



## **Response of RJ Lee Group**

to the

**United States Environmental Protection Agency Region IX  
Response (dated April 20, 2006) to the November 2005**

**National Stone, Sand & Gravel Association Report**

**Prepared by the R.J. Lee Group, Inc [sic]**

**"Evaluation of EPA's Analytical Data from the  
El Dorado Hills Asbestos Evaluation Project"**

**Regarding**

**Evaluation of EPA's Analytical Data**

**from the El Dorado Hills**

**Asbestos Evaluation Project**

**Exhibit A**

**Attachment A-8a**

***Particles and their Related Extinction  
Angles***

**Date: July 2006**

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## Exhibit A: Attachment A-8a

### *Particles and their Related Extinction Angles*

#### Summary

Optical microscopy studies were undertaken to determine the angle of extinction for tremolite minerals that were collected from three locations in California, and for the National Institutes of Standards and Technology (NIST) sample, 1867a. The extinction angles for fibers and particles from each sample were measured and each particle was classified by their optical properties as having 3 or more characteristics of asbestos, 2 characteristics of asbestos, or as a non-asbestiform particle. The results were plotted to show the distribution of extinction angles for each group of particles.

#### 1.0 Background

The use of parallel extinction is a defining characteristic of asbestos fibers as noted by Verkouteren and Wylie<sup>1</sup> and in the analytical protocols<sup>2</sup> when the fibers also exhibit other characteristics of asbestos. However, the observation of parallel extinction without other asbestos characteristics does not absolutely define a particle as asbestos. Asbestos is characterized by bundles of easily separated fibers, very thin fibers (less than 0.5  $\mu\text{m}$ ), fibers showing curvature, and fibers with very high aspect ratios. When a population of particles does not exhibit any of these characteristics and does not show parallel extinction, the population of particles is clearly not asbestos.

The PLM methods state that asbestos fibers have parallel extinction while nonasbestos particles have oblique extinction. As noted in the PLM method used by the EPA (NIOSH 9002), tremolite-actinolite will have oblique extinction ( $10^\circ - 20^\circ$ ) for fragments. As noted in OSHA ID-191 (section 3.5): "... cleavage fragments of the monoclinic amphiboles show inclined extinction under crossed polars with no compensator. Asbestos fibers usually show extinction at zero degrees or ambiguous extinction if any at all." The draft ASTM method (P236) that was circulated by NIST to all NVLAP laboratories states: tremolite asbestos and actinolite asbestos has extinction "parallel in most fibers". The EU method (1997) states that "polarized light microscopy (PLM) can be used to exclude some elongated cleavage fragments on the basis of their non-parallel extinction angle" (page 13). As noted in EPA's own 1993 PLM method refractive indices are to be measured on tremolite-actinolite when the fiber exhibits extinction at a zero degree orientation (page

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<sup>1</sup> J. R. Verkouteren, A. G. Wylie (2002). "Anomalous optical properties of fibrous tremolite, actinolite, and ferro-actinolite," *American Mineralogist*, 87, p 1090-1095.

<sup>2</sup> R. L. Perkins and B. W. Harvey (1993). "Method for the Determination of Asbestos in Bulk Building Materials", U.S. Environmental Protection Agency, EPA/600/R-93/116, July 1993.

15). Wylie,<sup>3</sup> Dorling and Zussman,<sup>4</sup> and Verkouteren and Wylie<sup>1</sup> report that asbestos fibers have parallel extinction or, if too thin, anomalous extinction properties.

The National Institute of Standards and Technology (NIST) certificates accompanying Standard Reference Materials (SRM) 1867 and 1867a<sup>5</sup> indicate that "Asbestiform: crystallizes with the habit of asbestos. These asbestos minerals possess properties such as long fiber length and high tensile strength. Under the light microscope, [some portion of]<sup>6</sup> these samples exhibit the asbestiform habit as defined by several of the following characteristics: 1) mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5  $\mu\text{m}$ ; 2) very thin fibrils, usually less than 0.5  $\mu\text{m}$  in width; 3) parallel fibers occurring in bundles; 4) fiber bundles displaying splayed ends; 5) fibers in the form of thin needles; 6) matted masses of individual fibers, and 7) fibers showing curvature" (page 2).

## 2.0 Extinction Angle Study

Samples of tremolite collected from Jamestown, California, Harvard Way in El Dorado Hills, California, soil from El Dorado Hills, California, and the NIST 1867a tremolite standard were analyzed using a polarizing light microscope (PLM). The extinction angle of a number of particles from each sample was measured and recorded. Images of each particle as it appeared both extinct and non-extinct were collected for each particle analyzed.

Using the criteria described in the SRM 1876a Certificate of Analysis<sup>7</sup> the analyzed particles were separated into three categories: 1) fibers containing 3 or more criteria, 2) fibers possessing 2 criteria; and 3) particles possessing no criteria, or non-asbestiform particles.

## 2.1 Results

The percentage of particles that were above and below an extinction angle of ten degrees are shown for each class of particle in Table 1. The data is graphically presented in Figure 1.

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<sup>3</sup> A. Wylie (1979). "Optical properties of the fibrous amphiboles", *Ann NY Acad Sci*, 330, p. 611-619.

<sup>4</sup> M. Dorling and J. Zussman (1987). "Characteristics of asbestiform and non-asbestiform calcic amphiboles", *Lithos*, 20, p. 469-489.

<sup>5</sup> NIST SRM 1867 and 1867a contain samples of tremolite, actinolite, and anthophyllite and are referred as "Uncommon Commercial Asbestos".

<sup>6</sup> The words in brackets are from the SRM 1867a certificate.

<sup>7</sup> National Institutes of Standards and Technology Standard Reference Material 1867a Certificate of Analysis, 2003.

Table 1. Percentage of particles with extinction angles above and below 10 degrees

Extinction Angle (°)	3 or more criteria met (%)	2 criteria met (%)	No criteria met – non-asbestiform (%)
0-10	87	77	43
>10	13	23	57

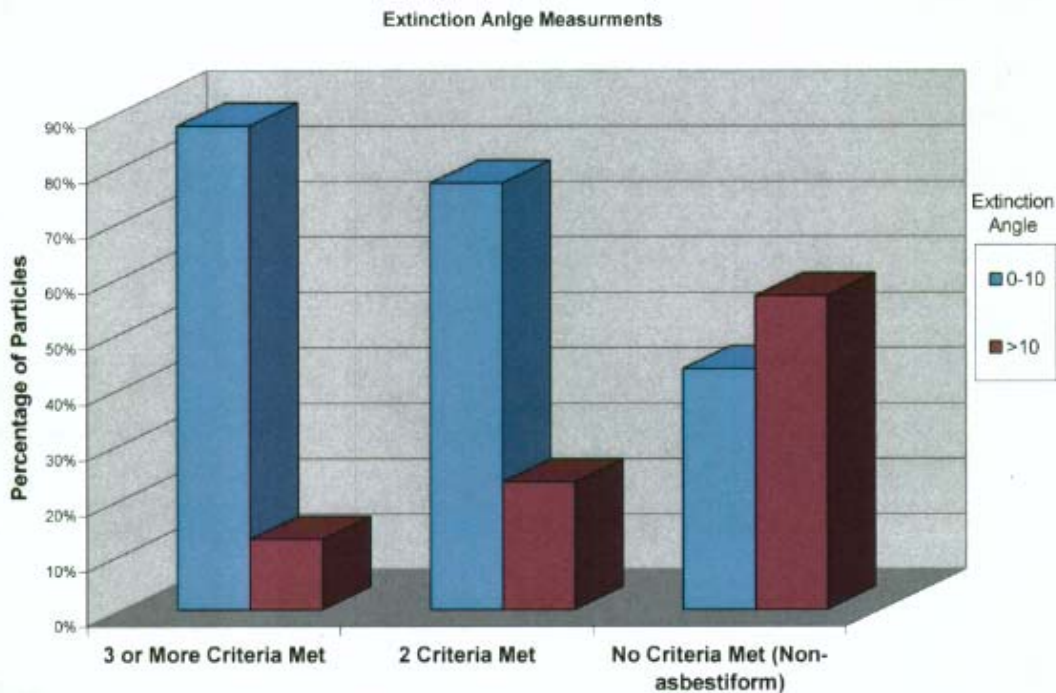


Figure 1. Chart showing the percentage of particles with extinction angles less than and greater than ten degrees for each category.

## 2.2 Images of Fibers

The extinction angle of a number of particles from each sample was measured and recorded. Images of each particle as it appeared both extinct and non-extinct were collected for each particle analyzed.

### 2.2.1 Fibers with 3 or more Criteria of Asbestos

Fibers containing 3 or more criteria of asbestos are presented in Figure 2 through Figure 63. Two images for each fiber were taken to show the extinct and non-extinct appearance of the fiber. The fiber is circled, and the field of view and measured extinction angle are displayed in each image for clarification.

2.2.1.1 Harvard Way

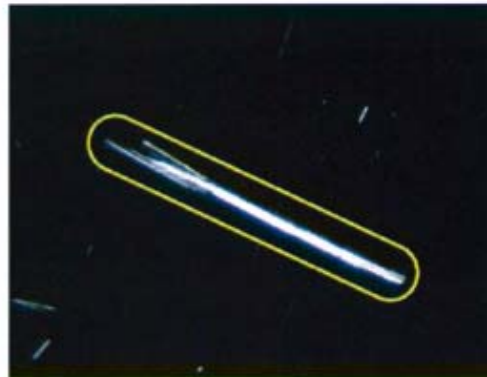


Figure 2. Field of View: 0.5mm; Parallel extinction.

