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A DENSITOMETRIC ANALYSIS OF COMMERCIAL 35mm FILMS

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ABSTRACT

IIaO films have been subjected to various sensitometric tests. They have included thermal and aging effects and reciprocity failure studies. In order to compare the special IIaO film with popular brands of 35mm films and their possible use in astrophotography, the following brands: Agfa, Fuji and Kodak print and slide formats, as well as black and white and color formats, were subjected to sensitometric, as well as densitometric analysis. A scanning electron microscope was also used to analyze grain structure size, and shape a function of both speed and brand. Preliminary analysis of the grain structure using an ISI-SS40 scanning electron microscope indicates that the grain sizes for darker densities are much larger than the grain size for lighter densities. We will analyze the scanning electron microscope findings of the various grains versus densities as well as enhancement of the grains, using the IP-8500 Digital Image Processor.

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Intorduction

As the United States reestablishes its space exploration program, accurate reproduction by electronic and photographic recording techniques will remain an integral part of these studies. The use of film as a recording medium in astronomy is well documented. In hopes of establishing another method of calibration, and to determine whether or not commercial films can be used in astrophotography, films of color, black & white, print and slide formats were subjected to various tests. We wish to make it perfectly clear that this paper is analyzing films after development, and the results are not to be misinterpreted as proof of a particular film's superiority over another brand.

Experimental Procedure

The films were exposed on a densitometer which contained thirty neutral density wedges of differing values. These wedges simulate thirty different exposure times. Once the rolls were processed, by the same commercial lab, a densitometer was used to obtain the gray levels of the wedges. These levels were recorded and then plotted for each film. The lightest and darkest wedges of each sample were then placed in our ISI-ss40 scanning electron microscope. (*The terms light and dark refer to the translucence of the film.*) Photographs were made of each wedge at two different energy levels to analyze both the surface and the grains of each wedge. At 10 kv, the electrons lack the energy to fully penetrate the emulsion of the film, thereby showing the grains, peaks and valleys of the surface. When the energy is increased to 30 kv, the surface effects are lost and the grains are seen as they react to the secondary electrons. The Polaroids were then digitized using our Gould IP-8500 digital image processor. The enhanced and false color images were then studied. Grain counts and sizes were made and plotted for a visual comparison. The results of these tests follow.

Light Surfaces

For Plus X, (Fig. 1.3R) hereinafter referred to as Px5062, the boundaries of the larger conglomerates of grains and their depth or proximity to the surface is assumed by their focal clarity. This ambiguity may be overcome by placing the image in false color. Pcmake is one of the methods used to do this. Through experimentation and carefully choosing contrasting and complementary colors, the background grains, emulsion, and grain boundaries can be enhanced or diminished (Figs. 6.1 & 6.2).

While looking at the Tri-X, Tx5063 (Fig. 1.4R), one is immediately able to see that there are fewer but larger grains present on this surface. The pcmake version gave the illusion of depth for a 3-D effect and had great resolution, but still did not fully isolate the foreground. The pseudocolor image lacked resolution, but did a better job of separating the foreground and background of the emulsion (Figs. 6.5 & 6.6).

The T-Max 400, Tmy5053, had a surface unlike any of the previous samples. Fewer and smaller grains with a few conglomerates appear to be the composition of this film. The pseudocolor version showed three fairly distinct regional densities. Other samples tended to have more uniform dispersion of the density.

Fuji Pr.III, referred to simply as Fuji, has a surface that is more like the Tmy5053 than any other. The pcmake and pseudocolor versions again show a more regional grouping of grain densities than in previous samples.

Dark Surfaces

It is immediately apparent that on the surface, the dark wedge has many more grains. This is both characteristic and to be expected. The dark wedges have far more grains, and thus allow less light to pass through. Fig. 1.3L is of Px5062, and the pcmake version gives a 3-D effect, while the pseudocolor mode decreases the background (Figs. 6.3 & 6.4).

Fig. 1.4L is of the surface of the dark Tx-5063 wedge. More spaces or holes are present than in the Px5062, but again the film has more grains than its light counterpart. However, this time the pcmake version has done a better job of separating the background from the higher level grains.

The Tmy5053 surface is interesting because it seems to have a couple of separate levels; one with loose grains suspended in space, and the other more of a surface like the lighter wedges.

