NO. 176 LATITUDE MEASURES OF JUPITER IN THE 0.89μ METHANE BAND

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ABSTRACT

Jupiter has been photographed by the Lunar and Planetary Laboratory in the 0.89μ methane band since October 1968. A photometric evaluation of these photographs has not yet been carried out, but a visual study of this collection and a comparison with the color records has been made. This comparison, together with diameter and latitude measures of the methane records, shows that the albedos and latitudes of most features shown in 0.89μ vary with time and that there is no simple correlation between the visual color and/or intensity of a feature and its intensity in the methane band. The latitudes of the Red Spot and South Tropical Zone have remained unchanged, while those of the Equatorial Zone, North Tropical Zone, and South Polar Hood have changed. Measures of images taken near opposition show the polar diameter to be within 0.5% of the American Ephemeris value, but the equatorial diameter as 1.3% smaller. Measures near quadrature suggest a phase defect 3.5 times greater in value than the American Ephemeris value. The large phase defect and bright South Polar Hood contribute to the circular appearance of Jupiter in methane. Latitude variations of the North edge of the South Polar Hood support the 1964 Münch and Younkin hypothesis that this feature is composed of frozen methane.

Jupiter has been photographed in the 0.89μ methane band with the 154-cm reflector from October 1968 through 1972, and with the Cerro Tololo Inter-American Observatory 152-cm reflector in Chile in 1969. The images measured were obtained with both telescopes at f/13, at a scale of approximately 10"/mm, and with exposure times of 60-120 seconds on Kodak High-Speed Infrared (HSIR) film. In addition, photography in this band began with an RCA 6914 infrared image-converter tube in June 1971; but these images lack astrometric quality and continuity of the direct photographic images and have not been measured. The small scale and long exposures of the direct images cause a decrease in angular resolution as compared to more conventional photography. Other than the Red Spot (RS), bright and dark spots and similar small-scale markings are not recorded - only featureless belts and zones. There have been only two exceptions noted during these four apparitions. The South Equatorial Belt (SEB) disturbance white spot (WS) was photographed July 10, 1971; and the long-lived South Temperate Zone (STeZ) White Oval BC was barely recorded August 23, 1972. As part of the present study, the LPL color photographs have been carefully compared with the methane records.

TABLE I

Mean Latitudes and Standard Deviations

(0.888μ)

Feature	Apparition			
	1968-69	1969-70	1971	1972
^{n}/SPH	-67°.9±1°.3	-69°.4±1°.2	-70°.2±0°.7	-69°.0±1°.3*
^{s}/STeZ	--	-41.3±1.2	--	--
^{n}/STeZ	--	-35.1±1.0	--	--
^{s}/RS	--	-29.3±0.6	-30.0±0.4	-28.5±0.2
^{s}/STrZ	-26.5±0.8	-27.0±0.6	-27.1±0.6	-26.2±0.5
^{n}/STrZ	-18.0±0.8	-19.6±0.8	-19.9±1.4	-19.6±0.5
^{n}/RS	--	-16.7±1.4	-15.4±0.4	-17.2±0.3
^{s}/EZ	- 5.7±0.5	- 8.5±0.8	- 7.0±0.8	-10.5±0.7
^{n}/EZ	6.5±0.8	1.8±2.7	4.0±1.3	8.4±0.7
^{s}/NTrZ	17.6±1.0	16.9±0.7	17.6±0.7	19.0±0.5
^{n}/NTrZ	22.8±0.8	23.3±0.6	25.5±0.6	24.9±0.4
^{s}/NTeZ	--	30.6±0.5	--	--
^{c}/NTeZ	--	--	--	34.8±0.4**
^{n}/NTeZ	--	34.9±0.2	--	--
^{s}/NNTeZ	--	--	38.9±0.4	--
^{n}/NNTeZ	--	--	44.3±0.3	--

^{n}/: North edge
^{s}/: South edge
c/: center
*: -67.8±0.9 with 0.886μ filter
**: very faint, only center was measured

2. Method of Measurement

The latitude measures were made with the digitized Mann measuring machine, previously used by D. W. G. Arthur for selenodetic measures. Six digits of X and Y to 0.001 mm, plus seven digits of keyboard information, constitute one setting with a nineteen-digit field. The central meridian (CM) of the image is brought into coincidence with the Y crosshair and measures are made along the CM at power 3x. Four settings each are required for a North and South determination; South limb, South edge of feature, North edge of feature, and North limb. The tape-to-card program punches one card containing four settings. Each image is measured at least three times for each feature. The latitude reduction program (JLAT) utilizes the LPL IBM 1130 computer, and calculates from four settings the North and South latitudes of the feature, the latitude of its center,

