

CALÁN-TOLOLO SURVEY. VI. ONE HUNDRED NEW SOUTHERN QUASARS

J. Maza¹, M. Wischnjewsky¹, R. Antezana¹, and L.E. González¹

Depto. de Astronomía, Universidad de Chile

Received 1995 April 17; accepted 1995 June 5

RESUMEN

Se presenta la sexta lista de la Exploración Calán-Tololo. Contiene información acerca de 100 nuevos cuasares australes. Los objetos tienen una magnitud B en el intervalo $16 \leq B < 20$, con 81 objetos para los cuales $17.5 \leq B < 19$. Los corrimientos al rojo z son tales que 53 objetos cumplen con $1.8 \leq z < 2.4$, 20 objetos tienen z tal que $2.4 \leq z < 3.4$ y 27 cuasares tienen un z menor que 1.8. Estos cuasares fueron encontrados en Cerro Calán explorando placas de prisma objetivo tomadas en Cerro Tololo usando la cámara Curtis-Schmidt con el prisma ultravioleta delgado y placas IIIaJ. Se presentan cartas de identificación, coordenadas ecuatoriales, una estimación de la magnitud azul, B , y un valor preliminar del corrimiento al rojo. Todos los cuasares de esta lista han sido confirmados espectroscópicamente, información que será publicada posteriormente (Maza 1995).

ABSTRACT

The sixth list of the Calán-Tololo Survey is presented. It contains information for 100 new southern quasars. The objects have a B magnitude in the range $16 \leq B < 20$; for 81 objects $17.5 \leq B < 19$. The redshifts z of these quasars are such that for 53 objects $1.8 \leq z < 2.4$, for 20 objects $2.4 \leq z < 3.4$ and for 27 quasars $z < 1.8$. These quasars were found at Cerro Calán, searching objective prism plates taken at Cerro Tololo using the Curtis-Schmidt telescope, the thin UV prism and IIIaJ plates. Identification charts, equatorial coordinates, an estimated blue magnitude, B , and a preliminary redshift for every object are presented. All quasars in this list have been confirmed using slit spectroscopy. The spectroscopic data shall be presented elsewhere (Maza 1995).

Key words: **QUASARS-GENERAL**

1. INTRODUCTION

The Calán-Tololo Survey (hereinafter CTS) is an objective prism survey conducted at Cerro Calán (Department of Astronomy, Universidad de Chile) in Santiago, using photographic plates obtained at Cerro Tololo Inter-American Observatory (CTIO). We have used the Curtis-Schmidt telescope, IIIaJ plates and the thin UV prism. The CTS is a southern extension to the Tololo Survey (Smith 1975; Smith,

Aguirre, & Zemelman 1976) and to the Michigan Survey (MacAlpine, Lewis, & Smith 1977; MacAlpine, Smith, & Lewis 1977a, 1977b; MacAlpine & Lewis 1978; MacAlpine & Williams 1981). The main goal of the CTS is the discovery of new emission line galaxies and quasars. A description of the survey, the procedure and other details can be found in Maza et al. (1988a, 1988b, 1989, 1991, 1992).

List No. 1 of the Calán-Tololo Survey containing 30 new Seyfert 1 galaxies was published in 1989 (Maza et al. 1989). List No. 3 presenting 42 H II galaxies was published in 1991 (Maza et al. 1991). List No. 2 containing data for 40 Seyfert 1 galaxies was published in 1992 (Maza et al. 1992). List No. 4 presenting data for 50 Seyfert 1 galaxies was published in 1994 (Maza et al. 1994). List No. 5 con-

¹ Visiting Astronomer at Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories, operated by the Association of Universities for Research in Astronomy under contract with the National Science Foundation of the U.S.A.

taining data for 200 quasars was published in 1993 (Maza et al. 1993). The present list contains information for 100 new additional quasars discovered in the Calán-Tololo Survey and fully confirmed by slit spectroscopy at CTIO.

2. OBSERVATIONS

Objective prism photographic plates have been obtained for 266 fields in the southern hemisphere at galactic latitude b such that $|b| \geq 20^\circ$, covering 5150 deg^2 . To the original 163 fields of the CTS — see Figure 1 in Maza et al. 1989 — additional strips at $\delta = -30^\circ$ (strip F), $\delta = -50^\circ$ (strip G), and $\delta = -55^\circ$ (strip H) have been added in the right ascension interval $19 \text{ h} \leq \alpha \leq 6 \text{ h}$.

We have used the Curtis-Schmidt telescope at CTIO equipped with the thin UV prism that yields a reciprocal dispersion of 1740 Å mm^{-1} at $H\beta$, 1340 Å mm^{-1} at $H\gamma$, and 1100 Å mm^{-1} at $\lambda 3727 \text{ Å}$ (Blanco 1974). We have used Eastman Kodak IIIaJ plates baked in 2% forming gas and exposed to the sky limit (90 min) without trailing. Objects as faint as 19th mag in B are visible at the plate limit. The UV prism spectral resolution at the Curtis-Schmidt plate scale ($97'' \text{ mm}^{-1}$) is $\sim 30 \text{ Å}$ at $H\beta$ and $\sim 20 \text{ Å}$ at $\lambda 3727 \text{ Å}$ for a $2''$ seeing.

