

**ANALYSIS OF TALC BY X-RAY DIFFRACTION
AND POLARIZED LIGHT MICROSCOPY**

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Contract No. CDC 210-75-0063

**U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Cincinnati, Ohio 45226**

May 1977

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☒ Plt.	☐ Def.
Exhibit No. <u>38</u>	I.D.
Patricia Rubv. M.P. <u>8-12-88</u>	
Witness <u>Mulryan</u>	

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BIBLIOGRAPHIC DATA SHEET		1. Report No.	2.	3. Recipient's Accession No.
4. Title and Subtitle ANALYSIS OF TALC BY X-RAY DIFFRACTION AND POLARIZED LIGHT MICROSCOPY			5. Report Date May 1977	
7. Author(s) Lucy B. McCrone			8. Performer's Organization Rept. No.	
9. Performing Organization Name and Address Walter C. McCrone Associates, Inc. 2820 S. Michigan Ave. Chicago, IL 60616			10. Project/Task Work Unit No.	
			11. Contract Grant No. CDC-210-75-0063	
12. Sponsoring Organization Name and Address National Institute for Occupational Safety and Health 4676 Columbia Parkway Cincinnati, OH 45226			13. Type of Report & Period Covered Final Report	
15. Supplementary Notes			14.	
16. Abstracts One hundred talc samples have been analyzed by polarized light microscopy, dispersion staining, x-ray diffraction and, when necessary, by transmission electron microscopy and electron microprobe. The analytical methods were refined in scope, sensitivity and accuracy as a part of the project. The samples ranged from 1 to 99% talc with an average of 63%. Twenty-three other minerals were identified including the serpentines: antigorite, lizardite and chrysotile; the amphiboles: anthophyllite, tremolite and actinolite; the carbonates: calcite, dolomite, ankerite and magnesite; the talc-like mineral chlorite as well as quartz, mica, feldspars, magnetite, coal, graphite, hydroxygarnet, clays, hydrous iron oxides and rutile. Chrysotile was found in only one sample which, however, contained only 1-2% talc. More than one-third of the samples contained tremolite or actinolite often in major amounts and usually partly fibrous. This report was submitted in fulfillment of Contract No. CDC-210-75-0063 by Walter C. McCrone Associates, Inc. under the sponsorship of the National Institute for Occupational Safety and Health.				
17. Key Words and Document Analysis. 17a. Descriptors				
x-ray diffraction		dolomite		
microscopy		magnesite		
polarized electromagnetic radiation		quartz		
talc				
asbestos				
amphiboles				
serpentines				
calcite				
17b. Identifiers/Open-Ended Terms				
chlorite minerals				
dispersion staining				
x-ray step scanning				
17c. COSATI Field Group				
18. Availability Statement		19. Security Class. This Report UNCLASSIFIED		21. No. of Pages 60
		20. Security Class. This Page UNCLASSIFIED		22. Price 57

ABSTRACT

There has been considerable controversy during the past few years over the composition of talc as used in cosmetic talc products. At one time most of these products were reported to contain chrysotile. Although these data were shown to be erroneous it seemed desirable to examine a large number of raw material talcs from various mines to determine precisely what minerals are present. One hundred talc samples have been analyzed by polarized light microscopy, dispersion staining, x-ray diffraction and, when necessary, by transmission electron microscopy and electron microprobe. The analytical methods were refined in scope, sensitivity and accuracy as a part of the project.

The samples ranged from 1 to 99% talc with an average of 63%. Twenty-three other minerals were identified including the serpentines: antigorite, lizardite and chrysotile; the amphiboles: anthophyllite, tremolite and actinolite; the carbonates: calcite, dolomite, ankerite and magnesite; the talc-like mineral chlorite as well as quartz, mica, feldspars, magnetite, coal, graphite, hydroxypapatite, clays, hydrous iron oxides and rutile. Chrysotile was found in only one sample which, however, contained only 1-2% talc. More than one-third of the samples contained tremolite or actinolite often in major amounts and usually partly fibrous. This report was submitted in fulfillment of Contract No. CDC-210-75-0063 by Walter C. McCrone Associates, Inc. under the sponsorship of the National Institute for Occupational Safety and Health.

