

Limb Profiles of the Moon from Grazing Occultation Observations Collected at RGO

Mitsuru SÔMA and Yuji KATO*

(Received March 29, 2002)

Abstract

From lunar grazing occultation observations it is shown that the present lunar limb profile data have sometimes large errors, and therefore it is apparent that they need to be modified. For that purpose observations of grazing occultations collected at the Royal Greenwich Observatory until 1980 were analyzed and lunar limb profile data were obtained. As a result the number of the lunar limb profile data obtained from grazing occultations was almost doubled. These profile data are being used for the predictions of lunar grazing occultations in order to locate observers at better positions, so that they can also get good grazing occultation data to improve the lunar limb profiles. These profile data will be used in the future analyses of solar eclipse observations and of the possible errors of the Hipparcos proper motion system.

Key words: Lunar grazing occultations, Lunar limb profiles.

1. Introduction

For the lunar limb irregularity corrections in the lunar occultation analyses, Watts' (1963) charts are still being used. In 1994 lunar topographic features were observed by the Clementine lunar mapping mission (Smith et al. 1997), but the Clementine laser altimeter data were too sparse (they only covered narrow meridional strips separated by almost 3° of selenographic longitude) to replace Watts' data, and the altimeter data for the polar regions were not obtained. Margot et al. (1999) obtained lunar polar topography from radar interferometry, and Cook et al. (2000) derived them from Clementine stereoisages, but derived lunar limb profiles from them did not agree well.

There is a Japanese SELENE mission which will start in 2003. The Moon-orbiting SELENE satellite will observe Moon's surface, and it is expected that the observations will help to derive the lunar limb profiles. But for the present, lunar occultation observations are the only ways to get precise lunar limb profile data. Those data will be used to detect the variation of the solar diameter from analyzing solar eclipse timing observations (Fiala et al. 1994). They are also useful for detecting errors of the Hipparcos proper motion system (Dunham 1997, Sôma 2000).

Lunar grazing occultation observations are of an advantage to getting lunar limb profile data in the lunar polar regions, and they can be used for predictions of future grazing occultations with near librations. The International Lunar Occultation Centre (ILOC) in Tokyo has been collecting lunar total and grazing occultation observations made in the world since 1980. Sôma (1999) analyzed those grazing occultation observations collected at the ILOC using the planetary and lunar ephemerides DE405 (Standish 1998) and the Hipparcos Catalogue of stars (ESA 1997), and published the lunar limb profile data obtained from the analysis. They have been be-

ing used for the predictions of grazing occultations provided by IOTA (International Occultation Timing Association) each year, but they are not enough for the predictions so that many predicted grazing events still have inaccurate profile data for the observations as will be explained in Sect. 2 below.

Until 1980 the lunar total and grazing occultation observations were collected at the Royal Greenwich Observatory (RGO), and the total occultation data were provided in the machine-readable form, but the grazing data were only publicized on the microfiche (Appleby et al. 1984) and those in the machine-readable form were lost. However Dietmar Bütner and other IOTA/European Section members digitized the data recently, and they kindly provided the data to the authors. We checked the data and some errors in the digitized data were corrected with the help of David Herald in Australia. In Sect. 3 these grazing occultation observations are analyzed with the same lunar and planetary ephemerides and the same star catalog as was used by Sôma (1999) and the lunar limb profile data obtained from the analysis are given in the same format of table 1 by Sôma (1999).

Our goal is to give lunar limb data for any libration and any position angle. The grazing occultation observations made hitherto are not enough to provide them. But the data in the present paper are intended to be used for the lunar limb profile predictions for future grazing occultations in order to locate observers at better positions, so that they can also get good grazing occultation data to improve the lunar limb profiles.

The data presented in this paper have been provided in the machine-readable form to IOTA computers, who are responsible for grazing occultation predictions for observers in their countries or regions, and are used for the predictions for 2002. One of the authors (MS), as the Vice President for Grazing Occultation Services of IOTA from 1998, is receiving grazing occultation observations made by the IOTA members. The authors will reduce them, update the limb profile data, and provide them annually to the IOTA computers. The data can also be provided in the machine-readable form to anyone upon request.

* A scholarship student sent to National Astronomical Observatory of Japan by the Astronomical Society of Japan from 2001 April 1 to 2002 March 31.

2. Recent Examples of Successful Grazing Occultations

The lunar limb profiles obtained by Sôma (1999) have been used for the predictions of lunar grazing occultations distributed annually from IOTA, but there are still many grazing events which have no observed lunar limb profiles in the predictions. The grazing occultations of the 5.1-magnitude star 97 Tauri (ZC 730) observed on 2000 July 27 in Florida, U.S.A. and on 2000 August 23 in Japan were two of such events, and Watts' (1963) lunar profile charts had large errors for those events, but through international collaboration those events were successfully observed, as explained below.

Just a few days before the 2000 July event David W. Dunham, the president of IOTA, remembered that he and an IOTA member Robert H. Stewart observed the grazing occultation of the same star on 1995 July 23 in Virginia, U.S.A., and from their observations he suspected that while Watts' charts gave rather low lunar limb profile for that region, the actual profile was not so low. So he reported their observations to Sôma and Dunham's suspicion was confirmed from Sôma's analysis of their observation as given in figure 1. The fact was also consistent with the grazing occultation of ZC 478 observed on 1977 August 7 in Maryland, U.S.A. (figure 2), whose observations were archived at the ILOC in Tokyo, although the latitude librations b of the Moon of them differed by about 1° . The Watts angle (the position angle used in Watts' charts; it was Watts' intention that this angle was identical with that

measured from the north pole of the Moon, but actually they differed by about $0^\circ.24$) of those profiles were larger than the central graze Watts angle of the 2000 July event by about 10° , but Sôma found that a few other grazing occultations that were within a few degrees of Watts angle and librations of the 2000 July event showed the actual lunar limb profile being close to the lunar mean limb, which was about $0''.5$ to $1''.0$ higher than Watts' profile, as shown in figures 3–6 (it is noted that, as shown in the figures, the longitude librations l and the latitude librations b of the Moon for these events vary in the regions $-1^\circ.1 \leq l \leq +3^\circ.2$ and $+3^\circ.60 \leq b \leq +6^\circ.11$, but all of the observed lunar limb profiles are close to the lunar mean limb). Based on this information the 2000 July grazing occultation of 97 Tauri was successfully observed, and 9 observers in three expeditions got a total of 65 contacts. A month later, on 2000 August 23, another grazing occultation of the same star occurred over almost the length of Japan (figure 7). In order to help positioning Japanese observers of the event, the timings and locations of the observations in Florida were all determined and they were sent to Sôma by a few days before the date of the Japanese event. Based on the reduced lunar profile as given in figure 8, the Japanese event was successfully observed, and 31 observers in five expeditions were able to time a total of 198 contacts. As a result the lunar limb profile was accurately determined as shown in figure 9.

It is regretted that the Japanese expeditions failed to observe the top of the highest mountain located at Watts angle

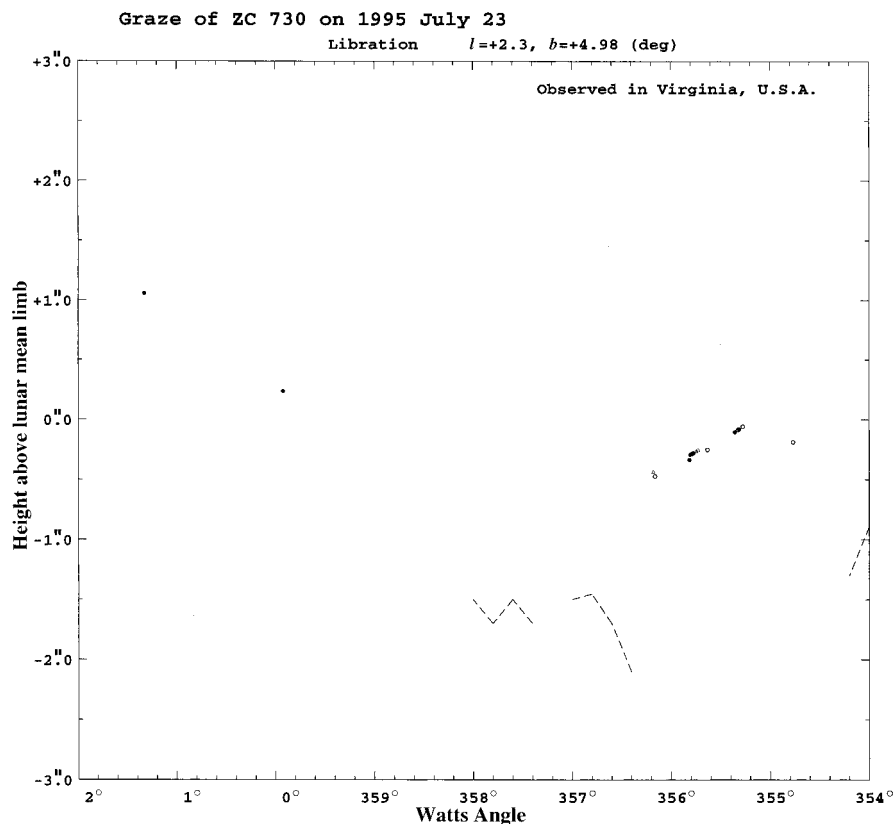


Fig. 1. Limb profile from the 97 Tauri (ZC 730) graze observed on 1995 July 23 in Virginia, U.S.A. The plot uses the mean limb as the horizontal axis. The abscissa is WA (see the text). Since a 1° arc of the Moon's limb at average distance subtends $16''$, the vertical scale on the plot is exaggerated by a factor of about 19 over the horizontal scale. The filled circles are from disappearances, the open circles from reappearances, the filled triangles from blinks, and the open triangles from flashes. The curved line represents the profile data from Watts' (1963) charts, the solid part being the one given as accurate and the broken part being the extrapolated inaccurate one.