The strong emission lines present in the spectrum of a high redshift quasar — Lyman α , ($L\alpha$), most of the time — are resolved on our objective prism spectra. This makes confusion with high redshift starburst galaxies very small. Our method of selecting a quasar candidate relies heavily on the presence of emission lines. The most favorable case is when $L\alpha$ is near $\lambda 4000 \text{ Å}$ and the C IV ($\lambda 1549 \text{ Å}$) line is at $\lambda 5000 \text{ Å}$; that situation corresponds to a quasar with a redshift $z \sim 2.2$. The lines used for candidate selection on the objective prism plates are: $L\alpha$ ($\sim 75\%$ of the time), C IV ($\lambda 1549 \text{ Å}$) and Mg II (at $\lambda 2798 \text{ Å}$). In a few cases broad absorption lines quasars (BALs) have been found because their spectra look quite conspicuous on the objective prism plates; they look like unusual carbon stars.

3. LIST No. 6

Figure 1 presents identification charts and Table 1 contains the corresponding data for 100 additional quasars found and confirmed in our survey. Quasar candidates are selected from the objective prism plates and they are confirmed using slit spectroscopy at the CTIO 4-m and 1.5-m telescopes. If a candidate turns out to be a known quasar we leave it aside. We are presenting here quasars that, to the best of our knowledge, are new.

Table 1 contains for quasars numbered from 401 to 500 a name, labeled "Object" obtained from a contraction of the letter designating the strip on the sky, the field number in the strip and the candidate

number in that field. For example, object A1505 is the fifth candidate selected in area "A15" (fifteenth field in strip "A") (see Fig. 1 in Maza et al. 1989).

Equatorial coordinates (J2000.0) were obtained using the Digitized Sky Survey (DSS), the STSDAS software package and the corresponding tasks, in the IRAF working environment on SUN workstations at Cerro Calán. A preliminary set of coordinates for each candidate was obtained by overlaying a grid on the objective prism plate. Then a $15' \times 15'$ image was extracted from the DSS. The object was identified in that image and coordinates were obtained using the plate solution in the header of each image, using the appropriate tasks in the STSDAS software package. The astrometric accuracy of these coordinates is $\leq 1''$.

Table 1 presents a B magnitude estimated from the ESO Quick Blue Chart for every object. The CCD sequence F342–10 from Stobie, Sagar, & Gilmore (1985) was used for our eye estimates. Two of us (MW and RA) made independent estimates, the average of which is presented in Table 1. The agreement between these two data sets is $\pm 0.50 \text{ mag}$. As quasars in Table 1 could present photometric variability it is necessary to emphasize that the magnitudes quoted correspond to an eyeball estimate made on plates taken at least 15 years ago; those magnitudes do not necessarily correspond to the apparent magnitudes of the quasars in the objective prism plates. These B magnitudes are presented here as a reference.

Column 10 in Table 1 presents preliminary values for the redshifts of the quasars. These figures were obtained at the telescope when the spectroscopic confirmation of the quasars was made. The details of the spectrophotometry shall be presented elsewhere (Maza 1995). The final redshift values will be reported there. The figures given here are just for a general orientation to prospective observers; these redshifts should be accurate to ± 0.02 .

Finally Table 1 shows in the last two columns the ESO Quick Blue chart number and the DSS disk number, respectively, where the quasar can be found.

4. STATISTICAL PROPERTIES OF LIST No. 6

In List No. 5 (Maza et al. 1993) a preliminary analysis of the statistical properties of quasars found in the CTS was performed. Figure 2 presents a histogram of the redshifts for these new 100 quasars. In the lower part of Figure 2 four horizontal lines show the redshift interval of visibility in our objective prism spectra for the most prominent emission lines usually present in quasars, as labeled to the right of the horizontal lines.

In the upper part of Figure 2 the redshift range has been divided in four intervals containing 7, 20, 53, and 20 objects, respectively. If we divide in the same way the histogram in Figure 1 of List No. 5 (Maza