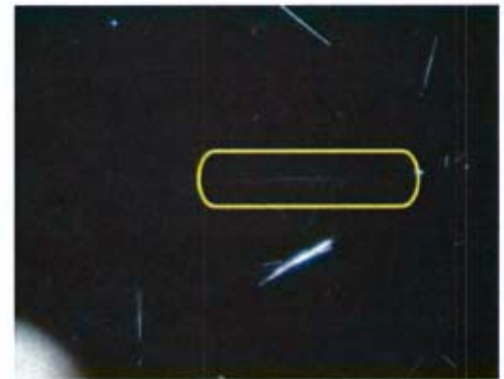
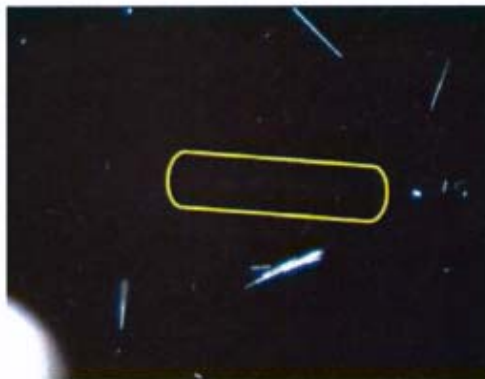


Figure 3. Field of View: 0.5mm; 7 degree extinction angle.

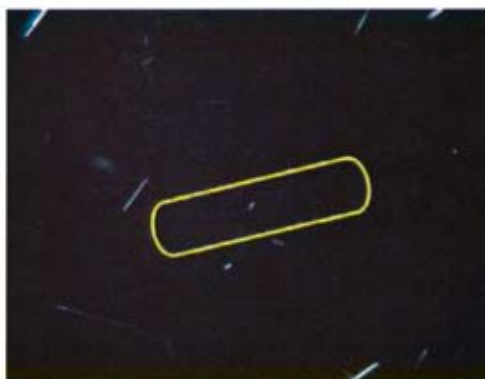


Figure 4. Field of View: 0.5mm; 12 degree extinction angle.

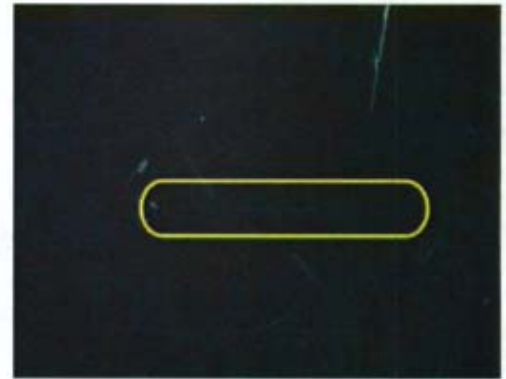
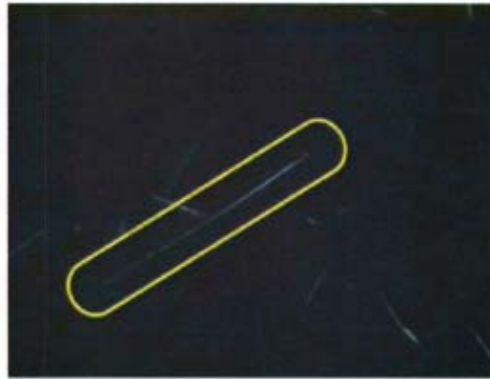


Figure 5. Field of View: 0.5mm; parallel extinction.

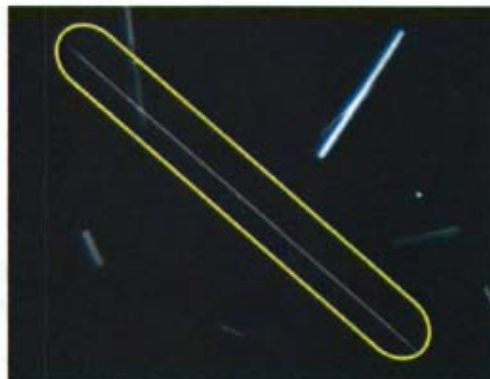


Figure 6. Field of View: 0.5mm; Parallel extinction.

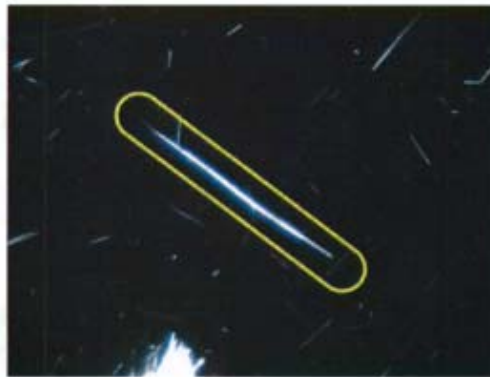


Figure 7. Field of View: 1.0mm; Parallel extinction.

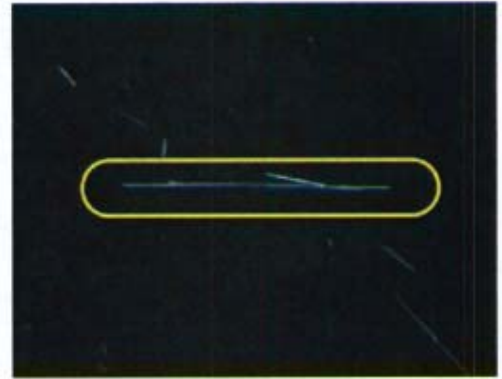
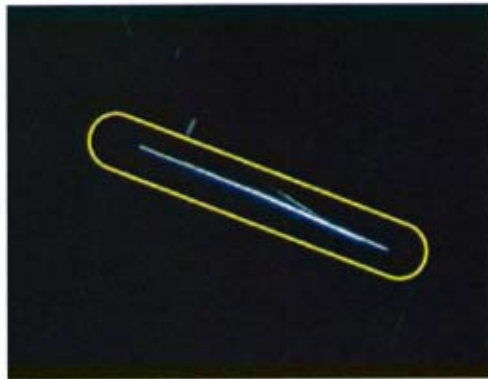


Figure 8. Field of View: 0.5mm; Parallel extinction.

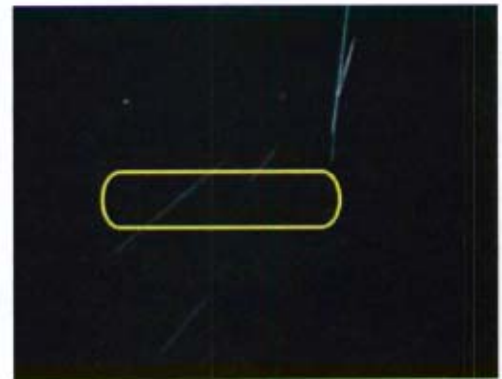
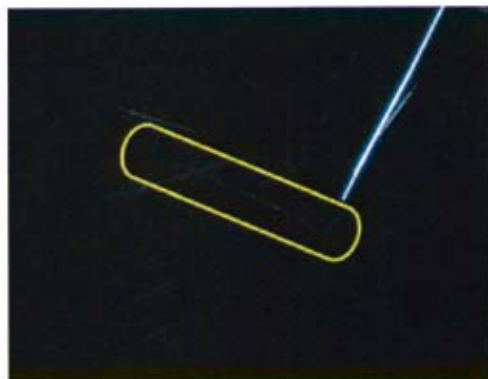


Figure 9. Field of View: 0.5mm; 2 degree extinction angle.

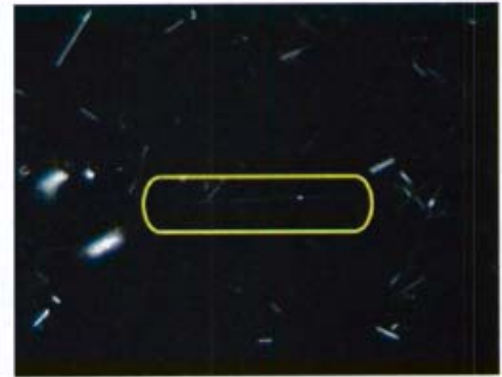
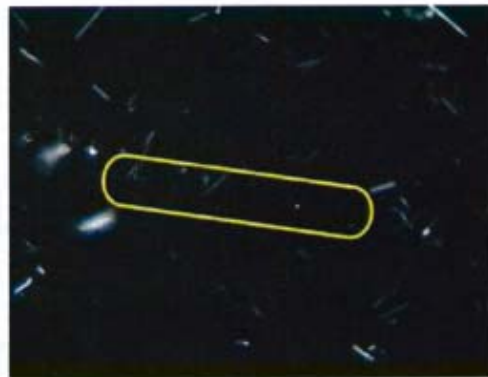


Figure 10. Field of View: 0.5mm; 11 degree extinction angle.

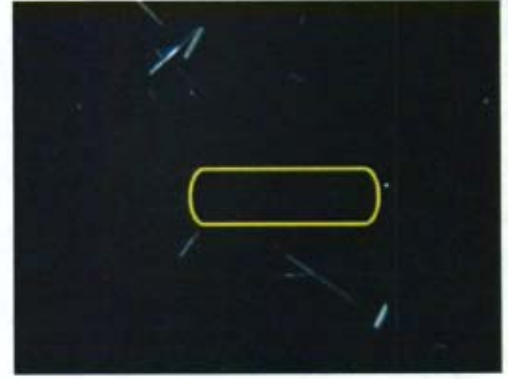
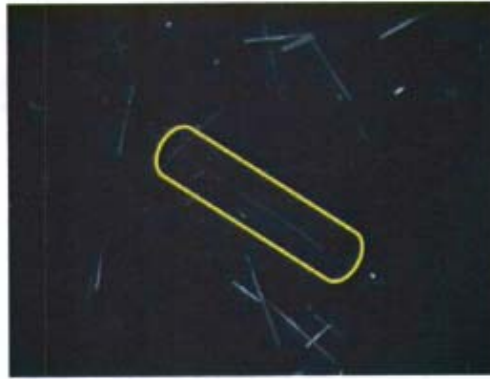


Figure 11. Field of View 0.5mm; Parallel extinction.

