MMTO Internal Technical Memorandum #02-1

Smithsonian Institution &
The University of Arizona®

Effects of CO_2 Cleaning and Detergent Washing on Specular and Diffuse Reflectance of the MMT 6.5m Primary Mirror

W. Kindred

August 2002

On July 30, 2002 the MMT 6.5m primary was thoroughly CO_2 cleaned. It had received no attention since aluminizing on November 9, 2001. For almost nine months the mirror held up remarkably well, suffering noticeable particulate accumulations only within the last month and some rain damage about two weeks ago. After "snowing" with CO_2, a small area was washed with detergent, rinsed, and then dried with high-pressure N_2. Spectral specular reflectance was measured at each stage with the Minolta CM-2002 and MMT reflectometer. The objective was to evaluate the relative efficacies of CO_2 cleaning and detergent washing in order to provide a sound basis for deciding whether to wash the entire primary—a very substantial undertaking.

This is our first use of the Minolta spectrophotometer, and for reasons presently unknown its reflectance numbers are in excess of ideal aluminum. They are included nonetheless—the relative numbers are probably of value. This unit is also capable of excluding the specular component, giving us a measure of scattering losses. The Minolta is designed to contact the surface being measured and therefore will not be used on our standard (SRM 206) until we fabricate a fixture that protects the NIST mirror.

				Specular Reflectance (%)			
λ(nm)	400	450	500	550	600	650	700
Initial	93.8	92.7	92.6	92.3	91.8	91.1	90.1
After CO_2	95.5	94.2	93.9	93.4	92.8	91.9	90.9
Δ	**1.7**	**1.5**	**1.3**	**1.1**	**1.0**	**.8**	**.8**
After Wash	95.6	94.3	94.0	93.6	92.9	92.1	91.1
Δ	**.1**	**.1**	**.1**	**.2**	**.1**	**.2**	**.2**
				Diffuse Reflectance (%)			
Initial	2.2	2.4	2.5	2.6	2.8	2.8	2.8
After CO_2	1.0	1.0	.9	.9	.9	.8	.8
Δ	**-1.2**	**-1.4**	**-1.6**	**-1.7**	**-1.9**	**-2.0**	**-2.0**
After Wash	.5	.4	.4	.4	.4	.3	.3
Δ	**-.5**	**-.6**	**-.5**	**-.5**	**-.5**	**-.5**	**-.5**

Table 1. Specular and diffuse reflectance of the MMT 6.5m primary before and after CO2 cleaning, "snowing", and after a further detergent wash — measured with a Minolta CM-2002 Spectrophotometer. Only relative values are valid (see text).

	Specular Reflectance (%)				
λ(nm)	310	380	450	550	700
Initial	88.2	86.1	87.4	87.4	85.1
After CO_2	89.1	90.1	90.9	90.0	88.6
Δ	**.9**	**4.0**	**2.5**	**1.6**	**3.5**
After Wash	90.3	91.1	90.7	90.9	87.9
Δ	**.8**	**1.0**	**-.2**	**.9**	**-.7**
SRM 206	88.3	88.3	90.0	89.1	87.2
NIST Report	89.0	89.4	89.6	89.4	87.5

Table 2. Reflectance of MMT 6.5m primary measured with the MMT reflectometer.

Each measurement above is the mean of three taken at six o'clock, about 90% zone on the horizon-pointing primary. Visually the primary appeared quite dusty (Figure 1 left). The water spot density was estimated at $1.5/in^2$ in the worst areas. Mean diameter of these spots was about 3mm and the entire spot area was diffusely reflecting (Figure 2 left). CO_2 cleaning could not completely remove them—thin annuli remained, maybe 20% of the area (Figure 2 middle). Washing further thinned the annuli and might have completely removed a small percentage.

Our measurement uncertainties notwithstanding, we obviously get the most return for our effort with CO_2 cleaning. In terms of reflectance we gain very little by washing this mirror. The scattering data suggest a modest improvement. I surmise that this small gain will be short lived however, rapidly disappearing, perhaps within weeks of again exposing the mirror to the elements.

Based on these results we decided to forgo washing at this point. The substantial effort and risk involved does not justify the gain.