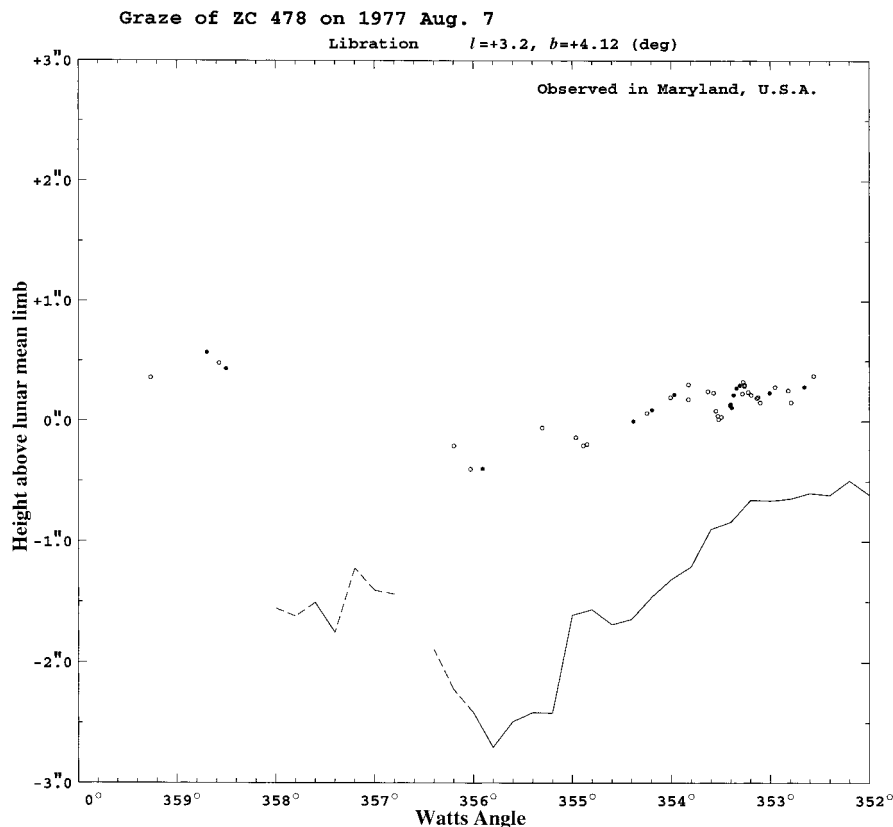


Fig. 2. Limb profile from the ZC 478 graze observed on 1977 Aug. 7 in Maryland, U.S.A. For the explanation, see figure 1.

346°. But about nine hours earlier of the Japanese event a grazing occultation of a 6.9-magnitude star X 5788 (SAO 93963) was observed in North Carolina, U.S.A., and fortunately the top of the mountain at Watts angle 346° was obtained from the observation as shown in figure 10. It is also noted that the two profiles obtained from the two events are slightly different due to the slightly different librations of the Moon.

These grazing occultation observations were summarized in *Sky and Telescope* by Dunham (2001) as the most successful grazing events in the year 2000.

3. Lunar Limb Profile Data

The lunar limb profile data obtained from the grazing occultation observations collected at the ILOC were published by Sôma (1999) and they are used for the predictions of lunar grazing occultations distributed annually from IOTA, but as discussed in the previous section, there are still many grazing events which have no observed lunar limb profiles in the predictions.

Before 1980 lunar grazing occultation observations were collected at RGO. The data were digitized recently by Büttnner and other IOTA/European Section members. In total there were about 17,000 timings for 842 grazing occultations in the RGO data, whose number is comparable to the total number of grazing occultations collected at the ILOC and analyzed by Sôma (1999). Those RGO data were analyzed using the same procedure and the same values of the parameters as used by Sôma (1999), which are summarized as follows:

Lunar and planetary ephemeris: DE405/LE405 (Standish 1998)

Star catalog: Hipparcos Catalogue (ESA 1997)

Correction to the Moon's ecliptic longitude and latitude at mean distance (384, 400 km): $\Delta\lambda = +0''.50$ and $\Delta\beta = -0''.24$

Radius of the Moon: $R_0 = 1738.107$ km

Correction for the ellipticity of Watts' datum: $\Delta\rho = +0''.128 \sin 2(\text{WA})$

Relation of Watts angle (WA) with axis angle (AA): $\text{WA} = \text{AA} + 0^\circ.24$

Here WA is the argument of position angle in Watts' charts, and AA is the position angle measured from the lunar north pole. For the basis of each adopted value, see Sôma (1985).

It should be noted that nowadays precise geodetic coordinates of the observation stations can be obtained from GPS measurements, but during the intervals of the observations of which the current analysis was made those coordinates were usually measured from geographical survey maps whose accuracy is considered to be typically about 1 arcsec. This accuracy corresponds to within 0''.02 arcsec for the obtained lunar limb profile accuracy, which is enough for the purposes of the present paper.

The obtained lunar limb data are given in table 1 for every 0.2 deg of Watts angle. In order to preserve only reliable data, observations with only a small number of limb points or with many inconsistent data are rejected. In table 1 the observations which have the mean number of observed limb points for every 0.2 deg of WA of more than 1.5 are given, and the rejected data are stored in another file to be used for future analyses.

The data in table 1 are given in the format which is compatible with the input data for IOTA's ACLPPP (Automatic Computer Lunar Profile Printing Program) profile predictions. The byte-by-byte description is given below.

1st line for every grazing occultation:

1-4 Watts Angle range in $0^{\circ}.1$
 5-8
 9-10 Limit: 1 means northern limit, -1 means southern limit
 11-14 Usable latitude libration range in $0^{\circ}.01$
 15-18
 19-22 Usable longitude libration range in $0^{\circ}.01$
 23-26
 27-33 Catalog identifier and number in the catalog of the star; Catalog identifier X means XZ (Schmidt & Van Flandern 1977) and ZC means Robertson's (1940) zodiacal catalog
 35-42 Observation date MM/DD/YY (Year is subtracted by 1900)
 43-45 Number of the profile data given
 46-50 Libration in longitude in degrees
 51-55 Libration in latitude in degrees
 57-59* Basis of the analysis (99B is the basis in the present paper)
 61-65* Number of observed profile points used to derive the data
 66-70* Standard error in the star's declination
 71-74* Star's magnitude

The values in the columns indicated by * were not given in the original ACLPPP input data.

2nd and the following lines for every grazing occultation:

The profile data and the accuracy code are given successively for every WA at an interval of $0^{\circ}.2$ in each of the 5 columns. In one line the data for up to 16 Watts Angles can be given. In each of the 5 columns the first 4 byte gives the limb profile height in $0''.01$, and the last byte gives the code for the accuracy of the limb profile height (3 means good and 4 means extrapolated).

The data are arranged so that the data for brighter stars come later and therefore information farther down in the table can be regarded as more reliable. Hence the data farther down can override the earlier data for the same librations and WA.

The data in table 1 can be used for the predictions of lunar grazing occultations together with the profile data provided by Sôma (1999). The positions on the lunar surface where the profile data were obtained are shown in figures 11 and 12. The figures use P and D coordinates where D is the distance from the meridians of longitude $l = \pm 90^{\circ}$ measured positively toward the Earth and P is measured along those meridians from the north pole counterclockwise as seen from the Earth. Formulae to obtain P and D from the librations l and b and the position angle Π are given by Watts (1963). As shown in figures 11 and 12 the number of the lunar limb profile data obtained from grazing occultations are almost doubled by the current analysis.