INTRODUCTION

Using the techniques of x-ray diffraction and polarized light microscopy we have analyzed 100 samples of talc powder supplied by NIOSH. When necessary electron microscopy and electron microprobe analysis have been used to supplement the data developed by the other techniques. The purpose of the work was to furnish NIOSH with the analytical results which are tabulated in the attached Data Summary, (Appendix A.) While so doing we have tried to refine the microscopical and x-ray methods used as they apply to the analysis of talc.

METHODS OF ANALYSIS

Each sample was analyzed by x-ray diffraction and microscopy. The x-ray work was done using a Philips x-ray generator and diffractometer. Each sample was first scanned continuously to record a diffraction pattern representing the whole sample. The minerals identified were listed and any questionable peak assignments were noted, for confirmation or resolution by polarized light microscopy including dispersion staining. Quantities of each component were estimated whenever possible, both by polarized light microscopy and from the continuous scan.

X-ray step scanning was done, preferably after microscopy, for amphibole and serpentine minerals and for quartz, in order to determine any quantities of these present in the talc. Results of these three types of analysis were reconciled with each other and then combined and presented in individual reports for each sample.

X-RAY DIFFRACTION

Sample preparation

To insure the best x-ray powder diffraction results the contract specifies that samples in which the average particle size exceeds 10 μm must be ground finer before undertaking x-ray diffraction analysis. Judgment of whether size reduction was necessary was made by determining the particle size distribution microscopically. The sample was used as received if the average particle diameter was below 10 μm . If the average particle was larger than 10 μm , or if the sample was not homogeneous because it contained lumps or huge particles, a 2-gram portion was milled in isopropanol for about 10 minutes in a McCrone Micronizing Mill and dried by slow evaporation to a free flowing powder.

APPENDIX A

Data Summary

Appendix A is a five page table which summarizes the analytical results for each of the 100 samples. Four methods of quantitation were used and are coded as follows:

<u>method</u>	<u>code</u>
x-ray diffraction step scanning	S
x-ray diffraction line scanning	L
polarized light microscopy	M
difference	D

The method usually used in finding the quantity of a given mineral is noted after the % sign in the column heading for that mineral. When a method different from that noted in the heading was used the letter code for that method follows the percentage listed in the table for the particular sample.

In the case of tremolite-actinolite "% fibers" means the percentage of the total tremolite and/or actinolite that is fibrous, as contrasted with massive particles. This was, of course, always determined by polarized light microscopy with the use of dispersion staining.

PRODUCT TALC SAMPLES
FOR LABORATORY ANALYSIS

DSHEFS Sample #	Company and Sample Designation	Source of Sample
001	Gouverneur Talc Company (NY) Nytal 300	Supplier
002	Gouverneur Talc Company (NY) Nytal 400	Supplier
003	Gouverneur Talc Company (NY) 5X	Supplier
004	Gouverneur Talc Company (NY) 325	Supplier
005	Gouverneur Talc Company (NY) X	Supplier
006	Gouverneur Talc Company (NY) FT	Supplier
007	Gouverneur Talc Company (NY) 3X	Supplier
009	Johnson & Johnson, Vermont Product Talc (98% Pure)	Company
034	Hitchcock Talc Company Murphy, N.C., Product Talc	Harvard
035	Windsor Minerals, Cassetts "37" July 29, 1975 (Vermont)	Harvard
036	Windsor Minerals, West Windsor Mineral Ray Grind Composite, Vermont	Harvard
037	Windsor Minerals, Ludlow "36" July 29-30, 1975 (Vermont)	Harvard
038	Windsor Minerals, "Cassetts" 36, July 28-30, 1975 (Vermont)	Harvard
039	Vermont Talc Co-Bagging Bulk Sample, 7/16/75, 2nd shift, VT	Harvard

