refl.
P. Devadas &		
K. Murugesh	Madras, India	355mm refl.
A. Diepvens	Balen, Belgium	150mm OG
J. Dijon**	Champagnier, France	310mm refl.
	Pic du Midi Obs., France	600mm refl.
C. L. Evans	Hampton, Virginia, USA	152mm OG
K. Fabian	Hickory Hills, Illinois, USA	203mm Schmidt--Cass.
M. Falorni	Arcetri Observatory,	360mm OG &
	Florence, Italy	205mm refl.
D. Fernandez	Barcelona, Spain	158mm refl.
D. Fisher	Sittingbourne, Kent	215mm refl.
M. Foulkes	Hatfield, Herts.	254mm refl. &
		203mm Schmidt-Cass.
M. Gelinas	ND-Ile-Perrot, Quebec,	152mm OG &
	Canada	203mm Schmidt--Cass.
M. Giuntoli	Pistoia, Italy	80mm OG
D. L. Graham	Brompton-on-Swale, N. Yorks.	152mm refl.
	Gilling West, N. Yorks.	406mm refl.
D. Gray	Spennymoor, Co. Durham	415mm Dall-Kirkham
		refl.
W. H. Haas	Las Cruces, New Mexico,	152mm, 203mm &
	USA	320mm refls.
A. W. Heath	Long Eaton, Notts.	300mm refl.
C. Hernandez	Miami, Florida, USA	203mm Schmidt--Cass.
N. D. Hewitt	Northampton	203mm Schmidt--Cass.
H. Hill	Wigan	254mm refl.
K. Ishadoh	Naha City, Okinawa, Japan	310mm refl.
A. Johnson	Knaresborough, N. Yorks.	210mm refl.
D.P.Joyce**	Bartlett, Illinois, USA	508mm refl.
A. P. Lenham	Swindon, Wilts.	203mm refl.
L. T. Macdonald	Newbury, Berks.	222mm refl.
C. MacDougal	Tampa, Florida, USA	150mm refl.
R. J. McKim	Oundle, Northants.	216mm & 300mm refls.
V. Makela	Helsinki, Finland	135mm OG
G. Marabini	Campo Catino Obs., Italy	150mm OG
M. Marchand	Annemasse, France	400mm refl.
K. J. Medway	Southampton	102mm OG
F. J. Melillo	Holtsville, New York, USA	203mm Schmidt--Cass.
C. Meredith	Prestwich, Manchester	216mm refl.
M. Minami	Fukui City Observatory, Japan	200mm OG
I. Miyazaki*	Naha City, Okinawa, Japan	400mm refl.
Name	*Location(s)*	*Instrument(s)*
P. A. Moore	Selsey, Sussex	320mm & 390mm refls.
S. L. Moore	Fleet, Hants.	222mm refl.
Y. Morita*	Hiroshima, Japan	250mm refl.
M. J. Morrow	Hale Hoku Obs., Hawaii	406mm refl.
R. Neel	Venissieux, France	310mm refl.
D. Neichoy	Gottingen, Germany	203mm Schmidt-Cass.
T.Nyberg	Helsinki, Finland	135mm OG
D.C.Parker**	Miami, Florida, USA	410mm refl.
T. Piatt**	Binfield, Berks.	320mm refl.
G. Quarra Sacco,		
A. Leo &		
D. Sarocchi**	Florence, Italy	300mm Cass.
D. J. Raden	Fort Meade, Florida, USA	203mm OG
K. Rhea	Paragould, Arkansas, USA	102mm OG &
		254mm refl.
R. L. Robinson	Morgantown, W. Virginia,	254mm refl.
	USA	
J. H. Rogers	Linton, Cambs.	254mm refl.
M. Dal Santo	Saletto, Italy	200mm refl.
W. H. Sheehan	Pic du Midi Obs., France	1060mm Cass.
R. W. Schmude,	College Station, Texas, USA	254mm refl. &
Jr.*		356mm Schmidt-Cass.
D. Shirreff	Marlborough College, Wilts,	254mm OG
E. Siegel	Mailing, Denmark	203mm Schmidt-Cass.
D. P. Stephens	Solihull	220mm refl.
D. Storey	Witney, Oxon	80mm OG
K. M. Sturdy	Helmsley, N. Yorks.	216mm refl.
G. Teichert	Hattstatt, France	279mm Schmidt-Cass.
L.Testa	Bologna, Italy	203mm Schmidt-Cass.
B. Timmers	Genk, Belgium	200mm OG
D. Topping	Tredegar, Gwent	300mm refl.
D. Troiani	Schaumberg, Illinois, USA	444mm refl.
A. van der Jeugt	Lokeren, Belgium	125mm OG
H. Vandenbruaene	Beernem, Belgium	250mm refl.
F. van Loo	Genk, Belgium	200mm OG &
		250mm refl.
J. Vantomme	Ekeren, Belgium	150mm refl.
E. Verwichte	Bilzen, Belgium	250mm refl.
	Genk, Belgium	200mm OG
D. Vidican	Bucharest, Romania	120mm refl.
J. Warell	Ulricehamn, Sweden	152mm refl.
	Uppsala, Sweden	161mm OG
S. R. Whitby	Hopewell, Virginia, USA	152mm refl.
M. Will	Herrin, Illinois, USA	203mm refl.
A. Winberg	Horsens, Denmark	102mm OG
D. Wright	Sanderstead, Surrey	82mm OG

*denotes the submission of photographs; ** CCD images.

Observations by Makela, Nyberg, Mrs Siegel and Winberg of the 'Nordic Mars Observers' (SAAF Planets Section, Sweden) were sent by Johan Warell, those of Mrs Murugesh by Devadas, those of Marchand (GIOSP, France) by Regis; Neel, those of Morita (Oriental Astronomical Association, Japan) by Dr Masatsugu Minami, those of Bosselaers, Diepvens, Timmers, Vandenbruaene, van Loo, Vantomme and Verwichte (Vereniging voor Sterrenkunde, Belgium) by Frank Daerden, and those of Marabini anc1 Testa (Unione Astrofili Italiani) by Roy Cerreta. Numerous report:s of the following members of the Association of Lunar and Planetary Observers (ALPO, USA) were kindly sent by Dan Troiani: Carlino, Carroll, Darling, Evans, Fabian, Joyce, MacDougal, Melillo, Morrow, Niechoy, Raden, Rhea, Robinson, Teichert, Whitby and Will.

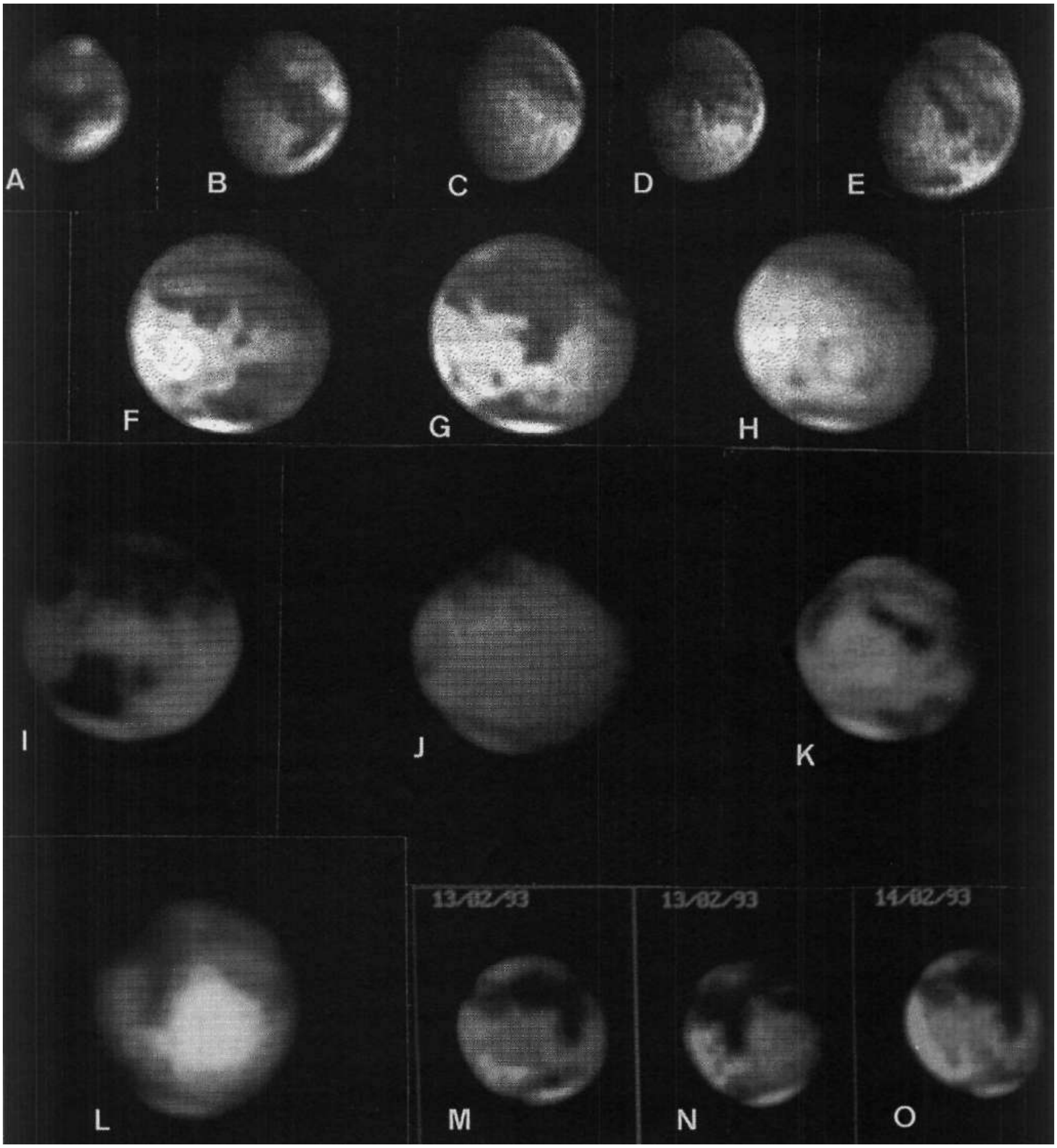


Figure 2. CCD images by Arbour (400mm refl., 0.05 sec, Starlight Xpress camera); Dijon (600mm refl., 0.01 sec, homemade camera with Thomson chip); Parker (410mm refl., F/49, 0.2-0.8 sec, Spectrasource Lynxx cooled camera); Piatt (320mm refl., Starlight Xpress camera) and Quarra Sacco *et al.* (300mm Cass., F/50, 0.2 sec, Electrim EDC-1000TE camera). All images have been produced by combining individual exposures taken in rapid succession (typically four to eight), generally followed by flat-field correction and unsharp masking. Images by Parker and Quarra Sacco downloaded to a printer; the others photographed direct from the monitor screen.

Top row: very early images by Parker (D= 4".96 - 6".6 only (!)).

A. 1992 May 5d l0h 26m, ω= 287°, red (W23A) filter. Note SPC. *Hellas* and surroundings normal.

B. 1992 July 21d lOh 17m, ω= 246°, W23A. *Hellas* light.

C. 1992 August 1d l0h 04m, ω= 136°, W23A. Shading in *Memnonia* parallel to *Mares Sirenum* and *Cimmerium.*

D. 1992 August 9d lOh 18m, ω= 61°, W23A. *MelasLacus* quite large and dark; many fine details.

E. 1992 August 16d 09h 32m, ω= 342°, red (W25) filter. Small SPC remaining; *Chryse* light in a.m.

Second row: images by Quarra Sacco *et al.*

F. 1993 February 3d 21h 10m, ω=11°, W25 red filter.

G. 1993 February 11d 20h 29m, ω=289°, W25.

H. 1993 February 20d 20h 41m, ω=210°, W25. *Elysium* dull; *Trivium Charontis* smaller than *Propontis I.*

Third row: images by Piatt.

I. 1992 December 29d Olh 30m, ω= 41°.

J. 1993 January 25d 23h 05m, ω= 120°. *Aonius Sinus, Gallinaria Silva* well seen. The N. half of *Phasis* may be visible. *N.Arcadia* and *Tempe* are light.

K. 1993 February 6d 21h 27m, ω= 349°. Note *Deuteronilus.*

Bottom row: images by Arbour (L) and Dijon (M, N, O).