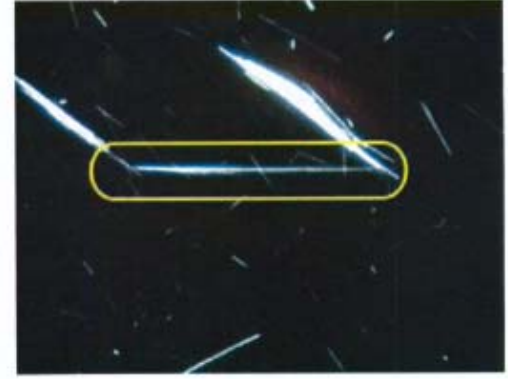
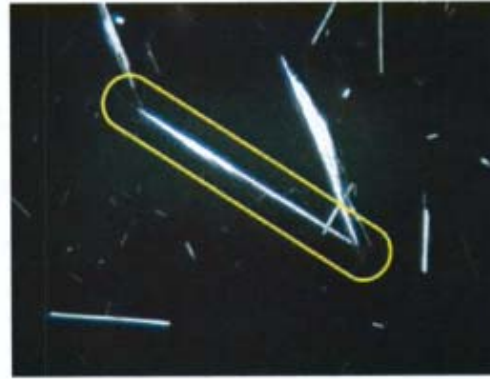


Figure 12. Field of View: 0.5mm; Parallel extinction.

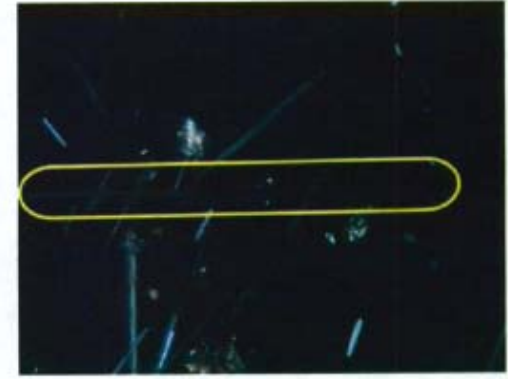
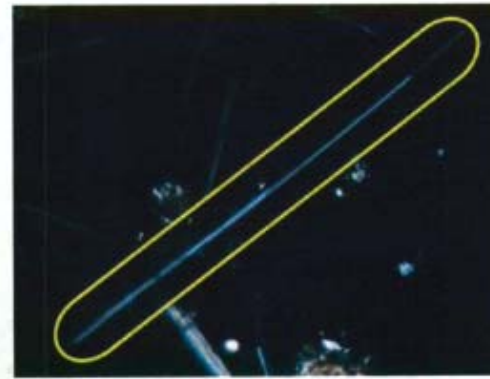


Figure 13. Field of View: 1.0mm; Parallel extinction.

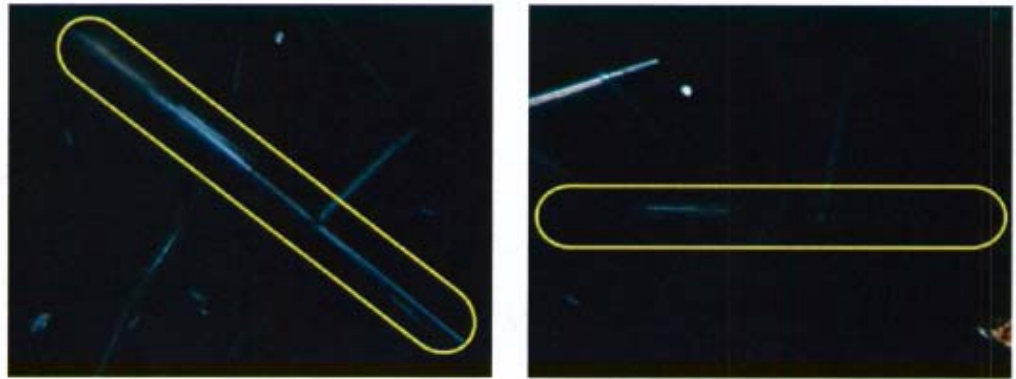


Figure 14. Field of View: 0.5mm; Parallel extinction.

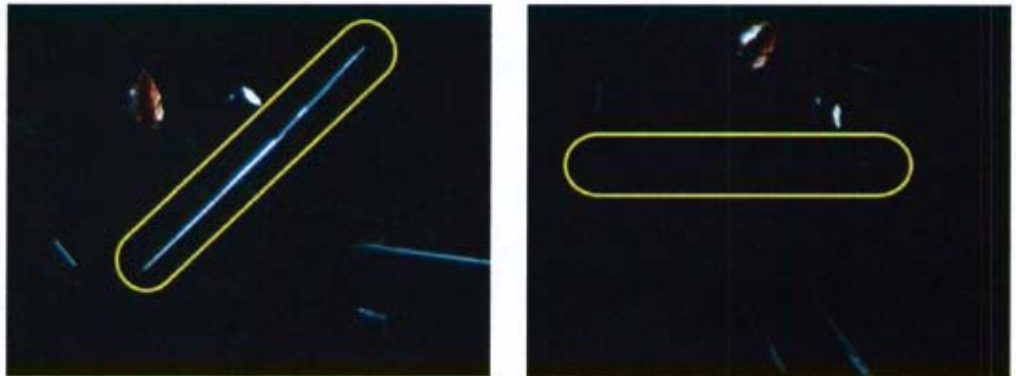


Figure 15. Field of View: 1.0mm; Parallel extinction.

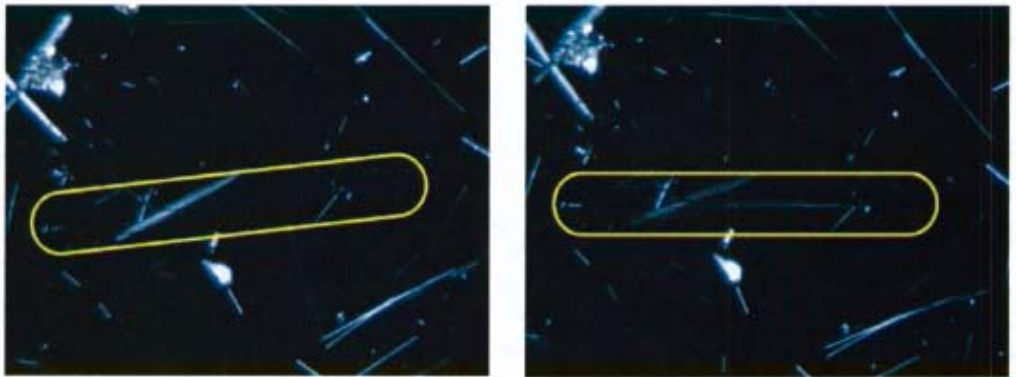


Figure 16. Field of View: 1.0mm; 7 degree extinction.



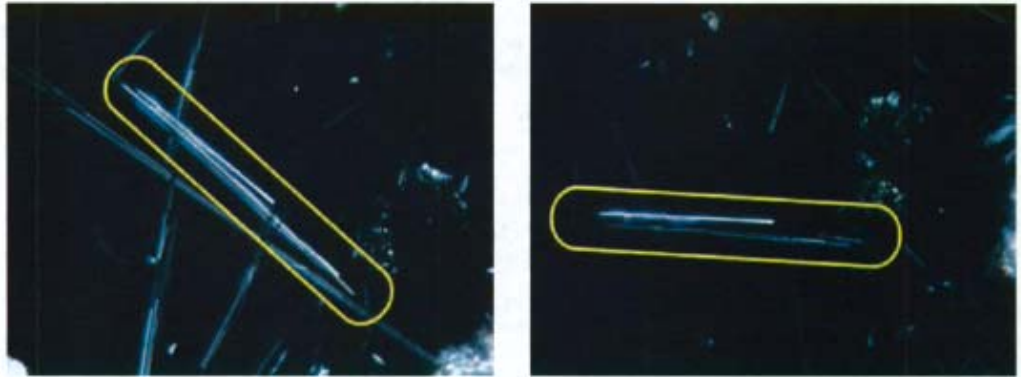


Figure 17. Field of View: 1.0mm; Parallel extinction.

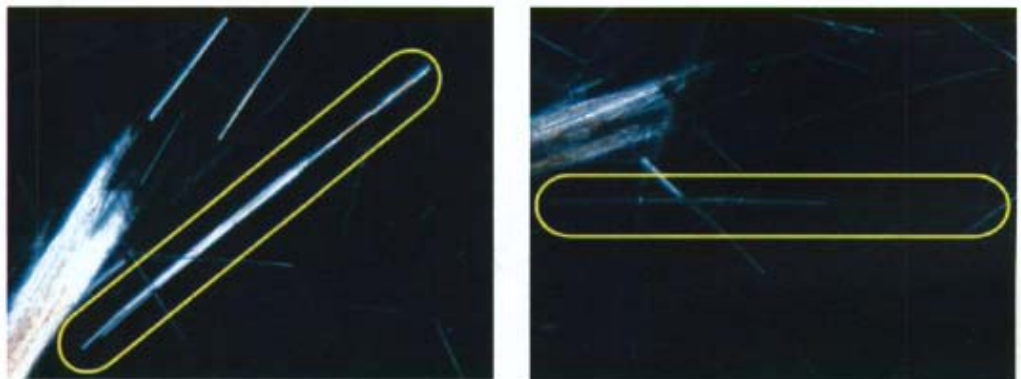


Figure 18. Field of View: 1.0 mm; Parallel extinction.