PRODUCT TALC SAMPLES
FOR LABORATORY ANALYSIS

DSHEFS Sample #	Company and Sample Designation	Source of Sample
040	Vermont Talc Company - Bagging Bulk Sample, vertical XXXD 9/17/75 1st shift (Vermont)	Harvard
041	Southern Talc Co. (Cohutta Mill) Chatsworth, Ga. Product (Powder) Sample Mine I.D. 04-00493	MESA
042	Packer Station #3, Vanderbilt Talc, Mill #1 Gouverneur, N.Y. 1st shift 11/4/75 (FT)	NIOSH Survey
043	Packer Station #2, Vanderbilt Talc, Mill #1 Gouverneur, N.Y. (Nytal 100), 1st shift 11/4/75	NIOSH Survey
044	Ceramitalc HDT, Vanderbilt Talc Co. 1st shift 11/4/75 (NY)	NIOSH Survey
045	Bagging Station #3, Vanderbilt Talc Co., Mill #1, Gouverneur, N.Y. 11/4/75 (Nytal 200)	NIOSH Survey
046	Hitchcock Corp. #5 Mine ID# 3100222 (NC)	MESA
047	Hitchcock Corp., #3 Mine ID#3100683 (NC)	MESA
048	Wray Mine & Mill, Inc. Minerals and chemicals ID# 31-0008 (Vermont)	MESA
049	Bagging Station, Vandervilt Talc Co. 2nd shift, Mill #1 Gouverneur, N.Y. (Nytal 300) 11/3/75	NIOSH Survey
050	Bagging Station, Vanderbilt, 2nd shift, 11/3/75 (Nytal 200) Mill #1, Gouverneur, N.Y.	NIOSH Survey
051	Southern Talc Co., Southern Mill Product Talc sample, Chatsworth, Ga Rock Cliff Mine, ID# 0900492, 9/3/74	MESA
052	Southern Talc Co., Southern Mill, Chatsworth, Ga. ore from Rock Cliff ID# 09-00492	MESA
053	Southern Talc Co., Southern Mill Ore from Judge Hole Mine ID# 09-00492	MEAS
054	Winterboro Mine & Mill. American Talc Co., Alpine, Ala. Willowcreek Mine, Ore from (Mont), ID#01-00433	MESA

PRODUCT TALC SAMPLES
FOR LABORATORY ANALYSIS

DSHEFS Sample #	Company and Sample Designation	Source of Sample
055	Thompson-Weinman Co., Cartersville, Plant, Cartersville, Ga., Ore from Brady Mine, ID#09-00224	MESA 9/5/74
056	Cohutta Mill, Southern Talc Co. Chatsworth, Ga. 9/3/74, Ore from Ernest Mine ID#09-00493	MESA
057	American Talc Co., Alpine, Ga. Winterboro Mine & Mill, 9/5/75 #01-00433, Final Prod. Ore from Mont	MESA
058	Pioneer Talc Co, Garren Pit Prod. #6, Allamore, Hudspeth Co., Texas ID# 41-00869	MESA
059	Pioneer Talc Co. Inc., Apache Pit Product, #4, Texas ID# 41-00869	MESA
060	Pioneer Talc Co. Inc., #4 Texola Pit Product, Texas ID# 41-00869	MESA
061	Southern Clay Products, #2, Bottom Product, Allamore, Hudspeth Co., Texas #18	MESA
062	Milwhite Co. Inc., Van Horn, Culberson Co, Texas ID#41-01527 Ground Calcined Product	MESA
063	Milwhite Co. Inc., #11, Van Horn, Culberson Co. Texas,, Eagle Hat Pit Crude ID#41-01527	MESA
064	Pioneer Talc Co., Allamore, Hudspeth Co, Texas, #8 Garren Ceramic ID# 41-00869	MESA
065	Milwhite Co. Inc., Van Horn, Texas #14 Tumble Down Pit Product, ID# 41-01527	MESA
066	Emtal 42, Eastern Magnesia Talc Co. Vermont 8/28/75	HARVARD
067	Pfizer (Barretts Mill) Montana minus 12 micron	NIOSH Survey
068	Pfizer (Barretts Mill) Montana minus 325 mesh	NIOSH Survey
069	Pfizer (Barretts Mill) Montana minus 20 microns	NIOSH Survey