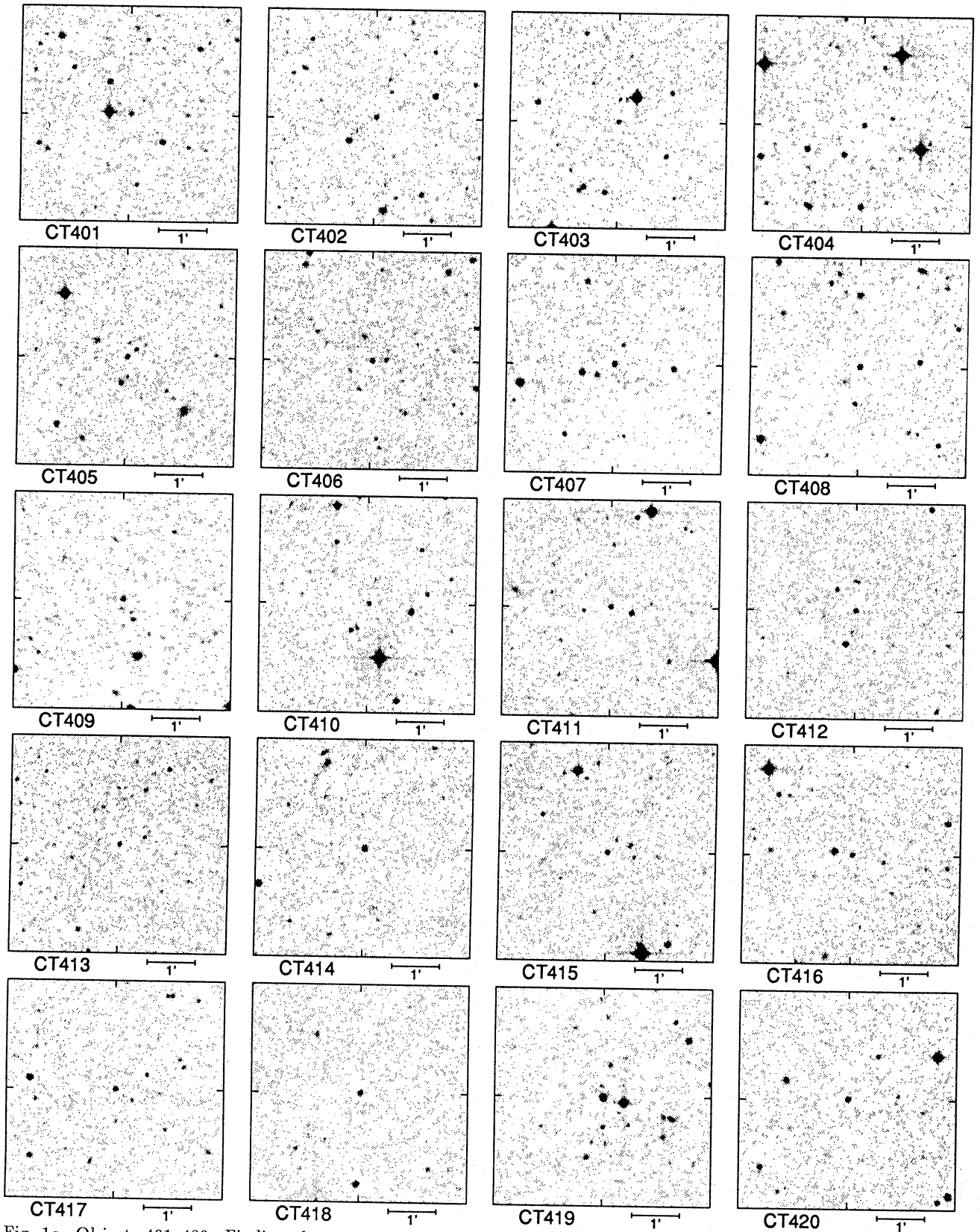


Fig. 1a. Objects 401–420. Finding charts for Calán-Tololo quasars from the Digitized Sky Survey (DSS). North is to the top and east to the left. Each chart covers $4' \times 4'$.

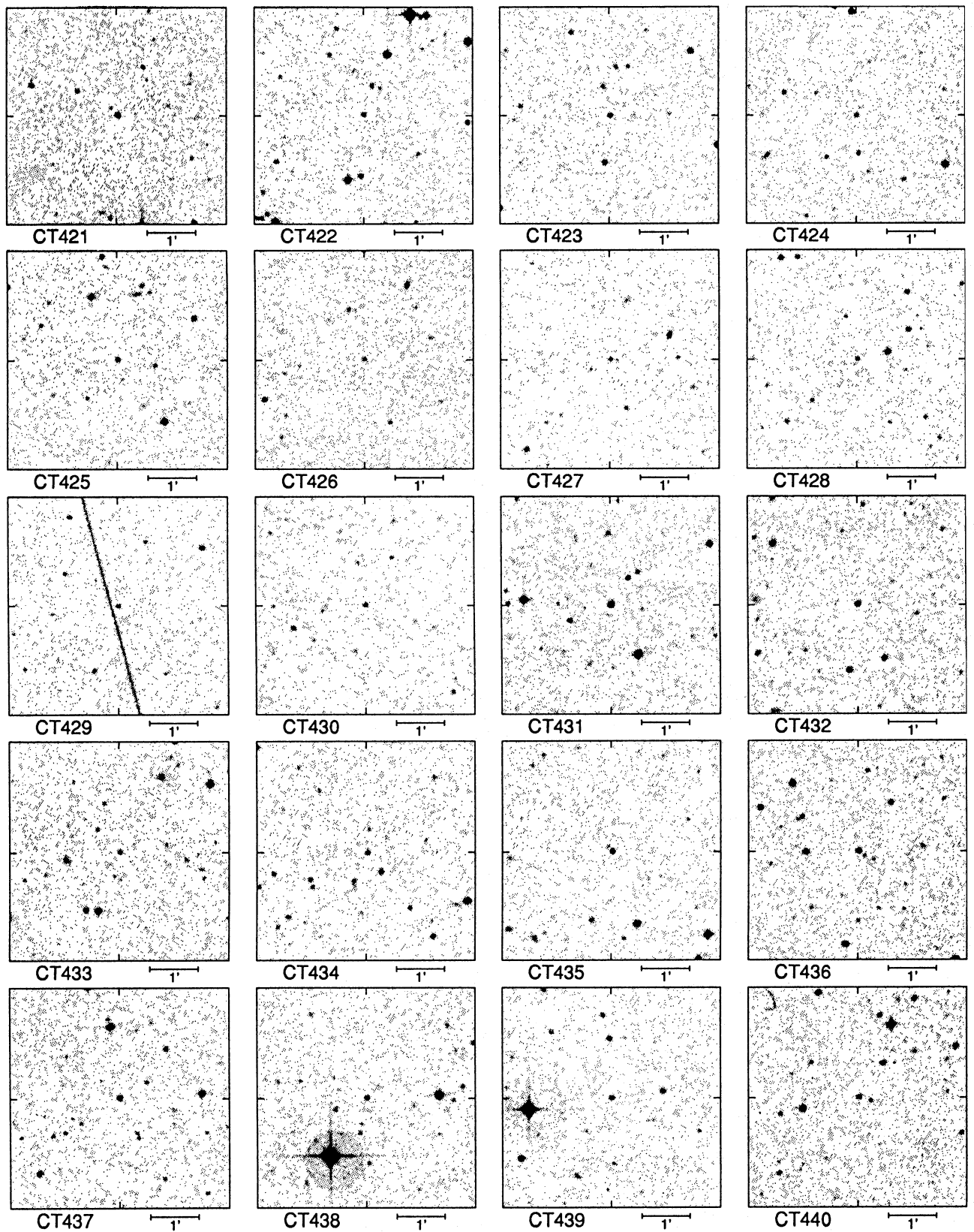


Fig. 1b. Same as Figure 1a for objects 421–440.