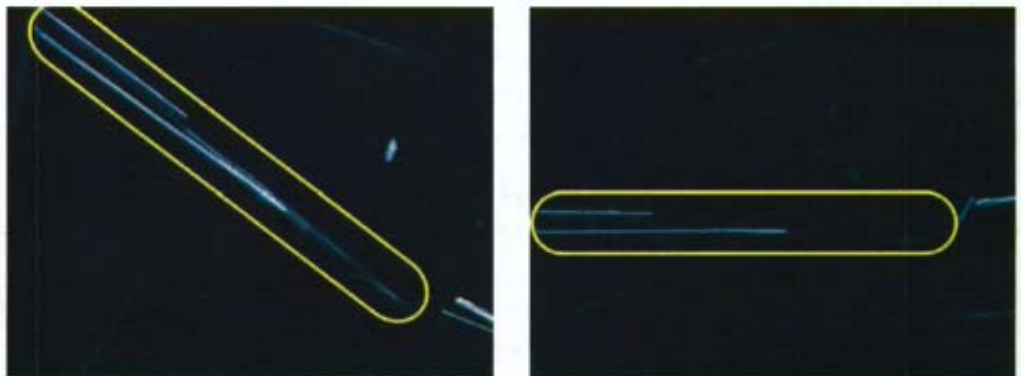


Figure 19. Field of View: 0.5mm; Parallel extinction.

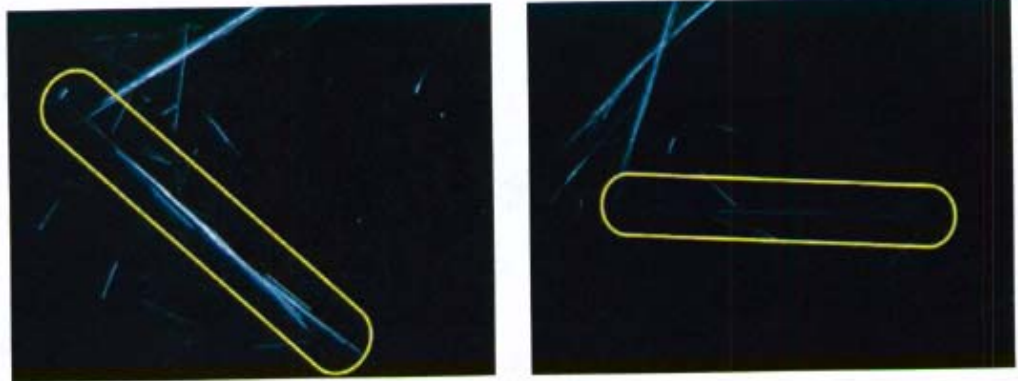


Figure 20. Field of View: 2.5mm; Parallel extinction.

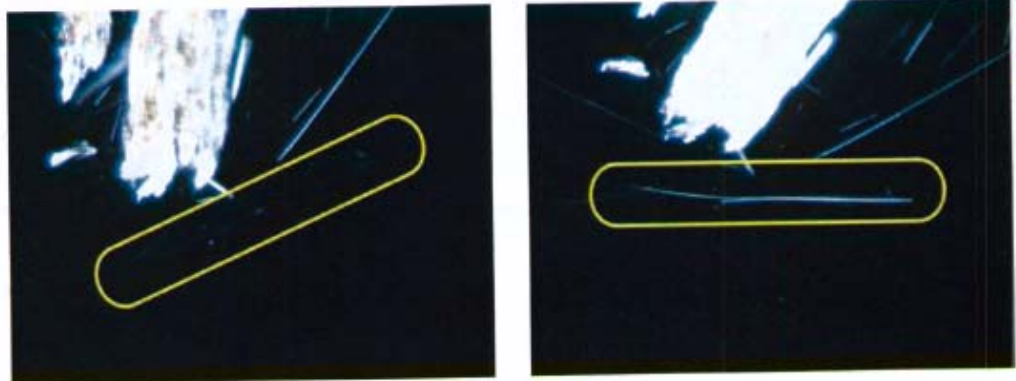


Figure 21. Field of View: 1.0mm; 25 degree extinction angle.

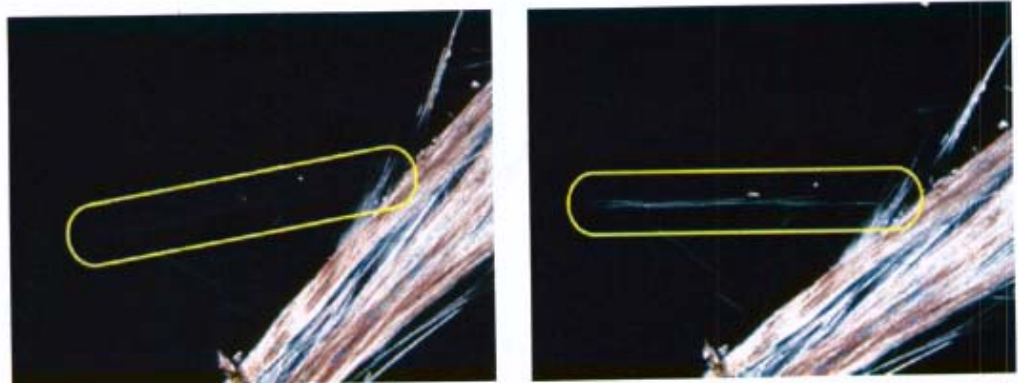


Figure 22. Field of View: 2.5mm; 12 degree extinction angle.

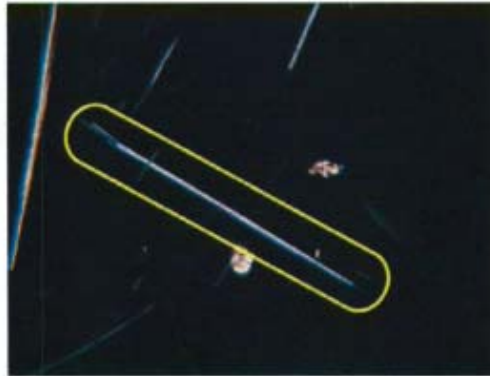


Figure 23. Field of View: 4.0mm; Parallel extinction.

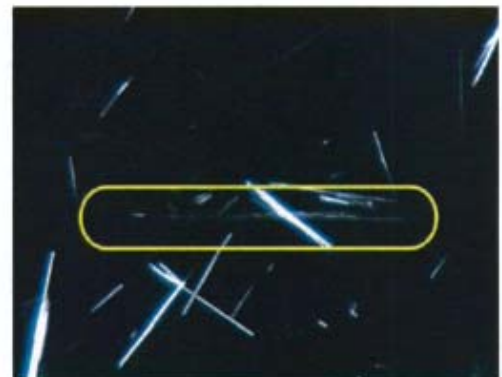
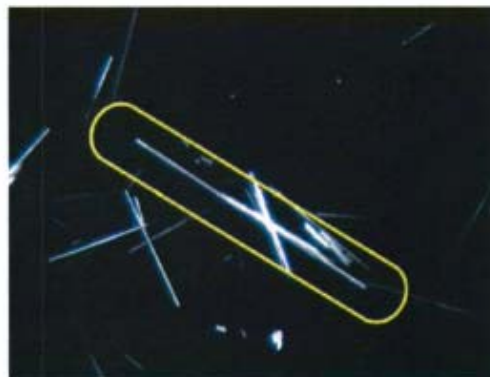


Figure 24. Field of View: 1.0mm; Parallel extinction.

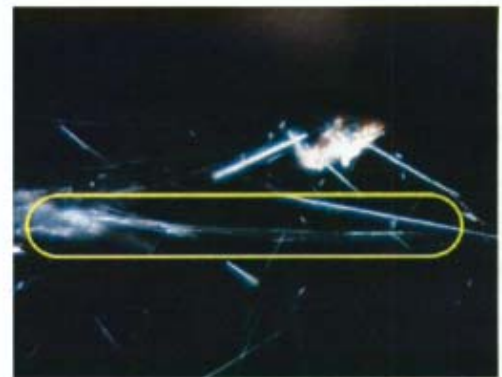
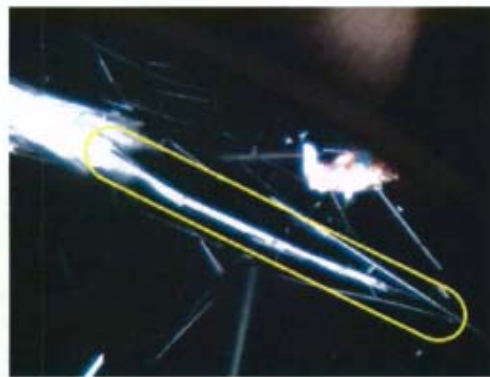


Figure 25 Field of View: 1.0mm; Parallel extinction.