PRODUCT TALC SAMPLES
FOR LABORATORY ANALYSIS

DSHEFS Sample #	Company and Sample Designation	Source of Sample
070	Cyprus (Three Forks Mill) Montana minus 325 mesh	NIOSH Survey
071	Cyprus (Three Forks Mill) Montana Mistron Vapor (minus 10 micron)	NIOSH Survey
072	Cyprus (Three Forks Mill) Montana Floor Sweepings (Bagging Area)	NIOSH Survey
073	Cyprus (Yellowstone Mine) Montana Drill Hole	NIOSH Survey
074	Southern Talc (Southern Mill) Ga. 98% passing 200 mesh	NIOSH Survey
075	Southern Talc (Southern Mill) Ga. 99% passing 325 mesh (#1767)	NIOSH Survey
076	Southern Talc (Cohutta Mill) Ga. 95% passing 325 mesh	NIOSH Survey
077	Southern Talc (Cohutta Mill) Ga. 25% passing 200 mesh	NIOSH Survey
078	Milwhite Talc Co. Inc. (Tex.) Finished CM4 product	NIOSH Survey
079	Westex Talc Co. (TDM) Dark -(Milwhite Inc.) Tex.	NIOSH Survey
080	Milwhite Talc Co. (Tex) Marshall mix - 92-200 mesh	NIOSH Survey
081	Westex Talc Co. (Milwhite Inc.) (Tex) White mine 93-200 mesh	NIOSH Survey
082	Southern Clay Products - Tex. Garren Mine #2	NIOSH Survey
083	Texas Talc Co. - TPl (Tex.) Mine (Texas Pacific)	NIOSH Survey
084	Texas Talc Co. Tex. David Mine	NIOSH Survey

PRODUCT TALC SAMPLES
FOR LABORATORY ANALYSIS

DSHEFS Sample #	Company and Sample Designation	Source of Sample
085	Texas Talc Co. (Tex.) TP2 Mine	NIOSH Survey
086	Cyprus Industrial Minerals Co. Loyce Fine Mine (Tex.)	NIOSH Survey
087	Pioneer Talc Co. Inc. (Tex.) Texola Mine	NIOSH Survey
088	Pioneer Talc Co. Inc. (Tex.) Dees Mine	NIOSH Survey
089	Milwhite Co. Inc. Bryant Soapstone Mine Arkansas	NIOSH Survey
090	Laws Mill (Calif.) Clay sample, kaolin + 1% glue	NIOSH Survey
091	Laws Mill Micro talc from White Eagle Mine (Calif) Standard Industrial Minerals	NIOSH Survey
092	Laws Mill (Calif) Desert Talc Standard Industrial Minerals	NIOSH Survey
093	Laws Mill (Calif) Holiday Talc Standard Industrial Minerals	NIOSH Survey
094	Keeler T-076 (Cyprus) (Calif) Tecopa Mine (100% Panamint)	NIOSH Survey
095	Keeler HGO-55 Blend (Cyprus)(Cal) 4 Panamint, 3 Oasis, 3 White Eagle	NIOSH Survey
096	Keeler Sierra Cloud Blend (Cyprus) 4 Panamint, 1 White Eagle (Calif)	NIOSH Survey
097	Keeler, MSC Mistron (Cyprus)(Calif) Panamint + 0.5% stearite	NIOSH Survey
098	Keeler Sierralite (Cyprus)(Calif) Talc City (Frisco)	NIOSH Survey
099	Keeler Glacier 200 (Cyprus)(Calif) Talc City (Tailings)	NIOSH Survey