4. Conclusions

The grazing occultations collected at RGO were analyzed. The resulted lunar profile data can be used together with

the data provided by Sôma (1999) for the predictions of lunar grazing occultations in order to locate observers at better positions, so that they can also get good grazing occultation data to improve the lunar limb profiles. These data will be used in the future analyses of solar eclipse observations and the possible errors of the Hipparcos proper motion system.

Mr. Dietmar Büttner in Germany and other IOTA/Euro-pean Section members provided us the digitized grazing occultation data. David Herald in Australia corrected some of the errors in the digitized data. The authors would like to express their hearty gratitude to all of them. Thanks are also due to many amateur astronomers who made the observations analyzed in this paper.

References

- Appleby, G. M., Morrison, L. V., and White, M. T. 1984, "Catalogue of observations of total occultations of stars by the Moon for the years 1972 to 1980 and of grazing occultations for the years 1963 to 1980", *Roy. Greenwich Obs. Bull.*, No. 192.
- Cook, A. C., Watters, T. R., Robinson, M. S., Spudis, P. D., and Bussey, D. B. J. 2000, "Lunar polar topography derived from Clementine stereomages", *J. Geophys. Res.*, **105**, No. E5, 12023-12033.
- Dunham, D. W. 1997, "Current value of timings of total lunar occultations", *Occultation Newsletter*, **6**, 411.
- Dunham, D. W. 2001, "Recent grazes of 97 Tauri and SAO 93963", *Sky and Telescope*, **101**, 120.
- European Space Agency 1997, "The Hipparcos Catalogue", ESA SP-1200.
- Fiala, A. D., Dunham, D. W., and Sofia, S. 1994, "Variation of the solar diameter from solar eclipse observations, 1717-1991", *Solar Phys.*, **152**, 97-104.
- Margot, J. L., Campbell, D. B., Jurgens, R. F., and Slade, M. A. 1999, "Topography of the lunar poles from radar interferometry: A survey of cold trap locations", *Science*, **284**, 1658-1660.
- Robertson, J. 1940, "Catalog of 3539 zodiacal stars for the equinox 1950.0", *Astron. Papers Am. Ephemeris*, **10**, Pt. II, U.S. Government Printing Office, Washington, D.C.
- Schmidt, R., and Van Flandern, T. 1977, "The XZ catalog", U.S. Naval Observatory, Washington, D.C.
- Smith, D. E., Zuber, M. T., Neumann, G. A., and Lemoine, F. G. 1997, "Topography of the Moon from the Clementine lidar", *J. Geophys. Res.*, **102**, No. E1, 1591-1611.
- Sôma, M. 1985, "An analysis of lunar occultations in the years 1955-1980 using the new lunar ephemeris ELP2000", *Celest. Mech.*, **35**, 45-88.
- Sôma, M. 1999, "Limb profiles of the Moon obtained from grazing occultation observations", *Publ. Nat. Astron. Obs. Japan*, **5**, 99-119.
- Sôma, M. 2000, "Examination of the Hipparcos proper motion system from lunar occultation analysis", *Towards Models and Constants for Sub-Microarcsecond Astrometry* (Proc. IAU Coll. 180), U.S. Naval Observatory, Washington, D.C.
- Standish, E. M. 1998, "JPL planetary and lunar ephemerides, DE405/LE405", JPL IOM 312.F-98-048.
- Watts, C. B. 1963, "The marginal zone of the Moon", *Astron. Papers Am. Ephemeris*, **17**, U.S. Government Printing Office, Washington, D.C.

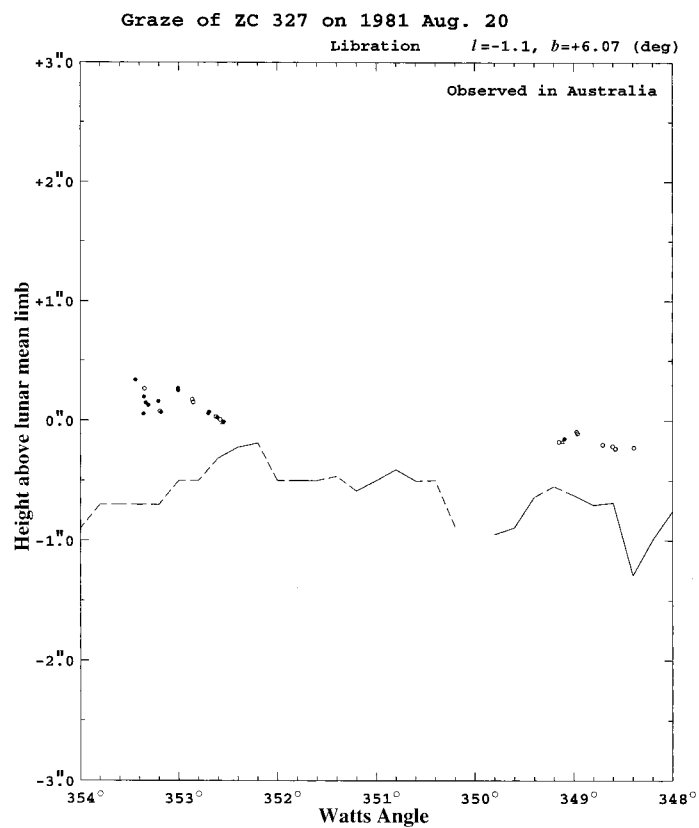


Fig. 3. Limb profile from the ξ^1 Ceti (ZC 327) graze observed on 1981 Aug. 20 in Australia. For the explanation, see figure 1.

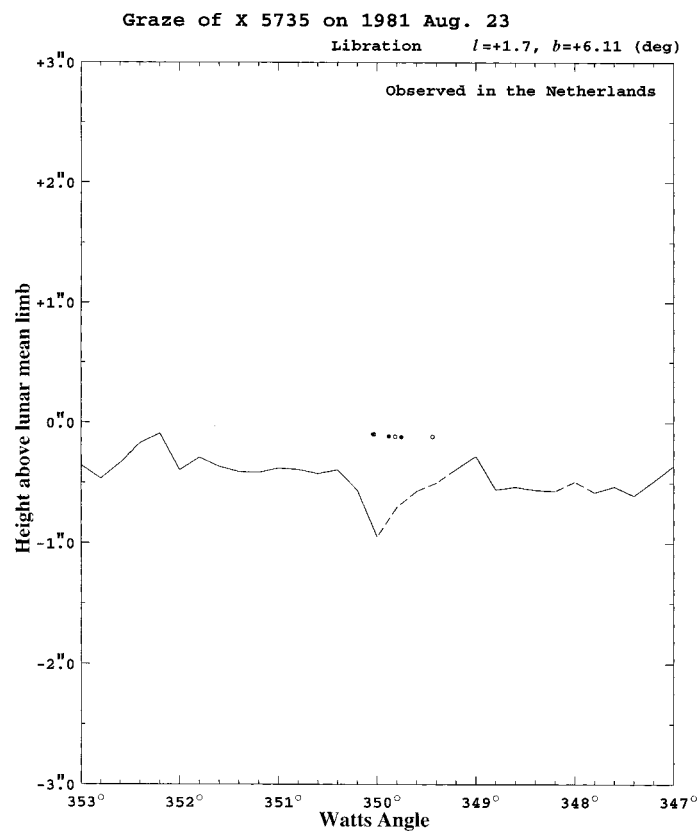


Fig. 4. Limb profile from the X 5735 graze observed on 1981 Aug. 23 in the Netherlands. For the explanation, see figure 1.

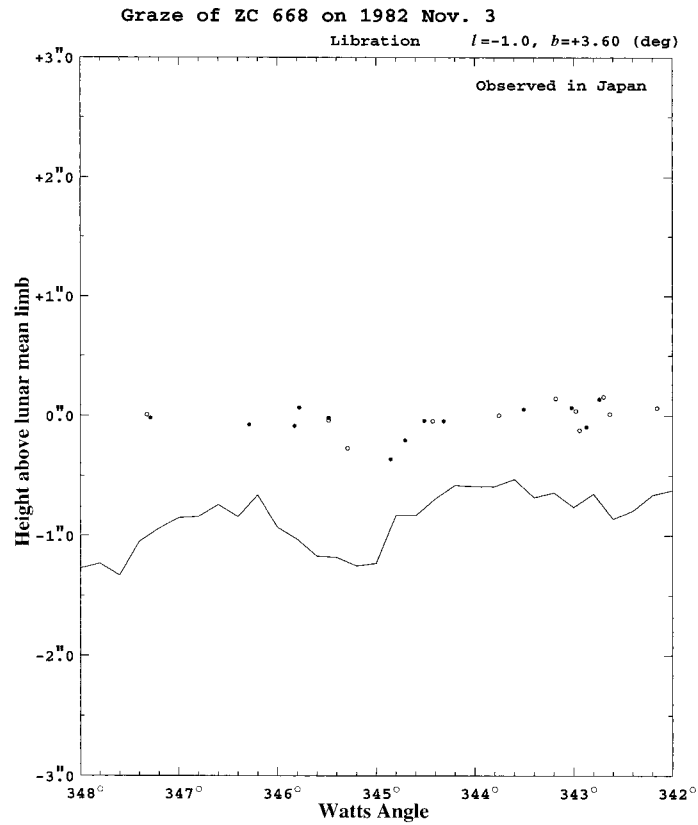


Fig. 5. Limb profile from the ϵ Tauri (ZC 668) graze observed on 1982 Nov. 3 in Japan. For the explanation, see figure 1.

