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Analysis of the Uccle Carte Du Ciel Catalogue (ROB033) Present in the WFPDB

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Abstract.

We present the in the Wide-Field Plate Database (WFPDB) recently incorporated catalogue of the Carte du Ciel plates collected at the Royal Observatory of Belgium (ROB). The catalogue comprises the descriptive information for 682 plates obtained with the Gautier 0.33-m equatorial telescope in the framework of the Carte du Ciel project in the period 1908–1939. An analysis of the catalogue's content is presented. The catalogue, as well as the plate previews taken with a resolution of 250 dpi, are available on-line at `http://www.skyarchive.org/`.

1 Introduction

The Carte du Ciel project is the very first photographic all-sky survey. This project started in 1887 and was accomplished thanks to the efforts of 20 observatories worldwide: Greenwich, Vatican, Catania, Helsingfors, Nizamiah, Uccle, Oxford, Potsdam, Paris, Bordeaux, Toulouse, Algiers, San Fernando, Tacubaya, Cordoba, Perth, Cape of Good Hope, Sydney, Melbourne and Edinburgh (for measurements of the Perth plates only). The aim was to map the entire sky up to the 14th photographic magnitude (later on the limiting magnitude turned out to be 15), to produce an atlas, known as the Carte du Ciel (CdC), and to catalogue all the stars up to the 11th magnitude (later on extended to the 12th magnitude), known as the Astrographic Catalogue (AC). All plates had to be taken with identical 33 cm astrographs on 16 cm $\times$ 16 cm plates covering a field of $2^\circ \times 2^\circ$. Each field had to be overlapped in order to assure good sky coverage – the corner of one plate to be in the center of the next one, it means that about 22,000 plates to be obtained were foreseen.

The involvement of the Royal Observatory of Belgium (ROB) in Uccle in the CdC project (the part concerning the CdC sky atlas) started in 1907 (zone $+32°$–$+39°$) thanks to the director G. Lecointe and his cooperation with the Paris Observatory (see the published correspondence in [1]. A photographic equatorial telescope of type Henry-Gautier (Diameter = 33 cm, Focal Length = 3.43 m, Field = $2° \times 2°$, Scale = 60 arcsec/mm) was chosen as in all the French observatories, which took part in the CdC project. However, the ROB officially only joined the CdC project when the decision to complete the Potsdam zone was made at the Fourth IAU General Assembly in 1932. According to the plan some 1232 plates had to be collected.

The Uccle CdC plates were taken using triple exposures (with stellar images displaced to form an equilateral triangle of size 11" [2] with a duration of 15 to 30 minutes. For the measurements of the stellar positions, a grid of lines called *reseau* with a step size of 5 arcmin was printed on the plate before its development. The CdC plates were next enlarged 2 times and the plate images were engraved on copper plates, from which paper charts were produced in Paris (by the French company Schutzenberger). In this process, some stellar images have been lost.

In the period 1940–1950, 320 plates were taken with the Uccle CdC astrograph for the declination zones $+34°$ and $+35°$ of the Astrographic Catalogue (AC) [3, 4], with four images on a diagonal and with exposures of 30 sec, 5 min, 5 min and 30 sec. Unfortunately, these plates are not available at the ROB. In the context of the agreement between the observatory authorities, it is known that the Uccle AC plates were sent to the Paris Observatory for measurement and for publication of the results [3, 4]. However, these plates were not returned according to J. Dommanget (private communication).

Except for the CdC project the telescope was used also for:

- Photographic observations of minor planets;
- Observations of double and multiple stars from the Catalogue of Components of Double and Multiple Stars (CCDM) [5];
- Orbits of comets;
- Astrometric positions of Pluto, Mars and Jupiter.

The quality of the ROB CdC plates is good. Keeping in mind that the plates, provided they are kept under appropriate storage conditions, should outlast both paper and computer media as information holders, the CdC plates are stored in their original wooden boxes while waiting for a dedicated storage room with temperature and humidity control at the ROB.

Next, we will present and analyse the contents of the Uccle CdC catalogue on the basis of the plate inventory as retrieved from the WFPDB.