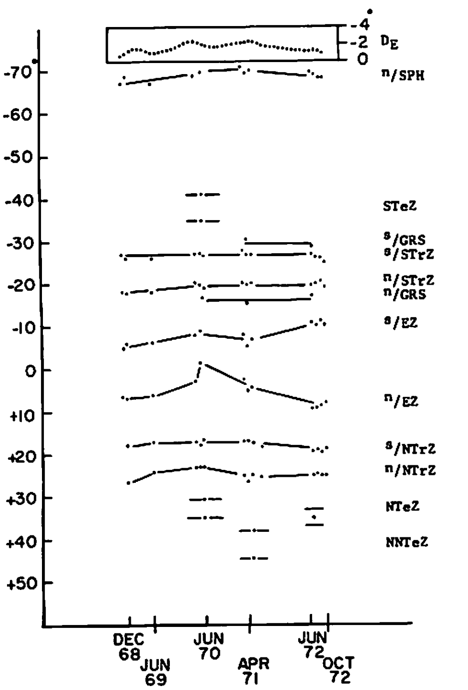

Fig. 1 Summary of latitude measures of features observed on methane records. South is up. Explanation of dots in Fig. 2. D_E (insert on top) is on different scale

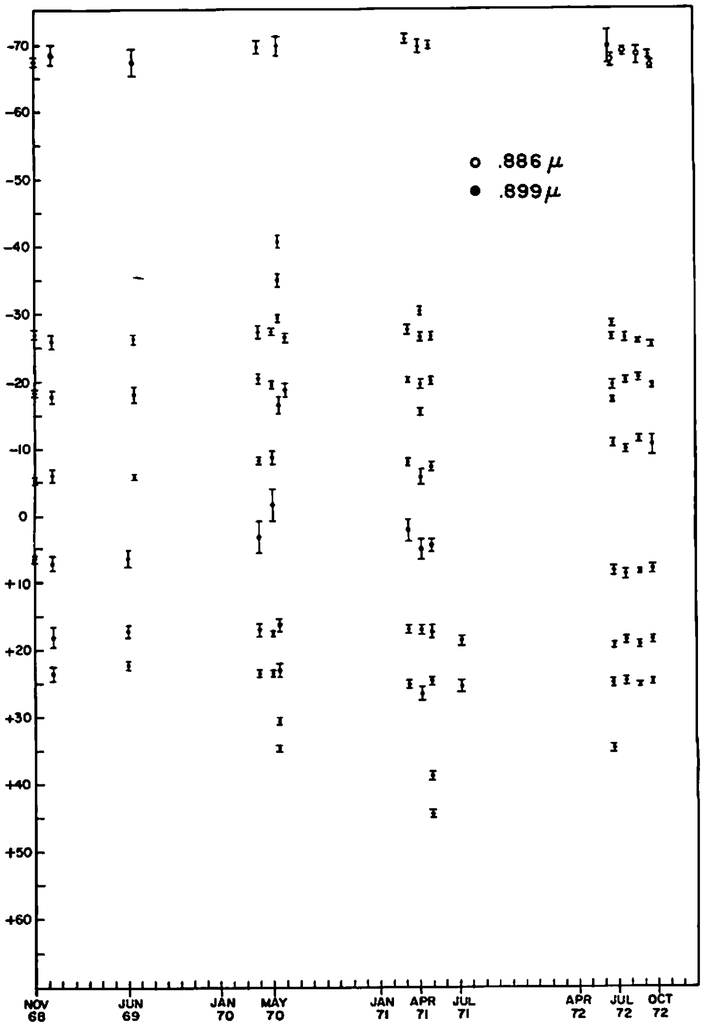

Fig. 2 Explanation of dots used in Fig. 1. Most points represent averages over 2-4 weeks; error bars are standard deviations for that period.

the width, and a ratio named AVG. R. This is the angular ratio of the measured polar diameter to that of the American Ephemeris diameter. AVG. R. provides a check of measuring consistency and possible scale changes. This has proven valuable toward consistent measures of black-and-white and color original images of varying density, contrast, and scale. If the scale is unknown, AVG. R. cannot be found. In this event, an approximate value of the scale is calculated in JLAT from the limb settings and latitudes are redetermined from this average scale value. This procedure reduces the systematic and random errors in measures of features at high latitudes. Finally, the cards are arranged by feature and desired time interval, and run to calculate averages and standard deviations. The large number of measures required for this type of program dictates the use of a digitized Mann and computer reduction. The present study is based on 780 latitude and 100 diameter measures.

3. Measurement Errors

In 1972 a new methane filter (0.886μ) was acquired. Figure 3 shows the transmission of this filter, the older filter (0.899μ), the sensitivity curve of the HSIR film, and of the SI image tube. It is seen that, used with the image tube, the new filter is much superior to the old one; with the HSIR film, the contribution of μ>0.900 was not too serious. Fifty-four comparative measures of identical features on images taken nearly simultaneously with the two filters show that the standard deviation (sd) of latitude measures of all features for the 0.899μ filter is 0°.75 in latitude, and 0°.62 for the new 0.886μ filter, which gives higher contrast.

The first test of accuracy was a measurement of the methane polar diameter and a comparison with the American Ephemeris value. The oblateness of Jupiter in methane light was in question because of the apparent circularity of many images. If there was a difference, additional investigation and modification to JLAT would be necessary. Toward this comparison, the author secured 38 methane images taken within 35 hours of opposition. Seventeen of the best images taken on June 25.35, 1972 were measured.