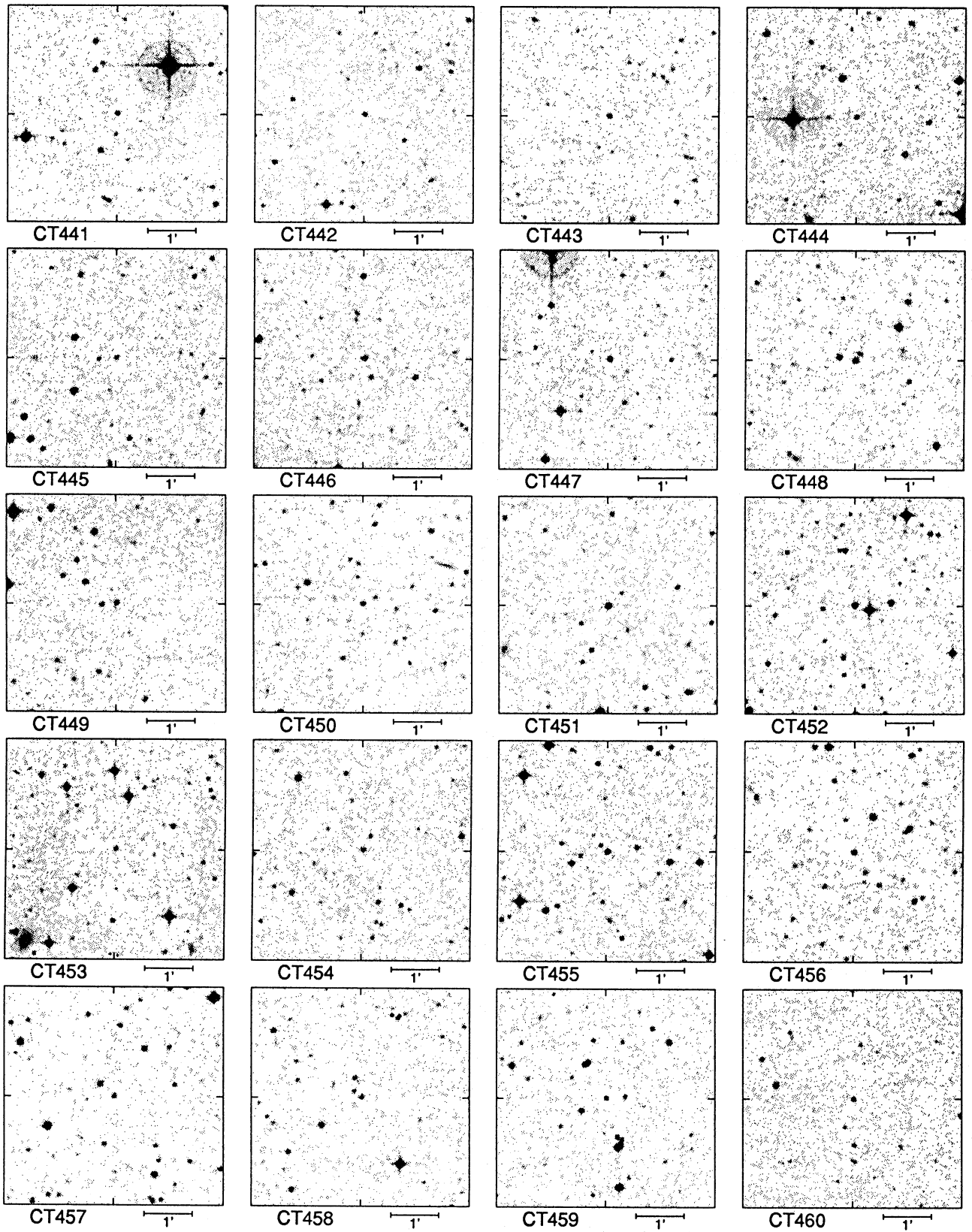


Fig. 1c. Same as Figure 1a for objects 441–460.