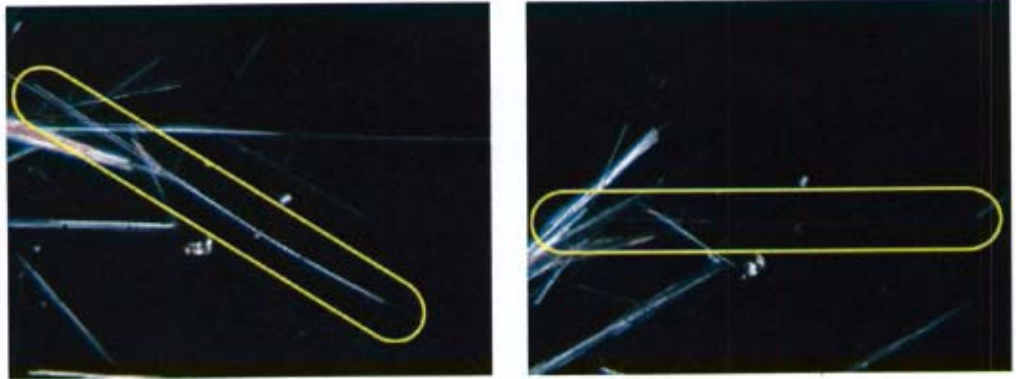


Figure 26. Field of View: 1.0mm; Parallel extinction.

2.2.1.2 Jamestown

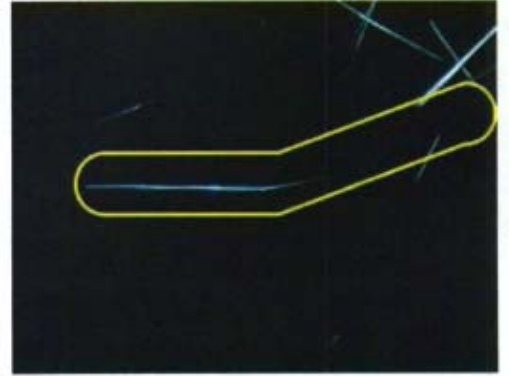
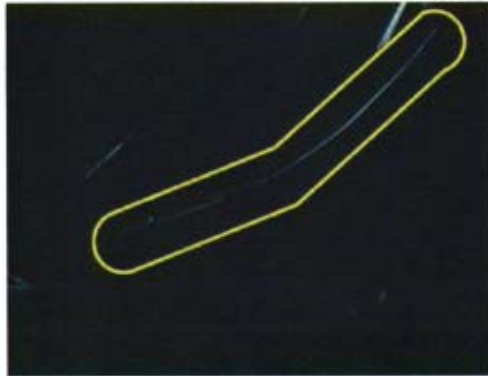


Figure 27. Field of View: 1.0mm; 18 degree extinction angle.

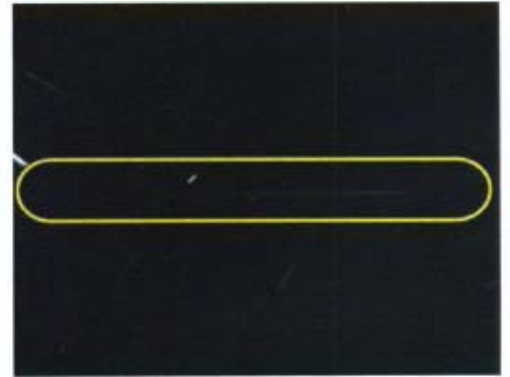
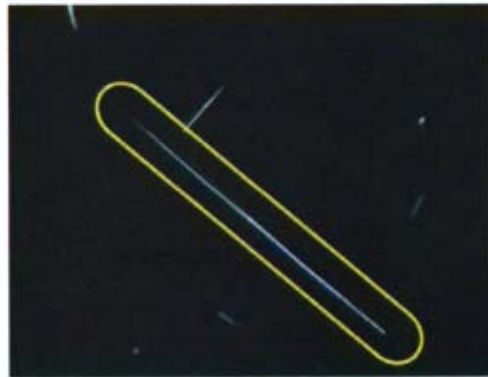


Figure 28. Field of View: 1.0mm; Parallel extinction.

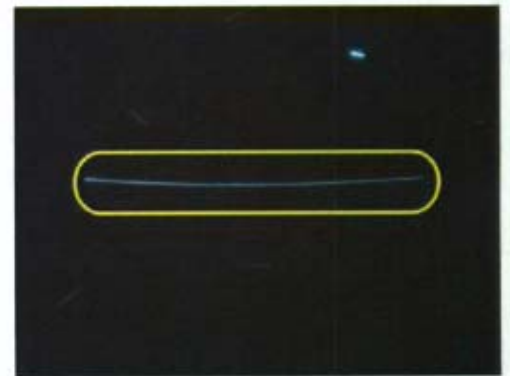
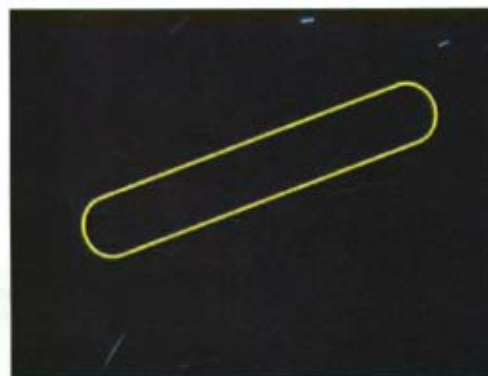


Figure 29. Field of View: 1.0mm; 20 degree extinction angle.

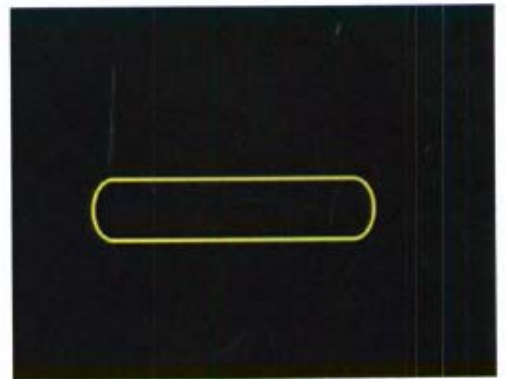
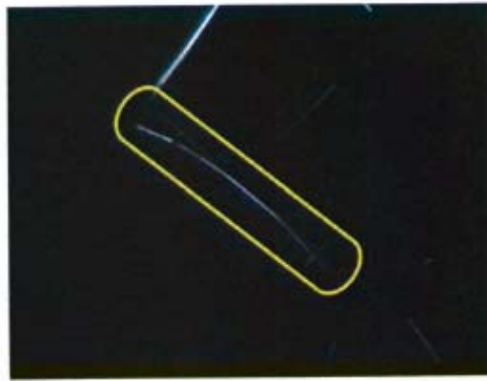


Figure 30. Field of View: 0.5mm; Parallel extinction.

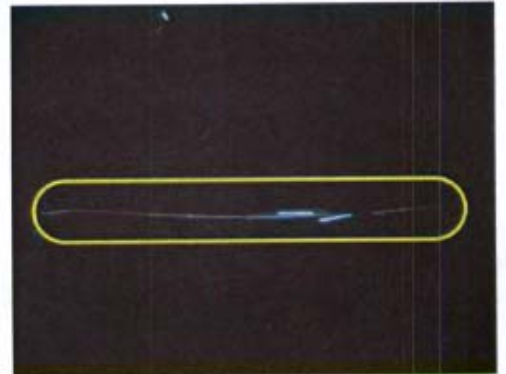
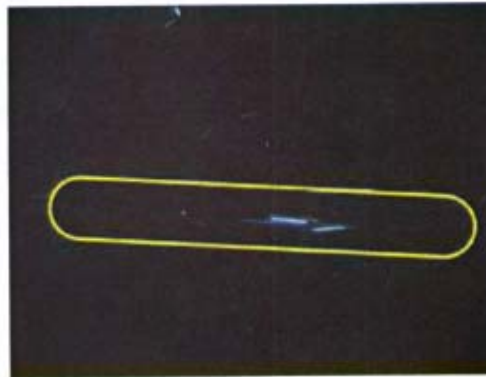


Figure 31. Field of View: 1.0mm; 6 degree extinction angle.

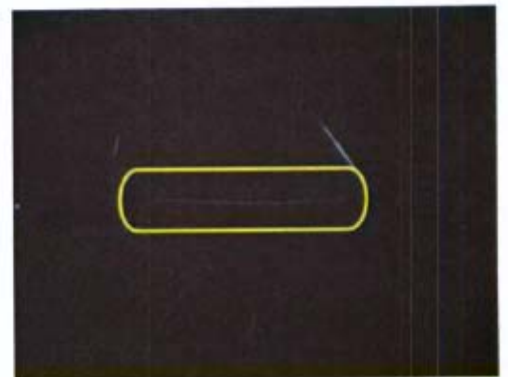
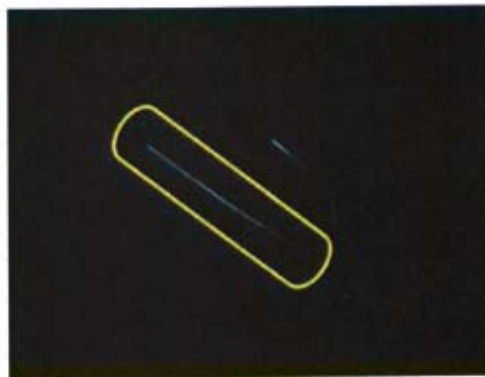


Figure 32. Field of View: 1.0mm; Parallel extinction.

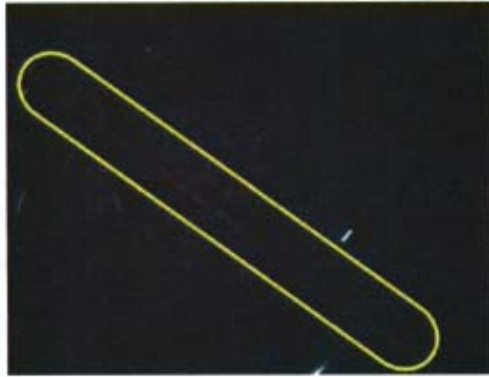


Figure 33. Field of View: 2.5mm; Parallel extinction.