L. 1993 January 2d 22h 17m, ω= 310°. Fine details around *Utopia-Boreosyrtis.*

M. 1993 February 13d 20h 12m, ω= 267°. *Elysium-Cebrenia* bright on p. side.

N. 1993 February 13d 23h 11m, ω- 311°.

O. 1993 February 14d 20h 55m, ω=268°. Compare with M.

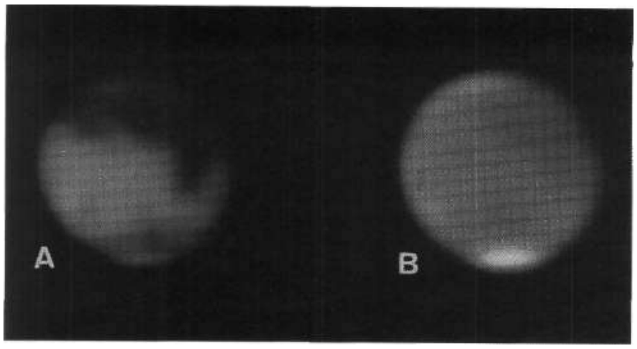


Figure 3. Filter photographs by Miyazaki with 400mm refl. on TP2415 film, 1993 February 2d:
A. 13h 16m, ω=265°, F/187, 5 sec, red (R60) filter.
B. 13h 20m, ω= 266°, F/130, 20 sec, blue-violet (B390) filter. A slight 'blue clearing' is shown in B; *Elysium* is light in both red and blue.

MareAcidalium-NiliacusLacus-Nilokeras brownish (Dec-Jan), but Foulkes and Hill found *Mare Acidalium* dark grey and greenish grey respectively (Dec). The northern component of *Nilokeras* was especially dark, running from *Mare Acidalium* into *Idaeus Fons. Idaeus Fons* and *Achillis Fons* together formed one large bifurcated condensation on *Nilokeras:* their unusually large size has been notable since 1986 (Figures 2F, I, 4A, B, 5H, 6B, D, 9D). *Lunae Lacus* was scarcely differentiated from *Nilokeras,* or from the broad *Ganges* to the south.

Mare Erythraeum was a perpetually dark feature (Figures 2F, I, 4A, 5H, 6A-C), and was especially intense on its western side as it ran southwest into *Bosporus Gemmatus* (etc.), the latter visible only in part owing to the northward tilt. To McKim, the western part of *Mare Erythraeum* ranked as one of the darkest regions on the planet, and this was confirmed by the CCD work. Sheehan from Pic du Midi in August resolved the *Mare Erythraeum* into a complex of small spots (Figure 9A) with the 1-metre reflector.[15,22] To the south, *Argyre (I)* was often bright and bluish-white throughout the martian day, suggestive of ground frost rather than cloud (Figures 2K, 4A, D, 6B-D). *Argyre (II)* and *Mare Australe* were too far south to study.

Margaritifer Sinus was normal and quite dark, appearing bluish-grey to Hill (Dec). At a similar seasonal date in 1977-78 it was rather pale, averaging only intensity 3.5 from Collinson's report,[17] against 4.6 for the present apparition. To its east, *Thymiamata* was sometimes light, and the delicate third component of the dark, doubled *Meridiani Sinus* was seen in some CCD images. To the north, *Oxia Palus* was a prominent dark inverted triangle, with a pale *Indus* seen by some visual observers (Figures 5F-H, 9B) and recorded in several CCD images. The *Pyrrhae Regio-Eos* area was not especially light, but as in several recent apparitions it was bordered to the north by a rather intense *Aurorae Fretum* which ran west into a dark *Aurorae Sinus.* Hill found *Aurorae Sinus* bluish-grey, Sep 10. *Orestes* was seen as a well-marked northward projection.

The region around *Solis Lacus* was, as always, a focus of interest. The 'Eye of Mars' itself remained large and dark (Figures 2D, I, J, 4A, B, 6B-H, 9A), possessing the same form shown since 1986, and joined to *Mare Erythraeum* by the broad, dark, *Nectar.* Although close to the southern limb, it was possible to see indications of the two dark southward projections from *Solis Lacus* which were first recognised by the writer, from Pic du Midi in 1986.[23,24] One is tempted to suggest that there can have been no large dust storms in the region during the period of the planet's last solar conjunction. Figure 6G provides a comparison with 1990. *Aonius Sinus* (Figures 2J, 6E, F) was a moderately dark feature to the S W. *Gallinaria Silva* persisted as a dusky oasis to the west, with an unnamed 'canal' running westward and petering out in W. *Daedalia. Gallinaria Silva* and this canal were imaged by Parker and Piatt and accurately drawn by new observer Ishadoh (Figures *23,* 6F). The 'canal' *Phasis* (1984-1990) was very faint or invisible between *Aonius Sinus* and *Gallinaria Silva,* but it was detectable between the latter and the dusky, slightly SE-NW elongated *Phoenicus Lacus* northwest of *Solis Lacus.* This was a minor change since 1990-91. There were traces of the classic 'canals' around *Solis Lacus* but they were faint: *Geryon, Calydon, Bathys. Ophir-Candor* was sometimes light.

Running from *Aurorae Sinus* were three projections: *Iamunae Sinus* (small), *Baetis* (dark, running to a small but equally dark *Juventae Fons)* and *Agathodaemon (Coprates).* Parker's Feb 7 colour CCD image shows all these features especially clearly. Cave saw *Juventae Fons* well: 'extremely easy and like a small drop of ink'. *Agathodaemon* was habitually dark, as was its terminal spot

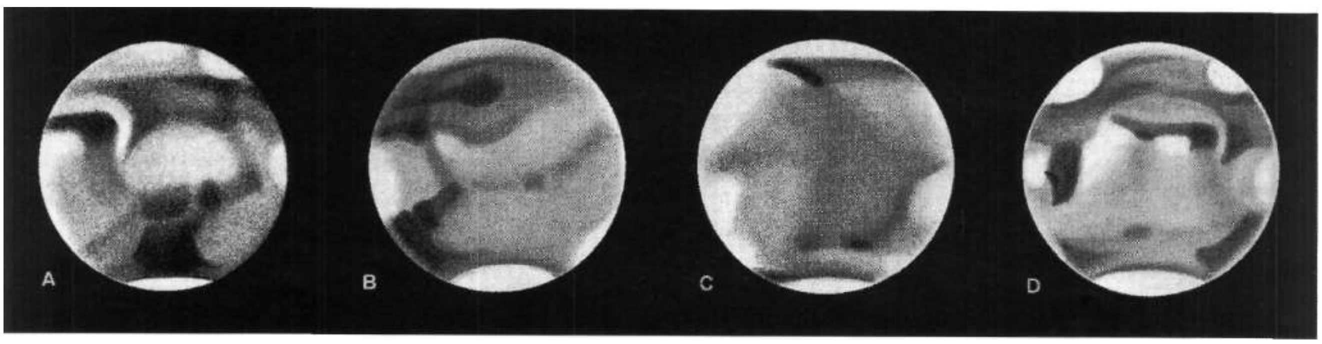


Figure 4. Drawings by the Director:
A. 1993 February Id 20h 54m, ω= 26°, 300mm refl., x353. *Idaeus/Achillis Fons* very dark, as is W. end of *Mare Erythraeum.* Bright areas over Argyre *I* and *Protei Regio.*
B. 1992 December 21d 00h 25m, ω= 96°, 216mm refl., x232. *Chryse* light on p. side; S. pre-polar hood visible; *Ascraeus Lacus* follows CM.
C. 1993 January 17d 21h 00m, ω= 160°, 300mm refl., x353. *Mare Sirenum* narrow and dark; *Propontis I* and *Castorius Lacus* to N; light a.m. and p.m. clouds.
D. 1992 December 31d 22h 20m, ω= 328°, 300mm refl., x353. Many bright patches; note *Pandorae Fretum, Hellespontus* and *Ismenius Lacus.*

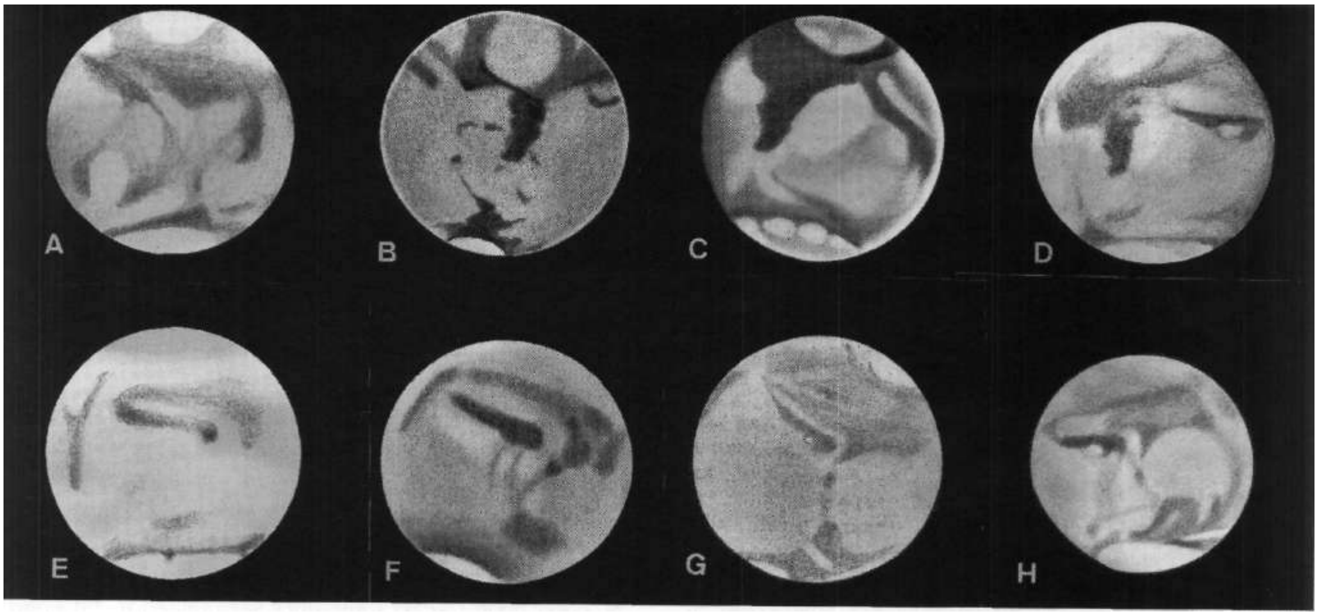


Figure 5. *Region I,* ω= 250-010°:

A. 1993 January 2d 18h 10m, ω= 250°, 200mm OG, x400, *Minami.* Shows *Nodus Alcyonius,* lightish areas over *Elysium* and *Cebrenia.*

B. 1993 January 8d 23h 30m, ω= 276°, 250mm refl., x241, x483, Daerden. Intricate structures around *Utopia,* etc.

C. 1992 November 28d OOh 50m, ω= 308°, 415mm Dall-Kirkham Cass., x262, x415, yellow (W15) and red (W25) filters, *Gray.* Bright patches *in Hellas; Mare Serpentis* very dark; N. polar hood shows complex bright patches.

D. 1993 January 24d 1lh 00m, ω= 312°, 200mm OG, x400, *Minami. Huygens* crater identifiable.

E. 1993 January 3d OOh 30m, ω= 342°, 390mm refl., x400, *P. A. Moore.* Notch *(Arethusa Lacus)* in S. edge of the cap.

F. 1993 January 31d 18h 10m, ω= 354°, 400mm refl., x286, yellow (W12) filter, *Graham.* Note *Oxia Palus* and diffuse 'canals' nearby.

G. 1993 January 26d 15h 50m, ω= 005°, 355mm refl., x230, *Devadas. Edom* bright, *Mare Acidalium* and *Niliacus Lacus* separated.

H. 1992 December 21d 19h 10m, ω= 010°, 310mm refl., x530, *Ishadoh.* Hazy cloud streak in *Mare Acidalium; Deuteronilus* and other desert details shown.