2 Preparation of the computer-readable catalogue

A first list of 608 Uccle CdC plates was compiled by A. Fresneau (Strasbourg) on the basis of copies of the paper charts. This list contains the "theoretical" plate center (selected to full coverage of the Uccle declination zone), the number of stars recorded on the chart as well as on the original plate, the date of the observation, and the mean local sidereal time.

The preparation of the computer-readable catalogue and the creation of the corresponding digital plate "previews" (*i.e.* images for plate visualization) started in March 2002. The plate information was retrieved from the plate itself as well as from the stored paper chart because no logbook could be found.

The Uccle CdC plate collection comprises 682 plates of good to very good quality.

3 Preparation of plate preview images

To allow for a quick estimation of the plate's appropriateness for a given task, a plate preview is needed. At the beginning of the preparation of the computer-readable catalogue of the Uccle CdC plates in 2002, the observatory did not possess a suitable scanner for this task. That is why the first plate previews were made with a digital photo-camera. Since 2004 however, a flatbed scanner AGFA (model DUOSCAN HiD) is available. All subsequent plate previews were obtained with a resolution of 250 dpi and in TIFF format (of size 2.5 MB).

4 Incorporation in the WFPDB

The original plate catalogue was converted to the standard WFPDB format. The description of this format can be found at `http://vizier.u-strasbg.fr/viz-bin/Cat?VI/90` (in the Byte-by-Byte Description of the file Maindata). After correction of the mistakes revealed during the preparation of the needed files (Maindata, Quality, Notes, Observer, Availability, Digitization), final incorporation in the WFPDB occurred in March 2006. In the Wide-Field Plate Database – Sofia Search Page (`http://www.skyarchive.org/search/`), the information on every plate from the catalogue can be retrieved using the WFPDB observatory identifier (ROB) followed by the instrument aperture (033), plus the original plate number. If the original plate number exists more than once, a suffix (A, B, and so on) is added. More details concerning the ROB033 archive can be found by clicking on the option "033" in the Wide-Field Plate Database – Sofia Search Result (such as location of the observatory possessing the archive and of the archive itself, parameters of the telescope used, period of operation, number of plates taken, number of plates included in the WFPDB, name of the astronomer in charge, and an all-sky dis-

tribution of the plate centers). Clicking on "more" will provide the details for a certain plate (for example, see Details for: ROB033 000001 in Figure 1), as well as the plate preview. It is the first CdC catalogue with a complete inventory accessible through the WFPDB.