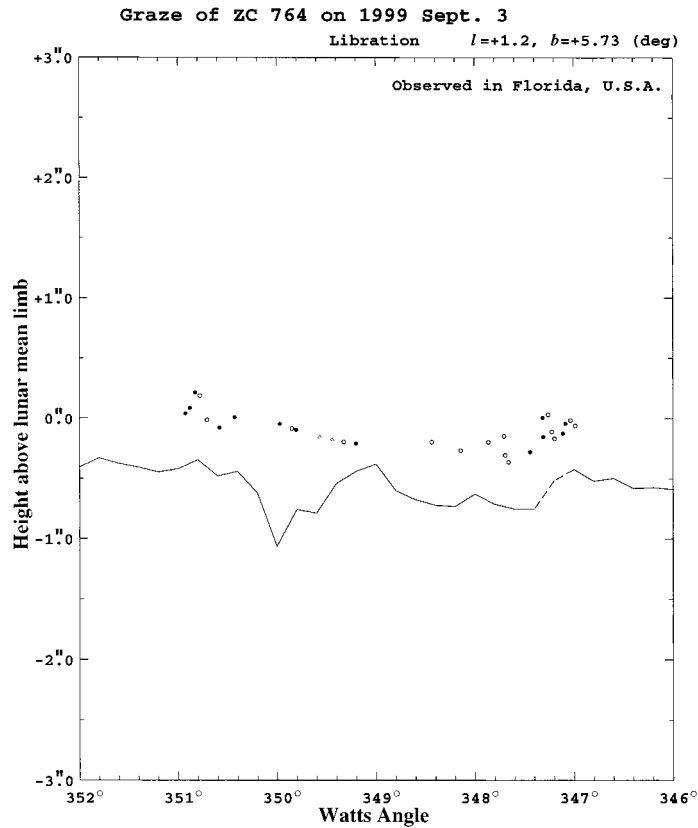


Fig. 6. Limb profile from the 104 Tauri (ZC 764) graze observed on 1999 Sept. 3 in Florida, U.S.A. For the explanation, see figure 1.

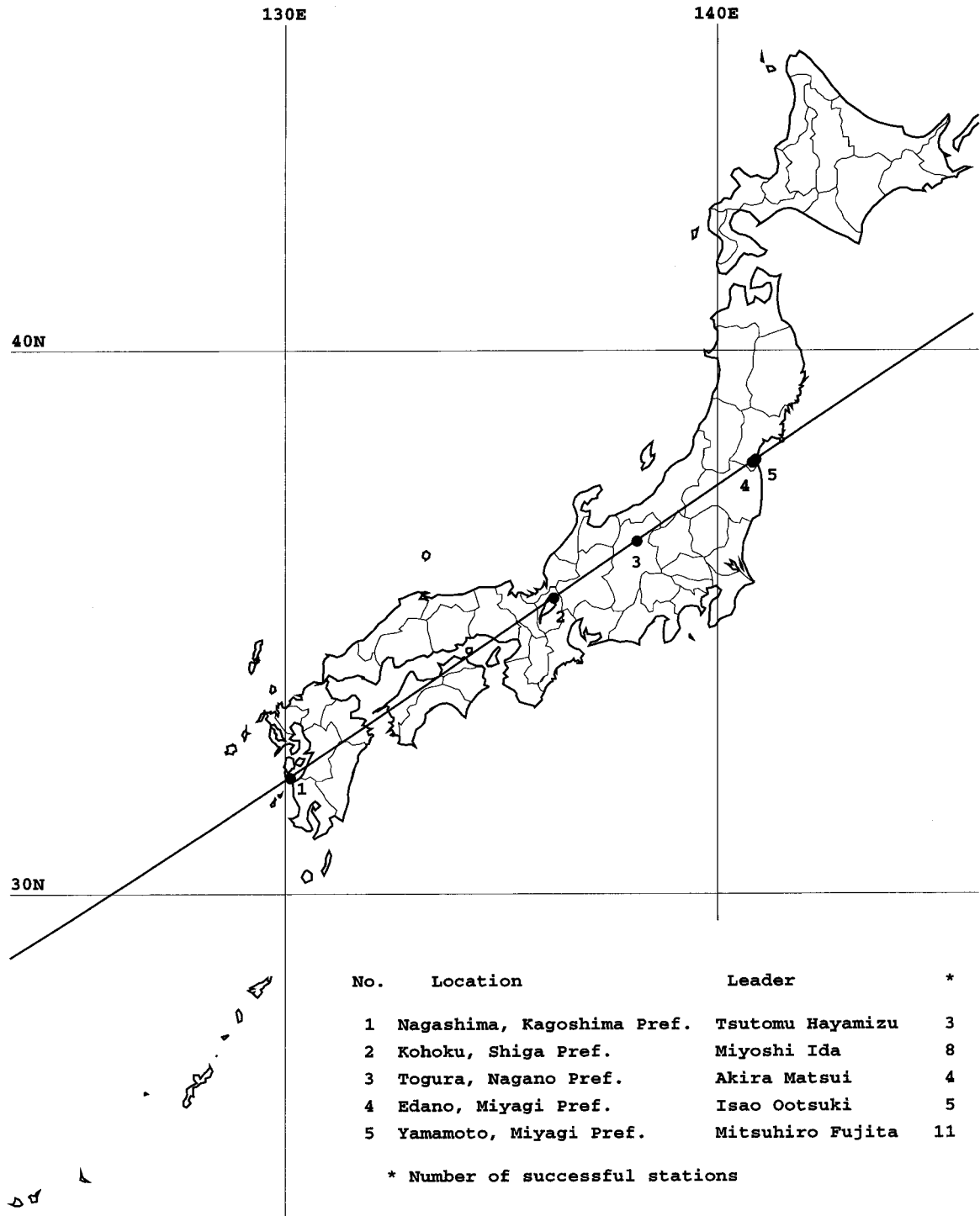


Fig. 7. Northern limit of the 97 Tauri (ZC 730) graze on 2000 Aug. 23. The dots represent the places where the observations were made.

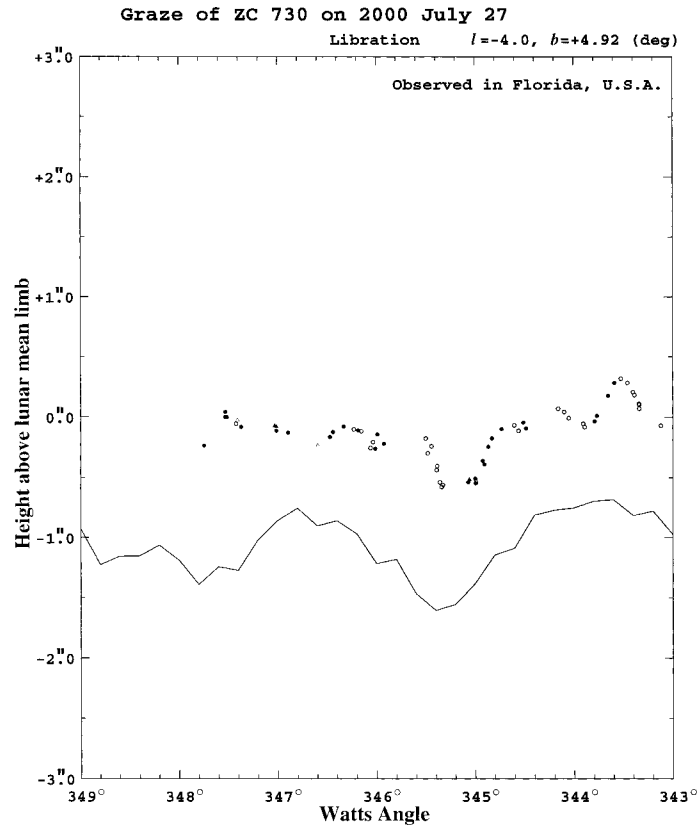


Fig. 8. Limb profile from the 97 Tauri (ZC 730) graze observed on 2000 July 27 in Florida, U.S.A. For the explanation, see figure 1.