	0.886μ	A.Eph.	O-C
P. Dia.	43".76 ± 0.25 (sd)	43".55	+0".21
Eq. Dia.	46".06 ± 0.34 (sd)	46".67	-0".61

There is no difference in the polar diameters greater than the standard deviation of the measures. This difference is less than one part in 175 for 17 images. For latitude measures of a single image, an AVG. R. of 0.9900 to 1.0100 is tolerated.

Investigation of a possible systematic error due to the bright South Polar Hood (SPH) was made by comparative measures of the latitude of J1 (Io) in methane light and blue light. These images were taken within a maximum time interval of 15 minutes and were secured with J1 near the CM. Forty-eight North and South latitude measures of 3 methane images and 5 blue images yield:

	0.899μ	0.430μ	Diff.
J1 Latitude	17°.31 ± 0°.49	16°.86 ± 0°.46	+0°.45 (N)
J1 Width	5°.32 ± 0°.52	3°.37 ± 0°.48	+1°.95

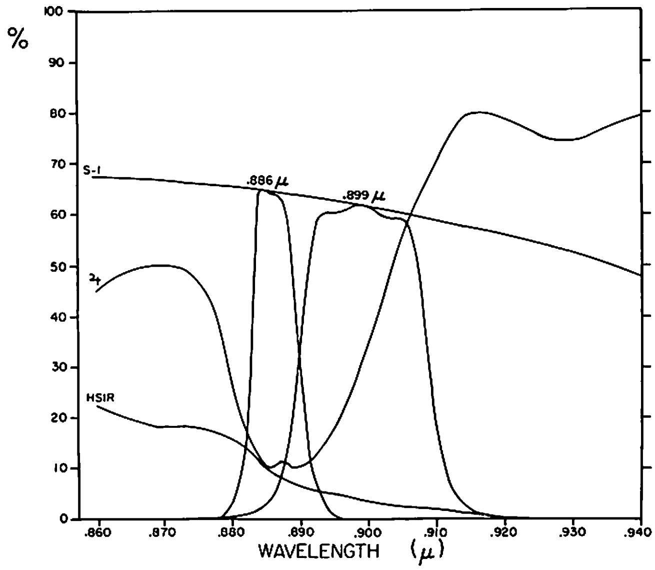

Fig. 3 Relative response of S-1 photo-emissive surface (RCA 6914), with 100% assumed at 0.370μ; Sun/Jupiter intensity ratio for EZ, from Carl Pilcher (1971); relative sensitivity of Kodak HSIR film, with 100% assumed at 0.400μ; and transmission of 0.899μ and 0.886μ filters

The latitude difference is less than $0\overset{\circ}{.}5$ or 1 part in 230 of Jupiter's diameter. The blue sd is large because of the poor visibility of J1 at the CM in blue light. In contrast, the brightness of J1 relative to Jupiter's disk in methane results in an irradiation of $0\overset{\circ}{.}98$ at the North and South edges at -17° latitude. This value should represent an upper limit, as all methane features have an albedo below that of J1. The conclusion is that the methane polar diameter is in agreement with the American Ephemeris, and that the bright SPH does not contribute a systematic error greater than the random errors of measurement.

When the scale is defined, JLAT uses limb settings to determine the center of the disk. Latitudes are calculated from the fractional distance of a feature from the center of the polar diameter, using the Ephemeris value and the known plate scale. There will be no error in the location of the measured center as long as the errors in the polar limb measurements, depending on the density of the images, are the same. If the plate scale was unknown, the polar radius was determined from the polar limb settings. In that case the center of the disk is still well determined, but the derived latitudes will be affected by systematic errors in the limb settings.

Test measures of a computer-drawn (GLOBE) grid with scale unspecified indicate that North and South limb settings, each $\frac{1}{2}$% of a polar diameter too large,resulted in an O-C error of $+1\overset{\circ}{.}3$ at -70° latitude, and $+0\overset{\circ}{.}1$ at 0° latitude. With a specified scale, these errors were reduced to zero for both latitudes. Test measures with scale unspecified and with only the South limb 1% too large gave errors of $+2\overset{\circ}{.}7$ at -70° latitude, and $+0\overset{\circ}{.}8$ at 0° latitude. With a specified scale, these errors were reduced to $1\overset{\circ}{.}6$ and $0\overset{\circ}{.}7$,respectively.

The scale should be known to at least ±0.2% for latitude and longitude measures of Jupiter. Double-star photography in early 1972 with the Catalina telescope at f/13.5 allowed determination of the present scale to within this limit, and also showed that this limit is exceeded when the film plane moves more than 28 mm in either direction along the optical axis. Consequently, because of scale uncertainties, measures prior to 1972 have been run twice on the IBM 1130. The first run determined a scale for every four settings if scale was unknown. It was found that a minimum of four scale values was required for the four apparitions. The second run used the appropriate scales and also calculated average latitudes and their sds. The sd of all latitude measures arranged by year and telescope are: 1972 Catalina 0°.57, 1971 Catalina 0°.67, 1970 Catalina 0°.91, 1969 Cerro Tololo 1°.00, and 1968 Catalina 0°.79.