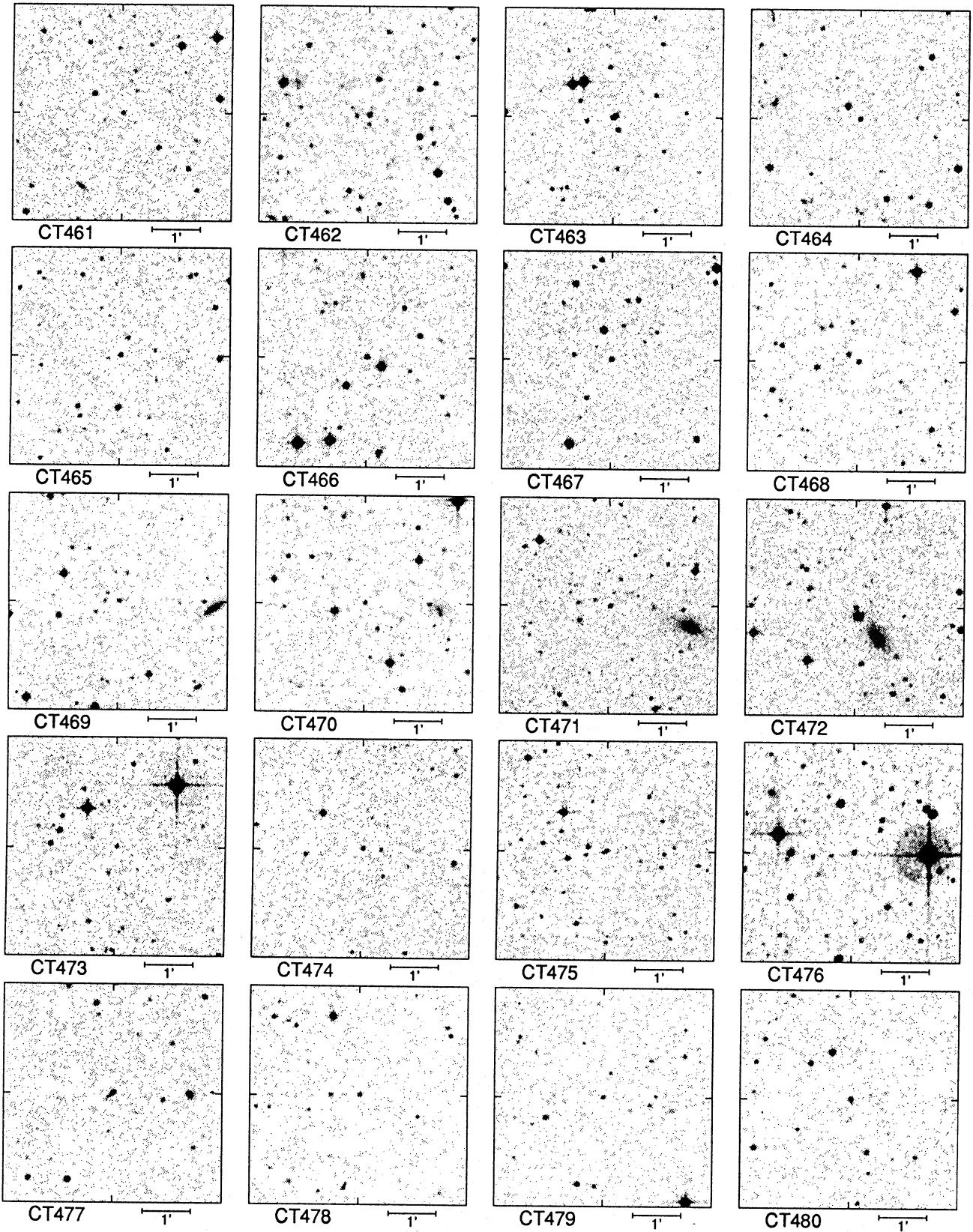


Fig. 1d. Same as Figure 1a for objects 461–480.