PRODUCT TALC SAMPLES
FOR LABORATORY ANALYSIS

DSHEFS Sample #	Company and Sample Designation	Source of Sample
100	Keeler USP (Cyprus)(Calif) Oasis Mine (100%)	NIOSH Survey
101	Keeler (Calif) (Cyprus) White Eagle Screenings	NIOSH Survey
102	Keeler (Calif) (Cyprus) * Suggar Mine	NIOSH Survey
103	Pfizer (Cal) Talcron CP 44-31 Eclipse, Bonnie, Mongolian	NIOSH Survey
104	Pfizer (Cal) Cercron CF 96-38 Eclipse, Acme, Mongolian	NIOSH Survey
105	Pfizer cercron CF 96-36 (Calif) White Eagle, Mongolian, Apex	NIOSH Survey
106	Cyprus (LA) Furnace Creek (Calif) Tecopa (100% Panamint)	NIOSH Survey
107	Cyprus (LA) Vanderbilt crude Soft LB (Calif)	NIOSH Survey
108	American Talc (Alabama) 84 Color Dark 200 Mesh ore from Willow Creek Mine in Mont.	NIOSH Survey
109	American Talc (Alabama) 92 Color 99% 400 Mesh ore from Willor Creek Mine in Mont.	NIOSH Survey
110	Ludlow Gassetts Mill (Vermont) Windsor Minerals Product	
111	West Windsor Mill (Vermont) Windsor Minerals Product	
112	West Windsor Mill (Vermont) Hammondsville Mine Windsor Minerals	
113	Vermont Talc Company (Vermont) Chester Mill - Vertal 77	
114	Vermont Composite Sample Moretown, Vermont	Dr. Froines

PRODUCT TALC SAMPLES
FOR LABORATORY ANALYSIS

DSHEFS SAMPLE #	COMPANY AND SAMPLE DESIGNATION	SOURCE OF SAMPLE
115	R.T. Vanderbilt (NY) Mouldene	Company
116	Resubmittal of #071	
117	Resubmittal of #089	
118	Resubmittal of #098	
119	R.T. Vanderbilt (NY) Fibertal 1	Company
120	R.T. Vanderbilt (NY) Fibertal 6	Company
121	R.T. Vanderbilt (NY) Fibertal 12	Company
122	California Mine no longer in operation	MESA
123	Western Talc (California) (R.T. Vanderbilt) MESA ID #0401138	MESA
124	American Talc Co, Alpine, Ala. Winterboro Mine & Mill Primary Crusher, Sample 9/5/74, ID#01-00433 Ore From Willow Creek Mine in Alder, Montana	MESA
125	Georgia Mine no longer in operation	MESA

APPENDIX A
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Sample No.	Size, mm	% Lom sulfonite	% S sulfonite	% M calcite	% L chlorite	% S large illite	% L dolomite	% L feldspar	% Lom illite	% L magnetite	% L mica	% S quartz	% D talc	% S hematite- siderite	% of 10-100 microns	% of 10-100 microns
001	2.77		18	<1			<1 M		10-16			2.5	40-55	20-25		
002	4.44		0	<1					10-16			0.5	20-45	15-25		
003	1.07		19	<1			<1 M		10-16			1.5	20-40	15-25		
004	5.00		11-15	<1			<1 M		10-16			1.5	10-35	45-55		
005	5.11		0	<1					10-16			0.7	10-20	0.75-1.0		
006	6.0		5	4.6			<0.5 M		10-16			0.2	10-20	0.75-1.0		
007	4.65		16	<0.2			<0.2 M		10-16			1.1	10-20	0.75-1.0		
008	4.3				<1.8		10-20		10-16				10-20	0.75-1.0		
009	6.37				10-20		10-20		10-16				10-20	0.75-1.0		
010	2.9				10-20		10-20		10-16				10-20	0.75-1.0		
011	2.81				10-20		10-20		10-16				10-20	0.75-1.0		
012	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
013	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
014	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
015	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
016	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
017	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
018	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
019	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
020	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
021	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
022	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
023	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
024	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
025	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
026	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
027	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
028	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
029	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
030	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
031	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
032	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
033	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
034	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
035	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
036	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
037	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
038	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
039	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
040	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
041	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
042	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
043	4.2				10-20		10-20		10-16				10-20	0.75-1.0		
044	4.2				10-20		10-20		10-16				10-20	0.75-1.0		