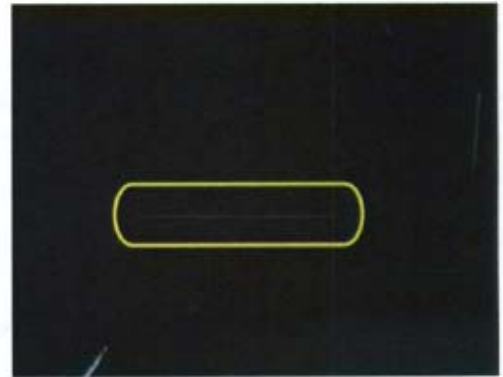
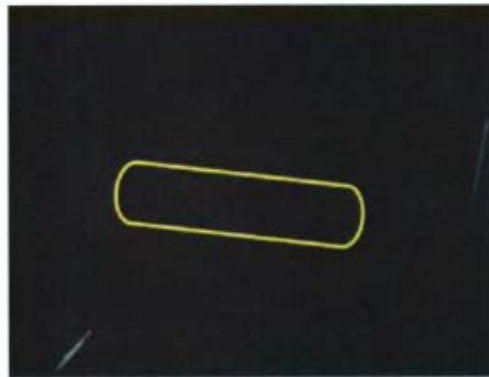


Figure 34. Field of View: 0.5mm; 6 degree extinction angle.

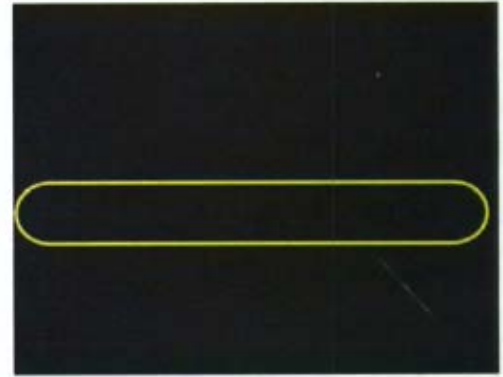
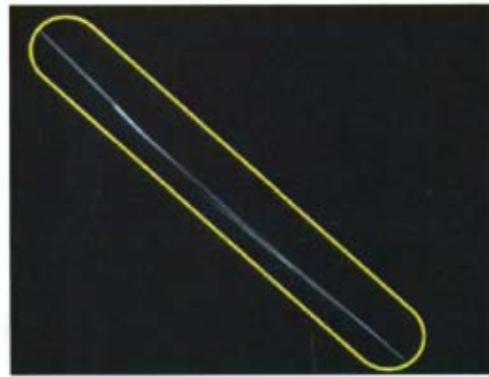


Figure 35. Field of View: 0.5 mm; Parallel extinction.

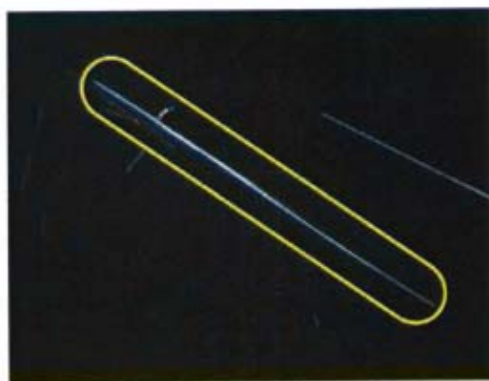


Figure 36. Field of View: 0.5mm; Parallel extinction.

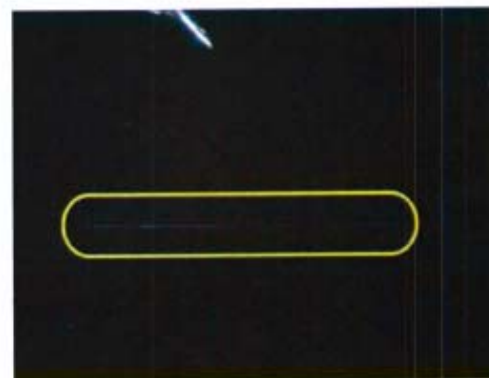
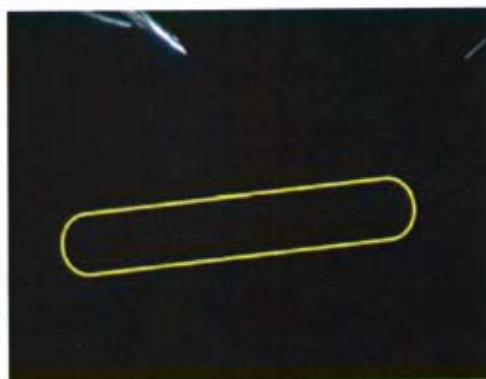


Figure 37. Field of View: 1.0mm; 6 degree extinction angle.

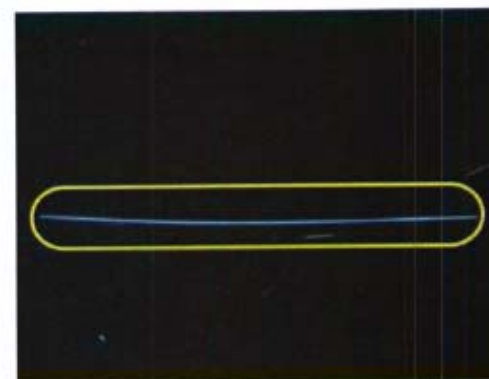
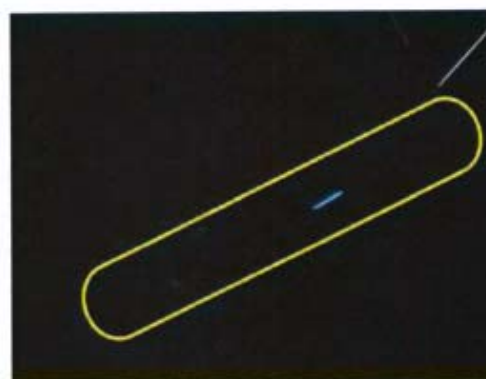


Figure 38. Field of View: 1.0mm; 24 degree extinction angle.



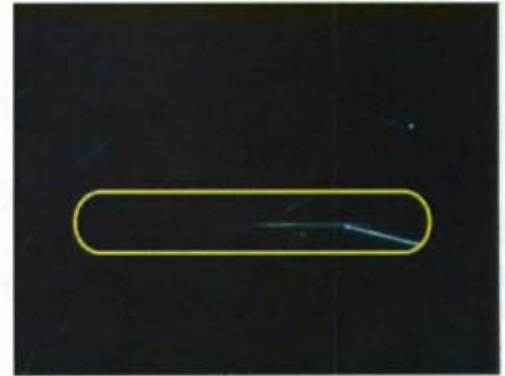
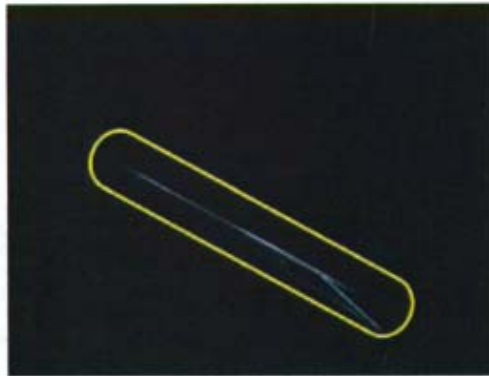


Figure 39. Field of View: 0.5 mm; Parallel extinction.

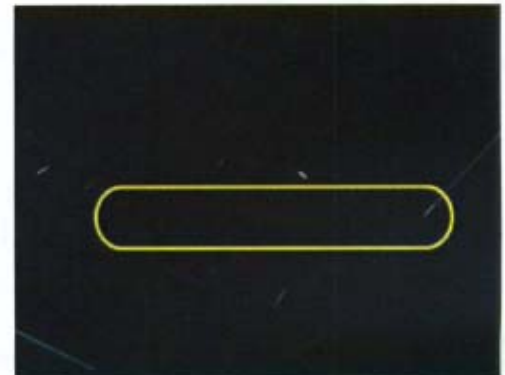
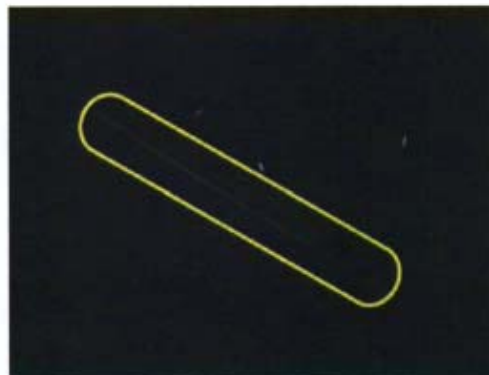


Figure 40. Field of View: 0.5, Parallel extinction.