The final surface to be analyzed here is that of Fuji. This surface has very few loose grains, and has a more uniform density. A change in density occurs near the edge of the sample.

Light Grains

The energy of the electrons was increased to 30 kv so that they would have the energy necessary to penetrate the emulsions of the film. There are fewer but larger grains than were previously seen. By placing the image in pcmake false color, the boundaries of the grains become more distinguishable.

Figure 5.1R is of Px5062 and set next to its dark counterpart for a contrast. The large but relatively fewer grains are clearly evident in this side by side comparison.

The number of grains present in Tx5063 (Fig. 5.2R) was still further reduced. An increase in the size of the grains is noticeable, especially in the pseudocolor version of the sample, where the boundaries of the grains are readily discernible.

The grains of Tmy5053 (Fig. 5.3L) appear to be twice as large as those of Tx5063. The pcmake version highlights the few grains closest to the surface of the emulsion.

The light Fuji (Fig. 5.4R) film grains in the equalized version were an unresolved blob. The pcmake version turns the image into a well defined image of the grains. Similarly, the pseudocolor view makes boundary and size analysis possible.

Dark Grains

The last samples to be analyzed by electron microscopy are the dark wedge grains. Px5062 (Fig. 5.1L) had a far greater number of grains that were considerably smaller. The large number of grains would make boundary identification and size distinction very difficult if not for the false coloring techniques.

The dark wedge grains of Tx5063 (Fig. 5.2L) revealed the difference that choosing different colors can make in analysis. This first pcmake version decreased the background, and defined the boundaries better than the second version which tended to only moderately decrease the background.

Tmy5053 (Fig. 5.3R) showed a considerable grouping of grains towards the bottom center of the wedge. The pseudocolor image supports the pcmake analysis.

Fuji (Fig. 5.4L) had a fairly uniform clustering of grains throughout the wedge. The pseudocolor image better defines the grain boundaries than does pcmake, which, however, had a better resolution.

Graphs of the Gray Levels

The gray levels of the films were plotted against each other by color format (Figs. 1.1 & 1.2). In analyzing the graphs of the films, Fuji, Pan-X, Plus-X, and T-Max have relatively the same optical densities. As the exposure increases, their optical densities vary significantly. Based upon this, one can assume that a fairly reasonable amount of quality control is present. The films that vary from the beginning have a significantly different ASA. The same situation is true for the color format. The curious difference is that the highest ASA film in black & white has the highest optical density, while the opposite is true in the color format. Research is being conducted to find the reason for this behavior.

The Grain Chart

The average and number of grains in a 9 cm^2 area were calculated and recorded on the chart (Fig. 2). An approximation of the shape of the grains was made. The grains were categorized by translucence. The chart should require no explanation.

Bar Graphs

The average area of the grains of the light and dark wedges were graphed together as were the number of grains in a 9 cm^2 area. A possibly significant but definitely interesting trend was found (Figs. 3 & 4). In each case of either a light or dark wedge the highest value peak has as its counterpart not the lowest, but the next to the lowest peak of the opposite wedge.