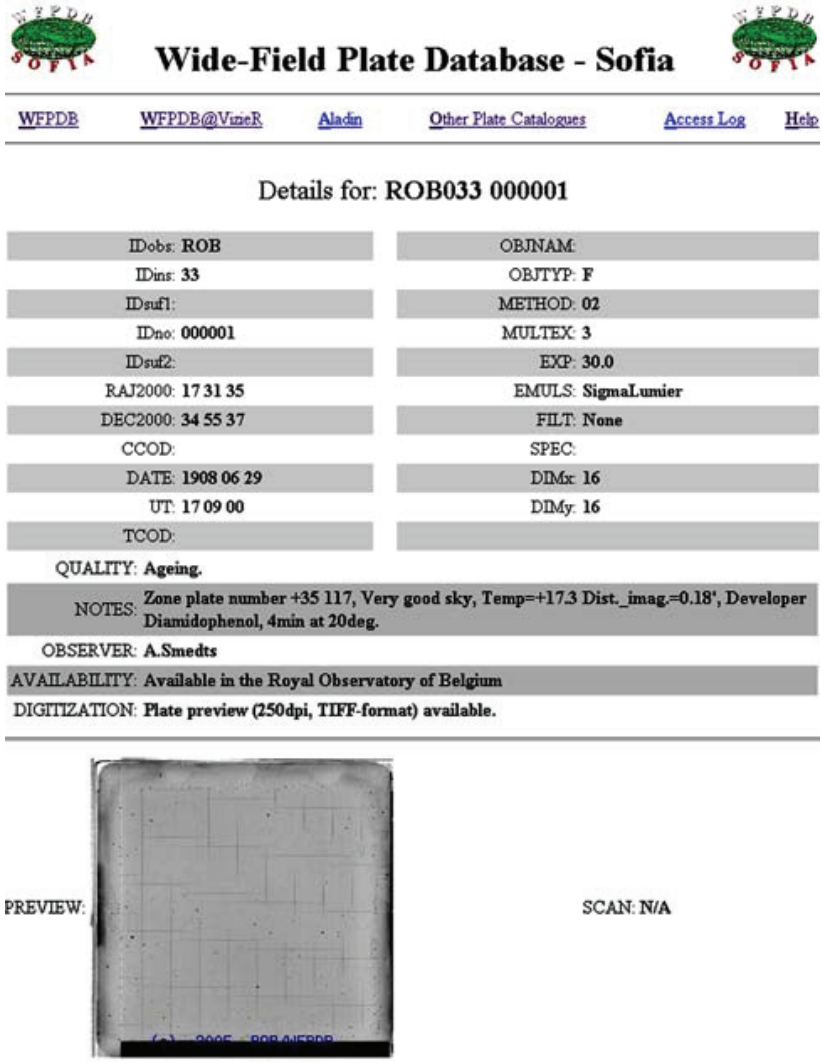

Figure 1. View of the WFPDB-Sofia search result with details for ROB033 000001 plate.

5 Analysis of the WFPDB ROB033 catalogue

The subsequent analysis of the catalogue's contents aims to illustrate and to facilitate a possible repeated use of the plates. One of the first questions a potential user might address could be how many times and on how many plates a specific target can be found and measured. For example, in the case of the ROB033 archive, the total number of plates in this archive was expected to be 1,160; the number of included plates is 682. The all-sky distribution of the included plates is shown in Figure 2. The Uccle zone ($+32°$–$+39°$) was subdivided into smaller declination zones: $+33°$, $+35°$, $+37°$, and $+39°$ in order to have overlapping sky fields. According to the prescriptions the CdC zones had to be overlapped twice following the pattern: the corner of one plate to be in the center of a next one. In Uccle the step of sky coverage for every $2°$ declination zone, *i.e.* $+33°$, $+35°$, $+37°$ and $+39°$, is 9–10 min in R.A.. In Figure 2, as well as in Figure 3, one can see that the sky coverage is better for the declination zones $+33°$ and $+35°$ whereas the coverage for the zones $+37°$ and $+39°$ is poorer (decreasing number of plates). Also, there is a gap in the all-sky distribution at R.A.$= 16^h - 17^h$ (with 10% less plates than the mean value) and a very dense coverage around R.A.$= 20^h - 22^h$ (with 37% more plates than the mean value).

We present the distribution in time of the ROB033 CdC plates for the period 1908–1939 in Figure 4, as well as the monthly distribution of the plates in Figure 5. This may be of interest for research in which observations need to cover as much as possible a full period of a specific phenomenon (*e.g.* a variability cycle or an orbital period).

The start of the contribution of Uccle to the CdC project is 1908, *i.e.* after 1907.0 which is the average epoch of the CdC plates acquired by the other participating observatories with the exception of Toulouse and Sydney as their plates were taken in the course of several periods. For the period 1908–1939, the distribution

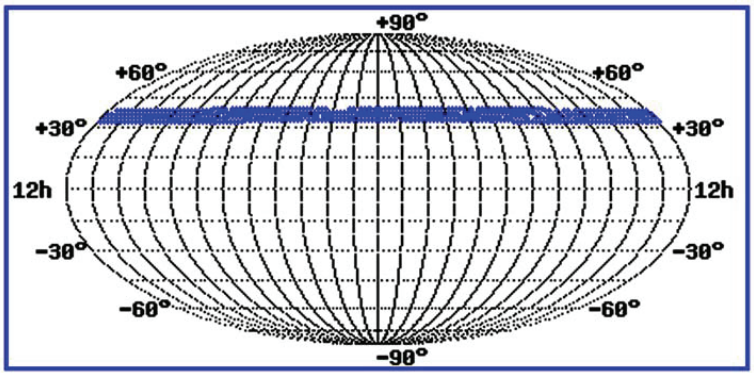

Figure 2. All-Sky distribution of the Uccle Carte du Ciel ROB033 plate centers.