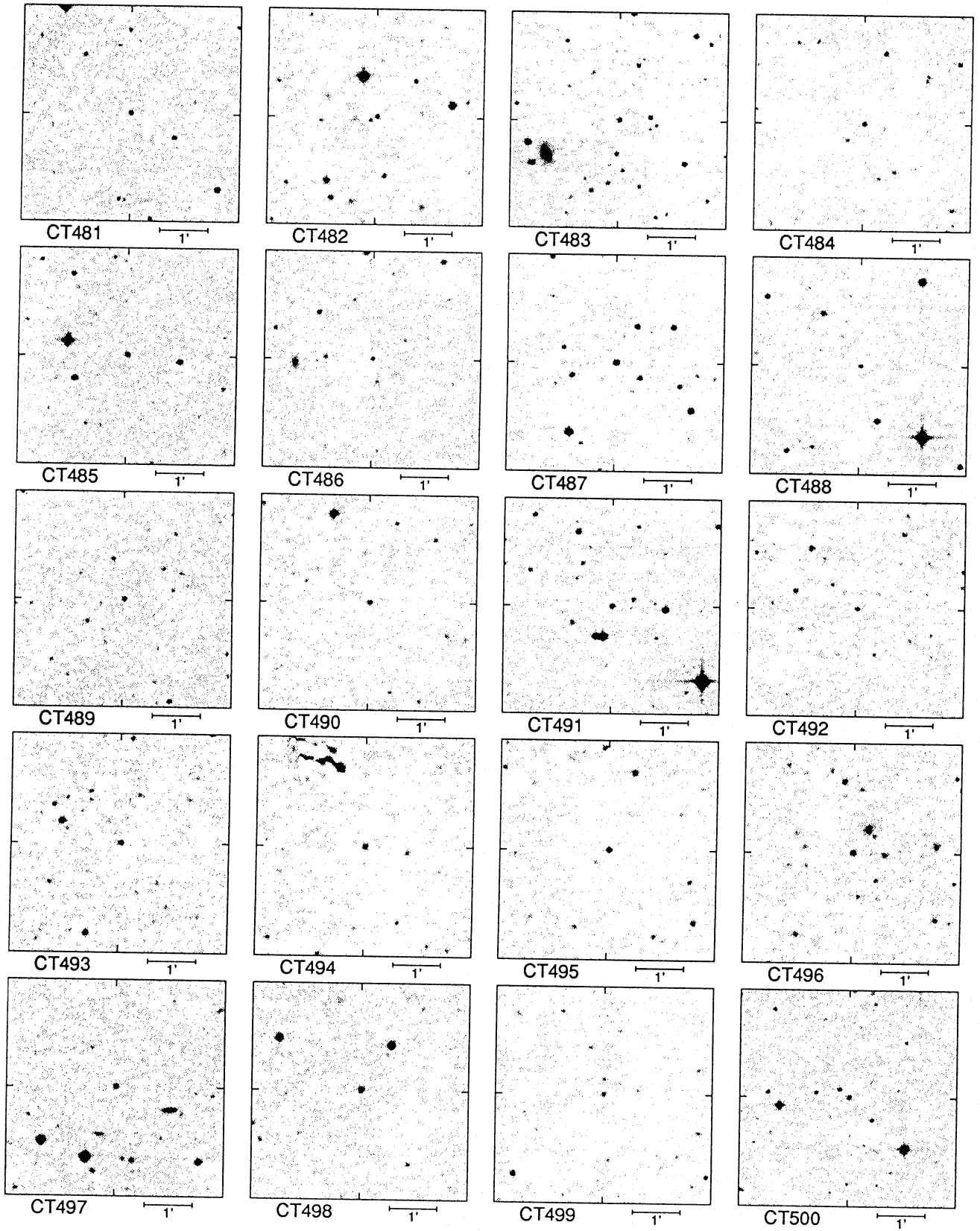


Fig. 1e. Same as Figure 1a for objects 481-500.

TABLE 1
CALÁN-TOLOLO SURVEY LIST NO. 6: QUASARS

CT#	Object	α (J2000.0)			δ			<i>B</i>	<i>z</i>	ESO	DSS
		h	m	s	°	'	"				
401	A1505	00	07	19.38	−33	15	17.5	18.6	2.03	349	24
402	C1609	00	09	27.20	−47	03	16.4	18.2	1.99	241	17
403	A1605	00	21	02.99	−35	02	32.3	18.8	2.0	350	24
404	G1706	00	21	14.51	−48	34	31.3	18.1	1.34	194	14
405	A1604	00	22	18.46	−35	16	50.8	18.7	2.0	350	24
406	A1716	00	34	26.84	−37	12	52.4	18.2	3.18	350	20
407	A1715	00	38	28.06	−36	24	26.0	18.1	0.40	351	24
408	G1801	00	41	31.49	−49	36	12.4	17.9	3.24	194	14
409	G1909	01	08	03.77	−50	47	54.0	18.2	2.19	195	14
410	A1821	01	09	28.57	−34	25	26.9	18.2	1.26	352	24
411	A2011	01	34	41.12	−33	14	16.3	18.1	1.28	353	24
412	A2001	01	41	53.71	−33	24	17.0	17.9	2.51	353	24
413	H2205	01	48	18.07	−53	27	02.0	19.1	3.13	152	11
414	C2208	01	58	41.41	−43	25	04.4	17.2	1.29	245	17
415	C2207	01	58	53.55	−45	58	49.4	18.2	2.57	245	17
416	C2210	02	05	51.04	−43	46	19.6	18.2	2.8	245	17
417	A2214	02	08	14.56	−32	37	14.4	17.8	2.26	354	24
418	A2219	02	17	41.76	−37	00	59.9	18.4	2.91	355	24
419	C2416	02	45	54.02	−44	59	39.6	17.6	0.28	247	17
420	C2417	02	52	10.85	−45	56	25.2	18.3	1.61	247	17
421	H2501	02	52	40.12	−55	38	32.0	17.4	2.37	154	11
422	G2501	03	01	27.03	−50	53	52.4	18.2	2.18	199	14
423	H2502	03	04	50.24	−53	19	41.1	18.1	2.27	155	11
424	H2606	03	16	43.86	−56	51	44.6	18.6	3.02	155	11
425	H2609	03	16	50.40	−55	11	09.9	17.9	2.53	155	11
426	H2612	03	17	41.25	−53	11	58.7	19.1	2.33	155	11
427	H2613	03	17	43.26	−53	11	03.4	19.1	2.33	155	11
428	H2623	03	31	29.61	−53	18	19.2	19.6	2.38	155	11
429	H2626	03	33	19.88	−54	16	46.0	18.3	2.05	155	11
430	C2615	03	34	43.28	−44	11	52.4	18.3	2.11	249	17
431	H2703	03	50	59.32	−52	40	34.6	16.8	1.54	156	11
432	H2709	03	56	43.37	−56	43	30.2	17.9	2.33	156	11
433	A2741	04	02	18.77	−32	31	28.0	18.1	1.62	359	25
434	C2902	04	13	16.43	−47	24	18.5	18.4	2.14	201	17
435	A2811	04	14	02.37	−32	45	19.1	18.2	2.04	360	29
436	H2902	04	26	44.43	−52	08	20.2	17.8	2.25	202	14
437	A2907	04	38	37.33	−37	03	41.6	17.0	1.43	361	25
438	G3004	04	42	34.33	−48	21	30.6	18.0	2.63	202	14
439	F2732	04	47	46.52	−31	21	51.6	18.0	2.10	421	29
440	H3105	04	52	21.91	−55	26	08.0	18.3	2.22	158	11
441	H3102	04	53	05.91	−53	27	39.8	18.6	2.34	158	11
442	B2724	04	53	13.70	−41	47	25.5	18.1	2.11	304	21
443	A3024	04	53	59.84	−37	42	45.1	18.1	1.98	304	21
444	H3106	04	55	39.54	−55	57	41.0	18.6	2.35	158	11
445	H3101	04	55	46.58	−52	43	54.1	18.9	2.33	158	11

TABLE 1 (CONTINUED)