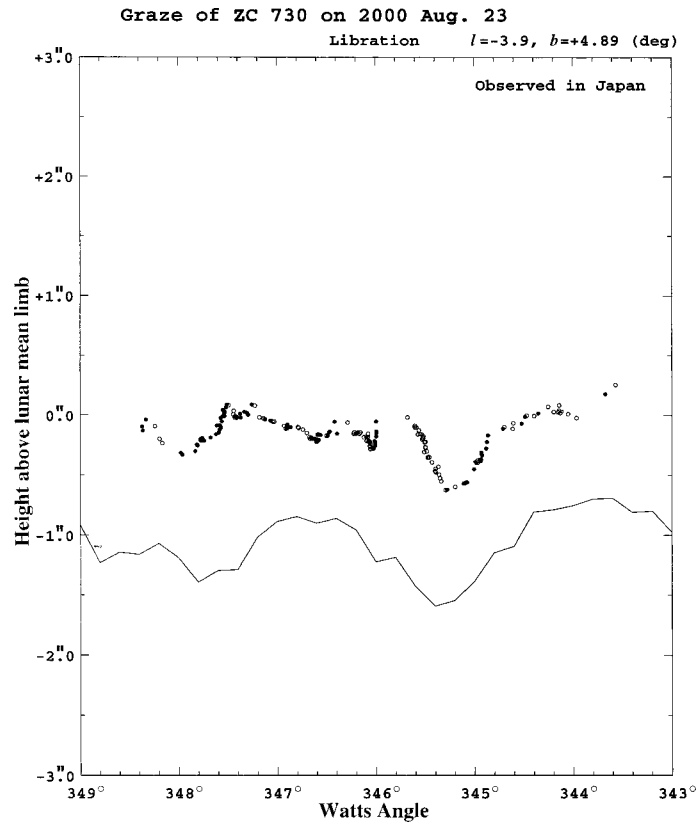


Fig. 9. Limb profile from the 97 Tauri (ZC 730) graze observed on 2000 Aug. 23 in Japan. For the explanation, see figure 1.

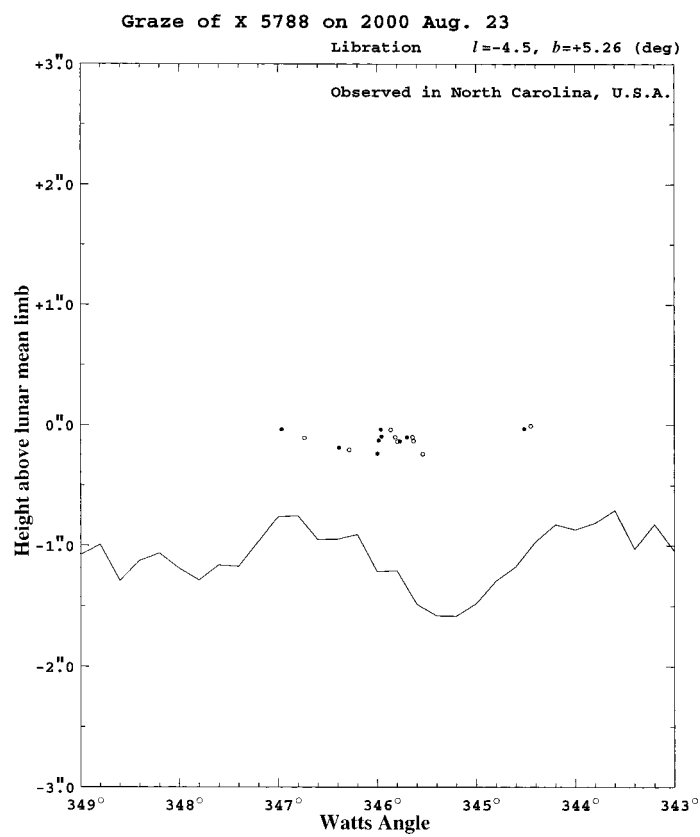


Fig. 10. Limb profile from the X 5788 (SAO 93963) graze observed on 2000 Aug. 23 in North Carolina, U.S.A. For the explanation, see figure 1.

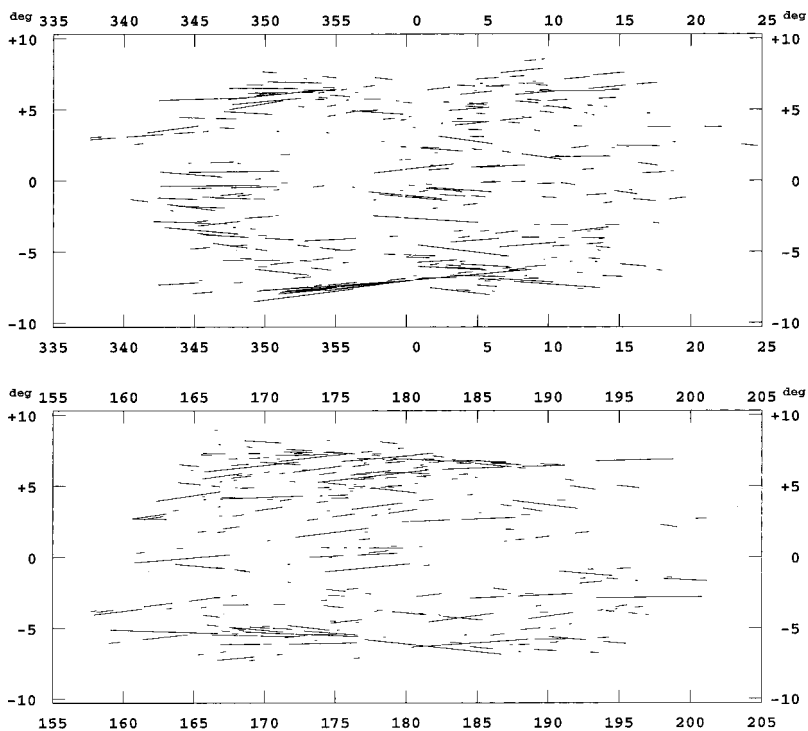


Fig. 11. Location on the moon in the P - D frame that has the limb profile data given by Sôma (1999).

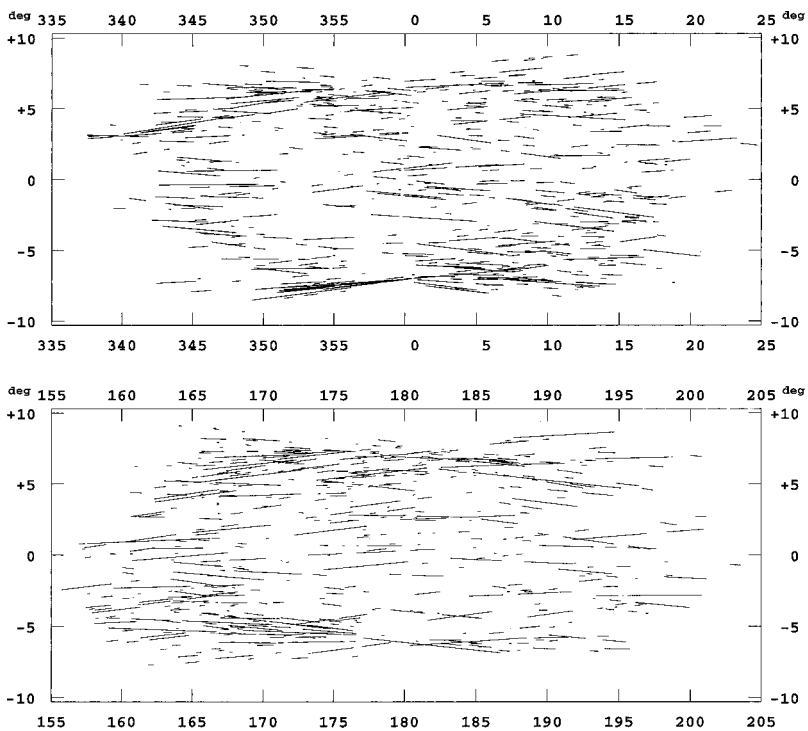


Fig. 12. Location on the moon in the P - D frame that has the limb profile data given by Sôma (1999) and in the present paper.

Table 1. Lunar Limb Profile Data.