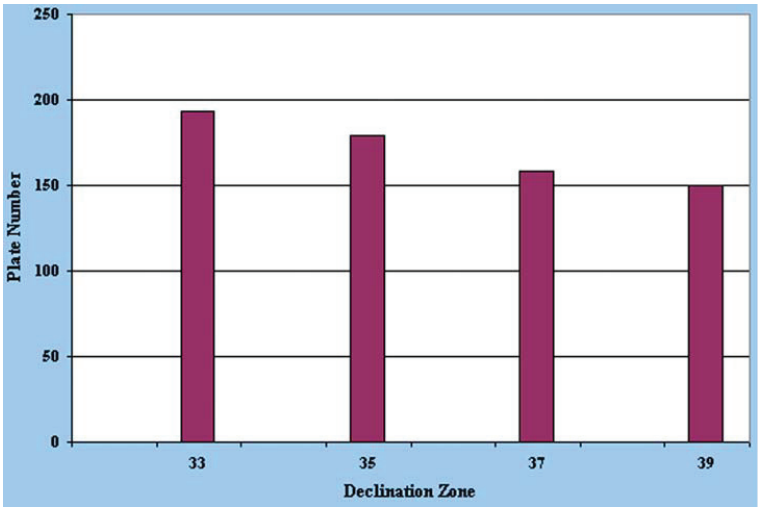

Figure 3. Distribution of the plate number versus the declination zone.

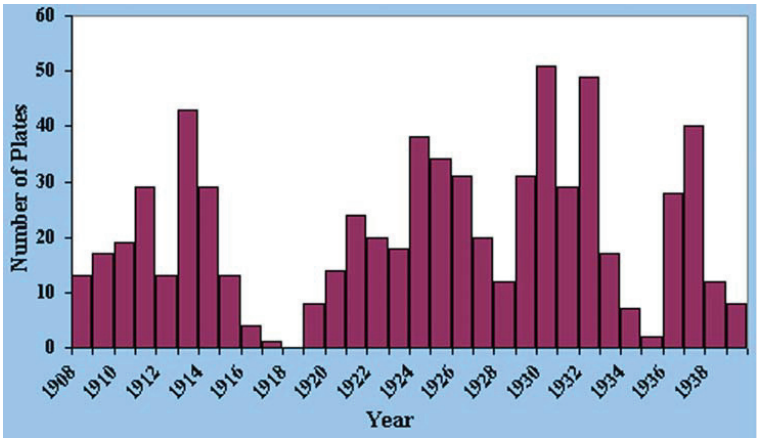

Figure 4. Time Distribution of the ROB033 CdC plates.

in time of the number of plates shows single maxima in the years 1913, 1924, 1930, 1932, and 1937. As for all other wide-field plate archives, the gap in the distribution caused by WWI (1914–1919) is well visible. We do not know the reason for the gap in 1934–1935. As was also the case for various other, later involved, observatories which came in replacement of those observatories that were unable to complete their zones (the new zones known as Hyderabad-North, Hyderabad-South, Oxford II and Cordoba), the acquisition of the AC plates continued until much later (*e.g.* until 1950 at Uccle).

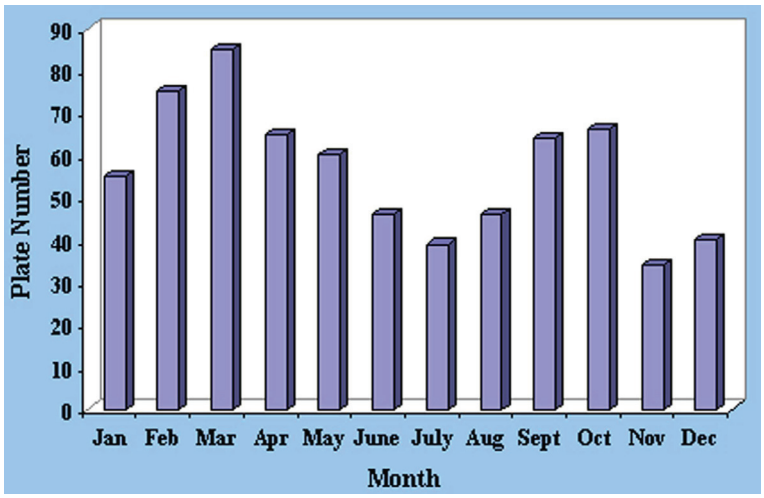

Figure 5. Monthly distribution of the plate number.