CT#	Object	α (J2000.0)			δ			B	z	ESO	DSS
		h	m	s	°	'	"				
446	H3110	05	08	24.51	-55	09	10.1	18.1	1.50	158	11
447	F2901	05	20	59.78	-27	37	19.0	17.6	2.20	423	29
448	H3202	05	33	20.58	-54	26	47.9	18.1	2.35	159	11
449	H3404	05	44	29.00	-55	46	15.5	18.4	0.34	159	11
450	H3401	05	45	12.88	-52	41	05.6	18.1	1.31	159	11
451	H3402	05	52	00.50	-53	12	43.5	16.6	1.59	160	11
452	A3302	05	54	45.76	-33	05	17.0	16.7	2.36	364	25
453	A3304	06	06	07.26	-34	47	39.6	18.6	2.28	364	25
454	H3405	06	14	01.49	-55	13	06.3	17.6	1.93	160	11
455	J0111	09	47	45.73	-21	55	47.3	17.4	0.32	566	38
456	M0040	10	06	50.39	-26	05	50.6	18.4	1.88	499	34
457	M0042	10	06	59.32	-27	02	19.4	18.9	2.20	499	34
458	J0317	10	13	42.34	-21	06	20.5	18.0	1.53	567	39
459	M0130	10	23	58.63	-24	28	56.1	18.4	2.28	500	34
460	M0306	10	39	09.51	-23	13	25.7	18.0	3.13	501	34
461	M0280	10	39	13.78	-25	09	29.6	17.8	1.56	501	34
462	M0245	10	43	31.57	-28	40	29.1	17.4	1.49	437	30
463	J0524	11	06	33.48	-18	21	25.0	17.9	2.31	570	39
464	J0610	11	15	24.46	-20	44	18.1	18.3	1.94	570	39
465	J0714	11	44	27.25	-22	14	36.8	18.2	2.27	571	39
466	J0907	12	20	25.92	-20	52	22.9	18.2	0.33	573	39
467	J0904	12	23	10.53	-18	16	43.0	18.1	2.16	573	39
468	J1017	12	31	06.91	-20	07	28.7	17.9	1.34	574	39
469	J1010	12	33	05.86	-20	43	07.6	18.5	1.97	574	39
470	M1225	12	57	33.39	-25	33	26.6	18.6	1.90	507	34
471	J1110	12	58	56.09	-17	50	36.3	18.1	2.06	575	39
472	J1125	12	59	14.02	-19	25	08.7	18.0	1.14	575	39
473	J1139	13	02	36.47	-21	43	50.6	19.1	1.59	575	39
474	J1121	13	09	26.33	-18	24	50.5	18.2	1.07	575	39
475	J1701	14	51	17.80	-21	45	13.1	18.6	1.93	580	39
476	J1706	14	56	49.83	-19	38	52.0	18.7	3.15	581	39
477	G1213	22	45	58.87	-51	33	44.2	18.4	2.29	238	17
478	G1209	22	48	34.11	-50	02	02.9	18.6	1.94	238	17
479	G1212	22	52	15.15	-50	45	12.0	18.6	2.84	239	17
480	G1211	22	52	44.03	-50	21	38.2	17.9	2.90	239	17
481	A1222	22	56	54.81	-35	52	51.9	17.9	2.64	406	28
482	C1426	23	08	47.41	-45	23	03.6	18.2	1.31	291	20
483	C1403	23	09	58.60	-45	02	53.7	18.2	2.08	291	20
484	A1323	23	18	14.53	-34	57	45.3	18.0	1.69	407	28
485	A1303	23	19	57.78	-33	22	10.4	17.8	1.88	407	28
486	A1326	23	20	58.46	-36	59	55.2	18.6	2.0	407	28
487	A1308	23	22	10.83	-34	47	57.2	16.5	0.42	407	28
488	A1305	23	24	20.87	-33	40	13.9	18.5	2.28	407	28
489	C1462	23	25	19.81	-44	49	57.4	18.3	2.0	291	20
490	A1310	23	25	28.57	-35	57	54.0	17.9	0.36	407	28
491	A1317	23	26	06.46	-35	34	50.0	17.2	2.43	407	28
492	C1468	23	29	12.78	-45	45	10.1	18.4	2.41	291	20

TABLE 1 (CONTINUED)

CT#	Object	α (J2000.0)			δ			B	z	ESO	DSS
		h	m	s	°	'	"				
493	A1426	23	40	05.34	-36	16	30.9	17.9	2.43	408	28
494	C1508	23	43	13.59	-46	40	02.8	16.4	1.97	292	20
495	C1513	23	43	46.92	-44	07	19.1	16.5	1.90	292	20
496	C1507	23	46	40.59	-46	12	29.9	16.4	1.89	292	20
497	A1415	23	49	58.83	-33	26	48.0	17.7	1.84	408	28
498	C1505	23	50	34.21	-43	25	59.6	16.3	2.9	292	20
499	A1405	23	51	23.84	-36	42	28.9	18.4	1.89	349	24
500	A1402	23	52	11.34	-32	59	07.5	18.1	2.45	349	24

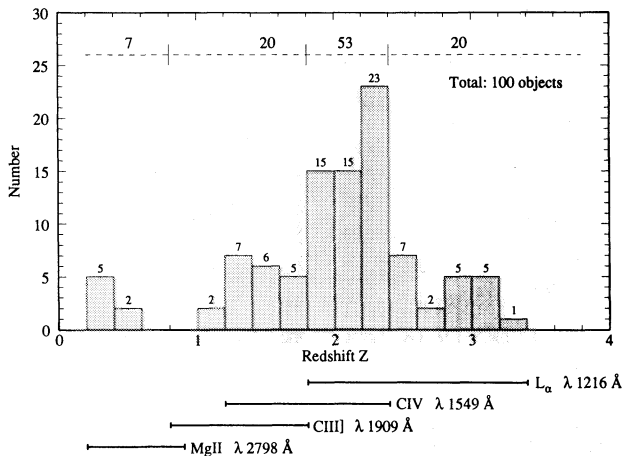


Fig. 2. Histogram of the redshift distribution of Calán-Tololo quasars contained in List No. 6 (present paper). Horizontal lines at the bottom indicate the redshift intervals where the most prominent emission lines in quasars are found on our objective prism spectra.