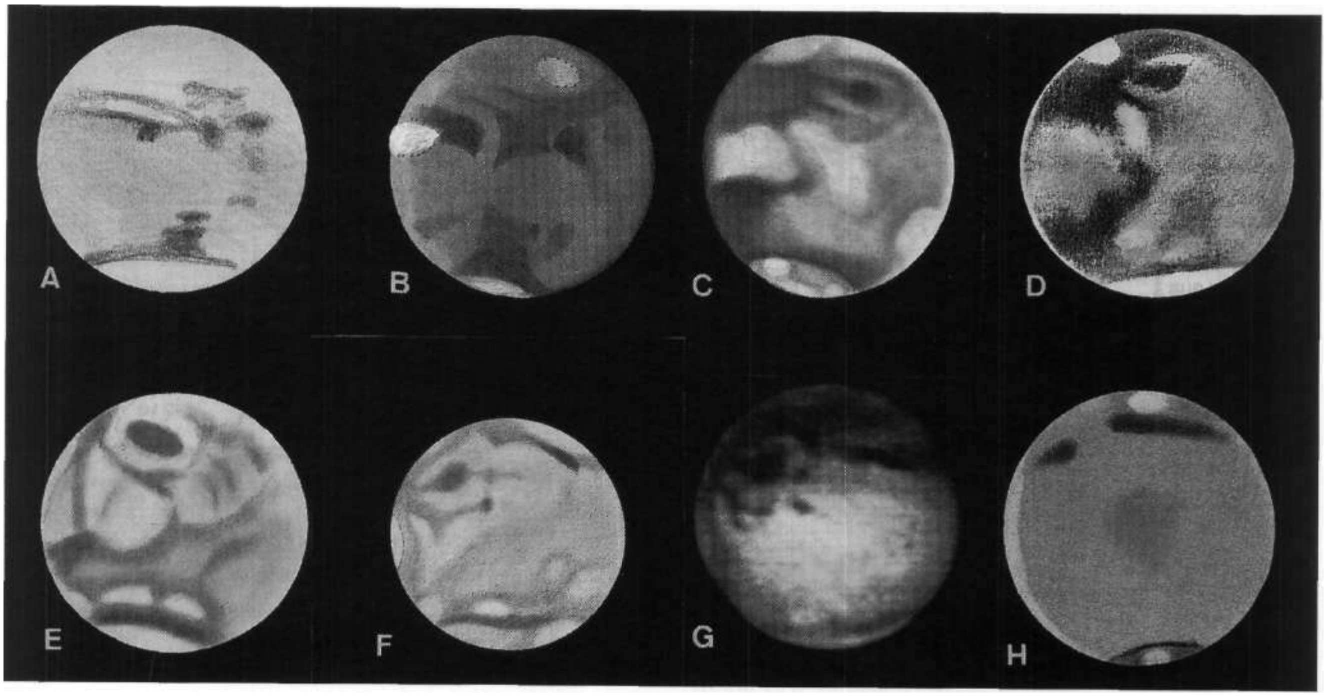


Figure 6. *Region II, ω*- 010-130°

A. 1993 January 3d 03h 00m, ω= 19°, 390mm refl., x400, *P. A. Moore. Meridiani Sinus* divided.

B. 1993 January 25d 17h 15m, ω= 34°, 210mm refl., χ 195, *Johnson.* Bright clouds over *Edom* and *Argyrel.*

C. 1992 November 14d OOh 40m, ω= 75°, 415mm Dall-Kirkham Cass., x262, W25, *Gray.* Several details in *SolisLacus* region; dull NPH with brighter patches.

D. 1993 January 21d 18h 00m, ω= 81°, 360mm OG, x370, *Falorni.* Structure *in Nilokeras;* bright clouds over southern *Thaumasia* and in *Argyre I.*

E. 1992 December 20d OOh 05m, ω= 100°, 400mm refl., x286, *Graham. Phasis* faint; bright clouds in N. *Tempe* and *Arcadia.*

F. 1993 January 9d 13h 20m, ω= 117°, 310mm refl., x530, *Ishadoh.* Weak *Phasis* visible in N. part from *Phoenicus Lacus* to *Gallinaria Silva. Acampsis* runs from *SolisLacus* through *Gallinaria Silva,* extending to the west; *Nix Olympica* lightish; clouds over *Alba, Xanthe* and N. *Tempe.* NPH on the morning side of the cap.

G. 1990 December 5d Olh 24m, ω= 121°, 1000mm refl., F/22, *Quarra Sacco.* An enhanced CCD image (with Electrim EDC-1000TE camera) obtained at CIDA, Venezuela, from the last apparition for comparison with the present. Note fine details in *SolisLacus* region.

H. 1993 January 27d OOh 00m, ω= 124°, 300mm refl., x190, x318, *Heath.* Bright cloud over *Phaethontis* on S. limb. *Olympus Mons* faint near CM.

to the west, *Melas Lacus. Tithonius Lacus* was a bifurcated continuatiof *Agathodaemon,* with a light interior. *Noctis Lacus* was small. *Chryse* and *Xanthe* were normal, and again seemed the focus of dust activity during the apparition. To the west, *Ascraeus Lacus (Ascraeus Mons)* was seen as a darker condensation (Figure 4B). It was connected to *Lunae Lacus* by a very weak *Uranius* (Figures 4B, 6E, F). There was no trace of *Ceraunius.* Some observers drew *Ulysses* as a dusky band (Figures 4B, 6E) that interconnected the *Tharsis* ridge volcanoes: *Ascraeus Mons, Pavonis Mons {Lacus), Arsia Silva.* These were not easily noted as separate albedo features in 1992-93. The volcanoes' locations were as usual revealed by bright orographic clouds in the late evening, but the season at opposition was a little early to see them at their best. Parker's series of CCD images (Figure 8) shows the diurnal development of the orographic clouds very well. Likewise the bright patch *Nix Olympica,* marking *Olympus Mons,* was seen in the evening (Figures 4C, 7E, 9G). The volcano itself appeared as a vague smudge. On Jan 27 in perfect seeing, Heath (Figure 6H) found the shading around *Olympus Mons* mottled and brownish, contrasting with the orange of the surrounding deserts. *Tempe* was normal, while the *Arcadia* desert showed only very low-contrast shadings. The dusky *Mare Boreum* was visible only in its southern half. Both *Tempe* and *Arcadia* showed some small white clouds in their northern parts (Figures 2J, 6E, F).

Region III: ω = *130-250°*

Refer to Figure 7. The southern deserts, in particular *Phaethontis, Electris* and *Eridania* were very bright at opposition and covered by cloud (Figures 2G, M, 4C, 5A, 6F, H, 7A, C-E, H, 9F). *Mare Chronium* was too far south to see well. *Mares Sirenum* and *Cimmerium* (the latter appearing greenish to Marchand, Jan 8, bluish-grey to McKim, Dec 2 and bluish to Minami, Nov 23) were dark. As in 1986-90 *Mare Sirenum* continued to end at $\lambda \approx 160°$ to the northwest, and *Caralis Fons* was imaged by Parker to its south (see the colour CCD images). *Mare Cimmerium* showed the *Laestrygonum Sinus* and *Cyclopia/Gomer Sinus* as albedo features on its northern edge, and its W. end again ended in a tapering point. As in 1988-90 some faint shadings in the southern deserts just north of *Mares Sirenum* and *Cimmerium* united to form an apparently continuous band running E-W (Figures 1, 2C, H). *Hesperia* was dusky and *Cerberus (III)* was invisible. Further descriptions given for 1988 and 1990[1] will not be repeated here.

The equatorial deserts bordering the above maria were a little lighter than those further north. *Amazonis* was full of faint low-contrast details that included *Tartarus* and *Eumenides-Orcus* (Figures 4C, 7A,D). *Elysium* was surrounded by rather pale markings, making it hard to distinguish, except when whitened by cloud. Figures 2H, M, 3A, 4C, 5A and 7 all show the area. Minami (Nov 24) found the pentagonal *Elysium* slightly light and with a pinkish tint near the CM. The area was the scene of a local dust storm in February. *Trivium Charontis* was a very small dusky spot, hard to see visually, and like *Cerberus* seemed fainter than in 1990. The figures in the last Report[1] show that the surroundings of *Elysium,* excepting the *Aetheria* darkening, were already rather faint. *Pambotis Lacus* was inconspicuous, *Eunostos* virtually invisible. *Phlegra/Styx* formed the pale E. border of *Elysium,* from *Trivium Charontis* to the site of the invisible *Hecates Lacus. Chaos* marked the N. edge quite clearly, and the *Aetheria* development (1978-) was dusky at the NW corner of *Elysium.* The main dark patch, which was brownish to Minami (Jan), probably an enlargement of *Morpheos Lacus,* had a short extension due west, while the faint *Hyblaeus* formed the W. border of *Elysium* and extended somewhat further south across *Aethiopis.* The region is best illustrated in Figure 1 and the colour CCD images.

There was no sign of *Thoana Palus* nor *Nodus Laocoontis* between the *Aetheria* darkening and *Nodus Alcyonius* in Region I.

Propontis (I) was a dark E-W elongated spot (Figures 2H, 4C, 7A, B, F). It was brownish to Minami (Dec), darker on the E. side and had a slight SW extension. Haze from the N. polar hood (NPH) sometimes surrounded it. *Propontis (II)* could scarcely be differentiated from the dusky shadings bordering the retreating polar cap *(Scandia, Gyndes, Panchaia)* about latitude +60°. This band of shading was dark bluish to Minami (Dec). The region between the Propontides was light, not shaded as on Ebisawa's map, as has been the case for some years. *Erebus* was a vague halftone. *Cebrenia* was lightish, with *Arcadia* rather shaded in Region III. To the east of *Propontis (I), Euxinus Lacus* was a small dark spot (Figures 2J, 4C; colour CCD images).

Intensity estimates

White-light data appear in Table 2. Some potential contributors used a different (or wrong) scale, or made too few observations. The Director and his predecessor have published such tables since 1960, giving a record of albedo fluctuations over two 15- or 17— year 'cycles' of oppositions. It would be interesting to reexamine these data sets together with additional, unpublished observations, but the Director wonders if it would not be better for future investigators to use the excellent amateur photographic and CCD work now available for such studies. However, intensity estimates continue to allow observers to spot short-term changes and to quickly record the order of darkness of markings. Teifel *et al.*[25] have constructed a low-resolution Mars albedo map with isophotometric contours from 1990 images.

The martian atmosphere

White clouds

General

Bright areas at the limb, terminator and on mid-disk are generally classified here as 'white clouds', though some may be frost patches. Observations from October to March inclusive are complete in longitudinal coverage. Activity in the polar regions is covered separately.

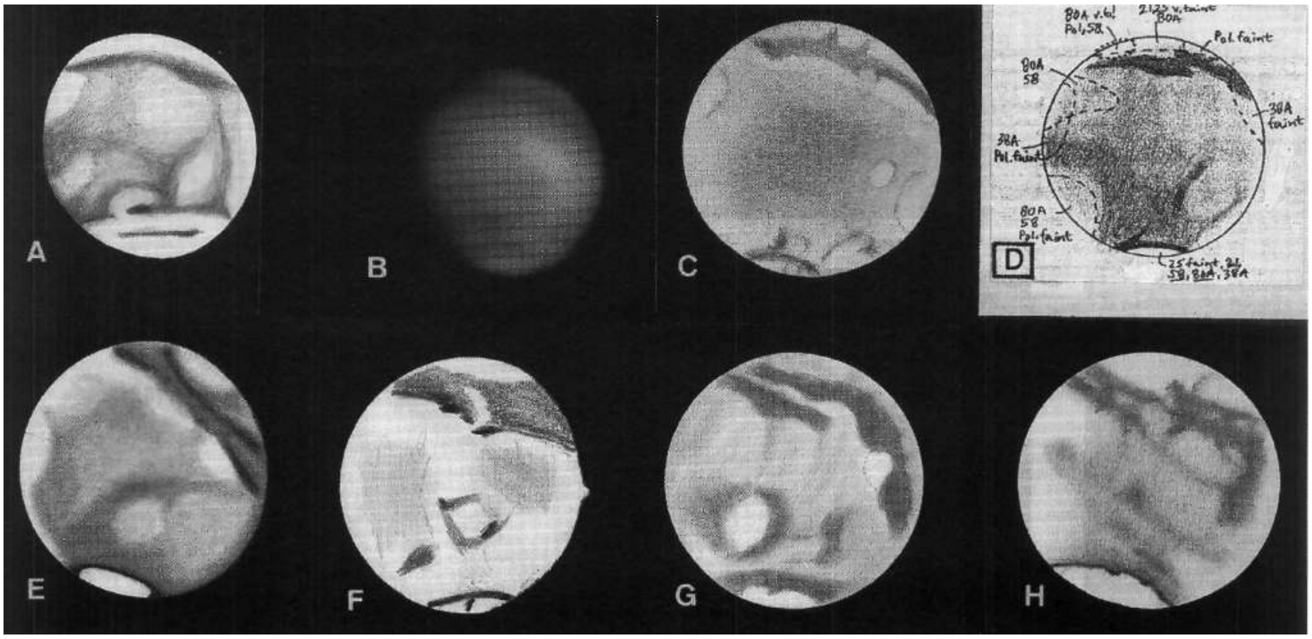


Figure 7. *Region III,* ω= 130-250°
A. 1992 November 28d 16h 30m, ω= 177°, 200mm OG, x480, *Minami.* NPH reaches *Propontis I.* Note dark streak in hood: compare with B.
B. 1992 December 5d 20h 52m, ω= 178°, 400mm refl., F/187, 3 sec. on TP 2415 film, *Miyazaki.* Seven days following A the NPH as imaged in white light has retreated north of latitude +60°, so that *Gyndes* (?) now borders the NPR instead of showing through it as a dark streak. Note how ill-defined the E. border *of Elysium* is. (In violet light the hood was more extensive).
C. 1993 January 7d 16h 15m, ω= 178°, 355mm refl., x230, *Devadas.* Intricate details in S. maria; *Elysium* lighter on f. side.
D. 1993 January 13d 19h 10m - 20h 30m, ω= 187°, 161mm OG, x200, x333, *Warell. Mare Sirenum* narrow in north-south dimension; various bright clouds, especially one irradiating over *Phaethontis* on *Sp* limb: see notes (filters are Wratten, 'pol.' = polarising filter).
E. 1993 March 30d 19h 10m, ω= 193°, 415mm Dall-Kirkham Cass., x415, x664, W15, *Gray.* Typical view of *Elysium* and S. maria; shrinking NPC.
F. 1993 February 28d 02h 40m, ω= 233°, 320mm refl., x350, x660, *Cave.* Notch in NPC, bright terminator cloud and projection.
G. 1993 January 9d 21h 35m, ω= 239°, 310mm refl., x310, *N eel.* Notch in NPC S. edge in longitude of *Sithonius Lacus.*
H. 1993 January 8d 21h 44m, ω= 249°, 215mm refl., x272, x345, Fisher. Fine detail in the S. maria.