The sds for 12 comparative measures of the SPH at -70° latitude are 1°.26 for the 0.899μ filter and 0°.75 for the 0.886μ filter. There is a systematic error between the 0.889-0.886μ filter of +1°.9 latitude (N). This stems from the reduced intensity of the adjacent polar region which introduced some additional irradiation. The magnitude of this error is exaggerated by the high latitude of the feature. Measures of all other features were mutually consistent to 0°.3 latitude and were averaged together with equal weight. Consolidated measures with both filters are listed as at 0.888μ.

4. Results

The measured equatorial diameter near opposition is 1.3% ± 0.7% (sd) less than the American Ephemeris value. This results from the large equatorial limb darkening. The equatorial diameter was measured again with Jupiter near evening quadrature on September 22.09, 1972, when the geometrical phase defect was 0".36 in angular width. Measures give an equatorial diameter 1".51 less than the American Ephemeris value of 38".63. The loss at each limb cannot be directly measured as there were no measurable features which would permit determination of the CM. The amount of recorded phase defect can be estimated by the measured limb loss at opposition compared to that at quadrature. The equatorial radius was measured to be reduced by 0.65% at each limb with no defect present. Subtracting this value from the total defect at quadrature would give an angular loss of 1".26 at the East limb. This is 3.5 times greater than the geometrical value and is defined as the "phase exaggeration". (Smith and Reese, 1968).

The measured latitudes of the RS and the South Tropical Zone (STrZ) are the most consistent with measures at 0.430μ; these features also varied by the least amount of latitude in methane light.

	1970			1971		
Feature	0.888μ	0.430μ	0.888-0.430μ	0.888μ	0.430μ	0.888-0.430μ
s/RS	-29°.3	-28°.6	-0°.7	-30°.0	-28°.9	-1°.1
n/RS	-16.7	-16.2	-0.5	-15.4	-16.2	+0.8
s/STrZ	-27.0	-24.8	-2.2	-27.1	-25.8	-1.3
n/STrZ	-19.6	-20.6	+1.0	-19.9	-20.0	+0.1

There is some tendency for measures at the North edges (n/) to be about 1/2° too high (N), and South edges (s/) about 1° too low (S). The measures of J1 show that some of this may be attributable to irradiation. The agreement in this comparison with external data (Reese, 1971, 1971*a*) exemplifies the measuring accuracy of other methane features.

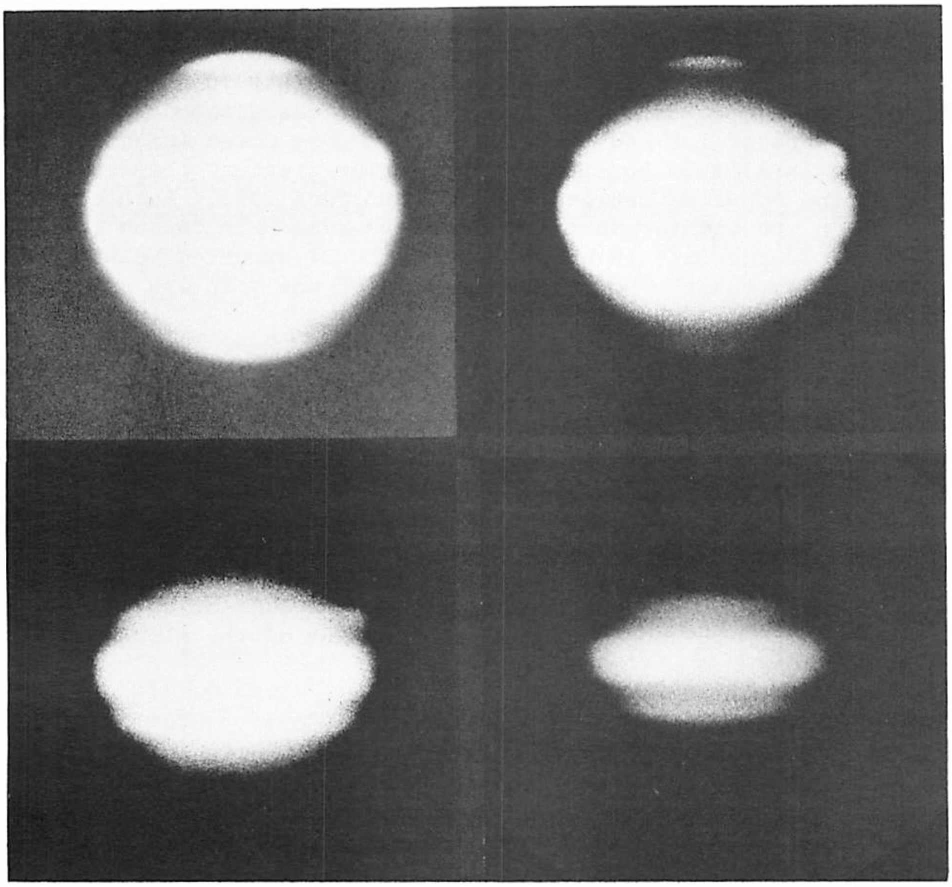

Fig. 4 1972 July 22, 04:11 UT, Jupiter at 0.886μ printed with high contrast at different densities to show relative densities in original image; no dodging

