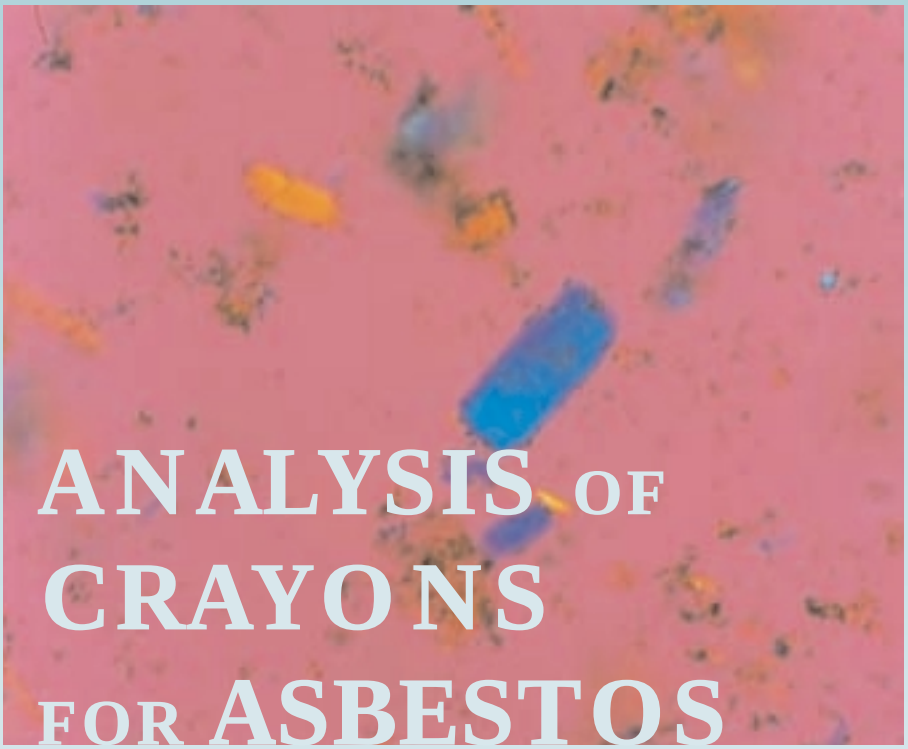

# ANALYSIS OF CRAYONS FOR ASBESTOS

and other Fibrous Materials, and Recommendations for Improved Analytical Definitions

EXECUTIVE SUMMARY

# Analysis of Crayons for Asbestos
## and other Fibrous Materials, and Recommendations for Improved Analytical Definitions

An independent report produced by Research Triangle Institute without funding from any outside source. This report focuses on issues related to analysis and identification of asbestos and other fibrous materials; implications of health risk from these materials are beyond the scope of this report.

by

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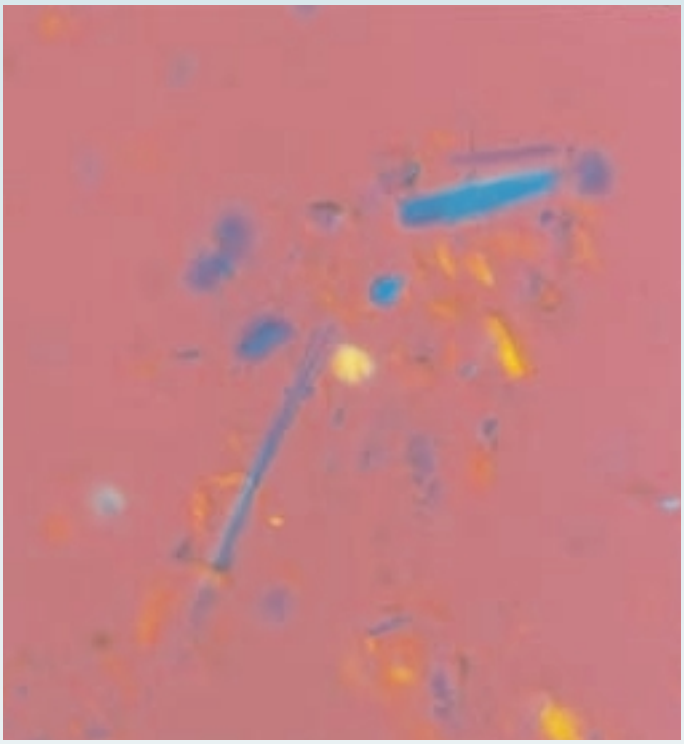

# EXECUTIVE SUMMARY

## BACKGROUND

In May 2000, reports of asbestos-containing crayons surfaced in the media. The asbestos was reportedly detected by laboratories accredited by the U.S. Government for asbestos analysis. The crayon manufacturer commissioned additional analyses by accredited laboratories, and the results showed there to be no asbestos material in the crayons. In the interest of providing information about possible causes of and remedies for these discrepancies, Research Triangle Institute (RTI) conducted an investigation designed to (1) identify any fibers present in crayons, (2) conduct quantitative analysis to determine if fibers are present in sufficient numbers to properly catalog and identify them, (3) theorize why fibers were identified differently by the laboratories, and (4) make recommendations for improving the analytical/quality assurance (QA) process.