1992 July — September

In July, Parker's CCD images already showed morning limb haze, with specific brightenings over *Eridania* and *Hellas. Amazonis* was light to Falorni on the morning side of the disk. Evening cloud was seen *over Hellas,* E. *Tharsis* and/or *Ophir—Candor.* In August, morning cloud was seen over *Amazonis, Arcadia, Chryse* (Figure 2E), *Hellas, Tempe, Tharsis* and *Xanthe.* Evening cloud was apparent over *Daedalia/E. Memnonia* and *Tharsis. Elysium* was dull near the CM and poorly contrasted with its surroundings. Unusually, *Aethiopis* was seen light on mid-disk by Falorni (20th). *Hellas* was whitish on the CM to Hill (15th). In September, *Aeria, Chryse, Hellas, Tharsis* and *Xanthe* exhibited morning cloud. There was evening cloud over *Ausonia, Chryse, Hellas,* S. *Noachis* and *Xanthe.* Cerreta saw a brightening in NW *Hellas* near the CM and Dal Santo saw the whole basin bright. A pale S. pre-polar hood (Ebisawa's nomenclature for pre-polar and polar hoods is used here) now edged the extreme southern limb (see also the S. polar region section).

1992 October

A.m. limb: *Aeria, Amazonis, Argyre (I), Hellas, Moab* and *Tempe;* p.m. terminator: *Aeria, Argyre(I), Hellas* and *Tharsis. Hellas* was not bright on mid-disk to Shirreff and Siegel, but Dal Santo saw it light.

Elysium remained dull on mid-disk; *Libya* was light near the CM to Dal Santo, and *Moab* was light near the CM to Testa. The southern deserts *Ausonia, Eridania* and *Electris* were bright throughout the martian day.

1992 November

A.m. limb: *Aeria, Amazonis, Argyre (I), Candor, Chryse, Hellas, Isidis Regio, Libya, Ophir, Tempe, Tharsis* and *Xanthe·,* p.m. terminator: *Aeria, Argyre (I)* (light but not bright to Gray (Figure 6C) and Whitby), *Chryse, Hellas* (sometimes only the NW, sometimes all the basin), *Isidis Regio, Libya, Memnonia,* E. *Tempe (Nix Tanaica?)* and *Mare Acidalium, Tharsis, Xanthe* and *Zephyria* (the small bright spot *Lubar* (Ebisawa) being seen by Devadas). *Elysium* was not bright on the evening terminator. *Hellas* was dull near the CM to Johnson and on Parker's CCD images (Nov 1), but it was bright occasionally (e.g., Siegel found the whole basin 'pure white' on Nov 26). *Libya* remained slightly white on mid-disk; Minami on the 23rd likewise saw part of *Elysium* to be slightly lighter, as well as an unusual white cloud crossing *Cebrenia,* bisecting the *Aetheria* dark patch. Haze from the N. polar hood sometimes surrounded *Propontis (I).* A whitish mid-disk cloud over *Edom* was seen by Dal Santo. Falorni detected an equatorial cloud band (ECB) at CML= 29° through the W47 filter on the 20th. The southern deserts *of Ausonia, Electris, Eridania* and *Phaethontis* were covered by white cloud more or less constantly, as far as their northern limits; at other longitudes a narrow bright fringe edged the extreme S. limb. Ebisawa[12] noted that the formation of these south-

Table 2. Martian intensity estimates

					Observer						
Feature	*Graham*	*Heath*	*Johnson*	*Lenham*	*McKim*	*Meredith*	*Schmude*	*Shirreff*	*Ave.*	*s.d.(±)*	*No.*
Achillis F.	–	–	–	–	5.4	–	–	–	5.4	(-)	5
Achillis P.	3.0	–	–	–	4.0	–	–	3.0	3.3	0.6	6
Acidalium, M.	6.3	5.3	5.4	6.1	6.1	4.3	4.7	5.2	5.4	0.7	65
Aeolis	1.8	–	2.0	2.0	1.5	–	–	2.0	1.9	0.2	23
Aeria	2.0	–	1.9	1.1	1.4	1.9	1.5	2.0	1.7	0.4	33
Aetheria	3.1	–	–	2.6	3.0	–	–	3.5	3.0	0.4	12
Aethiopis	1.9	–	–	2.6	2.2	2.0	2.0	2.0	2.1	0.2	27
Amazonis	2.6	–	1.8	3.5	2.0	2.0	–	2.0	2.3	0.6	30
Amenthes	2.0	–	2.0	1.6	1.6	2.0	2.0	2.0	1.9	0.2	29
Aonius S.	3.8	–	3.5	5.7	4.0	3.5	–	–	4.1	0.9	9
Arabia	2.2	–	2.0	2.2	1.8	2.0	2.0	2.0	2.0	0.1	32
Arcadia	2.6	–	2.1	3.8	1.8	2.0	–	2.0	2.4	0.7	36
Argyre (I)	1.3	0.2	1.1	1.6	0.2	0.9	1.1	1.5	1.0	0.5	39
Ascraeus L.	4.0	–	–	–	3.8	–	3.5	4.0	3.8	0.2	8
Aurorae F.	–	–	–	–	5.1	–	–	–	5.1	(-)	7
Aurorae S.	4.4	5.8	5.9	6.5	6.1	5.0	4.7	5.4	5.5	0.7	43
Ausonia	1.8	0.0	1.7	1.2	0.5	1.2	–	2.0	1.2	0.7	23
Baltia	3.0	–	5.0	–	4.1	–	–	–	4.0	1.0	10
Boreosyrtis	3.0	–	3.5	–	5.1	–	–	–	3.9	1.1	16
Boreum, M.	4.4	5.2	4.0	5.5	4.5	3.5	4.3	–	4.5	0.7	32
Callirrhoe	–	–	–	–	4.2	–	–	5.0	4.6	(0.4)	8
Candor	2.0	–	–	1.9	1.8	–	–	–	1.9	0.1	11
Casius	4.5	–	–	–	5.1	–	–	–	4.8	(0.3)	10
Castorius L.	–	–	–	–	4.5	–	–	–	4.5	(-)	1
Cebrenia	1.7	–	1.9	3.1	1.4	–	–	–	2.0	0.7	16
Cecropia	5.0	5.0	–	5.0	4.0	–	–	–	4.8	0.5	16
Cerberus (I)	3.0	–	2.9	5.6	3.5	–	2.5	3.0	3.4	1.1	20
Cerberus (II)	3.0	–	–	–	3.2	–	–	–	3.1	(0.1)	5
Chaos	–	–	–	–	3.5	–	–	–	3.5	(-)	3
Chryse	2.0	–	1.6	2.1	1.6	2.0	2.0	2.0	1.9	0.2	35
Cimmerium, M.	6.0	5.6	5.5	6.4	5.2	4.0	4.3	5.1	5.3	0.8	51
Claritas	2.1	1.0	2.3	1.5	2.0	1.2	–	–	1.7	0.5	17
Cyclopum S.	–	–	–	4.0	5.6	–	–	–	4.8	(0.8)	3
Cydonia	2.5	–	3.0	–	2.5	2.5	–	–	2.6	0.2	22
Daedalia	2.2	–	–	–	1.7	2.0	–	–	2.0	0.2	13
Deucalionis R.	2.7	1.6	2.4	2.3	2.3	2.0	2.5	2.7	2.3	0.4	25
Deuteronilus	–	–	3.0	–	3.6	–	–	–	3.3	(0.3)	5
Diacria	–	3.0	3.0	3.5	2.5	–	–	–	3.0	0.4	8
Dioscuria	3.0	–	3.0	–	3.2	2.7	–	–	3.0	0.2	11
Eden	2.1	–	2.5	–	1.9	2.0	2.0	2.0	2.1	0.2	31
Edom	1.5	–	1.0	1.4	1.5	–	–	–	1.4	0.2	13
Electris	1.5	0.5	1.8	–	0.8	1.2	1.5	2.0	1.3	0.5	24
Elysium	1.8	–	1.7	2.2	1.5	–	–	2.0	1.8	0.3	26
Eridania	1.3	0.5	1.9	–	0.6	1.5	1.8	2.0	1.4	0.6	27
Erythraeum, M.	4.5	4.0	4.6	5.5	5.5	4.0	4.4	5.3	4.7	0.6	43
Eumenides-Orcus	3.4	–	2.7	–	3.0	–	–	–	3.0	0.4	10
Ganges	3.8	–	3.5	–	3.5	2.5	3.5	–	3.4	0.5	21
Gehon	3.0	–	–	–	3.0	2.5	–	–	2.8	0.3	6
Hadriacum, M.	–	5.2	5.0	5.0	6.0	–	–	–	5.3	0.5	7
Hellas	1.1	0.5	1.7	0.9	0.7	1.1	0.5	2.0	1.1	0.5	37
Hellespontus	–	–	3.0	–	5.2	–	–	5.0	4.4	1.2	6
Hesperia	2.0	–	3.3	2.2	2.3	–	–	–	2.4	0.6	10
Iapigia	4.5	5.2	5.1	6.0	4.7	3.6	4.0	4.8	4.7	0.7	33
Idaeus F.	–	–	–	–	5.4	–	–	–	5.4	(-)	5
Isidis R.	2.2	–	1.5	1.7	2.0	2.1	2.0	2.0	1.9	0.2	29
Ismenius L.	4.0	–	3.3	4.9	3.8	–	3.5	4.7	4.0	0.6	13
Libya	1.8	1.0	1.5	–	1.5	1.9	–	–	1.5	0.4	25
Lunae L.	4.8	–	4.0	2.6	4.5	–	4.3	4.2	4.1	0.8	25
Margaritifer S.	4.2	4.0	5.2	4.8	5.6	3.8	3.8	5.0	4.6	0.7	40
Memnonia	2.0	–	1.3	1.6	1.7	2.0	–	2.0	1.8	0.3	21
Meridiani S.	6.2	5.0	6.1	6.5	6.4	4.5	4.9	6.0	5.7	0.8	40
Meroe	2.2	–	–	1.9	2.0	2.0	2.0	2.0	2.0	0.1	24
Moab	2.1	–	1.5	2.0	1.9	2.0	–	2.0	1.9	0.2	35
Nectar	–	–	4.5	5.7	5.7	–	–	–	5.3	0.7	6
NeithR.	2.2	–	–	1.8	2.0	2.1	2.0	2.0	2.0	0.1	25
Niliacus L.	4.5	–	4.8	5.7	5.5	–	4.3	5.0	5.0	0.6	37
Nilokeras	4.7	–	4.1	5.4	4.1	2.5	3.9	5.0	4.2	0.9	32
Noachis	2.5	–	2.0	2.0	2.5	2.0	–	2.0	2.2	0.2	19
Nodus Alcyonius	–	–	3.7	–	4.5	–	–	–	4.1	(0.4)	7
Ophir	2.0	–	–	–	1.8	–	–	–	1.9	(0.1)	8
Ortygia	4.5	–	4.8	5.0	4.6	–	–	–	4.7	0.2	16
Oxia P.	4.0	–	–	–	–	–	4.5	4.0	4.2	0.3	5
Panchaia	4.0	4.5	3.7	5.5	4.0	2.5	4.8	3.5	4.1	0.9	26