35803584	1-388-288	90	690X	6966	09/01/72	3	3.9	-3.38	99B	6	0.02	9.4			
383	503	343													
16301636	-1-631-531-340	260X	29210	12/18/74	4	-0.4	-5.81	99B	6	0.02	9.4				
-993	-1143	-993	-1133												
16981708	-1-631-531-340	260X	29210	12/18/74	6	-0.4	-5.81	99B	3	0.02	9.4				
-1354	-1314	-1284	-1243	-1194	-1153										
35583564	1-104	-4	360	900X	10477	09/30/72	4	6.6	-0.54	99B	6	0.03	9.3		
23	-163	-244	-333												
18421842	-1	450	550	140	740X	13920	10/20/73	1	4.4	5.00	99B	1	0.01	8.7	
2224															
18621866	-1	450	550	140	740X	13920	10/20/73	3	4.4	5.00	99B	4	0.01	8.7	
-223	-213	-63													
18741874	-1	450	550	140	740X	13920	10/20/73	1	4.4	5.00	99B	1	0.01	8.7	
704															
138	152	1	8	108-610	-10X	6976	04/26/74	8	-3.1	0.58	99B	4	0.01	8.7	
174	194	224	254	274	304	333	303								
160	180	1	8	108-610	-10X	6976	04/26/74	11	-3.1	0.58	99B	12	0.01	8.7	
163	153	174	183	203	233	154	73	24	-44	-94					
90	106	1	87	187-900-300ZC	495	03/07/76	9	-6.0	1.37	99B	6	0.02	8.7		
253	184	53	154	193	84	-44	-363	-393							
156	164	1	87	187-900-300ZC	495	03/07/76	5	-6.0	1.37	99B	4	0.02	8.7		
43	74	103	133	153											
18621864	-1	16	116	420	900X	14048	10/13/71	2	7.2	0.66	99B	3	0.01	8.6	
-804	-553														
19181920	-1	16	116	420	900X	14048	10/13/71	2	7.2	0.66	99B	3	0.01	8.6	
1473	1633														
72	80	1	-603-503	110	710X	5287	03/20/72	5	4.1	-5.53	99B	6	0.03	8.6	
-373	-344	-313	-343	-223											
114	126	1	-603-503	110	710X	5287	03/20/72	7	4.1	-5.53	99B	12	0.03	8.6	
-283	-173	-144	03	-103	03	-103									
158	170	1	-388-288	330	900X	10357	04/30/71	7	6.3	-3.38	99B	13	0.02	8.4	
83	163	133	173	113	183	213									
178	182	1	-388-288	330	900X	10357	04/30/71	3	6.3	-3.38	99B	3	0.02	8.4	
393	454	333													
104	106	1	457	557-900-440X	9495	05/04/76	2	-7.4	5.07	99B	5	0.01	8.4		
-623	-653														
166	166	1	457	557-900-440X	9495	05/04/76	1	-7.4	5.07	99B	2	0.01	8.4		
143															
60	64	1	48	148-830-230X	4099	03/06/76	3	-5.3	0.98	99B	8	0.02	8.3		
273	103	-43													
104	104	1	48	148-830-230X	4099	03/06/76	1	-5.3	0.98	99B	3	0.02	8.3		
-173															
54	58	1	-65	35	-80	520ZC	216	01/26/77	3	2.2	-0.15	99B	2	0.03	8.3
303	304	293													
88	96	1	-65	35	-80	520ZC	216	01/26/77	5	2.2	-0.15	99B	6	0.03	8.3
-283	-404	-213	154	-23											
35283548	1-494-394-850-250X	29942	03/30/73	11	-5.5	-4.44	99B	24	0.02	8.2					
53	204	283	243	63	303	213	223	154	-13	-63					
35603562	1-494-394-850-250X	29942	03/30/73	2	-5.5	-4.44	99B	6	0.02	8.2					
-313	-293														
80	88	1	-350-250-860-260X	5514	03/01/74	5	-5.6	-3.00	99B	7	0.01	8.2			
254	304	264	113	-43											
132	136	1	-350-250-860-260X	5514	03/01/74	3	-5.6	-3.00	99B	6	0.01	8.2			
153	373	363													
16381650	-1-474-374	-80	520X	27868	10/23/74	7	2.2	-4.24	99B	7	0.02	8.2			
-403	503	454	273	-493	-543	-813									
16601664	-1-474-374	-80	520X	27868	10/23/74	3	2.2	-4.24	99B	2	0.02	8.2			
-883	-304	154													
16801684	-1-474-374	-80	520X	27868	10/23/74	3	2.2	-4.24	99B	3	0.02	8.2			
893	343	243													
19201922	-1	622	722-150	450X	19119	12/12/71	2	1.5	6.72	99B	2	0.01	8.1		
1613	1533														
19301930	-1	622	722-150	450X	19119	12/12/71	1	1.5	6.72	99B	2	0.01	8.1		
853															
19681978	-1	622	722-150	450X	19119	12/12/71	6	1.5	6.72	99B	9	0.01	8.1		
213	183	223	374	513	603										

Table 1.

17321746-1	668	768-900-340ZC	2320	08/29/71	8-6.4	7.18	99B	25	0.01	6.9		
403	03	-54 443 613 443	-73 -553									
15841592-1-177	-77-850-250ZC	3149	12/22/71	5-5.5	-1.27	99B	10	0.01	6.9			
2073	2053	1973	1903	1623								
16101612-1-177	-77-850-250ZC	3149	12/22/71	2-5.5	-1.27	99B	6	0.01	6.9			
203	-153											
16321634-1-177	-77-850-250ZC	3149	12/22/71	2-5.5	-1.27	99B	6	0.01	6.9			
-723	-203											
16401642-1-177	-77-850-250ZC	3149	12/22/71	2-5.5	-1.27	99B	4	0.01	6.9			
-93	-453											
16621674-1-177	-77-850-250ZC	3149	12/22/71	7-5.5	-1.27	99B	14	0.01	6.9			
953	1144	1334	1523	1943	2303	2103						
106	108	1	476	576-570	30X	5788	04/21/77	2-2.7	5.26	99B		
-503	-493											
130	138	1	476	576-570	30X	5788	04/21/77	5-2.7	5.26	99B		
-273	-164	-53	43	143								
17421742-1	203	303-890-290ZC	1754	07/21/77	1-5.9	2.53	99B	2	0.01	6.9		
-204												
17501766-1	203	303-890-290ZC	1754	07/21/77	9-5.9	2.53	99B	11	0.01	6.9		
63	-623	-1054	-523	-253	03	-633	-643	-83				
17781778-1	203	303-890-290ZC	1754	07/21/77	1-5.9	2.53	99B	2	0.01	6.9		
-353												
17861790-1	203	303-890-290ZC	1754	07/21/77	3-5.9	2.53	99B	4	0.01	6.9		
-513	103	493										
18021804-1	203	303-890-290ZC	1754	07/21/77	2-5.9	2.53	99B	2	0.01	6.9		
1303	1704											
17601760-1-237-137	70	670ZC	3238	12/05/78	1	3.7	-1.87	99B	2	0.01	6.9	
533												
17681768-1-237-137	70	670ZC	3238	12/05/78	1	3.7	-1.87	99B	2	0.01	6.9	
263												
35823598	1-131	-31-880-280ZC	442	03/16/67	9-5.8	-0.81	99B	18	0.02	6.8		
-133	-303	-353	-353	-344	-323	33	73	-173				
35823598	1-655-555-850-250ZC	1436	09/30/67	9-5.5	-6.05	99B	38	0.02	6.8			
193	123	103	143	233	03	-73	53	103				
0	2	1-655-555-850-250ZC	1436	09/30/67	2-5.5	-6.05	99B	10	0.02	6.8		
53	-53											
132	148	1-470-370	200	800ZC	780	03/21/72	9	5.0	-4.20	99B		
484	623	573	454	473	603	423	244	183				
35163526	1-147	-47-900-430ZC	3134	04/09/72	6-7.3	-0.97	99B	7	0.01	6.8		
94	54	14	-33	-113	-203							
35543558	1-147	-47-900-430ZC	3134	04/09/72	3-7.3	-0.97	99B	7	0.01	6.8		
-303	-433	-173										
112	112	1-547-447-350	250ZC	553	04/06/73	1-0.5	-4.97	99B	2	0.01	6.8	
-203												
160	168	1-547-447-350	250ZC	553	04/06/73	5-0.5	-4.97	99B	7	0.01	6.8	
203	313	294	284	264								
35403546	1-537-437-600	0ZC	553	06/27/73	4-3.0	-4.87	99B	10	0.01	6.8		
293	273	304	103									
16381648-1-663-563-900-410ZC	3326	12/03/73	6-7.1	-6.13	99B	23	0.02	6.8				
-1133	03	-753	-733	-864-1003								
132	132	1	571	671-220	380ZC	1429	04/03/74	1	0.8	6.21	99B	
244												
142	160	1	571	671-220	380ZC	1429	04/03/74	10	0.8	6.21	99B	
-23	-113	-114	-253	-253	-363	-233	-243	-243	-243			
18401844-1	574	674	330	900ZC	1788	01/04/75	3	6.3	6.24	99B		
1604	1003	363										
18561858-1	574	674	330	900ZC	1788	01/04/75	2	6.3	6.24	99B		
24	404											
18761884-1	574	674	330	900ZC	1788	01/04/75	5	6.3	6.24	99B		
1024	924	824	723	513								
114	130	1	26	126-900-490ZC	642	03/19/75	9-7.9	0.76	99B	10	0.01	6.8
-573	-604	-773	-624	-614	-623	-293	-263	-283				
156	166	1	26	126-900-490ZC	642	03/19/75	6-7.9	0.76	99B	11	0.01	6.8
213	23	123	124	123	113							
76	102	1	298	398-900-430ZC	935	03/21/75	14-7.3	3.48	99B	11	0.01	6.8
223	204	184	113	73	14	-54	-103	-113	-104	-173	-173	

Table 1.