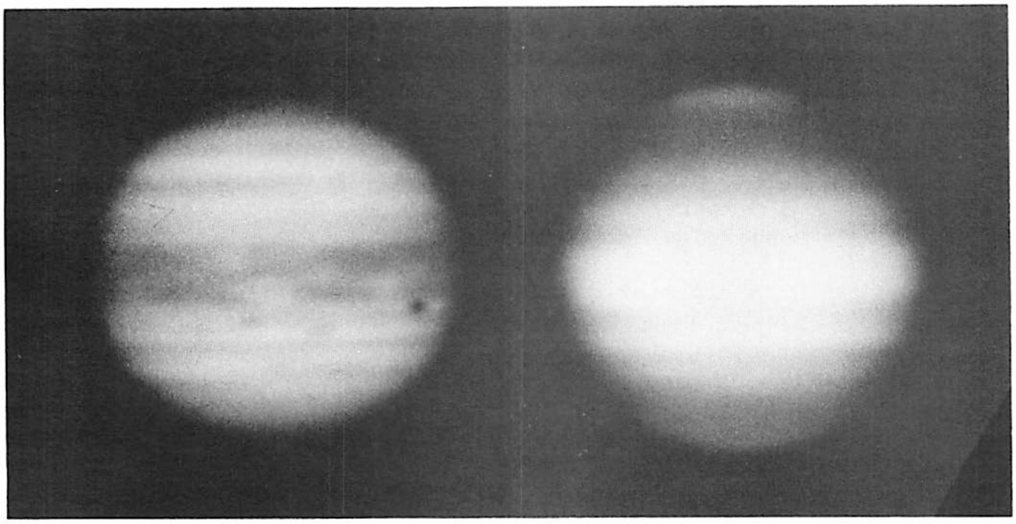

Fig. 5 *Left*: Panchromatic, 1972 June 19, 07:28 UT, λ_2=136.4. *Right*: 0.886μ, 1972 June 21, 09:22 UT, λ_2=146.2; 3 min exposure at f/45 with RCA 6914 infrared image-converter tube

The greatest change in latitude during this interval was the decrease and subsequent increase in width of the Equatorial Zone (EZ). The ^{n}/EZ changed from $+7\overset{\circ}{.}2$ in early December 1968 to $-1\overset{\circ}{.}5$ in early May 1970, to $+9^{\circ}$ throughout 1972. From late 1970 to early 1971, the ^{n}/EZ was castellated in longitude between the latitudes of $1\overset{\circ}{.}5$ and $+2\overset{\circ}{.}3$. The South edge moved irregularly from a minimum of $-5\overset{\circ}{.}7$ in 1968-69 to $-10\overset{\circ}{.}5$ in 1972. The greatest change in latitude of the South edge occurred between May 1971 and June 1972. Both edges were moving away from the equator at the highest observed rate during the 1971 apparition. The rapid increase in brightness of the EZ occurred between September 1971 and June 1972, but the Northward movement of the ^{n}/EZ was already in progress by March 1971.

The ^{n}/SPH varied in latitude by only $3\overset{\circ}{.}2 \pm 1\overset{\circ}{.}2$ (sd) during this interval. Because of this large uncertainty, a least-squares analysis of 43 measures from 1968-69 and 1970 was made and compared with a similar analysis of 29 measures from 1971 and 1972. No images taken with the 0.886μ filter were included. The first two apparitions give a slope of $-0\overset{\circ}{.}78$/yr $\pm$ $0\overset{\circ}{.}24$ (sd slope); and the last two, $+0\overset{\circ}{.}85$/yr $\pm$ $0\overset{\circ}{.}38$. During these time intervals, the slopes of the values of the declination of the Earth as seen from Jupiter (D_E) were $-0\overset{\circ}{.}83$/yr and $+0\overset{\circ}{.}73$/yr, respectively. The values of the declination of the Sun as seen from Jupiter (D_S) were $-0\overset{\circ}{.}83$/yr and $+0\overset{\circ}{.}80$/yr. Therefore, the latitudes of the ^{n}/SPH varied in the same direction as D_E and D_S, and within the sds of the slopes, by the same amount.

In 1971 the South edge of the North Tropical Zone (^{s}/NTrZ) moved about $4\overset{\circ}{.}5$ South and the ^{n}/NTrZ about 1° South at visible wavelengths, but in methane light the South edge remained stationary and the North edge moved about 2° North. Figure 1 depicts theseevents, Figure 9 shows the rapid change in latitude of the NTrZ in blue light (0.430μ), and Figure 6 shows Jupiter at 0.430μ and 0.886μ near opposition, 1972. Throughout 1971 and 1972 the widened NTrz in methane included both the NTrZ and North Temperate Belt (NTeB).