Table 2 (continued). Martian intensity estimates

Feature	*Graham*	*Heath*	*Johnson*	*Lenham*	*Observer* *McKim*	*Meredith*	*Schmude*	*Shirreff*	*Ave.*	*s.d.(±)*	*No.*
Pandorae F.	–	4.5	3.3	4.5	4.9	3.5	4.0	5.0	4.2	0.7	21
Phaethontis	0.5	0.5	2.4	-	0.8	0.8	1.2	2.0	1.2	0.7	18
Phlegra	3.2	-	3.4	-	3.6	-	3.0	-	3.3	0.2	13
Phoenicus L.	-	-	-	-	-	-	3.5	-	3.5	(-)	1
Propontis (I)	5.0	-	4.2	5.7	5.0	-	4.2	5.0	4.8	0.6	17
Protonilus	-	-	-	-	3.8	-	-	-	3.8	(-)	3
Pyrrhae R.	3.0	-	2.0	-	4.8	-	2.5	-	3.1	1.2	12
Sabaeus S.	5.8	5.3	5.2	5.8	5.9	3.2	4.5	5.5	5.2	0.9	44
Scandia	3.3	5.0	3.4	5.0	5.2	3.5	-	-	4.2	0.9	15
Serpentis, M.	5.0	-	4.1	6.2	5.5	3.2	5.0	5.3	4.9	1.0	21
Sirenum, M.	4.0	4.5	4.7	6.2	5.6	3.5	4.2	5.0	4.7	0.9	37
Solis L.	4.8	5.9	4.2	6.8	6.0	3.9	5.2	5.8	5.3	1.0	40
Syrtis Major	6.3	6.5	6.0	6.7	6.4	4.4	4.7	5.9	5.9	0.8	54
Syrtis Minor	6.0	-	-	-	6.3	3.9	5.0	5.3	5.3	0.9	17
Tanais	-	-	-	5.6	4.8	-	-	-	5.2	(0.4)	15
Tartarus	-	-	-	-	3.0	-	-	-	3.0	(-)	4
Tempe	2.0	-	2.0	2.0	1.8	2.0	2.0	2.0	2.0	0.1	31
Tharsis	2.0	-	2.0	1.8	1.7	2.0	2.0	2.0	1.9	0.1	34
Thaumasia	2.1	-	2.3	1.1	2.0	2.0	-	2.0	1.9	0.4	23
Thymiamata	-	-	2.5	1.8	2.3	-	-	-	2.2	0.4	9
Tithonius L.	4.0	-	4.3	4.4	4.0	4.0	4.0	4.0	4.1	0.2	16
Trivium Charontis	-	-	3.2	5.6	4.0	-	3.5	4.0	4.1	0.9	12
Tyrrhenum, M.	6.0	5.8	4.9	6.4	6.2	3.8	4.2	5.3	5.3	1.0	39
Ulysses	3.8	-	-	-	-	-	-	-	3.8	(-)	3
Uranius	3.8	-	-	-	3.2	-	-	-	3.5	(0.3)	6
Utopia	4.5	5.8	3.5	5.4	4.8	3.2	3.5	3.5	4.3	1.0	36
Xanthe	1.8	-	1.8	2.0	1.7	2.0	1.5	2.0	1.8	0.2	33
Yaonis F.	-	-	-	-	4.6	-	-	-	4.6	(-)	4
Zephyria	1.7	-	1.8	2.3	1.5	2.0	-	2.0	1.9	0.3	29
No. of useful estimates	283	84	350	259	604	245	122	157		Total	2,104
Period of observation	Oct 31-Mar30	Nov 10-Feb15	Oct 14-Mar13	Nov 19-Apr14	Nov 12-Feb21	Nov 17-Mar23	Oct 26-May21	Oct 30-Apr15			

ern 'pre-polar hoods' seemed to have begun soon after the S. hemisphere autumnal equinox (L_s= 0°; Nov 22).

1992 December

A.m. limb: *Aeolis, Argyre (I)* (Figure 4D), *Azania, Baltia, Bosporus Gemmatus* (Warell, December 22), *Candor, Cebrenia, Chryse, Cydonia, Diacria* (and around *Proponțis (I)), Edom, Hellas, Libya, Memnonia, Meroe, Noachis, Nodus Gordii* (McKim, 20th), *Ophir, Tempe* (sometimes covering *Mare Acidalium),* S. *Thaumasia* (Marchand, December 22), *Xanthe* and *Zephyria;* p.m. terminator: *Aeria, Aetheria, Amazonis, Argyre (I), Candor, Cebrenia, Chryse, Diacria* (and around *Propontis (I)), Edom* and the N. 'coastline' of *Sinus Sabaeus, Hellas* (especially NW corner; Figure 4D), *Isidis Regio, Libya* (very large and bright (Figure 4D), sometimes irradiating at the evening terminator where it tended to merge with the *Isidis* cloud), *Memnonia, Ophir, Tempe* (including*Nix Tanaica), Tharsis, Thymiamata, Xanthe* and *Zephyria.* Of the *Tharsis* clouds, *Nix Olympica* (the orographic white cloud over the slopes of *Olympus Mons)* was first shown clearly by Parker's CCD images from December 18 (L_s= 13°), together with several other clouds over *Alba (Alba Patera), Ascraeus Lacus (Mons), Pavonis Lacus (Mons) and Arsia Silva (Mons)* (see Figure 8). These clouds were not normally visible until the late martian afternoon, but Cave recorded *Nix Olympica* near the CM on the 27th. As earlier, the S. deserts and S. limb areas *(Ausonia, Argyre (I), Electris, Eridania, Phaethontis,* etc.) were consistently bright. *Argyre (I)* in particular was brighter still when rising or setting. Other areas that were bright or slightly white on mid-disk were: S. *Aeolis, Aeria,* N. *Arcadia* (Figures 6E, F), *Diacria* (and around *Propontis (I)), Dioscuria* (small but bright cloud seen, Verwichte, 30th), *Edom* crater and the N. 'coastline' of *Sinus Sabaeus, Hellas* (all or just the NW), *Libya,* S. *Memnonia* (i.e., the N. 'coastline' of*Mare Sirenum),* NW *Nodus Gordii,* N. *Tempe* (including *Nix Tanaica;* Figure 6E), *Tharsis* and S. *Zephyria. Elysium* was light at the morning limb, but dull on mid-disk (slightly whiter to Hernandez and Robinson, Dec 15-16). It showed little tendency to brighten in the evening this month. Parker's CCD images on Dec 19 (CML= 178°) and 21 (CML= 143°) and a Dec 26 (CML= 123°) drawing by Hernandez suggested the presence of ECBs.

1993 January

A.m. limb: *Aeria, Aetheria, Aethiopis, Arabia, Arcadia, Argyre (I), Cebrenia, Chryse, Cydonia, Deucalionis Regio, Edom, Hellas, Isidis Regio, Libya* (indenting the/7, side of *Syrtis Major* to Heath on the 7th), *Meroe, Neith Regio, Noachis* (Vandenbruaene, 2nd), *Tempe, Tharsis* and *Xanthe;* p.m. *limb: Aeria,Amazonis, N.Arcadia,Argyre (I)* (Figure 6D), *Bosporus Gemmatus* (Testa, 21st), *Candor, Cebrenia, Chryse, Daedalia, Dia, Eden, Edom* (irradiating to Johnson, 25th; Figure 6B), *Hellas, Isidis Regio, Libya, Memnonia* (irradiating to Johnson, 17th), *Neith Regio, Ophir,* N. *Tempe* (Figure 2J), *Tharsis, Thaumasia, Xanthe* and *Zephyria.* The *Tharsis* orographies continued to be well seen: e.g., *Nix Olympica* was photographed by Miyazaki in blue-violet light, imaged by Parker and drawn by Johnson and McKim (Figure 4C) on the evening side; it was faint to McKim on the CM on the 25th and to Ishadoh on the morning side on the 9th (Figure 6F), while Devadas saw *the, Arsia Silva* cloud near the CM on the 13th. The southern deserts were again light, *Argyre (I)* and *Phaethontis* (Figures 6H, 7D) especially so.

Clouds on mid-disk: S. *Aeolis,* N. *Arcadia* (Figure 2J), *Candor, Cebrenia* (Figure 5A), S. *Chryse* (e.g. bordering *Margaritifer Sinus), Deucalionis Regio, Dia, Edom* and the N. coast of *Sinus Sabaeus* (Figures 5F, G), *Hellas* (especially NW, but the whole region dull to Minami, 24th), *Libya, Ophir, Protei Regio* (Devadas, 18th), N. *Tempe,* S. *Thaumasia* (Figure 6D), *Thymiamata,* S. *Xanthe* and S. *Zephyria. Elysium* was generally dull on mid-disk, but part of it was whitish on Morita's Jan 1 photograph. Parker's images showed it was whitish at the morning limb (Figure 4C), but dull at midday, after which it brightened towards evening (Figure 5A).

1993 February

A.m. terminator: *Arabia, Argyre (I)* (Figures 2K, 4A), *Bosporus Gemmatus, Cebrenia, Chryse, Deucalionis Regio, Elysium, Hellas, Libya* (on Feb 28 Cave (Figure 7F) saw a terminator projection near +5°, 290°, associated with bright morning cloud here and visible for 35 minutes), *Tempe, Tharsis,* N. *Utopia* (small cloud seen by Graham, 17th), *Xanthe* and *Zephyria;* p.m. limb: *Aeria, Aetheria, Aethiopis, Amazonis, Amenthes* (McKim, 5th), *Argyre (I), Chryse, Cydonia, Diacria, Eden, Edom, Elysium, Hellas* (sometimes irradiating; Figure 2K), *Isidis Regio, Libya, Memnonia, Meroe, Neith Regio, Ophir, Tharsis,* N. *Thaumasia* and *Xanthe.* The *Nix Olympica* evening cloud was seen by Devadas, Gray (Figure 9G) and McKim. The bright southern deserts were nearly continuous, but much foreshortened, along the S. limb. *Argyre (I)* was again especially bright throughout the martian day and *Phaethontis* was also conspicuous. Mid-disk clouds: S. *Aeolis, Aeria, Cebrenia, Deucalionis Regio, Edom, Hellas* (generally NW corner but whole basin bright and bluish-white to Marchand, 4th), *Isidis Regio, Libya,* S. *Memnonia,* the N. 'coastline' of *Sinus Sabaeus, Thymiamata* and S. *Zephyria.*

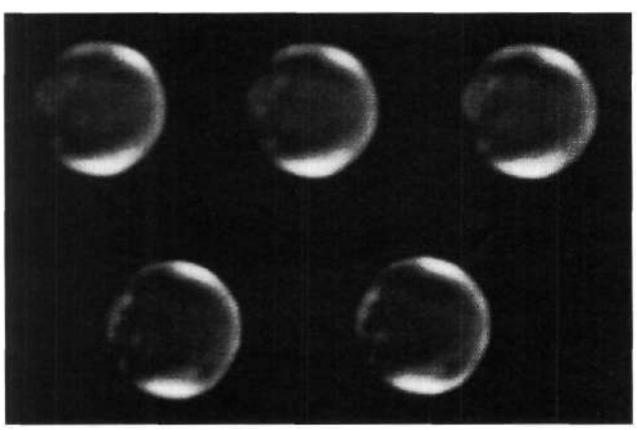


Figure 8. Orographic evening clouds. CCD images by Parker, 1992 December 21d, W47 + IR rejection filter, F/48,17.5s., other technical data in Figure 2. Top left to bottom right: 03h 40m-05h 16m, ω= 143-166°. Sequence shows part of evening ' W cloud, two other orographics, bright *Eridania* to south.

1993 March

A.m. terminator: *Aeria, Argyre (I), Candor, Chryse, Elysium, Eridania, Isidis Regio, Libya, Neith Regio, Ophir, Tempe, Tharsis* and *Xanthe;* p.m. limb: *Aeria, Aethiopis, Amazonis, Amenthes, Arabia, Arcadia, Argyre (I), Candor* and *Tractus Albus* (Gray, 5th), *Eden, Hellas* (mostly NW corner; irradiating to Warell, 12th), *Isidis Regio, Libya, Memnonia, Moab, Tempe, Tharsis,* S. *Thaumasia, Xanthe* and *Zephyria. Nix Olympica* was seen by Gray on the 30th on the evening side (Figure 7E) and on the CM on the 5th. The S. limb area was the same as in February but harder to see through greater foreshortening. Bright areas on mid-disk: *Amenthes, Argyre (I)* (sometimes looking like a S. polar cap), *Dia, Hellas* (normally dull but some brightenings especially in NW), *Libya,* a small cloud S. of *Mareotis Lacus* (Graham, 5th) and *Noachis* (Moore, 14th). *Elysium* was still dull near the CM. An ECB was recorded on a Parker CCD image (March 11, CML= 130°).

1993 April-August

By April, the disk diameter had fallen to 8". A.m. terminator bright areas: *Amazon is* (Schmude saw an apparent terminator projection associated with a bright morning cloud here near +37°, 176° on Apr 19: irradiation?), *Arcadia, Chryse, Isidis Regio, Libya, Tempe,* S. *Thaumasia, Tharsis* and *Xanthe;* p.m. limb: *Aeria, Aethiopis, Albos,* (Gray, 10th), *Argyre (I), Candor-Tractus Albus, Chryse, Eden, Hellas, Isidis Regio, Libya, Memnonia, Tharsis* and *Xanthe. Nix Olympica* was bright on the morning side to Gray on the 10th and Siegel on the 13th (who also found it brilliant through a W47 filter). It was not seen on the evening side, due to the now incomplete observations. The bright S. limb areas were still more foreshortened but otherwise as before; mid-disk brighter patches sometimes appeared over: *Dia, Hellas, Tharsis* and *Xanthe.* ECBs were sighted on the 10th (CML= 95°, Johnson), 14th (CML= 63°, Johnson and Lenham) and 20th (CML= 7°, McKim), but these may possibly have been simple contrast phenomena upon the diminutive disk. In May, fragmentary data revealed morning cloud over *Elysium,* and evening cloud over *Chryse, Hellas, Libya, Memnonia, Xanthe* and *Zephyria. Elysium* was still dull on mid-disk; the S. limb appeared as in April. On August 24, the day the ill-fated *Mars Observer* spacecraft[15] was due to be inserted into martian orbit, Schmude found a light evening limb cloud over *Libya-Isidis Regio.*

Finally we note that an excellent statistical survey of white clouds has been published by Lee, Ebisawa and Dollfus,[26] based upon many years of polarimetric work.

