Astrophotography: Do photographic plates still have a place in professional astronomy?

Introduction:
When I think of comparing photographic plates with CCD imagery, I think of three words: Hubble Space Telescope. On closer inspection of this subject, I see the line between CCD and photographic plate use in Astronomy is not so sharply delineated. Photographic plates use in Astronomy has enjoyed a very rich history. Using photographic emulsion to capture starlight was the day astrophysics was born. Supernova was discovered, as was variable stars. Comparing photo plates also led to the discovery of Pluto, and even a score of asteroids. However, even with the rich history of plates, Astronomy must bow to technology. CCD imagery is progressing at a rapid pace. It allows immediate results that can be shared, and makes the use of orbiting observatories possible. Ultimately it may not be the CCD that will end the reign of plate film; economics of plate film manufacturing may ultimately determine the demise of this once widely used format.

Early photography:
In the 1850’s, a very early version of the photographic process was used for the first time in Astronomy. Leon Foucault and Armand Fizeau photographed the Sun and its Sunspots on a type of film called a daguerreotype (Belkora, 2003), which used silver halide crystals on a copper plate. Later work by William Huggins would result in the photography of stellar spectra which gave birth to astrophysics (Belkora, 2003). Since then, film evolved rapidly to conform to ease of use and sensitivity and eventually resulted in a gelatin film that holds silver halide crystals in a form we know and love: the roll of film. Silver halide emulsion on a glass plate was still used professionally mostly because of rigidity – the film would not bend resulting in an evenly exposed image without artifacts. The plate process also allows much finer grains of silver emulsion possible, even as small as 9 microns in diameter.
Advantages and uses of plate film today:

One of the most important advantages of plate film use is the fact that plate film surveys of the entire sky already exist. In the 1950’s, the first set of an all-sky survey was initiated resulting in nearly 2000 exposures of the entire sky called the POSS (Palomar Oschin Sky Survey). With the availability of finer grained emulsion after 1970, it was decided to perform a second all sky survey in the 1980’s called the POSS-II (http://astro.caltech.edu/~wws/poss2.html). One of the advantages that plate film still has over the CCD camera is the field of view. Each plate of the POSS and POSS-II is a generous 14 inch square that covers an area of 6 degrees (http://lyra.colorado.edu/sbo/sboinfo/readingroom/poss.html). The results are images of extremely high resolutions, even by today’s standards. Another advantage of plate film is the availability of grains that are sensitive to specific wavelengths. For example, there are three widely used plate styles: IIIa-J emulsion for blue sensitivity, IIIa-F for red sensitivity, and IV-N for near infrared sensitivity (http://www.eso.org/org/dmd/pos/).

While the plates are not very useful for computer software to analyze, it is possible to provide excellent digital images from the existing plate film. Because the plates are clear, they can be illuminated from the rear and photographed either by regular film or by CCD. A group of European astronomers successfully tested wide field photography on standard film using the plates as a master (Zodet, Quebatte, and Heyer, 1994). One of the issues of a duplicate image, especially using CCD’s, is the introduction of noise. To help eliminate this, it is possible to stack the images in the digital realm resulting in a much cleaner image (Bland-Hawthorn and Shopbell, 1993). The high resolution plates have been archived digitally and are available through the DSS (digitized sky survey) thanks to the process of drum scanning1. Astronomers from around the world can access previously scanned sky surveys through the MAST (Multimission Archive at Space Telescope) at this website: http://archive.stsci.edu/index.html. The benefit is recent photographs can be compared to pervious photographs of an area of interest to look for changes such as stellar position, supernova, variable star discovery, or even the discovery of new asteroids. While using plate to plate comparison, Clyde Tombaugh discovered Pluto by

1 A drum scanner uses photomultipliers and is capable of 48bit, 64,000 dpi resolution.
discovering the shift of a very faint object. This same process is now possible in the
digital realm thanks to MAST.