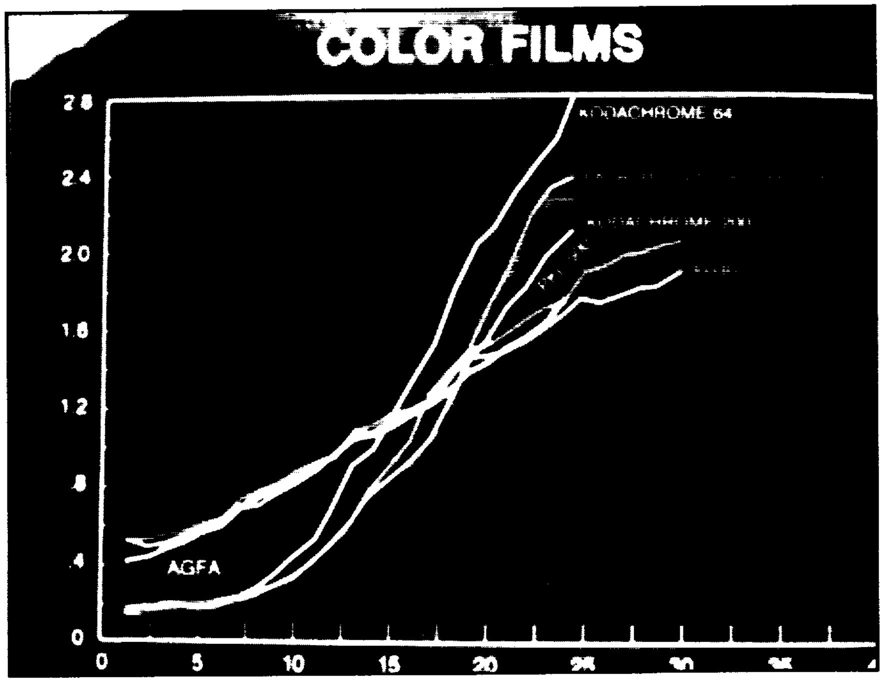

Figure 1.1

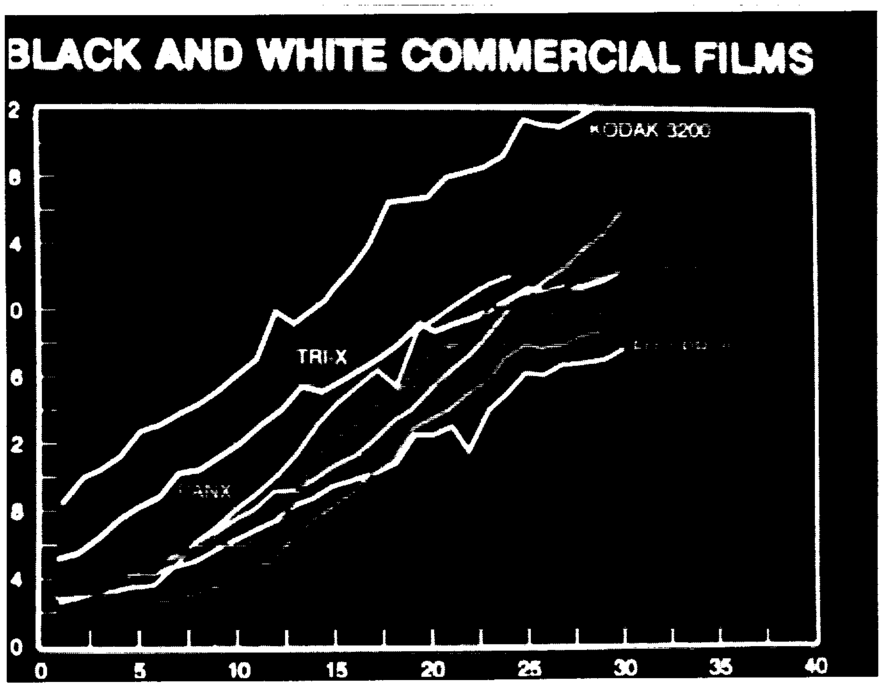

Figure 1.2

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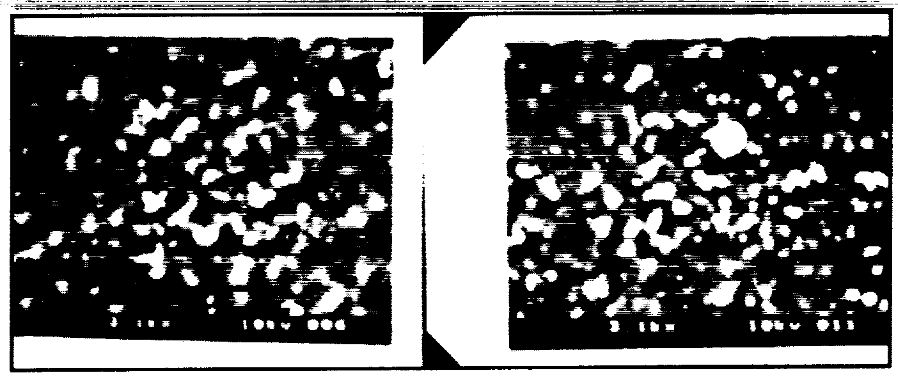
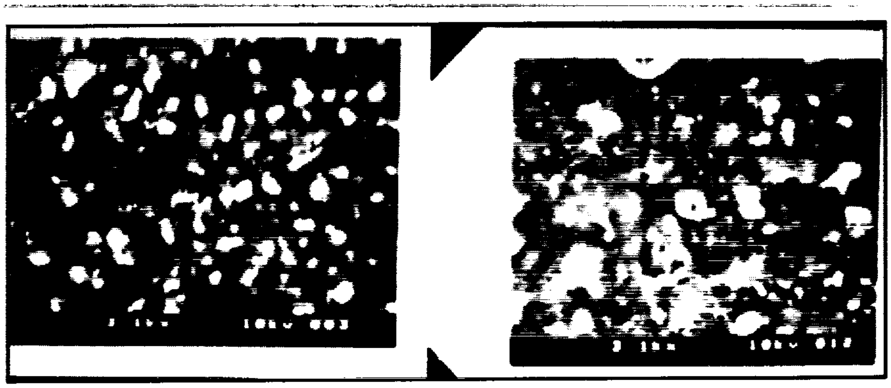
BLACK AND WHITE PHOTOGRAPH