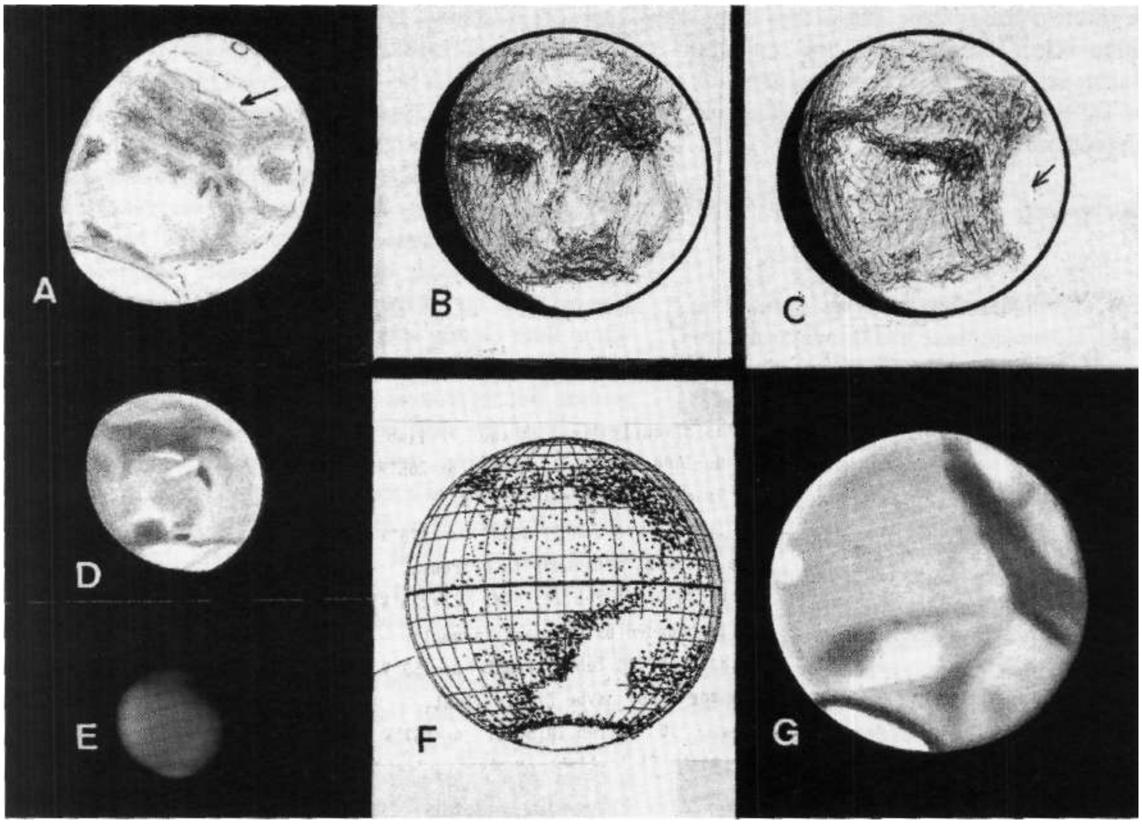


Figure 9. Dust storm activity.
A. 1993 August Id 03h 00m, ω= 33°, 1060mm Cass., x800, x1200, *Sheehan.* Probable yellow cloud in and around *ArgyreI,* elongated E-W (arrowed).
B. 1992 August 27d 19h 30m, ω= 22°, 490mm Cass., *Ebisawa.* A normal view.
C. 1992 August 31d 20h 00m, ω= 351°, 490mm Cass., *Ebisawa.* Bright yellow cloud over *Chryse, Xanthe,* etc., on the morning side (arrowed). Compare with B.
D. 1992 October 3d 20h 20m, ω= 39°, 310mm refl., x530, *Ishadoh. Mare Acidalium* visible. *Ganges* is abnormally dark, cut by a dull yellow cloud. Another such cloud lies *Np. Aurorae Sinus.*
E. 1993 February 12d 14h 30m, ω= 193°, 250mm refl., F/100, 1 sec. on TP2415 film, *Morita.* Bright dust in *Elysium-Cebrenia;* darkened E. border of *Elysium:* see text for details.
F. Drawing of Morita's photo in Figure 9E by Minami: compare Figures 9E, F with Figures 2M, O.
G. 1993 February 17d 19h 20m, ω= 218°, 415mm Dall-Kirkham Cass., x262, x415, *Gray.* Compare with E and F. *Nix Olympica* at p. limb.

Blue Clearings

Blue-violet light photographs by Miyazaki (Figure 3B), and CCD and visual data from 13 observers covered the period 1992 August 6 to 1993 May 10. Parker made CCD images through the W47 filter (with an IR blocking filter); the CCD response is poorer for short wavelengths, and the longer exposure needed blurs the images somewhat, but they are still useful. (Is the CCD less sensitive than visual work with a large aperture?) A weak Blue Clearing (BC) of order 1 was reported from October 17 to March 11, and a moderate clearing of order 2 was seen during November 14 to January 27, excluding unconfirmed reports outside these limits. There were no confirmed reports of order 3 clearings.

The BC effect was seen at all longitudes at some time within the stated periods, though positive reports were a little more frequent in the longitudes of major features (such as *Mare Acidalium* and *Mare Tyrrhenum).* It is clear that the BC was most intense near opposition (January 7), and somewhat asymmetric either side of it. Furthermore, earlier positive BC in November tended to be limited to the N. hemisphere only (Cerreta, McKim, Testa and Warell). Experienced observers also recorded apparent short-term fluctuations with time and longitude, e.g.:

Observer	*Date*	*CML*	*BC*
McKim	Dec 28	347	0
Heath	Dec 28	2	2
McKim	Dec 31	328	2
Siegel	Jan 2	291	2
Siegel	Jan 3	278	2
McKim	Jan 3	283	2
Siegel	Jan 4	256	2
Dal Santo	Jan 4	285	0
Dal Santo	Jan 5	291	2
Heath	Jan 7	284	1

But there were also some contradictions, usual in visual work, again showing that individual sensitivity is perhaps as important as excellent transparency (the latter being more important than seeing in BC work). Heath noted, Jan 7: '*Syrtis Major* became increasingly weaker in shorter wavelengths but this was less so for the other dark features.' In W47 Heath could see the dark regions S. of *Syrtis Major* but not the *Syrtis* itself. The *Syrtis* was weak but visible in blue (W44a) and green light. It is interesting that Parker's CCD images of Nov 7, 8, 13, Jan 14, 19, and Feb 22 show weak to moderate BC elsewhere over the disk but not over *Syrtis Major.*

The BC effect has been described by Thorpe (cited by Zurek[27]) as being due to the phase angle effect of scattering by dust in the martian atmosphere, and is thus essentially an Opposition effect'. Nonetheless, the temporal asymmetry and fluctuating strength of the phenomenon as noted above (and by Slipher historically[28]) continue to attract observational interest.

Yellow clouds (dust storms)

General

The probability of significant dust activity during the apparition was slight. However, there had been a local dust storm in the seasonally comparable 1977-78 apparition,[17] and in the event a few regions of the planet did exhibit yellow cloud activity in 1992-93.

*1992 August: Argyre **(I)***

The first record was a single observation from Pic du Midi on August 1-2 (L_s= 298°), when Sheehan (together with S. J. O'Meara) noted a yellow cloud over *Argyre (I)* on the 6 arcsecond diameter disk:[15,22,29] see Figure 9A. There was no obscuration of neighbouring features, but the observers were unable to follow it up during their brief stay at the Pic, so it must have been a short-lived event. Significantly, Parker's red-light (W23A) CCD images on August 9 and 16 (Figures 2D,E) showed these longitudes normal with no cloud or dust in *Argyre (I),* but comparison with a July 4 image suggests an enlargement since then of *Melas Lacus* and the neighbouring *Hebes Lacus.* Parker's early red light CCD images also show *Hellas* light on the CM on May 5 (Figure 2A; D= 5" (!)) and on the a.m. side on July 21 (Figure 2B); likewise *Eridania* on the a.m. limb, July 30, but there were no visible obscurations.

1992 August—1993 April: Chryse—Xanthe

The most significant dust storm activity was to occur in Chryse-Xanthe, the 'preferred' site in 1990. Observing from Tokyo with a 49-cm reflector on August 31 (L_s= 316°), Dr S. Ebisawa described a bright yellowish morning cloud covering *Chryse,Xanthe* (as well as *Ophir—Candor, Thar sis* and *Arcadia)*[12,15] (Figures 9B, C). Extending to longitude 20° on the east side and mixed with the normal morning white cloud, it was brightest in orange and red light, its dusty nature was confirmed by polarimetry, and it moved onto the disk with the planet's rotation. Ebisawa notes that Dr K. Iwasaki (Boscha Observatory) had seen nothing of the cloud on the 29th.[30] The large size of the cloud suggests it was already at least one day old on the 31st. The cloud expanded no further, and already appeared to be dispersing and becoming transparent on September 1. On August 16 Parker (Figure 2E), before this event, had imaged *Chryse* as bright in red light (as well as in green and blue) on the morning side.

A few confirmatory observations of Ebisawa's original storm were received.[15] Warell, September 7, saw a brighter area in *Chryse* on mid-disk (centred at +5°, 32°) in integrated and red light. Dust may have dispersed to the north, for Warell did not see *Mare Acidalium,* neither did Hill (who also missed the dark fringe to the NPH at the same longitude) on September 7 and 10 in otherwise normal views. (Less likely, the changeable NPH may have temporarily expanded to cover it.) All looked normal in later observations. With his large aperture Ebisawa noted that, even as late as 1993 spring, the regions of *Chryse-Xanthe* (as well as *Tharsis)* exhibited a yellowish tint, but only at the border of the disk, where the optical depth was greatest. To him, this longevity of airborne dust over some 8 months was a unique phenomenon in over 46 years' Mars observing. The yellowish colour was more apparent, noted Ebisawa, by comparison with the typical white or blue-white limb clouds over *Tempe* or *Argyre (I).* The colour differences were less easily perceived through smaller telescopes, but there were confirmatory remarks, to be listed later. Near the disk centre *Chryse-Xanthe* looked quite normal, showing delicate half-tones. To Ebisawa the region then showed a reddish-pink tint, which, he remarked 'is usually seen after the dispersion of the usual [yellow] cloud masses...'.[12] It is worth noting that Falorni on November 20 (CML= 29°) found the planet a strong rose colour, though there was no visible cloud over the centrally placed *Chryse.*

There was a specific outburst in *Chryse-Xanthe* in early October: on October 1 all was normal, but next day Y. Higa (OAA, Japan; L_s= 333°) videoed a darkening of *Ganges* and a cloud in *Chryse-Xanthe* that cut across S. *Nilokeras.*[9] Observing visually, Ishadoh saw two bright yellowish streaks near *Aurorae Sinus* on October 3[15] (Figure 9D), one lying over an intensely darkened *Ganges.* (The sudden, transient enhancement of albedo features is a certain indicator of dust activity.) When Ishadoh next observed on October 6 these features had returned to normal, but Ebisawa[12] (under CML= 2°) could still see the general yellowness of the *Chryse-Xanthe* region on the morning side. Troiani, October 22[8] (CML= 67°) saw a bright E-W cloud streak in red light in *Chryse-Xanthe,* confirmed on video by Carroll and Joyce. Selected later observations, chronicled below, suggest suspended dust was still detectable under oblique lighting until March. Ebisawa found the effect diminishing till mid-December, then increasing again. At the same time, it should be noted that the effects were not obvious to many observers, and the Director looked without success on various occasions.