The remarkable CCD sensor:

CCD stands for charged coupled device. The CCD chip is made of silicone, and operates
by absorbing photons of light that cause electrons to be released by the silicone (Howell,
2000). The silicone chip is divided into very small segments called pixels, and the
electrons associated with each pixel are measure by the internal electronics of the CCD
camera resulting in an assigned value. This value is interpreted by software and is
converted to an image. There are several advantages to using CCD sensors versus
standard film:

- The sensor is very sensitive to light and is comparable to standard film with 1600
  ISO²
- Greater range of brightness over film usually referred to as grayscale
- Linear response – twice the exposure equals twice the light gathering capacity
- Responds to the entire visible spectrum, and even into the near infra-red
- Capable of storing additional information such as bad pixel data for easy
correction
- Immediate results
- Defects of the CCD chip can be subtracted using software

(Covington, 1999). While the list of features of the CCD seems impressive, there are
several disadvantages. For example, the CCD operates with a continuous power supply
that results in increased heat. The CCD sensor will pick up this heat and read it as noise.
While the noise can be subtracted with software, the best solution is to cool the chip
using heat sinks, water cooling, or even liquid nitrogen. Also, while CCD sensors are
becoming larger and cheaper, they are still limited by its field of view. To equal the field
of view provided by a 14 inch by 14 inch plate film, a mosaic of CCD sensors must be
constructed. The price of such a sensor is (pardon the pun) astronomical. The cooling

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² ISO means International Standards Organization. 1600 speed is assigned to film with very large silver
crystals so more light is captured per crystal – at the expense of resolution.
requirements of such a chip are also greater. None the less, such mosaics have been constructed and are currently in use.

**Digital Processing:**
Digital processing is not limited to CCD images only. Photographic plates are scanned and saved in a digital image format just as CCD images are interpreted by software, and saved in a digital image format. Image processing software can take these two images and perform a variety of adjustments and measurements. Astrometry (measuring the precise coordinates of stars in an image) and photometry (measuring the brightness of a star) can be performed on any digital image. Improved image quality is possible by a process called “image stacking” multiple images of the same subject (Wodaski, 2002). While the processes of image enhancements are beyond the scope of this essay, it is important to understand that once in the digital realm, measurements and image processing can be performed regardless if the source is from a photographic plate or CCD sensor.

**CCD use versus Plate use:**
Currently there are no active projects exposing photographic plates. The sensitivity and resolution capabilities of the CCD sensor are far greater than any plate. Most observatories are joint ventures of several countries, so results are available electronically almost immediately. Only the CCD camera is capable of this. In addition, we have orbiting observatories like the Hubble Space Telescope that make full use of the CCD. Photographic plates used in orbit would not be possible. An example of the advances of CCD technology is the camera used on the CFHT (Canada-France-Hawaii Telescope); using a mosaic of forty 2,048 by 4,612 pixel CCD chips that result in a total of 350 million pixels (Cuillandre, 2004). While the field of view of this remarkable sensor is still not as great as plate film, the image quality, sensitivity and range of colors are far greater than any photographic plate ever produced.
Conclusion:
The advances of the CCD sensor are not the only reason that plate film is no longer used. The International Astronomy Union learned that Kodak has discontinued production of several photographic emulsions (IAU Symposium, 1993). In addition, consumer use of inexpensive, high quality CCD cameras have resulted in a shift in policy at several film manufacturing companies as well as film based camera manufacturers. In today’s computer driven market, it may not be financially possible to continue to support film. Regardless of the future trends, the photographic plates that exist are an invaluable tool for Astronomy today. The Digitized Sky Survey uses high resolution scans of the exposed plates from the 1950’s and the 1980’s and is available to anyone online. In the meantime, CCD technology is certain to progress resulting in greater CCD resolution at a cheaper price. Perhaps one day, a CCD sensor will finally achieve the 6 degree field offered by the photographic plates of the past.

References:
Internet Resources:

The Digitized Palomar Observatory:
http://taltos.pha.jhu.edu/~rrg/science/dposs/dposs.html

The SBO Palomar Sky Survey Prints:
http://lyra.colorado.edu/sbo/sboinfo/readingroom/poss.html

Data Management & Operations Division POSS II Project:
http://www.eso.org/org/dmd/pos