We will append to this memo as our knowledge base increases.

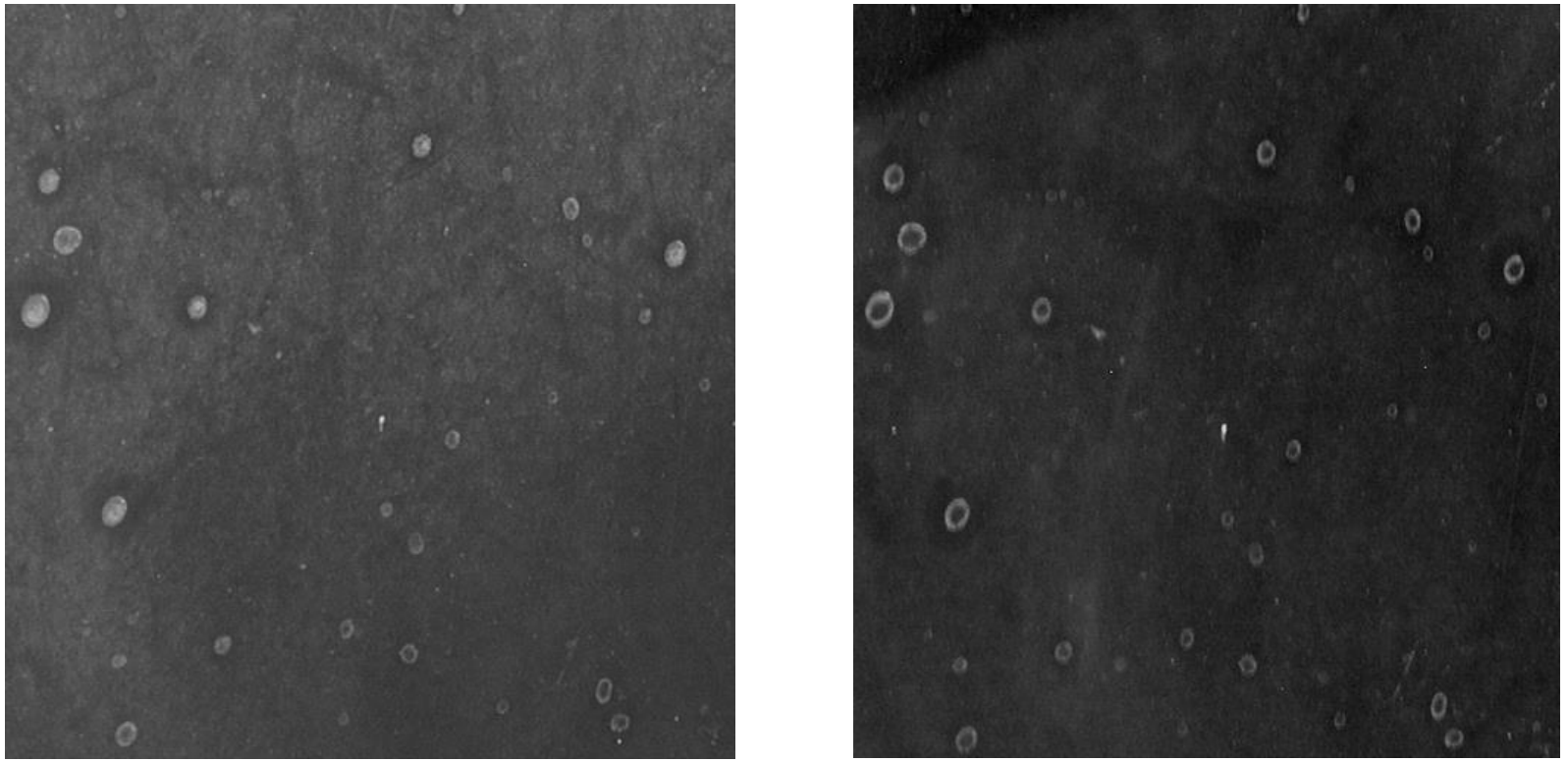

Figure 1. Before (left) and after (right) CO_2 cleaning. Mottling on the right is reflection of baffle felt.