L Figure 1.3 R



L Figure 1.4 R

Film Type	# grains/9 cm*cm	Average Area μ^2	Shape
Px 5062	80+	2,200	pebble
Tx 5063	50	9,070	elongated
Tmy 5053	50	5,050	pebble
Fuji	40	7,370	irregular

Dark Grains

Film Type	# grains/9 cm*cm	Average Area μ^2	Shape
Px 5062	12	7,980	pebble
Tx 5063	11	11,280	elongated
Tmy 5053	13	21,260	pebble
Fuji	17	12,230	irregular

Light Grains

Figure 2

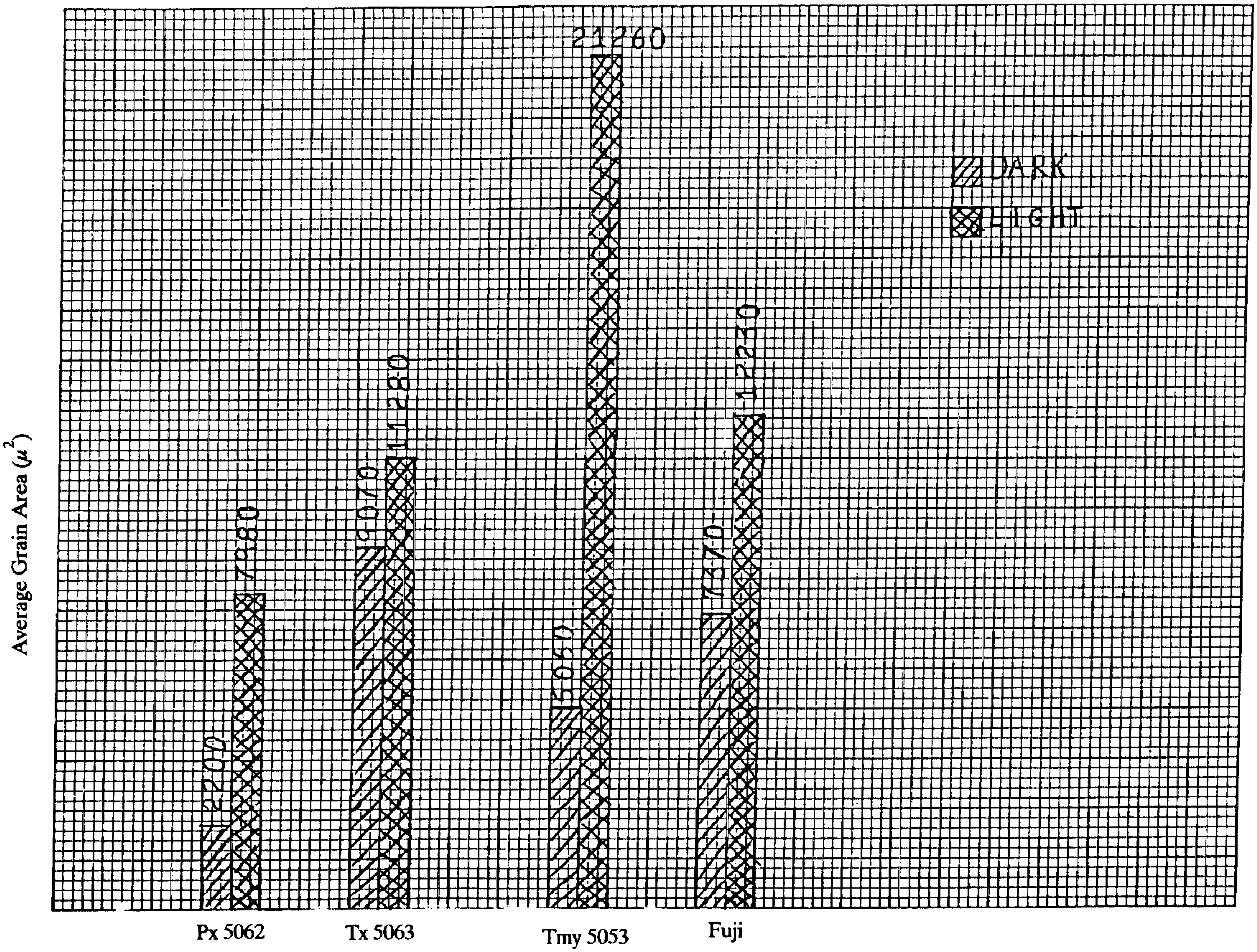


Figure 3.