Observer	*Date*	*CML°*	*Remarks*
Parker (CCD)	Oct 30	349	*Chryse* light in red (W25)
Warell	Nov 22	333	S. *Chryse* bright in Int/red (W25)
Schmude	Nov 27	25	Bright patch in Int/red (W25) near +10°, 50° *(Xanthe);* also seen on 29th
Whitby	Dec 6	2	*Chryse-Xanthe* bright in blue (W80A), more so in red (W23A)
Whitby	Dec 8	345-16	*Chryse-Xanthe* bright in Int/red, cloud appeared to rotate with planet
Warell	Dec 20	98	*Chryse-Xanthe* bright in Int/red but *Chryse* brighter in blue and green
Warell	Jan 2	344	*Chryse* bright in all colours; similar views on Jan 10, 31
Whitby	Jan 4	358	*Chryse-Xanthe* not bright (compare Dec 8); similar views Feb 8-10
Hernandez	Jan 6	352	*Chryse* bright in blue but not very bright in red
Parker (CCD)	Jan 6-14	328-32	*Chryse-Xanthe* not bright in red (nor in IR)

Warell	Jan 21	77	*Chryse* bright, especially in red; similar on 27th
Siegel	Jan 26	84	*Chryse* yellowish, and bright in all colours
Marchand	Jan 29	31	*Chryse* very bright and yellowish
Whitby	Feb 2	86	*Chryse-Xanthe* bright in Int, much brighter in red, not visible in blue
Schmude	Feb 6	86	*Chryse-Xanthe* bright in red
Parker (CCD)	Feb 11	2-5	*Chryse-Xanthe* bright in green and blue but not in red (00h53m UT)
Ebisawa	Feb 11	111	*Chryse-Xanthe* is bright yellow (08h20m UT)
Ebisawa	Mar 23	108	*Xanthe* shows yellowish evening cloud
Warell	Apr 15	70	*Chryse—Xanthe* evening cloud most conspicuous in blue (suggests little suspended dust remained)
Schmude	Apr 19	110	*Xanthe* bright in red
Warell	Apr 22	353	*Chryse* bright in all colours but brightest in blue (ditto from the p.m. side)
Schmude	Apr 23	81	*Chryse-Xanthe* white

1993 February: Elysium—Cebrenia

On February 12 (L_s= 39°) Morita (Japan) photographed an unusually bright area in *Elysium—Cebrenia,* separated from the NPC, with a rather dark eastern border apparently including *Cerberus (I), Trivium Charontis, Phlegra* and *Propontis (I)* (Figures 9E, F). All had been normal on the 10th,[9] with the E. border of *Elysium* weakly marked as usual (see 'Region III'). Although *Elysium* was subject to evening white cloud, the season was not advanced enough for it to whiten near the CM. This fact, together with the anomalous darkening of the E. border classifies the event as a local dust storm. Unfortunately there were no visual colour notes.

As the area became visible to European observers, Dijon at Pic du Midi imaged *Elysium-Cebrenia* as a bright patch in red light on the evening side on the 13th and 14th (Figures 2M, O), with an apparent extension into *Aetheria.* The cloud diffused further S. and W. on the 14th, but was imaged too near the limb. On the 13th P. A. Moore saw *Trivium Charontis* as 'prominent'; significantly he also noted: 'I have never seen the collar to the N. cap so dark.' Warell, Feb 13, and Ishadoh, Feb 14, found only N. and W. *Elysium* bright. Gray's Feb 17 drawing (Figure 9G) resembles Morita's photograph (Figures 9E, F); both he and Graham found *Elysium-Cebrenia* light that night. Quarra and Sarocchi CCD-imaged a marginally lighter NW *Elysium* on the 20th; significantly, *Propontis (I)* was again distinctly imaged. On Feb 21 McKim saw cloud covering both *Elysium* and *Cebrenia* on the morning terminator, with *Trivium Charontis-Cerberus* rather conspicuous. On Feb 22 in yellow and orange light Graham found a brighter patch in N. *Elysium* which extended a little SW (it was less obvious in blue light). Graham's was apparently the final observation of the dust core, whilst the albedo markings had already returned to normal by the 20th. Some airborne dust may have existed over *Elysium* during the preceding week, for Miyazaki's Feb 2 and 4 red and blue-violet images all show *Elysium* lightish. (However, Ebisawa's polarisation map of Feb 3[12] shows no *Elysium* anomaly).

Some observations show that dust diffused to neighbouring areas. Sturdy, Feb 17 found *Amazonis* bright and very yellowish on the p.m. limb. Similarly, Cave on Feb 25-26 wrote of a 'definite yellow cloud' in *Aethiopis*/ N.

Table 3. NPC latitude measurements, 1979-80*, 1981-82* and 1992-93

	1979-80		1981-82		1992-93	
Mean L_s(°)	*Latitude of S. edge of cap (°)*	*No. of measures*	*Latitude of S. edge of cap (°)*	*No. of measures*	*Latitude of S. edge of cap (°)*	*No. of measures*
343**	—	—	—	—	62.1t	21
348	-	-	-	-	59.2	12
353	-	-	-	-	63.9	16
358	-	-	-	-	61.1	38
3	-	-	-	-	62.6	42
8	-	-	-	-	63.3	32
13	-	-	-	-	65.2	64
18	-	-	-	-	63.4	76
23	-	-	-	-	65.0	61
28	-	-	-	-	63.8	65
33	-	-	-	-	66.3	72
38	-	-	-	-	65.5	47
43	68	9	-	-	64.4	40
48	70	26	-	-	66.4	36
53	70	17	-	-	68.5	32
58	72	24	-	-	70.6	29
63	72	23	-	-	74.5	13
68	74	89	-	-	73.4	14
73	77	59	74.3f	6	77.4	13
78	77	57	74.5	15	78.7	10
83	79	57	75.9	19	-	-
88	81	46	80.5	30	-	-
93	81	33	79.9	41	-	-
98	77	11	80.6	38	-	-
103	78	13	81.0	67	-	-
108	84	11	84.1	46	-	-
113	82	7	84.4	153	-	-
118	84	6	85.0	60	-	-
123	83	2	84.3	64	-	-
128	-	-	84.6	44	-	-
133	-	-	85.8	32	-	-
138	-	-	85.4	21	-	-
143	-	-	84.0	8	-	-
148	-	-	80.4	7	-	-
153	-	-	79.0	4	-	-
Totals		490 (500 analysed)		655 (693 analysed)		733 (743 analysed)

*data shown graphically only in the Section Reports.
** 5°- means in L_s, over intervals 1-5, 6-10, &c, used for the 1979-80 and 1992-93 observations, but 0-4, 5-9, &c, used in 1981-82.
t the decimals have been retained for plotting but are redundant.

Zephyria. Schmude, Mar 7, suspected a terminator projection near +32°, 213°, visible at high magnification (x815); high altitude dust? (There was no obvious associated bright cloud so the projection could not have been due to irradiation.) Ebisawa[12] considered that after mid-March *Elysium* as well as W. *Amazonis-Zephyria-Aeolis* showed a bright, somewhat yellowish tint suggesting dust activity, supported by his polarimetric data. Surely all these later observations represented dust diffused from the *Elysium-Cebrenia* event?

Discussion

The *Chryse-Xanthe* source had been active at least twice in 1990[1,31]: 1992 Aug 31 (L_s= 316°) and Oct 2-3 (L_s= 333-334°) fall exactly 8° later in seasonal date than the two most significant 1990 events at L_s= 308° and 326°. Ebisawa's polarisation data point to a mixture of dust and white cloud, as deduced for certain other past phenomena.[32]

The *Elysium-Cebrenia* storm at L_s= 39° fell at a similar seasonal date to yellow cloud activity in *Tempe-Arcadia* in

1978 (from L_s= 35°).[17, 33] The Section observed probable yellow cloud activity in *Elysium* in 1981-82.[21] The region showed occasional veiling in 1984,[34] but the dust had apparently spread from elsewhere. Anomalous darkenings of adjacent regions were noted for both the *Chryse-Xanthe (Ganges/ Lunae Lacus* darkened) and *Elysium—Cebrenia (Propontis (1)1 Phlegral Styx/ Trivium Charontisl* NPCB(?) darkened) events, consistent with dust excavation exposing darker underlying terrain. Dust for the latter event spread S. and W. but exact measures were impossible.

To conclude, the only dust activity of the apparition was of a local character. The activity in *Elysium* fits with the observed albedo changes occurring in this region. The lack of major albedo variations in the areas of *Hellas* and *Solis Lacus* suggests that these classic emergence sites have not been active in recent times, though they could not be monitored at the appropriate season during the past two apparitions.

North polar region

As soon as the tilt and disk diameter were favourable, the N. polar hood could be recognised as a bright diffuse region fringing the northern limb, first recorded on a July 4 CCD image (Parker) and by Ebisawa[12] from early June. The hood remained visible until December, just after the N. hemisphere Spring equinox, showing both temporal and diurnal changes, and sometimes appearing asymmetric or bifurcated, its border creeping equatorwards at the morning limb. Johnson found the hood to be dull in September, but brighter after mid-October. Throughout the period of visibility the bluish-white hood was best seen in violet light, appearing larger than in white light.

The NPR appeared dull or invisible to visual observers in red light and in red-filter CCD images until Nov 26, when Parker found it bright in red light. Coincidentally, Seigel noted on Nov 26 that the N. polar area appeared bright for the first time through the W25 filter. During Oct 25-Dec 6 Parker imaged some details within the southern parts of the apparently thinning hood, showing 'rifts' presumably through to underlying features such as N. *Mare Acidalium.* A similar effect was seen several times by Gray (Nov 14, 28; Figures 5C, 6C), whilst Minami from Nov 23 to early Dec (Figure 7A) drew a variable long rift amidst the NPH which was either *Gyndes* or the S. border of the cap beneath the hood. It is not clear whether the NPR to the N. of the rift was polar hood or ground cap. A few days later, Miyazaki's Dec 5 photos (Figure 7B) showed the hood had retreated so that *Gyndes* now marked its S. edge. On December 11 the NPC was imaged in red light by Parker. The OAA[9] found the NPC prominent at some longitudes from Dec 12. European observers witnessed the uncovering of the bright white ground cap about Dec 22: Falorni, McKim and Warell all noted that the hood remained more extensive in blue-violet than in white light during December 18-20, but McKim found no difference on or after the 22nd (confirmed by Warell, January 2). Thus the visual epoch for the continuous appearance of ground cap rather than hood was December 11-22 (L_s= 9-14°). Ebisawa[12] made polarimetric measures, concluding the hood to have been rather transparent: the ground cap appeared at L_s= 9°. Traces of hood could still be seen as late as 1993 January (Figure 6F) as a small patch of cloud on the morning side at the S. edge of the cap, or a southward deviation in the contour of the cap.

A band surrounding the cap was first noted to be dark and prominent from December, persisting until the planet was too distant to show fine details. (P. A. Moore, Siegel and Warell could still see the NPCB well on May 4-9).

The NPC recession was analysed by measuring drawings for the latitude of the S. edge of the cap on the CM from October 16 to May 18, L_s= 341-80°, and taking 5-degree means in L_s. The work of 47 observers was useful; blue-light drawings were excluded. Figure 10 and Table 3 compare these data with the historical average of Dollfus[36] (which includes the results of Baum *et al.* for seasonally earlier observations) and with BAA data from 1979-80[37] and 1981-82.[21] Our 1992-93 data agree well with those of Iwasaki *et al.,*[38] who analysed drawings, photos and CCD images. It can be seen that the cap/hood was quite static for several months, but a normal recession had begun by L_s= 50° (early 1993 March), with the cap edge never deviating by more than 1° from the Dollfus-Baum curve. Before L_s «25°, the cap/hood was slightly but significantly smaller than the latter historical mean. BAA 1979-80 data are in good accord, also never deviating more than 1° from the Dollfus-Baum curve. The 1981-82 data show scarcely any seasonal overlap and will be best compared with 1994-95.

All such comparisons must be treated with caution, and one should check that: (a) the measurement technique is the same, (b) there are sufficient observations for each datapoint, and (c) the disk diameter is at least 10". In comparing 1992-93 with 1979-80, the first two conditions are met for L_s= 46-80°, but *all three* conditions are met only for the single datapoint L_s= 48°! Even here, the difference between the two apparitions is small and within the standard devia-

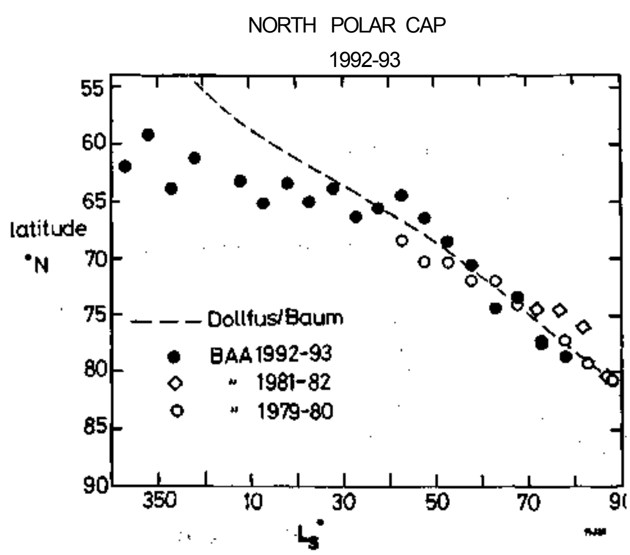


Figure 10. Regression curve for the NPC in 1992-93, from measures of the latitude of the S. edge of the cap in drawings. The dashed line provides a comparison with the standard work of A. Dollfus and W. A. Baum;[36] the other symbols allow comparison with recent apparitions. See also Table 3.

tions of the data sets (the latter incorporating both personal equation and slight cap asymmetry).*

In conclusion, the 1992-93 recession was normal, but the hood/cap was somewhat smaller than usual before L_s « 25°. Are some differences in historical NPC recession data in the literature partly due to the analysts' use of the 'diameter method' instead of the method adopted by the Section?