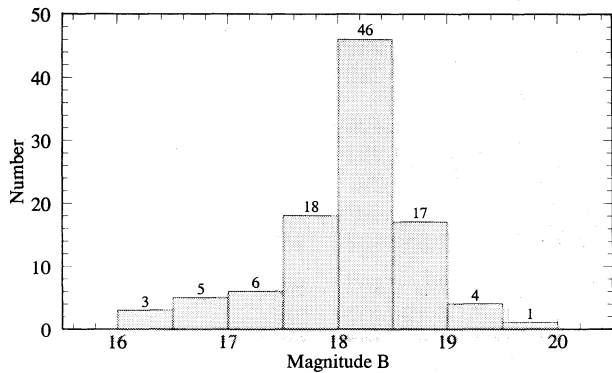


Fig. 3. Histogram of the B magnitude distribution of the Calán-Tololo quasars in List No. 6 (present paper). Thirty two objects have $B < 18$ and twenty two have $B > 18.5$.

et al. 1993) the numbers are 13, 23, 92 and 72 for a total of 200 objects (or 6.5%, 11.5%, 46%, and 36%, respectively). The present list contains a larger percentage of quasars in the redshift interval (0.8, 1.8) than List No. 5 and a smaller proportion of high redshift quasars—those with $2.4 \leq z < 3.4$ —. Quasars in the redshift range (0.8, 1.8) are harder to discover in this type of objective prism survey than quasars at $z \sim 2.2$. The reason why we now seem to be more effective detecting low redshift quasars may be associated with our broader experience searching the plates. On the other hand since many of the objects presented here (38 of them) were confirmed using the CTIO 1.5-m telescope it means a discrimination was made against our fainter candidates (which, on the average, are higher redshift objects). The majority of the quasars in this list were discovered at CTIO using the 4-m telescope. In every observing run at CTIO we test a small fraction of the candidates selecting those with the highest probability (we typically try 100 candidates per run out of 300 and we discover 85 new quasars).

Figure 3 presents the histogram of the B magnitudes. A total of 81 quasars have a B mag in the interval (17.5, 19.0). A comparison with Figure 3 in List No. 5 (Maza et al. 1993) reveals this new group of quasars has the same photometric properties as the first two hundred quasars. The median of both groups is ~ 18.25 . This new sample has a B histogram too sharply peaked; this could be an artifact of averaging two independent eyeball estimates.

List No. 7 of the CTS, (Maza et al. 1995) will contain another group of 100 additional quasars already confirmed by us. This will bring the total number of CTS quasars to 400 that will merit a global statistical analysis of the properties of the Calán-Tololo Survey.

We thank the Director and personnel of Cerro Tololo for their hospitality. The ID charts were pre-

pared using OZPS, a software developed by P. Ortiz. We are indebted to J. García and P. Ortiz for help with SUN workstations. This work was partially supported by FONDECYT under grants No. 92-1083 and No. 1950573.

REFERENCES

- Blanco, V.M. 1974, *PASP*, 86, 841
 MacAlpine, G.M., & Lewis, D.W. 1978, *ApJS*, 36, 587
 MacAlpine, G.M., Lewis, D.W., & Smith, S.B. 1977, *ApJS*, 35, 203
 MacAlpine, G.M., Smith, S.B., & Lewis, D.W. 1977a, *ApJS*, 34, 95
 ———. 1977b, *ApJS*, 35, 197
 MacAlpine, G.M., & Williams, G.A. 1981, *ApJS*, 45, 113
 Maza, J., Ruiz, M.T., González, L.E., & Wischnjewsky, M. 1988a, in *Progress and Opportunities in Southern Hemisphere Optical Astronomy*, ed. V.M. Blanco & M.M. Phillips, A.S.P. Conf. Ser. No. 1, p. 410
 ———. 1988b, in *Proceeding of a Workshop on Optical Surveys for Quasars*, ed. P.S. Osmer, A.C. Porter, R.F. Green, & C.B. Foltz, A.S.P. Conf. Ser. No. 2, p. 154
 ———. 1989 (List No. 1), *ApJS*, 69, 349
 ———. 1992 (List No. 2), *RevMexAA*, 24, 147
 Maza, J., Ruiz, M.T., Peña, M., González, L.E., & Wischnjewsky, M. 1991 (List No. 3), *A&AS*, 89, 389
 Maza, J., Ruiz, M.T., González, L.E., Wischnjewsky, M., & Antezana, R. 1993 (List No. 5), *RevMexAA*, 25, 51
 ———. 1994 (List No. 4), *RevMexAA*, 28, 187
 Maza, J., Ortiz, P.F., Wischnjewsky, M., Antezana, R., & González, L.E. 1995 (List No. 7), *RevMexAA*, 31, 159
 Smith, M. 1975, *ApJ* 202, 591
 Smith, M., Aguirre, C., & Zemelman, M. 1976, *ApJS*, 32, 217
 Stobie, R.S., Sagar, R., & Gilmore, G. 1985, *A&AS*, 60, 503

Roberto Antezana, Luis E. González, José Maza, and Marina Wischnjewsky: Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile. (jmaza@das.uchile.cl).