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OF POOR QUALITY

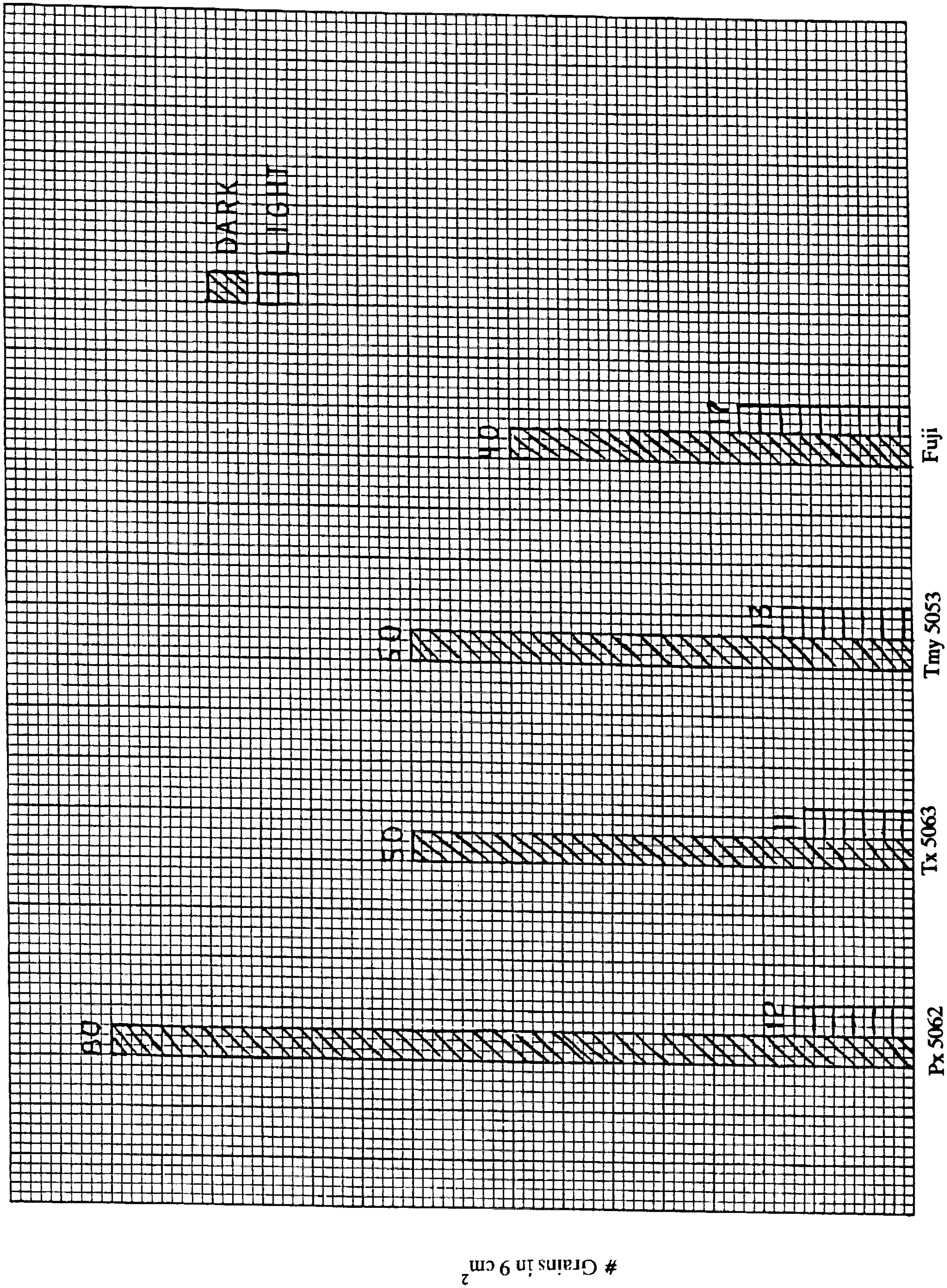
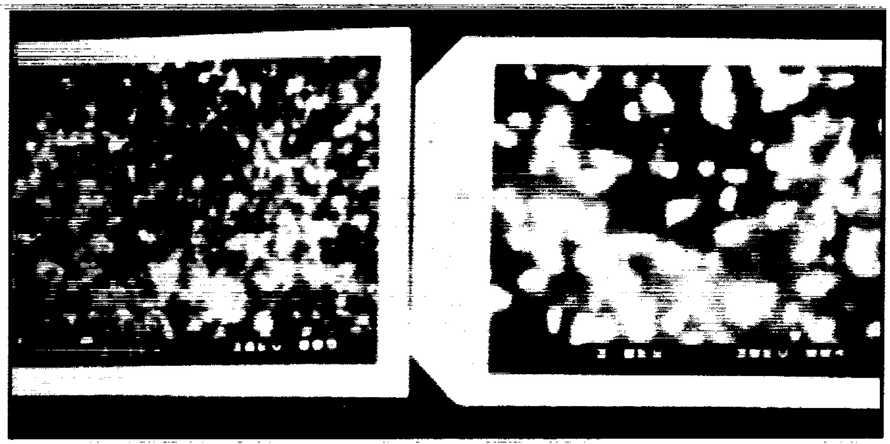