APPENDIX A
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No.	Size, mm	% Ann anorthite	% S orthopyroxene	% M calcite	% L chlorite	% S chlorite	% L dolomite	% L feldspar	% Ann hornblende	% L magnetite	% L mica	% S quartz	% D talc	% S Trimmite-actinolite	% other M opaque particles	% other M
046	8.2				1-2 M		2-3 M					0.5	94-97.5	0.1-0.5 M		
047	7.6				1-2 M		4-5 M						93-95			
048	6.85	3-5			3-5	4-5 M					5-8 muscovite M	0.25	1-2 M	8-9 M	10 feldspar	
049	6.8		10	<0.5			<0.5 M		10-15			0.8	30-40	300% (blue)		
050	5.24		15	<1			<0.5 M		~10			1.1	~14	39% (blue)		
051	4.5			-5	-15		-5 M				10-15 biotite M	3.6	-55	5% (blue)		
052	7.73		9	-5 L	-10		2-3 M	6-8 hornblende M	~1	1-2 M	15 biotite M	2.4	35-50	0.4% (blue)	1 magnetite	
053	5.73		12 P	0.5-1	3-8		3-5		5-10		1 muscovite M	2	55-84	15% (blue)	0.2 magnetite	
054	7.5				-5				6 M	1 M		0.6	90		1 graphite	<1 hydromagnetite
055	7.0				-60						10 muscovite	21	~5 L			0.3 hydromagnetite
056	24.8	15 M	0.1 M	2	5-10		5-8				5 biotite	9	25-45	0	1 magnetite	
057	6.14											0.5	~99			
058	3.22	1-2		~1			5-10					1.1	85-92			
059	5.8	<0.5 M					10-15					1.8	82-87		61 graphite	
060	15.2	1-2					1-2 M		~1-2			2	92-95	<0.2 M		
061	11.0						-5		6 M		0.5-1 biotite M	3.4	88-92			
062	5.7			~2 L			5-10		~1			4.3	77-88		<1 magnetite 1 graphite 1 magnetite	5 hornblende 5 hornblende
063	6.9			1-2 L			5-10					8.5	70-75			
064	5.81						5-10				~1 P	2.6	84-91			
065	4.44						10-20					3.0	76-87			

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	Rock Size mm	% LOM anfibolite	% S anthophyllite	% M calcite	% L chlorite	% S chrysotile	% L dolomite	% L feldspar	% LOM hornblende	% L magnetite	% L mica	% S quartz	% D talc	% S tremolite-actinolite	% Other: M opaque particles	% Other: M	
066	5.85			<1 L	2-5		1-2			30-50			43-67 L				
067	3.75				2-3							0.5	96-98				
068	6.91				1-2		<0.2 M					0.2	97-98		<0.5 graphite		
069	4.00				~1		<1 M					1.5	97		<0.5 graphite		
070	8.64			1			5 M		<1			1.5	90-92				
071	2.61						2-3 M					0.5	96-98				
072	5.51						2-3 M					0.7	95-97			0.5 hornblende	
073	4.5						~90 M						~10 M				
074	3.94				5-8		3-5		2-3		12 hornblende	1.6	72-80	5 (5% fibers)	12 magnetite		
075	9.3	1-2		1-2	5-8		5-10		1-2			0.4	70-82	1 (0% fibers)	1 magnetite		
076	9.85			1-2	~50		~1 M	24 hornblende M			2-4 hornblende	1.7	27-35	5 (2% fibers)	25 magnetite		
077	16.8			<1 P L	10-20 M		8 M		1-3		1-2	2.3	42-58	6	25 magnetite		
078	4.45			~5	5-8		5-10		~1			12	54-70			2 clay	
079	15.6						5-10					2.4	85-95				
080	5.3			~5	1-2		15		~1			2.2	67-76				
081	6.41			2-3 L	1-2		15-20		<1			2.5	65-80				
082	-						12					2.5	70-85				
083	-						12			~5		4	78-83				
084	-						10-12					3.7	75-86				
085	14.6			-			10					3.1	75-87				