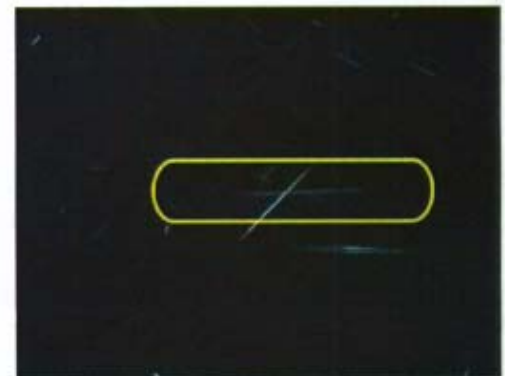
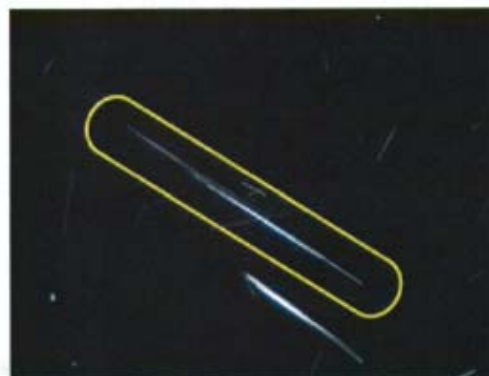


Figure 41. Field of View: 1.0mm; Parallel extinction.

### 2.2.1.3 El Dorado Hills Soil

No fibers meeting three or more criteria for asbestos were found.

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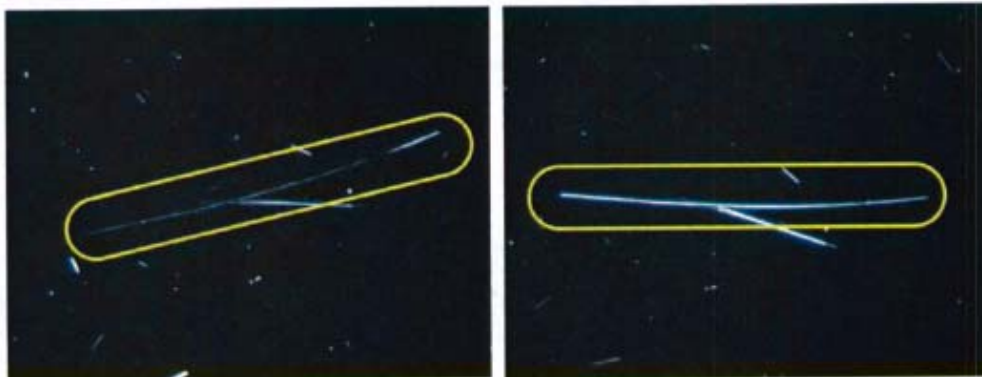


Figure 42. Field of View: 2.5mm; Parallel extinction.

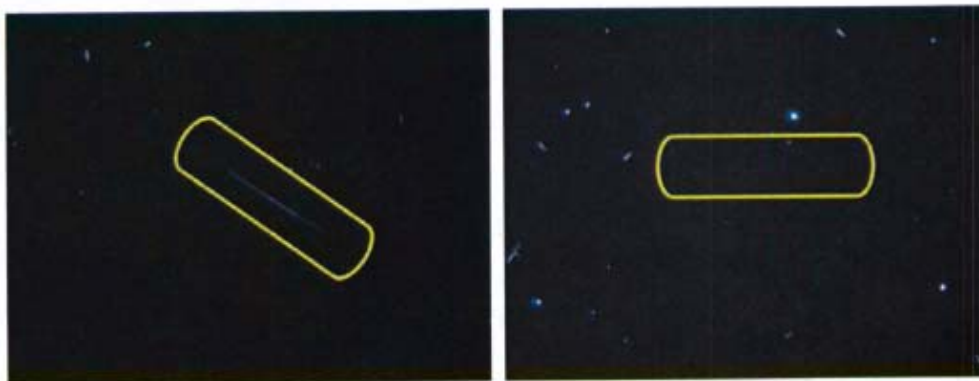


Figure 43. Field of View: 1.0mm; Parallel extinction.

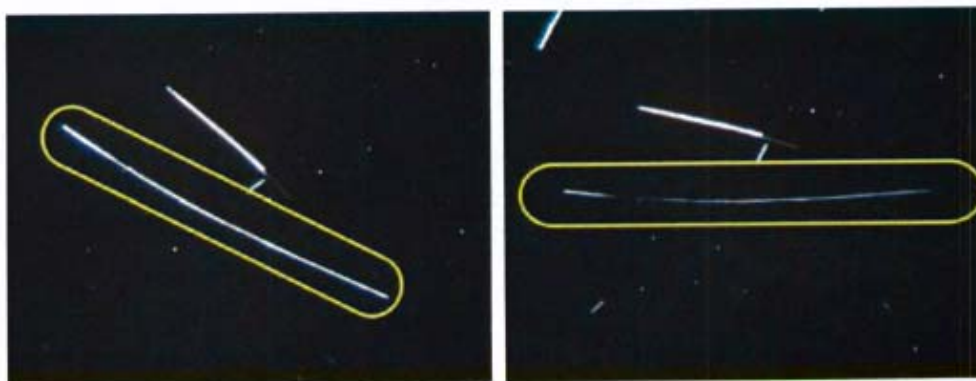


Figure 44. Field of View: 2.5mm; Parallel extinction.

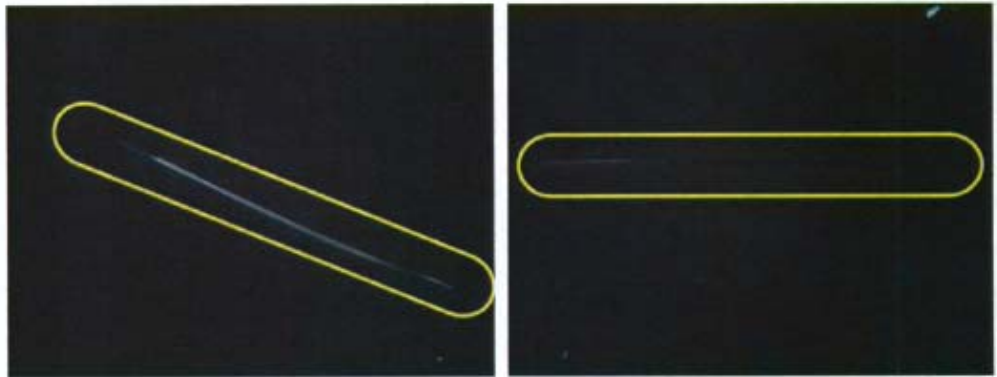


Figure 45. Field of View: 0.5mm; Parallel extinction.

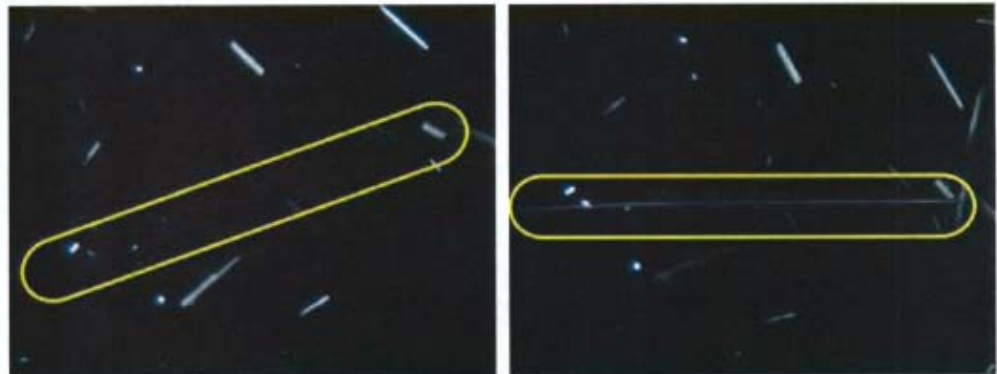


Figure 46. Field of View: 0.5mm; 22 degree extinction angle.

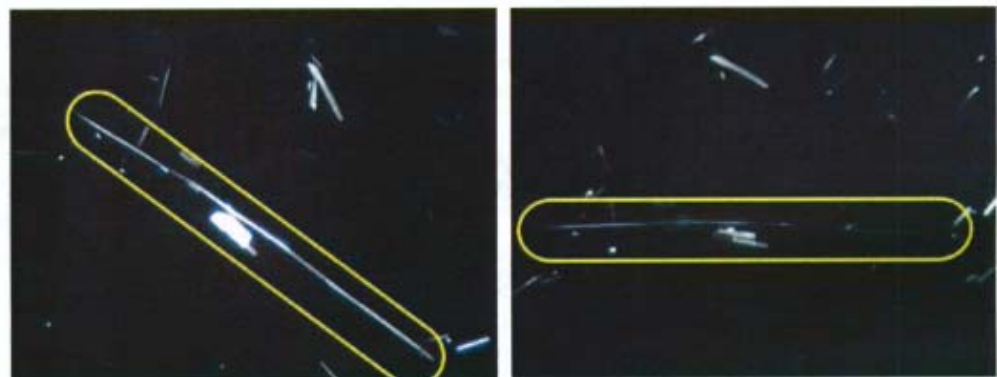


Figure 47. Field of View: 0.5mm; Parallel extinction.

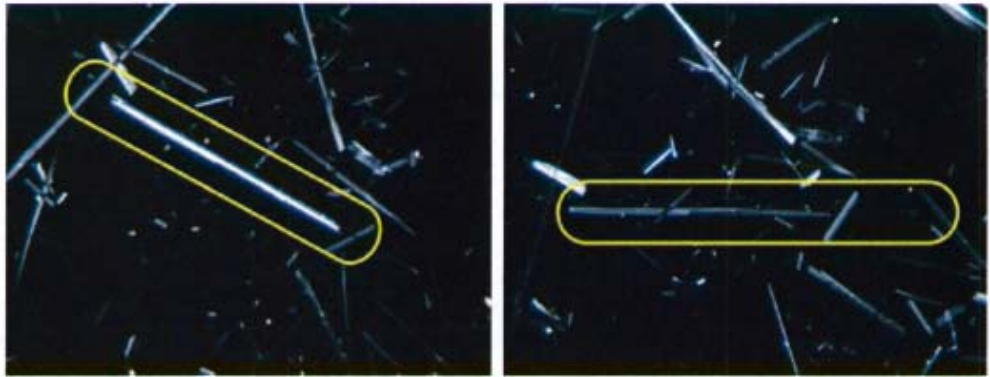


Figure 48. Field of View: 0.5mm; Parallel extinction.