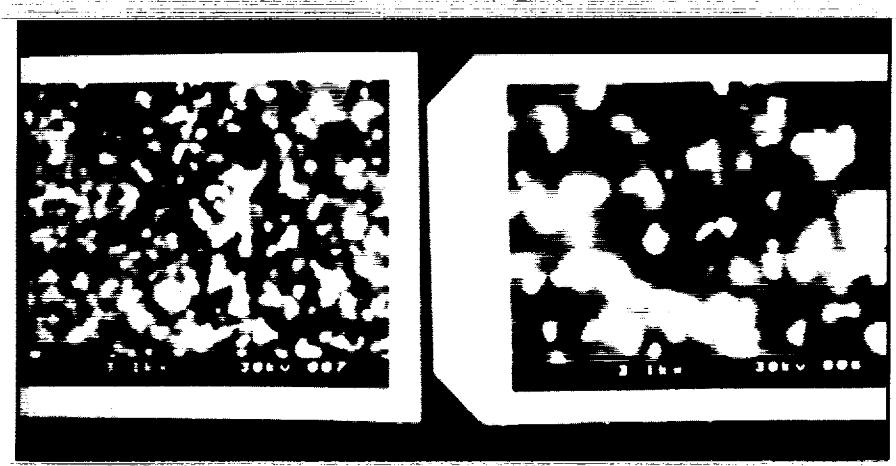

DARK
LIGHT
80
12
50
11
50
13
40
17
Px 5062
Tx 5063
Tmy 5053
Fuji
Grains in 9 cm2

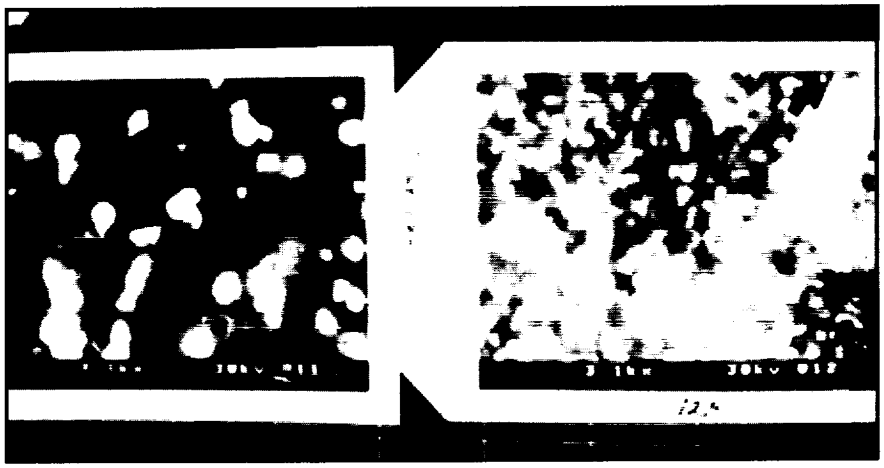
Figure 4.