In general, the monthly distribution of the plate numbers shows a maximum in September. But keeping in mind the prime aim of the CdC project to entirely cover the sky for the zones $+32°$–$+39°$ from Uccle, one could expect a flat monthly distribution. For the ROB CdC archive, various maxima can be observed: in February (75 plates), March (85 plates), September (64 plates) and October (66 plates). The reason is the existence of several duplicated plates (with the same coordinates) taken for improving the plate quality, obviously because of poor weather in February and March.

The next question a user in need of photometric information may have could be about the type of the emulsions used. Already in the beginning of the 20th century a lot of companies (Eastman-Kodak, Wratten & Wainwright, Ltd., Gevaert, *etc.*) produced emulsions for astronomical applications. All these companies were keen to improve the emulsions and their spectral sensitivity. That is why, for the period 1908–1939 (*i.e.* for almost three decades), an increase of the limiting magnitude may be expected. On the other hand, the limiting magnitude for a plate acquired in 1908 will be known less precisely than that one for a plate dating from 1939 (*i.e.* if we don't consider the different conditions of observation) because the quality and the homogeneity of the emulsions improved with time. The most adopted plate emulsion will thus be a compromise between the improving emulsion quality and the wish to preserve the homogeneity of the whole observing material. In this respect Figure 6 shows the distribution of the type of emulsion used during the period 1908–1939. As expected, the used emulsions changed over the years beginning with *Sigma Lumiere, Lumiere Violette* to the ones designated by *F.L.* and *Barnard A477*. The most used emulsion in the period from 1922 until the end of 1939 is the one called *Eclipse* (46% of all plates).

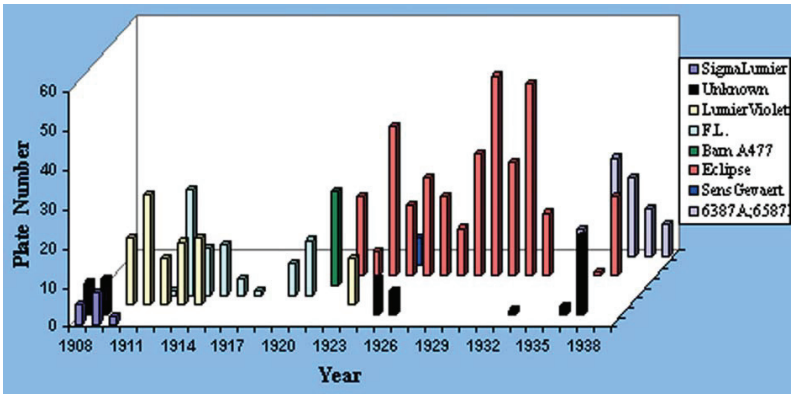

Figure 6. Time Distribution of the plates by the used emulsion.

There are only 7 plates of the emulsion type *Sensitive Gevaert* (a product of the Belgian company L. Gevaert & Cie), obviously used as an experiment in 1925.

The distribution of the plates according to the exposure duration is presented in Figure 7. In the beginning, an exposure duration of 30 min was used [2], but later on the observers turned to shorter exposures. The most used exposure durations were 20 min (37%) and 15 min (31%), while all other exposure durations (in range of 16 min up to 30 min) represent 32%.

In Figure 8, the time distribution of the number of plates per observer is shown.