The STeZ, North Temperate Zone (NTeZ), and North North Temperate Zone (NNTeZ) were not consistently photographed. In some cases when these features were absent, the photographic resolution was judged to be better than those images taken at other dates showing the features. The latitudes of these three zones are in good agreement with values obtained at 0.430μ by myself and Reese (1970, 1971). The NTeZ was only measurable once during the 1972 apparition - that of June 21, 1972 near System II longitude (λ_2) = 75°. Methane photographs taken later that night show this zone becoming broader towards the North and indistinct near λ_2 = 140°. Figure 5 compares a color image and a methane image at nearly equal CM System II (ω_2) longitudes only two days apart.

5. Interpretation of the Methane Photographs

The surface intensity at 0.888μ is inversely correlated with the amount of overlying methane gas. This is the basis of the following interpretative remarks based on visual inspection. At this time it does not seem justified to undertake a time-consuming photographic photometry of the methane collection.

Visual inspection of the original methane images in our collection shows that from 1968-69 through 1972:

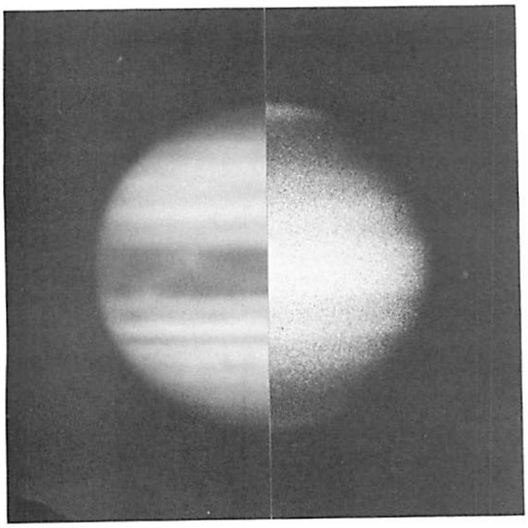

Fig. 6 *Left*, 0.430μ, 1972 July 21; *right*, 0.996μ, 1972 June 25

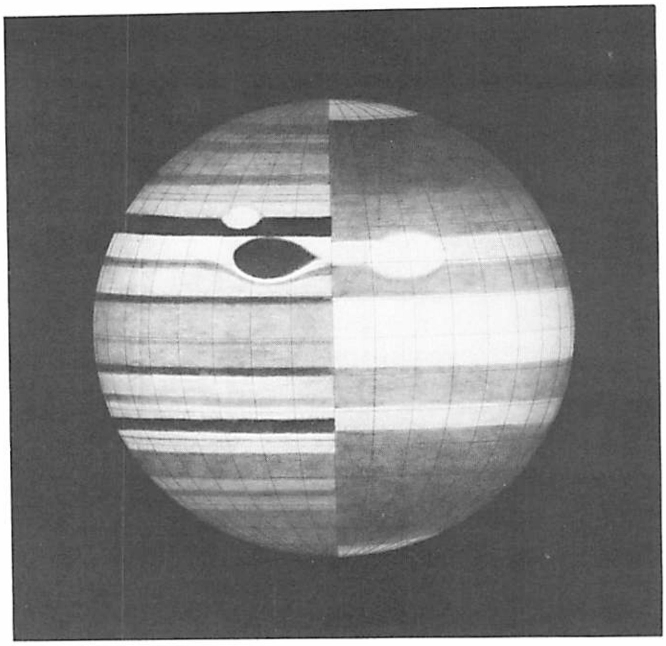

Fig. 7 Drawings from 0.430μ and 0.888μ latitude measures for opposition, 1972

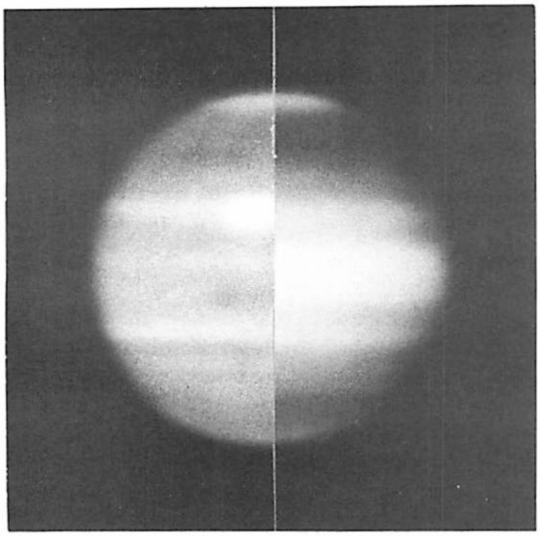

Fig. 8 *Left*, 0.899μ, 1970 May 16; *right*, 0.886μ, 1972 June 26; 90 sec exp at f/22 with RCA 6914