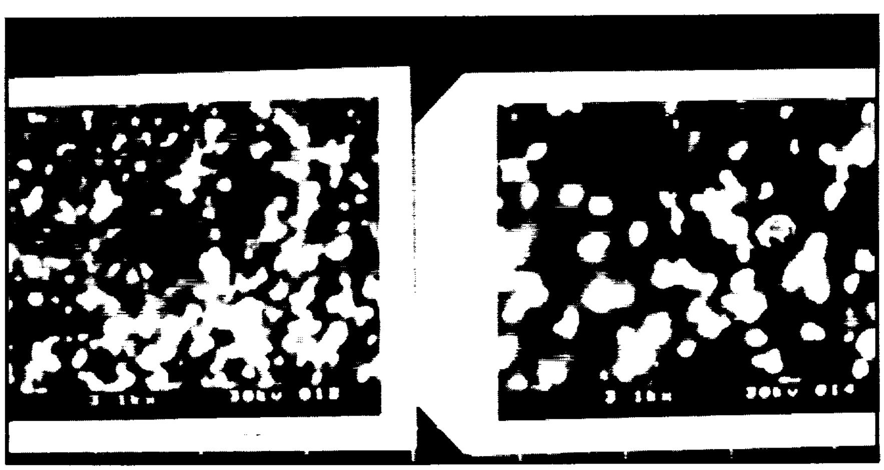
L Figure 5.1 R



L Figure 5.2 R



L Figure 5.3 R



L Figure 5.4 R

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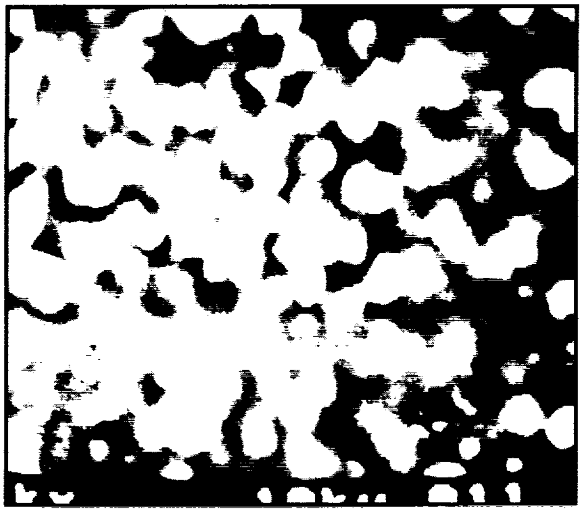


Figure 6.1

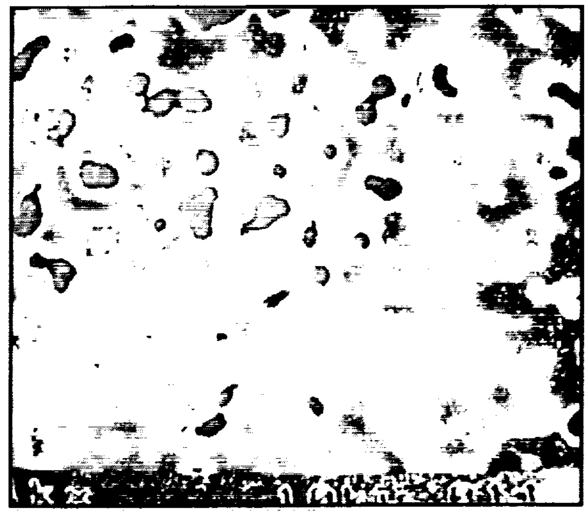
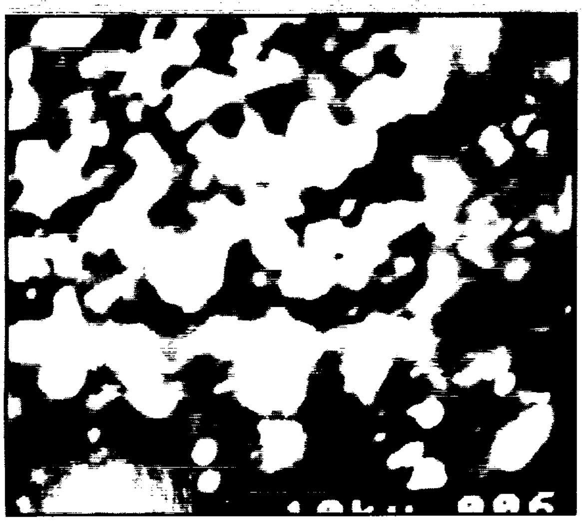