110	120	1	298	398-900-430ZC	935	03/21/75	6-7.3	3.48	99B	7	0.01	6.8			
-333	-553	-534	-523	-563	-293										
138	138	1	298	398-900-430ZC	935	03/21/75	1-7.3	3.48	99B	2	0.01	6.8			
-323															
146	146	1	298	398-900-430ZC	935	03/21/75	1-7.3	3.48	99B	1	0.01	6.8			
-43															
35663598	1-621-521-900-300ZC	51	06/14/74	17-6.0	-5.71	99B	24	0.01	6.8						
73	223	224	164	63	-73	-303	-13	-33	-33	-13	03	54 23 34 113			
153															
0	0	1-621-521-900-300ZC	51	06/14/74	1-6.0	-5.71	99B	1	0.01	6.8					
23															
64	72	1-328-228-520	80ZC	145	02/05/76	5-2.2	-2.78	99B	12	0.01	6.8				
353	364	303	483	323											
17381770-1-645-545	370	900ZC	3051	10/03/76	17	6.7	-5.95	99B	13	0.01	6.8				
-1793-1624-1453-1274-1093	-733	-554	-484-1003-1623-1164	-703	-303	-154	44	-323							
-943															
16721672-1-643-543	290	890ZC	3051	12/24/76	1	5.9	-5.93	99B	1	0.01	6.8				
914															
16781684-1-643-543	290	890ZC	3051	12/24/76	4	5.9	-5.93	99B	4	0.01	6.8				
1493	1263	993	843												
16941704-1-643-543	290	890ZC	3051	12/24/76	6	5.9	-5.93	99B	8	0.01	6.8				
-353-323	-233	-413	-803-1204												
17101754-1-643-543	290	890ZC	3051	12/24/76	23	5.9	-5.93	99B	19	0.01	6.8				
-1593-1534-1483-1603-1654-1703-2053-2084-2103-2114-2124-1994-1854-1713-1403															
-1133-1073	-964	-854	-733	-463	-993										
34683476	1-542-442-900-320ZC	1089	09/10/66	5-6.2	-4.92	99B	25	0.02	6.7						
-363	-403	-193	-153	303											
34843508	1-542-442-900-320ZC	1089	09/10/66	13-6.2	-4.92	99B	73	0.02	6.7						
103	43	-33	-133	-73	33	23	-193	-283	-113	03	-73	-223			
16441648-1	452	552-370	230ZC	20	12/20/66	3-0.7	5.02	99B	6	0.01	6.7				
1333	1403	1283													
16041612-1	251	351	90	690ZC	3240	11/16/69	5	3.9	3.01	99B	7	0.01	6.7		
653	744	843	1043	1033											
16301644-1	251	351	90	690ZC	3240	11/16/69	8	3.9	3.01	99B	9	0.01	6.7		
863	573	603	673	723	1054	1003	733								
35103532	1-626-526	480	900X	8040	09/22/70	12	7.8	-5.76	99B	10	0.01	6.7			
-143	-183	-284	-383	-303	-354	-403	-423	-424	-414	-413	-393				
35443548	1-626-526	480	900X	8040	09/22/70	3	7.8	-5.76	99B	6	0.01	6.7			
33	103	233													
16561670-1	-48	52-600	0ZC	3091	08/06/71	8-3.0	0.02	99B	17	0.01	6.7				
503	424	343	173	403	503	1013	1193								
16761702-1	-48	52-600	0ZC	3091	08/06/71	14-3.0	0.02	99B	24	0.01	6.7				
1123	663	433	243	233	-363	-503	-544	-583	-753	-963-1243-1424-1613					
15741576-1	-57	43-900-460ZC	3091	10/28/71	2-7.6	-0.07	99B	3	0.01	6.7					
1463	1923														
16101612-1	-57	43-900-460ZC	3091	10/28/71	2-7.6	-0.07	99B	3	0.01	6.7					
593	-53														
140	142	1-227-127	340	900ZC	1080	03/23/72	2	6.4	-1.77	99B	5	0.01	6.7		
553	483														
152	174	1-227-127	340	900ZC	1080	03/23/72	12	6.4	-1.77	99B	21	0.01	6.7		
353	423	504	583	653	614	583	623	554	484	413	423				
82	92	1	255	355	360	900ZC	1386	05/19/72	6	6.6	3.05	99B	11	0.01	6.7
1103	923	773	614	453	273										
104	116	1	255	355	360	900ZC	1386	05/19/72	7	6.6	3.05	99B	10	0.01	6.7
-263	-323	-384	-433	-443	-453	-463									
128	140	1	255	355	360	900ZC	1386	05/19/72	7	6.6	3.05	99B	10	0.01	6.7
-263	-184	-103	-53	113	283	413									
35303546	1-424-324-590	10ZC	524	08/21/73	9-2.9	-3.74	99B	9	0.02	6.7					
-183	73	94	114	133	244	353	354	03							
19581966-1	613	713	400	900ZC	1528	12/15/73	5	7.0	6.63	99B	16	0.01	6.7		
773	553	803	1143	1033											
100	114	1	626	726-740-140ZC	1320	04/20/75	8-4.4	6.76	99B	13	0.01	6.7			
-493	-303	-483	-304	-434	-433	-424	-413								
124	152	1	626	726-740-140ZC	1320	04/20/75	15-4.4	6.76	99B	27	0.01	6.7			
-304	-603	-533	-413	-153	-103	33	-123	64	73	03	253	233	244	253	

Table 1.