## DEFINITIONS

Some definitions for asbestos and other fibrous particles may be helpful in understanding terms in this report. ***Asbestos*** is a commercial term for long, thin mineral fibers of chrysotile, amosite, crocidolite, anthophyllite, tremolite, and actinolite. ***Asbestiform fibers*** are those having the crystal structure of the above minerals and having physical characteristics such as (1) mean aspect ratios (length to width) of 20:1 to 100:1 or greater for individual fibers; (2) very thin fibrils usually less than 0.5 µm in width; (3) and parallel fibers in bundles, bundles with splayed ends, matted masses of fibers, and/or fibers showing curvature. ***Cleavage fragments*** are mineral particles which are similar to asbestiform fibers but have low aspect ratios. These particles are not considered hazardous and are not regulated. ***Transitional fibers*** are asbestiform particles that do not fit a precise mineral category. Such fibers may have characteristics of asbestos fibers and non-asbestos fibers within the same particle.

## IDENTIFICATION OF FIBERS

Crayons contain a variety of components often including paraffin, talc, and various pigments.

The talc used in some crayons is primarily from a mine in Gouverneur, New York, and is a complex mixture of platy talc particles, cleavage fragments of tremolite, fibrous minerals such as talc and anthophyllite, and fibers that contain characteristics of more than one mineral; the latter are called transitional fibers. The fibers found in the Gouverneur talc have many characteristics similar to those of asbestos fibers. This report compares the characteristics of asbestos fibers to those of the fibers found in samples of the New York talc.

Various crayons were selected from local retail stores for inclusion in this study; results in this summary are restricted to Crayola® orchid and Crayola® atomic tangerine colors. The Gouverneur talc used in the crayons and obtained from Binney & Smith (Crayola®) was also included in the study. The crayons were analyzed by polarized light microscopy (PLM), x-ray diffraction (XRD), and transmission electron microscopy (TEM).

In the PLM analysis, both of the Crayola® crayon residues contained fibrous and nonfibrous talc, tremolite cleavage fragments, and an anthophyllite "transitional fiber" in varying concentrations, yet neither was found to contain fibrous anthophyllite concentrations over a trace level. XRD analysis identified talc, tremolite, serpentine, and anthophyllite, listed in decreasing order of peak intensities. It should be noted that XRD does not provide information as to the morphology of the mineral phase; therefore, the presence of asbestiform fibers cannot be confirmed by this analytical technique. However, analysis by PLM and TEM confirmed the presence of asbestiform fibers both in the raw talc material and in the crayons. TEM analysis determined that the nonfibrous material included irregularly shaped particles, platy material, and cleavage fragments. The smaller irregular particles and platy particles were predominantly talc, and the cleavage fragments and larger blocky particles were nonasbestiform tremolite. The asbestiform fibrous components were predominantly magnesium-rich anthophyllite, transitional fibers, and talc.

## QUANTITATIVE ANALYSIS

A summary of results from the PLM and TEM analyses of the crayons and the talc is provided in the table below.

**Comparative Summary of PLM and TEM Results**

| Fibers | PLM - Crayon | TEM - Crayon | TEM - Talc |
|---|---|---|---|
| Fibrous Talc | Trace - 2% | 0.067% (0.54%)[a] | 0.81% |
| Tremolite Cleavage Fragments | 5% - 10% | 3.8% (29%)[a] | 13% |
| Anthophyllite | Trace | 0.56% (4.3%)[a] | 4.4% |
| Transitional Fibers | 3% - 5 % | 1.9% (15%)[a] | 16% |

[a] Percentage in crayon; percentage in ash residue is in parentheses.

The results obtained using PLM and TEM are in agreement for fibrous talc, tremolite cleavage fragments, and transitional fibers. The quantitative results for anthophyllite by PLM and TEM do not agree. The PLM and TEM techniques disagreed on the categorization of the anthophyllite and transitional fibers. The criteria for identification of these species are unique for each technique. The identification of materials by PLM is made primarily on determination of the refractive indices of the materials. These values would exclude these fibers from identification as anthophyllite. Thus, the amount of anthophyllite as estimated by PLM is listed as "trace." The TEM analysis identifies these fibers as a form of anthophyllite with very little iron. It may be the low iron percentage that causes the fibers to exhibit lower indices of refraction than are generally expected for anthophyllite. The Selected Area Electron Diffraction (SAED) patterns confirm an anthophyllite pattern as indexed to zone axis 100 and confirm the material to be anthophyllite.