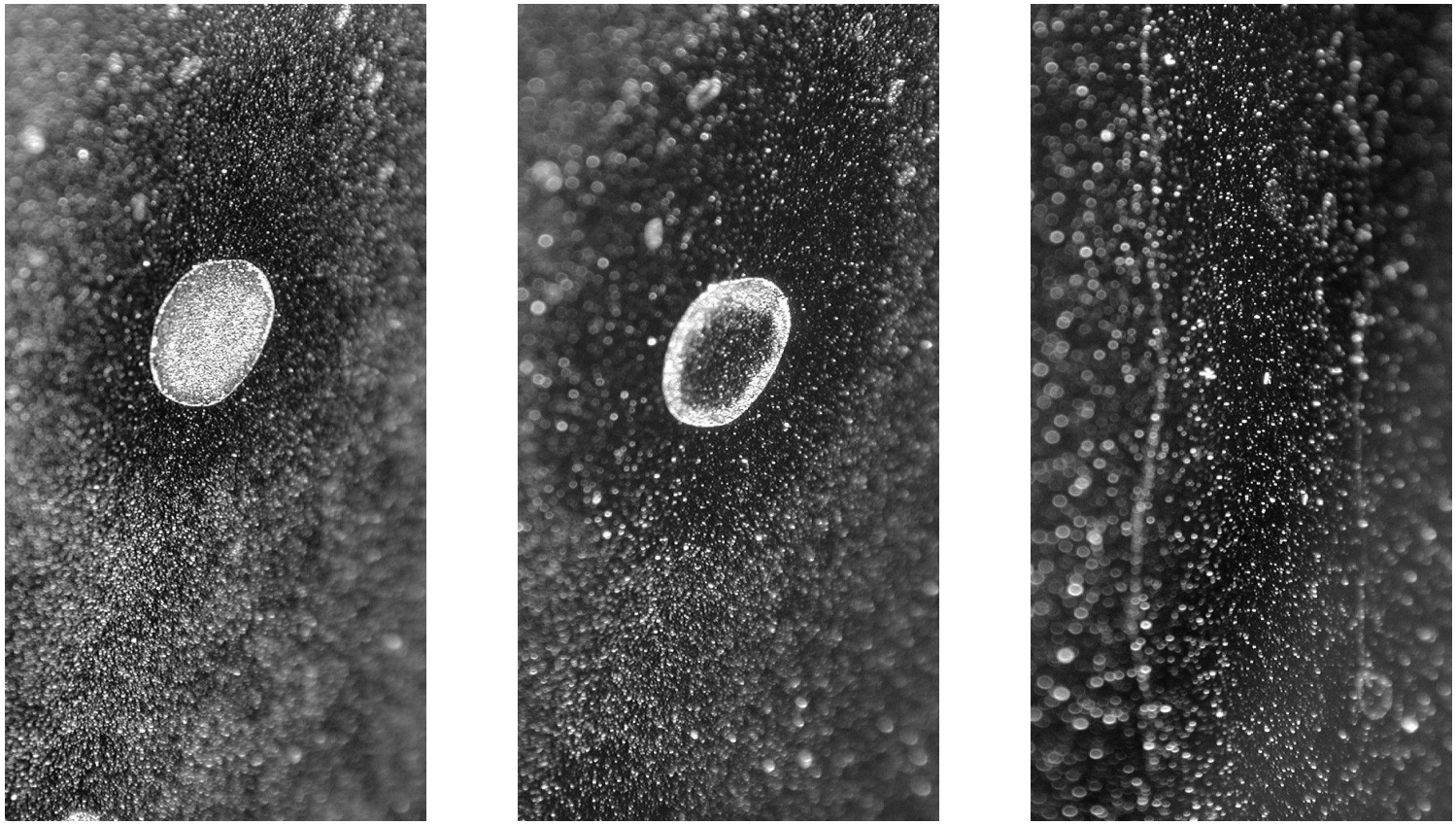

Figure 2. Before (left), after CO_2 cleaning (middle), and a different area after washing (right). Note the low-scatter areola surrounding the water spot(s), etiology unknown.