142 146 1-586-486 360 900ZC 840 03/05/71 3 6.6 -5.36 99B	5 0.01 6.3
403 554 483	
16041606-1-328-228-810-210ZC 3367 10/30/71 2-5.1 -2.78 99B	2 0.01 6.3
1593 1433	
16321646-1-328-228-810-210ZC 3367 10/30/71 8-5.1 -2.78 99B	8 0.01 6.3
-1083 -353 473 633 243 -413 -784-1153	
16581658-1-328-228-810-210ZC 3367 10/30/71 1-5.1 -2.78 99B	1 0.01 6.3
-814	
16741678-1-328-228-810-210ZC 3367 10/30/71 3-5.1 -2.78 99B	3 0.01 6.3
1833 1304 783	
16341640-1-655-555-580 20ZC 3455 09/30/74 4-2.8 -6.05 99B	4 0.01 6.3
-1384 -954 -704 -954	
17081712-1-655-555-580 20ZC 3455 09/30/74 3-2.8 -6.05 99B	2 0.01 6.3
-1193-1174-1163	
35463548 1-596-496-360 240ZC 3455 06/30/75 2-0.6 -5.46 99B	2 0.01 6.3
483 373	
35583576 1-596-496-360 240ZC 3455 06/30/75 10-0.6 -5.46 99B	14 0.01 6.3
23 114 203 143 -33 -54 13 33 173 463	
16361638-1-256-156 190 790ZC 2457 07/19/75 2 4.9 -2.06 99B	3 0.01 6.3
-533 -353	
16841686-1-256-156 190 790ZC 2457 07/19/75 2 4.9 -2.06 99B	2 0.01 6.3
493 453	
17961798-1 188 288 -70 530ZC 2017 11/30/75 2 2.3 2.38 99B	3 0.02 6.3
983 1583	
18061808-1 188 288 -70 530ZC 2017 11/30/75 2 2.3 2.38 99B	3 0.02 6.3
953 103	
18141818-1 188 288 -70 530ZC 2017 11/30/75 3 2.3 2.38 99B	2 0.02 6.3
-43 444 923	
18441846-1 188 288 -70 530ZC 2017 11/30/75 2 2.3 2.38 99B	2 0.02 6.3
1764 983	
64 64 1 678 778-380 220ZC 1003 04/14/78 1-0.8 7.28 99B	2 0.03 6.3
133	
72 80 1 678 778-380 220ZC 1003 04/14/78 5-0.8 7.28 99B	9 0.03 6.3
23 -163 23 1044 13	
35503564 1 129 229 150 750ZC 4 07/14/79 8 4.5 1.79 99B	13 0.01 6.3
133 223 13 -83 -213 -503 -423 -503	
17561768-1 456 556 350 900ZC 308 01/06/79 7 6.5 5.06 99B	10 0.01 6.3
1223 1923 2103 1864 1604 1093 493	
94 150 1 151 251-900-470ZC 1787 05/27/69 29-7.7 2.01 99B	50 0.01 6.2
293 233 184 133 133 -213 -323 -133 -513 -613 -644 -664 -683 -533 -443 -424	
-403 -503 -453 -313 -243 -103 -203 -83 -43 -43 13 24 43	
16021610-1-323-223 120 720ZC 2614 10/20/74 5 4.2 -2.73 99B	4 0.01 6.2
2463 2414 2373 2053 1623	
16381672-1-323-223 120 720ZC 2614 10/20/74 18 4.2 -2.73 99B	14 0.01 6.2
-233 63 43 53 -343 -404 -354 -313 -283 -204 -203 -204 -84 83 123 364	
614 864	
16801680-1-323-223 120 720ZC 2614 10/20/74 1 4.2 -2.73 99B	2 0.01 6.2
1553	
120 126 1 164 264-900-400ZC 755 04/16/75 4-7.0 2.14 99B	9 0.01 6.2
-543 -333 -333 -373	
134 138 1 164 264-900-400ZC 755 04/16/75 3-7.0 2.14 99B	7 0.01 6.2
-343 -453 -133	
180 186 1 164 264-900-400ZC 755 04/16/75 4-7.0 2.14 99B	8 0.01 6.2
-153 -123 -223 -303	
35403554 1 660 760-900-300ZC 1234 11/13/76 8-6.0 7.10 99B	11 0.01 6.2
-23 -63 -173 -233 -234 -223 -243 -283	
35723572 1 660 760-900-300ZC 1234 11/13/76 1-6.0 7.10 99B	1 0.01 6.2
-14	
17981798-1 -31 69-430 170ZC 3360 11/27/79 1-1.3 0.19 99B	2 0.01 6.2
243	
16581658-1 393 493-340 260ZC 620 02/20/64 1-0.4 4.43 99B	4 0.03 6.1
1423	
16701676-1 393 493-340 260ZC 620 02/20/64 4-0.4 4.43 99B	7 0.03 6.1
243 104 -44 -173	
33903394 1-305-205-640 -40ZC 566 07/31/67 3-3.4 -2.55 99B	13 0.02 6.1
193 283 383	

Table 1.

34343450	1-305-205-640	-40ZC	566	07/31/67	9-3.4	-2.55	99B	41	0.02	6.1					
-323	-273	-113	03	183	303	654	443	253							
34083486	1-641-541	480	900ZC	370	08/22/70	40	7.8	-5.91	99B	77	0.01	6.1			
683	1033	904	953	573	543	673	634	583	524	453	343	293	253	93	163
113	103	-243	-43	-273	-33	233	273	304	333	133	263	323	153	263	173
83	-63	24	93	174	253	193	263								
15901600	1-575-475-230	370ZC	2995	11/20/74	6	0.7	-5.25	99B	11	0.01	6.1				
703	1183	1553	1304	1304	1403										
16081636	1-575-475-230	370ZC	2995	11/20/74	15	0.7	-5.25	99B	31	0.01	6.1				
653	03-1004-1253-1503-1253-1663-1463-1223-1453-1273-1144-1084	-963-1023													
16441670	1-575-475-230	370ZC	2995	11/20/74	14	0.7	-5.25	99B	52	0.01	6.1				
-733-1054-1303-1903-1983-1533-1753-1563-1233	-953	93	183	-104	603										
16761680	1-575-475-230	370ZC	2995	11/20/74	3	0.7	-5.25	99B	12	0.01	6.1				
1083	503	-223													
90	104	1	430	530-510	90ZC	610	04/21/77	8-2.1	4.80	99B	14	0.01	6.1		
-383	-143	-123	-163	-323	-253	-334	-383								
124	142	1	430	530-510	90ZC	610	04/21/77	10-2.1	4.80	99B	16	0.01	6.1		
-343	-353	-334	-303	-293	-393	83	-13	-113	-113						
198	218	1-305-205	210	810ZC	1221	05/28/71	11	5.1	-2.55	99B	26	0.01	6.0		
-13	-33	-233	-113	63	23	-123	63	-233	-284	-313					
56	60	1	694	794	140	740ZC	1587	05/29/74	3	4.4	7.44	99B	6	0.01	6.0
-133	53	263													
130	134	1	694	794	140	740ZC	1587	05/29/74	3	4.4	7.44	99B	5	0.01	6.0
33	103	-13													
120	130	1	41	141-900-510ZC	651	03/19/75	6-8.1	0.91	99B	8	0.01	6.0			
-663	-633	-543	-453	-323	-353										
162	172	1	41	141-900-510ZC	651	03/19/75	6-8.1	0.91	99B	8	0.01	6.0			
103	64	33	-93	-73	13										
130	130	1	45	145-900-380ZC	651	04/15/75	1-6.8	0.95	99B	2	0.01	6.0			
-213															
164	166	1	45	145-900-380ZC	651	04/15/75	2-6.8	0.95	99B	2	0.01	6.0			
103	103														
18841898	1-532	632-900-380ZC	1072	10/26/75	8-6.8	5.82	99B	21	0.01	6.0					
1943	2123	1444	1503	1583	1263	1463	954								
19361948	1-532	632-900-380ZC	1072	10/26/75	7-6.8	5.82	99B	13	0.01	6.0					
843	763	1023	1183	1244	1363	1123									
74	92	1	602	702-900-360ZC	1072	06/01/76	10-6.6	6.52	99B	12	0.01	6.0			
333	234	123	73	-173	103	23	-143	-164	-333						
126	140	1	602	702-900-360ZC	1072	06/01/76	8-6.6	6.52	99B	13	0.01	6.0			
-263	-593	-453	-304	-143	23	-53	33								
17481748	1-609-509	340	900ZC	3187	10/04/76	1	6.4	-5.59	99B	1	0.01	6.0			
-544															
17541754	1-609-509	340	900ZC	3187	10/04/76	1	6.4	-5.59	99B	1	0.01	6.0			
-744															
17601760	1-609-509	340	900ZC	3187	10/04/76	1	6.4	-5.59	99B	1	0.01	6.0			
-814															
17701770	1-609-509	340	900ZC	3187	10/04/76	1	6.4	-5.59	99B	1	0.01	6.0			
-764															
46	56	1	445	545-570	30ZC	718	01/30/77	6-2.7	4.95	99B	4	0.01	6.0		
373	364	353	254	164	223										
86	100	1	445	545-570	30ZC	718	01/30/77	8-2.7	4.95	99B	10	0.01	6.0		
-243	-203	-313	-273	-173	-164	-193	-313								
17161728	1-752-652-700-100ZC	2460	10/07/78	7-4.0	-7.02	99B	9	0.01	6.0						
-1263-1343-1353-1443-1304-1483-1343															
15781580	1-236-136-900-490ZC	3064	10/17/72	2-7.9	-1.86	99B	6	0.01	5.9						
1303	1083														
15881592	1-236-136-900-490ZC	3064	10/17/72	3-7.9	-1.86	99B	4	0.01	5.9						
1143	973	1003													
16341638	1-236-136-900-490ZC	3064	10/17/72	3-7.9	-1.86	99B	4	0.01	5.9						
693	794	893													
16001608	1-319-219-520	80ZC	2902	10/05/73	5-2.2	-2.69	99B	4	0.02	5.9					
2313	2294	2263	1863	1203											
16321648	1-319-219-520	80ZC	2902	10/05/73	9-2.2	-2.69	99B	13	0.02	5.9					
-943	-403	483	893	503	323	-84	-483	-893							
16561686	1-319-219-520	80ZC	2902	10/05/73	16-2.2	-2.69	99B	18	0.02	5.9					
-923	-673	-84	513	1103	1214	1313	1943	2354	2233	1453	1323	823	613	564	513