RTI analyzed samples of the Gouverneur talc in 1992 for the EPA as part of an investigation of talc used in a paint product. The materials analyzed at that time gave analytical results similar to those of the current analyses. Fibers were observed, and SAED patterns indicated they were anthophyllite. However, the SAED patterns were described as having "extra reflections," which were interpreted as evidence of "talc inclusions." RTI has also analyzed National Institute of Standards and Technology Standard Reference Material (SRM) 1867; the anthophyllite asbestos fibers in the SRM also show "extra reflections" in the SAED patterns, which could result in their being labeled as fibers of mixed assemblage. XRD and TEM analysis indicate the presence of talc. Since "pure" minerals are rare in nature, it may be difficult to find a sample of pure asbestos based on these findings. If the inclusion of an additional mineral phase sufficient to produce an "extra reflection" in the SAED pattern of a fiber that appears to be predominately asbestos causes the fiber to be classified as a fiber of mixed assemblage, there may be no truly regulated anthophyllite asbestos.

If talc inclusions were present, the fiber would be considered a fiber of "mixed mineral assemblage," and EPA has stated that these fibers are not regulated. This criterion is troublesome in that strict interpretation of the policy would result in the likelihood that no mineral fiber can be called asbestos.

The U.S. Consumer Product Safety Commission (CPSC) reported on June 13, 2000, that trace amounts of asbestos were found in Crayola® and Prang® crayons. The CPSC report noted the trace amounts were "scientifically insignificant." The CPSC also reported "transitional" fibers to be present in these crayons and concluded the risk of exposure to these fibers in crayons is extremely low. CPSC concluded there is "no scientific basis for a recall" of these products. Nevertheless, the manufacturers of these crayons have agreed to reformulate the products and discontinue the use of these fibers within a year. Data in this report is from the analysis of crayons prior to any reformulation.

## REASONS FOR CONFLICTING RESULTS

The fibers reported by the media to be asbestos are in fact tremolite cleavage fragments. Amphibole asbestos (tremolite, actinolite, anthophyllite, crocidolite, and amosite) may occur as asbestos fibers or as cleavage fragments. Asbestos fibers are considered carcinogens, and they are regulated by various governmental authorities. Cleavage fragments are not known to be carcinogenic, and they are not regulated. Asbestos fibers have very high aspect ratios (ratio of length to width of the fiber). Criteria for distinguishing between asbestos fibers and cleavage fragments are confusing in the current compliance monitoring methods. The EPA 1982 method states that fibers with aspect ratios greater than 10:1 are asbestos fibers and those with aspect ratios less than 10:1 are cleavage fragments. But the method also instructs the analyst to count all fibers with aspect ratios greater than 3:1 as asbestos. The 3:1 criteria is a factor used for determining if a particle is fibrous but not for distinguishing asbestos fibers from cleavage fragments. A 1993 EPA method has clarified these criteria using standards that are more acceptable to mineralogists. The new criteria states that mean aspect ratios for asbestos fibers should be 20:1 to 100:1 or greater. EPA has recommended this new method, but the Agency has not formally adopted this procedure into its regulations.

Anthophyllite asbestos fibers were reported by the RTI TEM analyses in appreciable quantity but only at trace levels by PLM. It may be possible that the low iron, high magnesium anthophyllite in these materials has an index of refraction which by convention excludes these fibers from classification as anthophyllite.

## RECOMMENDATIONS

Criteria for clearly distinguishing between asbestos fibers and cleavage fragments need to be adopted by government agencies. The 1993 EPA method includes a better definition to distinguish between these fiber forms and should be considered as a formal replacement for the 1982 method. Analysts need to be reminded of the criteria for distinguishing between fibrous particles, asbestos fibers, and cleavage fragments.

Criteria for refractive indices for anthophyllite need to be examined to determine if the low iron, high magnesium anthophyllite should be included as an anthophyllite. A panel of expert mineralogists should be assembled to consider these criteria. Government agencies should also carefully examine the health risks associated with these fibers to determine if they should be regulated—regardless of their nomenclature.

The analysis of talc is a complex procedure and many errors in identification have occurred in previous investigations of talc containing products. A standard talc material which has been thoroughly characterized should be developed and distributed to laboratories as a standard reference material. This material should be incorporated into various quality assurance programs as a means of insuring reliable analysis of talc materials. Criteria for identifying the various components of these samples should be clearly stated in order to inform and assist the laboratory in such analyses.