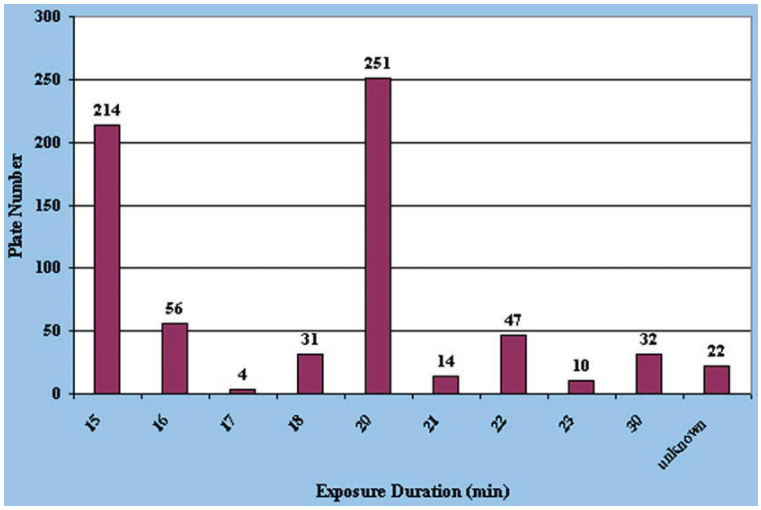

Figure 7. Time distribution of the plates according to exposure duration.

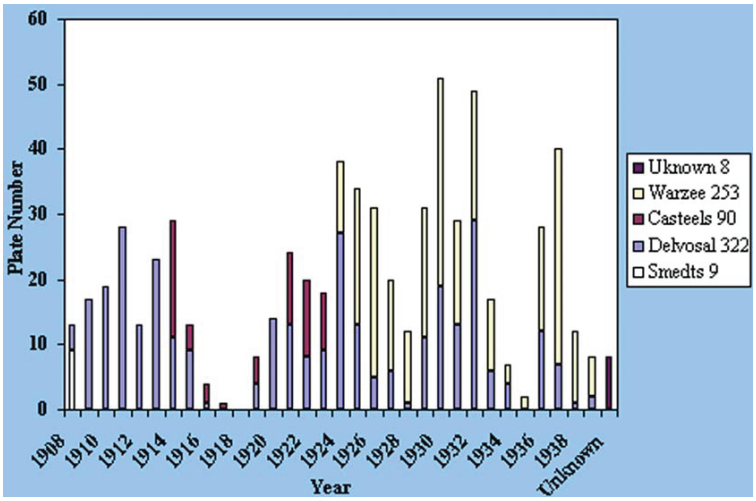

Figure 8. Time distribution of the plates according to observer's name.

Considering that the CdC project continued at the ROB for more than 30 years – a period coinciding with the duration of the working life of an astronomer – we can explain the small number of observers: A. Smedts, J. Delvosal, L. Casteels, J. Warzee and A. Lombeau (omitting 8 plates without information about the observer's name). One of them – J. Delvosal, who took more than 47% of all the plates, worked from the beginning onward until the end of the Uccle CdC project. J. Warzee joined in 1924 and took about 37% of all the plates until the end in 1939.

6 Present exploitation of the CdC plates

Well after the publication of the AC catalogue, the CdC plates continue to be useful for proper motion determinations. In 2006, a positional catalogue of 344,781 stars from the Bordeaux Carte du Ciel zone ($+11°$–$+18°$) was published [6], as part of the programme of proper motion measurements from the Bordeaux Observatory (the so-called CdC2000 Bordeaux Carte du Ciel catalogue) with standard errors of about 0.10 to 0.12 arcsec on the positions and of 0.6^m on the photographic magnitudes. This catalogue relies on the 512 Carte du Ciel plates archived at the Bordeaux Observatory and digitized with the Cambridge Automatic Measuring Machine (APM). The complete catalogue *PM2000 Bordeaux Proper Motion Catalogue of 2,670,974 stars down to* 15.4^m is presented in [7]. Depending on the magnitude, the positional precision at the mean epoch ranges from 50 to 70 mas while the precision of the proper motions varies from 1.5 mas/yr to 6 mas/yr.

The deep CdC plates taken for the CdC sky atlas have also been considered as material – with respect of age and sky coverage – which is well suited for the determination of proper motions of the stellar clusters in [8]. The digitized Paris CdC plates were used to determine the proper motions of 2,220 stars in the field of the open cluster NGC 1647 with an astrometric accuracy, which ranges from 100 to 200 mas.

The potential of the CdC plates for discoveries of quick brightness changes (time scales up to 20 minutes and flare amplitudes larger than 0.5^m) in stars with brightness in the photographic range 10^m–14^m was investigated in [9].

The CdC plates were also used in investigations of the differential rotation in the galactic plane up to 500 pc from the Sun [10, 11].

Acknowledgements

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