As the hood cleared, several inflexions in the cap's outline were reported. Most prominent *was Arethusa Lacus* (+60°, 330°) a darker patch which indented the cap edge during December-February (Figure 5E), sometimes followed by a bright spot (Devadas & Murugesh December 21-22; McKim, December 28); perhaps a bright cloud over *Ortygia.* Another notch — *Iaxartes* - was seen in the longitude of *Mare Acidalium* in February. Three other such features were attributed to *Copais Palus* (Dec-Feb) near +60°, 285° (Fig. 2M); *Maeotis Palus* (Dec-Feb) at +62°, 115° and *SithoniusLacus* (Jan-Feb) at +54°, 237° (Figures 7G, H). Cave found the NPCs serrated on February 25-26 (CML= 245-254°). These seasonal features had all been seen during the last aphelic opposition period (1977-1984).

In 1979-84 there was much interest in the reappearance, apparently after years of invisibility, of the NPC rift *Rima Tenuis?*[1] one end of which begins near λ= 330°. Although several saw a notch at the longitude of *Arethusa Lacus,* few saw anything more. Hernandez drew a fine rift further indenting the cap (Jan 18, L_s= 27°), but this must have been *Kison* so early in the season, as the *Rima Tenuis* is a feature of the *summer* cap (Schiaparelli, 1888[39]). (Troiani's Jan 30 drawing shows a partial rift near λ= 130°, the approximate longitude of the other end of this feature, but it cannot have been *Rima Tenuis* at that time). Late in the apparition, Schmude saw a deep notch near λ= 340° (May 5, L_s= 75°), which was possibly the real *Rima Tenuis,* but by then the tiny martian disk was hard to observe. We conclude there was no real evidence for *Rima Tenuis* this apparition. 1994-95 will give a much better opportunity to look for the NPC rifts in the late N. spring and summer.

The appearance of the NPH and NPC is shown in Figure 11 in polar projection. Visual NPC S. edge latitude data were binned in 20° intervals of L_s and averaged over 20-30° in CM longitude for the epochs: (a) Nov 14-Dec 24 (L_s= 356-15°, 176 observations); (b) Dec 25-Feb 5 (L_s= 16-35°, 274 obs); (c) Feb 6-Mar 22 (L_s= 36-55°, 155 observations). Contour (a) essentially shows the polar hood *{outline only:* ——), shortly before the uncovering of the ground cap. Contour (b) shows the ground cap about opposition (L_s= 22°). The hood has contracted somewhat from CML ≈ 200° through 0° to 45°, but has hardly moved elsewhere, confirming that it tended to disperse asymmetrically with longitude. The various observations of interior details have been drawn on (b). Contour (c) shows the retreating cap (outline only:........), which has regressed only a little from CML ≈ 290° through 0° to 100°. Further observations showing the more rapid regression were too few to allow a fourth contour to be drawn, and the disk diameter had become too small to see fine details by the time of the predicted seasonal separation of *Olympia* and other similar portions of the cap.

In closing, we note that an improved model of the polar seasonal cycles has recently been suggested by Dollfus *et al*[40]

*The E-W diameter of the 1992-93 cap was also measured. The data suggest a systematically smaller cap than the foregoing method over the period L_s = 16-55°. The writer regards the E-W data as unsatisfactory in the present instance, for over the latter period the tilt of the N. pole towards Earth passed through a minimum, and it seems that the full E-W extent of the severely foreshortened cap was not detected visually. There is no doubt that the 'diameter method' has its value for the asymmetric SPC, where the latitude of the cap edge on the CM can produce ambiguous results, but for the NPC it is not necessary to use it, and in the present case it has yielded systematically low results.

South polar region

The first view of the apparition - Parker's CCD image of May 4 (Figure 2A) - showed a small SPC. The cap had largely evaporated before the martian disk had reached 7" in diameter so no precise measurements were possible, but it was sketched in the early drawings of Bosselaers, Falorni, Giuntoli, Dal Santo, Sheehan (Figure 9A), Verwichte and Warell. In July and August (Figures 2B-E), as expected, the small asymmetric summer cap was less well seen on the λ « 220° side, being replaced by whitish haze; the last record of the cap was by Dal Santo, September 3 (CML= 73°, L_s= 317°). From then on the increasing northward tilt of the axis made further observation of the cap (which must have persisted much longer) impossible.

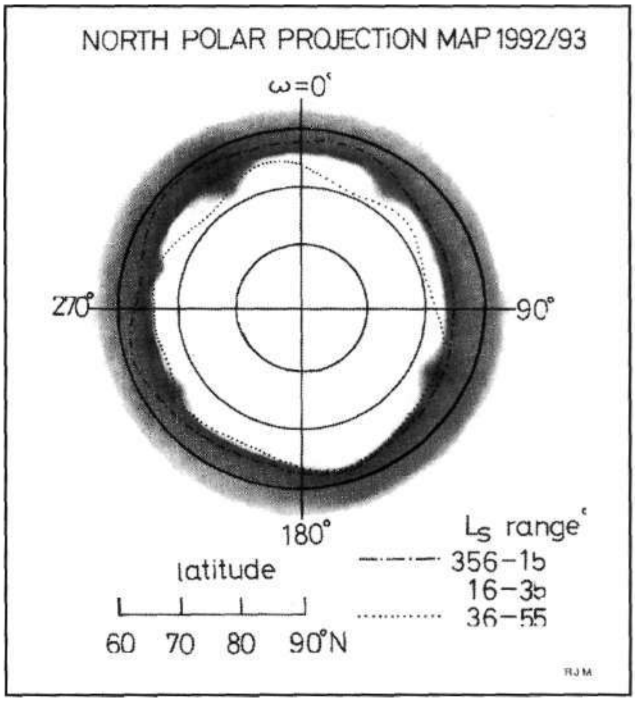


Figure 11. Stereographic polar projection maps of the NPC for the epochs:
(a) 1992 November 14-December 24 (L_s= 356-15°); (——)
(b) 1992 December 25-1993 February 5 (L_s= 16-35°); (with interior details drawn)
(c) 1993 February 6-March 22 (L_s= 36-55°); (.............)
Outline (a) shows primarily the hood boundary, the others the cap boundary. No attempt has been made to illustrate the albedo markings surrounding the NPR. Interior cap details are taken from the observations for the epoch of outlines (b) and (c). Note how the hood shrank asymmetrically between (a) and (b), as did the NPC between (b) and (c). Also note the near-circularity of the new winter NPC in (b).

A southern pre-polar hood was seen at some longitudes in September-October, becoming a more *continuous* bright region for the rest of the apparition. (See also the 'white cloud' section). Warell found the haze covering the S. limb bluish-white on December 22, as did Ebisawa generally.

Errata in 1990 report[1]

The *Memnonia* darkening shown in Figure 5D is not arrowed, but is about 6mm above and 9mm right of the disk centre. The following printer's errors should be noted. On page 249, for '189 photos', read '219 photos', and on the next line, for '45%' read '48%'. It is regretted that Figure 6D was damaged by the printers.

Address: 5 Ash ton Road, Oundle, Peterborough, PE8 4BY

References

1 McKim R. J., *J. Brit. Astron. Assoc,* **102,** 248 (1992)
2 James P. B. *et al.,* 'Monitoring Mars with the Hubble Space Telescope: 1990-1991 Observations', *Icarus,* **109,** 79 (1994)
3 Schmude R. W., *J. Roy. Astron. Soc Canada,* 86, 117 (1992)
4 Hagerich S. & Meyer J., *Mitteilungen fur Planetenbeobachter,* 15(1), 12 (1991); Teichert G. & Haug H., *ibid.,* **16(1),** 1 (1992); Berger H., *ibid.,* **16(1),** 3 (1992)
5 Iwasaki K. & Ebisawa S. (SPC regression 1990), *Proc. 25th ISAS Lunar and Planet. Symp.* (1992)
6 Nakajima T. & Minami M., 'Mars in 1990/91', *Bull, of Fukui Municipal Museum of Nat. History,* No. 40,1-13 (1993 December) (in Japanese)
7 MacRobert A. M., *Sky & Telesc,* **84(5),** 545 (1992); Beish J. D., *J. Assoc. Lunar Planet. Obs.,* 36, 97 (1992)
8 *The Martian Chronicle* (ALPO Mars Section Circular), 1992-94
9 *Communications in Mars Observations* (OAA Mars Section Circular), 1992-94
10 Teichert G. & Haug H., *Mittielungen fur Planetenbeobachter,* **16(2),** 21 (1992)
11 *The Mars Newsletter* (Nordic Mars Observers Circular), 1992-93. For a statistical review of NMO meteorological data, see Warell *J., J. Brit. Astron. Assoc,* in press (1995)
12 Ebisawa S., *Planetary Research Obs. Contributions,* Nos. 20-21, Tokyo, 1993
13 Schmude R. W. & Bruton D., *J. Roy. Astron. Soc. Canada,* 88, 69 (1994)
14 Parker D. C. & Berry R., *Astronomy,* 21, 72 (1993)
15 McKim R. J., *J. Brit. Astron. Assoc,* **102,** 312 (1992); **103,**58 and 278 (1993)
16 BAA *Circular* No. 720 (1992)
17 Collinson E. H., *J. Brit. Astron. Assoc,* **90,** 560 (1980)
18 Dragesco J., *Bull. Soc. Astron. France,* 95, 3 (1981)
19 Ebisawa S., *Contr. Kwasan Obs. Kyoto,* No. 89 (1960); McKim R. J., */. Brit. Astron. Assoc,* 96, 166 (1986)
20 McKim R. J., *J. Brit. Astron. Assoc,* **101,** 264 (1991); Lecacheux J. *et al.,* 'CCD images of Mars with the lm reflector atop Pic-du-Midi', *Planet. Space Sci.,* 39, 273 (1991)
21 McKim R. J., *J. Brit. Astron. Assoc,* **96,** 36 (1985)
22 Sheehan W. H. & O'Meara S. J., *Sky & Telesc,* **85(1),** 20 (1993)
23 Dragesco J. & McKim R. J., *J. Brit. Astron. Assoc,* **97,** 280 (1987)
24 McKim R. J., */. Brit. Astron. Assoc,* **99,** 215 (1989)
25 Teifel V. G. *et al., Sov. Astron. Lett,* 18, 110 (1992); *Pis'ma Astron. Zh.,* 18, 271 (1992) (in Russian)
26 Lee P., Ebisawa S. & Dollfus A., 'Crystal clouds in the Martian atmosphere', *Astron. Astrophys.,* **240,** 520 (1990)
27 Zurek R. W., in Keiffer H. H. *et al.* (eds.), *Mars,* Arizona University Press, 1992, ρ 806
28 Slipher E. C, *Mars: The Photographic Story,* Arizona University Press, 1962
29 IAU *Circular* No.5579 (1992)
30 Ebisawa S., personal communication, 1992
31 Parker D. C, Beish J. D. & Troiani D. M., *Sky & Telesc.,* **85(1),** 104 (1993)
32 Ebisawa S., *Planetary Research Obs. Contributions,* Nos. 17-18, Tokyo, 1991
33 Ebisawa S., & Dollfus A., 'Dust in the Martian atmosphere: polarimetric sensing', *Astron. Astrophys.,* **272,** 671 (1993)
34 McKim R. *J., J. Brit. Astron. Assoc,* 97, 139 (1987)
35 For a recent dust storm review which includes BAA work, see: McKim R. J., 'Historique des tempetes Martiennes', in *Bull. Soc. Astron. France,* **107,** 312 (1993)
36 Dollfus A, *Icarus,* 18,142 (1973)
37 McKim R. J., *J. Brit. Astron. Assoc,* 94, 197 (1984)
38 Iwasaki K. *et al.,* submitted to: *Proc. 26th ISAS Lunar & Planet. Symp.* (1993)
39 Schiaparelli's 1888 observations are conveniently summarised in: Flammarion C, *La Planete Mars,* volume 2, Gauthier-Villars, Paris, 1909
40 Dollfus A., Ebisawa S., & Crussaire D., 'Hoods, Mists, Frosts & Ice Caps at the Poles of Mars', *J. Geophys. Res.,* in press (1994)

Received 1994 December 29; accepted 1995 January 7