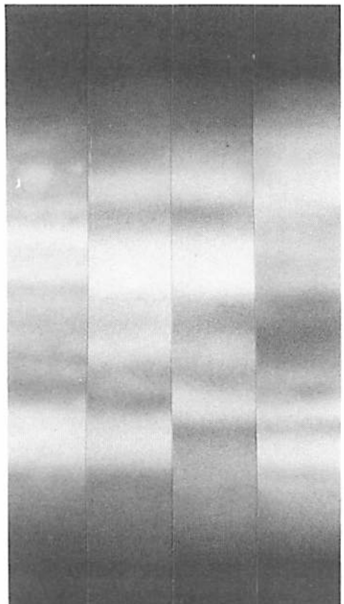

Fig. 9 Jupiter's belts and zones at 0.430μ for 1968-69 through 1972

(1) Both polar regions appear somewhat darker than the rest of the disk, excluding obvious zones.
(2) The South Polar Region (SPR) is slightly darker than the North Polar Region (NPR).
(3) The RS is the brightest feature.
(4) The STrZ is almost or equally bright as the RS.
(5) Except in 1968-69, the NTrZ is equal in brightness to the STrZ.

A visual comparison of the color and methane collection for these four apparitions (see Table II) reveals the following:

(1) Throughout the four apparitions the RS was always yellow-red in color, and was always bright in methane.
(2) Throughout the four apparitions the STrZ was always bright and nearly white, and was always bright in methane.
(3) From 1971 through 1972 the NTeB was yellow-red in color, and was bright in methane. Prior to this it was split and faint, and also faint in methane.
(4) In 1972 the EZ was yellow-red in color, and bright in methane.
(5) In 1969-70 the EZ was dominated by cyan-colored festoons, and was dark in methane.
(6) In 1969-70 when the NTrZ became light red in color, it also became bright in methane.
(7) During the four apparitions the NNTeZ was most prominent in 1971. This was true in methane as well.
(8) Throughout the four apparitions, the three long-lived STeZ White Ovals BC, DE, and FA, were frequently as bright as any zone, but they were nearly absent in methane.
(9) In 1968-69 the NTrZ was one of the brightest zones, but was faint in methane.
(10) Throughout the four apparitions, the STeZ was quite prominent, but was faint in methane.
(11) In 1971 prior to the two SEB disturbances, the South Equatorial Belt Zone (SEBZ) was the brightest zone, but was dark in methane.

6. Discussion

The latitude of the $^{n}/$SPH varied in the same direction and amount as the value of D_E and D_S. The visible effect of this is that the apparent width of the SPH remained unchanged. Because the sd of the slopes of the observations is greater than the difference between the slopes of D_E and D_S, either or both of these two parameters may have contributed to the observed latitude variations. A dependence on D_E would suggest that it is a diffuse feature and is rendered more easily visible by the increased light path when viewed edge-on. A dependence on D_S would suggest that insolation is responsible.

The latitude of the $^{n}/$SPH is very close (< sd) to the latitude of the South edge of the South Polar Belt ($^{s}/$SPB) measured by Reese at 0.430μ for the same apparitions. His measures also show a latitude variation of the $^{s}/$SPB very similar to that of the $^{n}/$SPH (Reese 1970, 1971, 1971*a*). This and the scarcity of features at these high latitudes is strong evidence that they are a common edge of two features. At both wavelengths, Jupiter becomes brighter South of this latitude. The North Polar Hood (NPH) was consistently weaker in appearance than the SPH and could not be measured.

The rapid brightening of the EZ appears to be a result of the June and July, 1971 SEB disturbances. The WS reported on p. 340 did move from the SEBZ into the Southern component of the EZ over a period of five weeks. Additional material may have been transported along this path, or the increased activity in the EZ evident at visible wavelengths was effective in mixing the higher gaseous atmosphere with the lower reflective cloud particles. In either case, the optical depth of the EZ at 0.888μ would be reduced.

The expansion of the EZ may coincide with these two disturbances. However, the Northward motion appears to have started within the interval three to twelve months prior to this. The Southward motion coincided with the disturbance more closely, but a longer coverage is needed before a relationship of these latitude variations can be suggested.

TABLE II

Visual Estimates of Colors and Intensities in Visible Light vs. Methane Light (explanations, p. 350)

Feature	1968-69 Color/I		CH_4	1969-70 Color/I		CH_4	1971 Color/I		CH_4	1972 Color/I		CH_4
SPR	G	4	0	G	4	0	G	4	0	G	4	0
SPB[a]	C[f]	3	4	C	3	4	Lt C	3	4	C	3	4
SSTeZ	--[e]			W	5		--			--		
SSTeB	G	4		G	3		G	4		G	4	
STeZ	W	6	0	W	6	2	W	6	2	W	6[g]	2
BC,DE,FA	W	6		W	6		W	6		W	6	
STeB	G[d]	3	G	G[d]	3		G[d]	3[h]		Br	3[h]	
STrZ	Lt C	7	6	W	7	6	W	7[g]	6	W	6	6
RS	Y+R	3	6	Y+R	3	6	Y+R	3	6	Y+R	3	6
SEBs	Lt R	5		G	4		G4/G3[j]			Lt R	5	
SEBZ	W	6		W	7[g]		W8[g]/k	5		Lt R	6	
SEBn	Br	4		Lt C	5		Br4/k	4		Lt R	5	
EZs	Br	4	6	Lt C	5	2	Br	4	2	Br	4	6
EZ[b]	Lt Y	5	6	Lt Y	5	2	Br5/k	4	2	Y+R	5	6
EB[c]	Y+R	4		C[i]	4		G4/k	4		--		
EZn	Br+C[i]	4		C[i]	4		Br+C[i]	4		Br	4	6
Festoons	C	4		C	3		C	4		C[n]	4	
NEBs	Br	3[h]		Br+R	3[h]		Br	3[h]		G	3	
NEBZ	Br	4		Br+R	4		--			G	4	
NEBn	Br	3		Br+R	3[h]		Br	3[h]		G	3	
NTrZ	W	7[g]	4	Lt R	7	6	W5/W7		6	W	6	6
NTeBs	--			--			Y+R[m]	4	6	Y+R[m]	4	6
NTeBn	--			--			Y+R[m]	4	6	Y+R[m]	4	6
NTeZ	W	7	2	W	6	2	--		2	W	6	2
NNTeB	--			--			--/G3			--		
NNTeZ	--			--			--/W5		2	--		
NPR	G	4	0	G	4	0	G[d]	4	0	G	4	0