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APPENDIX A

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No.	Field size, μ m	% L and antigorite	% S anthophyllite	% M calcite	% L chlorite	% S chlorite	% L dolomite	% L feldspar	% L and lizardite	% L magnesite	% L mica	% S quartz	% D talc	% S tremolite-actinolite	% other M opaque particles	% other M	
086	-						12					5	65-85				
087	8.7	<1					3-5		~ 3			1.6	85-95	25 (all black)			
088	-			~ 5 L			~ 15					4	68-90				
089	9.6			~ 2	8-10		10-20			15-25		2.4	53-57			5 andorrite	
090	1.51	~ 5		1-2	~ 1 M				~ 5			22	5-10 M			30 epidymite	25 clay
091	8.4			<1	1-2			1-5 phengite				2.7	88-95				
092	-			5	~ 1							2.1	77-90	15			
093	-			~ 1	1-3		1-2					1.5	89-95				
094	4.1			5			~ 5				1/3 biotite	2.5	67-90				
095	3.2			~ 5	~ 2		~ 5	1/3 phengite			< 1 M	1.6	59-88				
096	4.13			5-8 L	~ 1		2-4	1/2 phengite			1/2 biotite	1.2	69-90				
097	5.41			8-10 L	41		5-8					1.9	72-92				
098	6.05			3-4	92-95 D				0.2			0.8	~ 1 L			2 rutile	
099	4.33			~ 2	86-92 D		~ 5					1.4	2-4 L				
100	8.98			0.5	3-5								94-96	< 1			
101	-			< 0.5	1-3			5 (M and T)			1 M	1.7	80-94				
102	-			0.6	90-95 D							1.0	5-10 L				
103	7.05			5-10 L			5-10					1.5	70-93	< 0.1			
104	4.95			8			5-10		1-2			1.7	55-77	10			
105	4.66			10-15 L			4-5		1-2			1.2	52-81	10			

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APPENDIX A

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No.	Rock Size, mm	% L + M anorthite	% S anthophyllite	% M calcite	% L chlorite	% S chrysotile	% L dolomite	% L feldspar	% L + M hazardite	% L magnetite	% L mica	% S quartz	% D talc	% S Kramollite- actinolite	% Other: M opaque particles	% Other: M
106	607			8 L			5					1.8	82-93			
107	-			- 2 L			15				- 2 biotite	< 0.1 M	78-86			
108	667				15		0.5-1					0.75	82-84			
109	4.7				1							1	93-98			
110	230				3-4		61			40-50		0.1 M	45-55		< 1 coal	
111	8.8				1-2					~ 1			97-98			
112	333				6		15			30			45-75		< 1 magnetite - coal	
113	352				- 2		2			45			46-57		5 magnetite - coal	
114	685	1-2			5-8		1-2			15-20		0.9	66-87		< 1 magnetite < 1 coal	
115	417	1-2	11-18	0.2					1-3			3.8	29-71	44		
116	155				< 1?		~ 5					0.6	80-94			5 glass
117	11.2	2-3		1-2 L	2-3		10-15		1-2	10-15		5.5	55-76			
118	434	1-2		2-3	82-94 D						1 magnetite	< 0.25	2-3 L			
119	358	1-2	7	< 1					1-2			3.4	72-73	13.5		
120	423	6.2	10.5						2-3			3.2	32-68	37		
121	4.8		11.5-16	< 1					1-2			5.6	31-69	45		
122	885			5			1-2				1-2 biotite	< 0.25	90-93	0.1 (5% total) M		
123	5.6			1 L			2				1-3 phlogopite	0.8	93-95	0.01 (5% total) M		
124	8.9											3.5	77-85		25 coal	0.5% H ₂ O
125	9.15						80-88 D				1-2 magnetite	5	~ 1 L		25 glass	1 rutile

% Fibers % of total Kramollite