Figure 6.2



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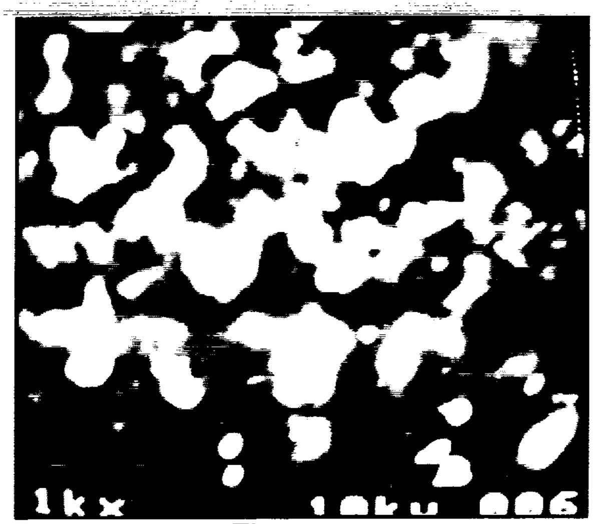
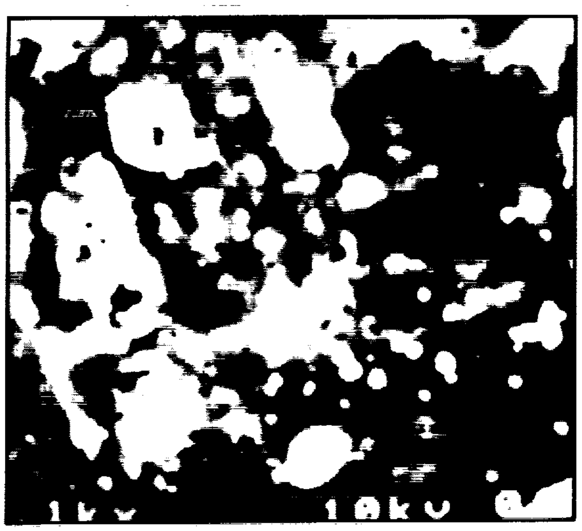


Figure 6.4



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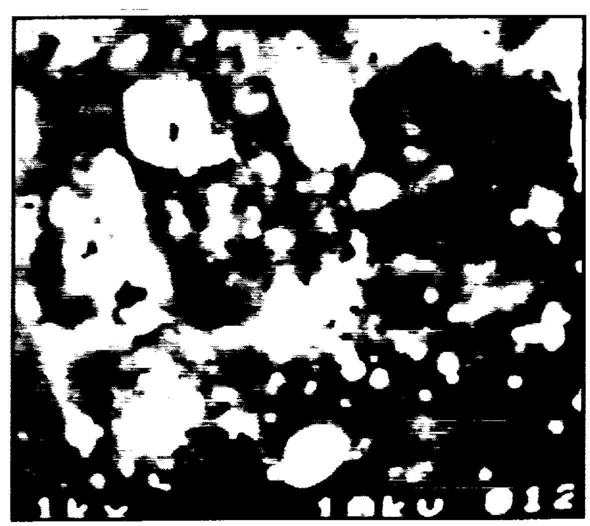

Figure 6.6

Conclusion

Because of the triple layer of emulsion, the color films were set aside until the black and white films were understood. The densitometric analysis is a viable method of calibration and comparison. Insofar as the use of commercial films in astro-photography is concerned, one has but to consult the density plot and choose a film based on the anticipated lighting.

Acknowledgments

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