Explanations of Table II

The colors are the apparition average, unless otherwise noted. They were determined by visual comparison with Kodak Color Compensating (CC) filters of similar density. The intensity estimates of color images are in accordance with the Association of Lunar and Planetary Observers Jupiter Handbook (1964) by Reese. The methane intensity estimates use four steps of intensity: 0 = dark, 2 = faint, 4 = average, and 6 = bright.

Superscripts:

a. SPB for visual light, SPH for methane light
b. ±7° latitude, excluding EB, darker markings, and festoons
c. Near 0° latitude
d. Grey color, also warm in tone
e. Absent or faint
f. Underlined colors are vivid
g. Brightest feature(s) on disk
h. Darkest feature(s) on disk
i. Festoons contributing color to that feature
j. Before/after the SEB disturbances
k. Much turmoil, colors include cyan, yellow, and red; colors vary with longitude
m. Joined into one belt, the NTeB
n. Very few in number

There may be a tendency for yellow-red belts to appear bright in methane, but this cannot be said for spots except the Red Spot. Many of these were noted during this interval, especially in the EZ, yet were not prominent or visible in the methane photographs. However, the lower resolution of the methane photographs will hinder detection of small colored features. The EZ was near maximum darkness when the cyan-colored festoons were most numerous and colorful. The absence of high clouds in methane at this time would suggest that festoons normally occur at lower levels. This is consistent with infrared observations at 5μ of a dark feature by Westphal (1969). LPL color photographs show this feature to be a cyan-colored festoon. The color may be indicative of locally greater amounts of Rayleigh scattering and absorption of the red by the atmospheric methane. LPL results since 1969 abundantly confirm this correlation of blue color with deep penetration (cf. p. 221 and refs. there given).

The sudden appearance of the yellow-red colored NTeB in 1971 appears to be responsible for the ^{n}/NTrZ moving North in latitude and including this belt in its expanse. Curiously, the ^{s}/NTrZ moved North by about 4° one year after the ^{n}/NTrZ moved North by the same amount.

The scarcity of long-lived zones poleward of the tropical zones, and the somewhat greater darkness of the polar regions in methane light, suggest an increased depth of the denser haze layer as one approaches the polar areas, no doubt owing to lower tropospheric temperatures. The meteorology of Jupiter within 100 to 200 km of the visible cloud deck has been suggested to be internally-driven (Kuiper, 1972), and the largest escaping flux appears to be within the boundaries of the tropical zones (Keay, Low, Rieke, 1972). A relatively stagnant SPR is consistent with the suggestion by Peek (1958) that spots at latitudes South of -45° have almost a uniform rotation period. The suggestion was made by Münch and Younkin (1964) that the bright Polar Cap observed with their spectrophotometer might consist of frozen methane. A temperature and pressure range of from 91°K at 1 atm to 64°K at 0.05 atm would permit methane to exist in a solid phase for a comparatively long time. If the equilibrium of the two phases was at a critical temperature and pressure, a small change in temperature resulting from a small change of D_S might produce a large shift in equilibrium. The Münch and Younkin hypothesis is consistent with the latitude variation of the North edge of the SPH.

This study illustrates the need for extensive time coverage in the study of Jupiter. One cannot catagorize the various types of telescopic features (belts vs. zones) by differing amounts of methane absorption based on a few observations only.

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ADDENDUM

Recommended Abbreviations (BAA system, with minor modifications) used in this and subsequent papers

A. Features, Locations, Directions

B	Belt	CM	Central Meridian
Z	Zone	Tr	Tropical
R	Region	Te	Temperate
H	Hood	n	North component of Belt or Zone
P	Polar	s	South component of Belt or Zone
E	Equatorial	p	preceding edge
N	North	f	following edge
S	South	c/	center
RS	Red Spot	s/	South edge
WO	White Oval	n/	North edge

B. Colors

G	grey	R	red
Cy	cyan (blue-green)	Br	brown
W	white	Lt	light
Y	yellow		