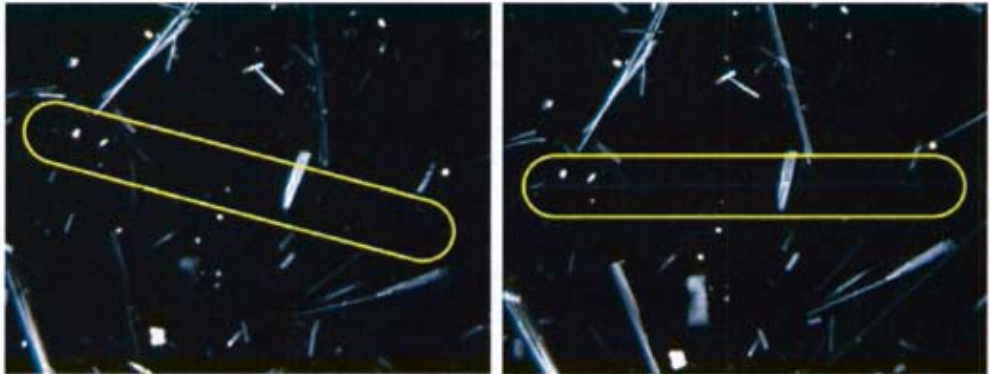


Figure 49. Field of View: 0.5mm; 10 degree extinction angle.

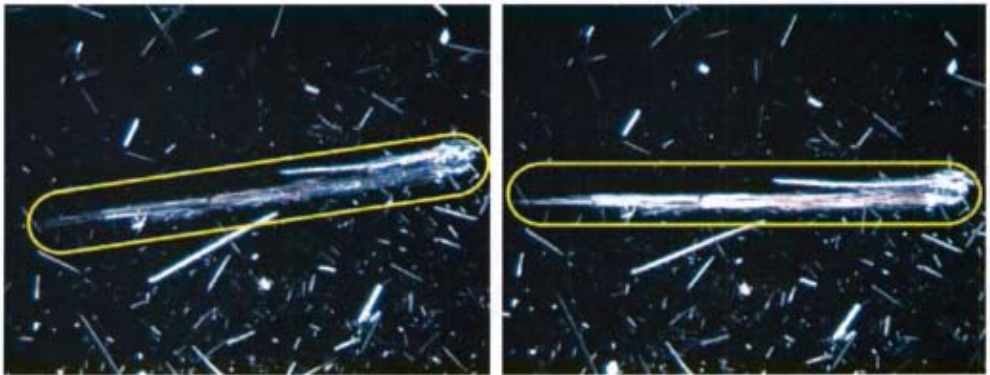


Figure 50. Field of View: 2.5mm; 7 degree extinction angle.

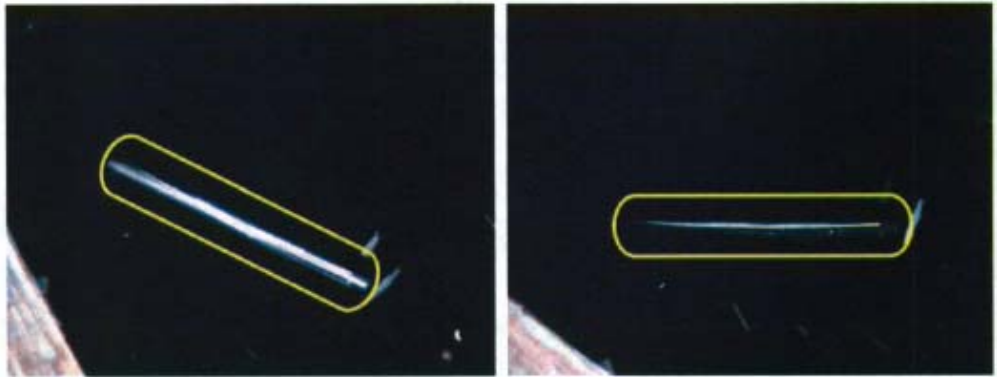


Figure 51. Field of View: 1.0mm; Parallel extinction.

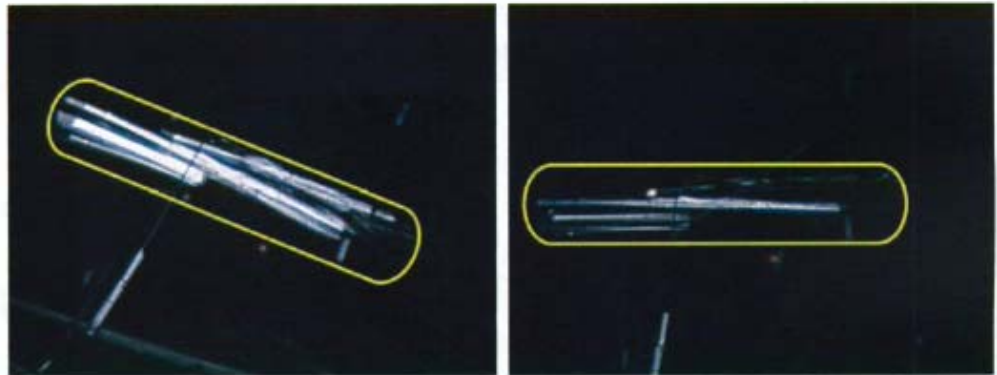


Figure 52. Field of View: 0.5mm; Parallel extinction.

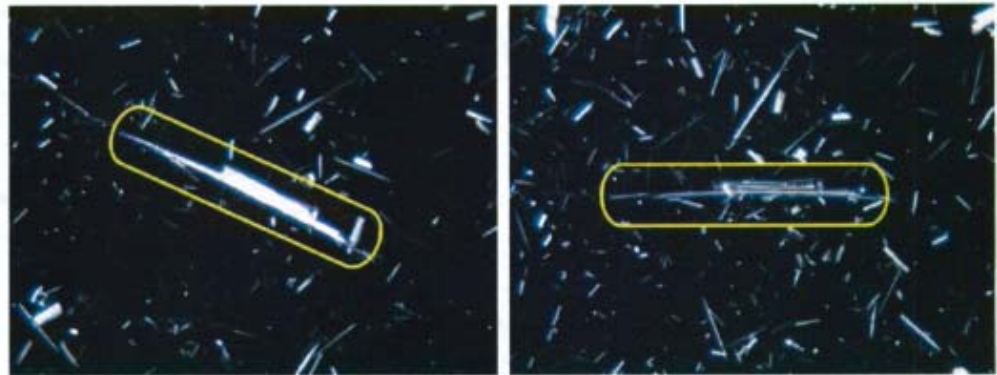


Figure 53. Field of View: 1.0mm; Parallel extinction.

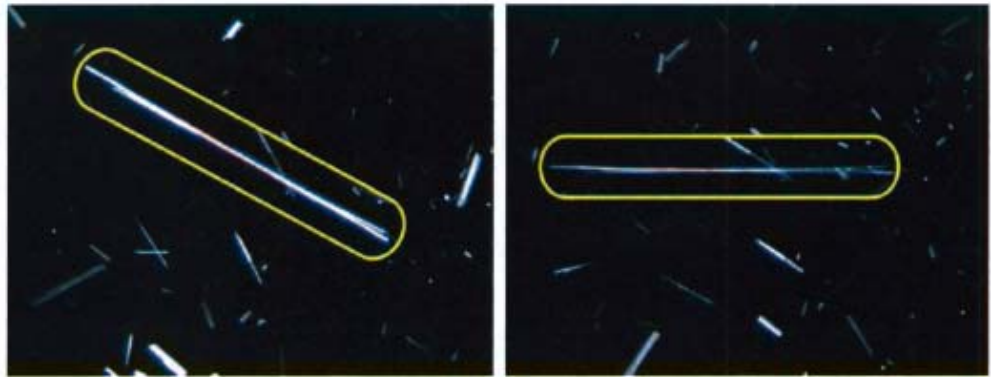


Figure 54. Field of View: 1.0mm; Parallel extinction.

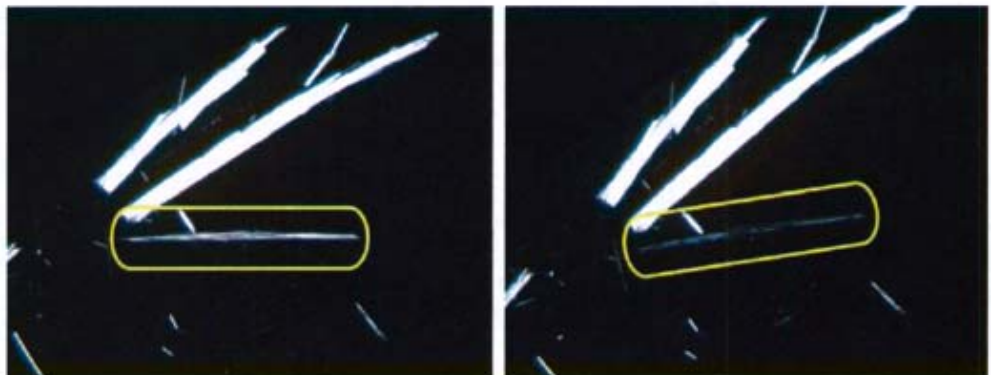


Figure 55. Field of View: 2.5mm; 7 degree extinction angle.

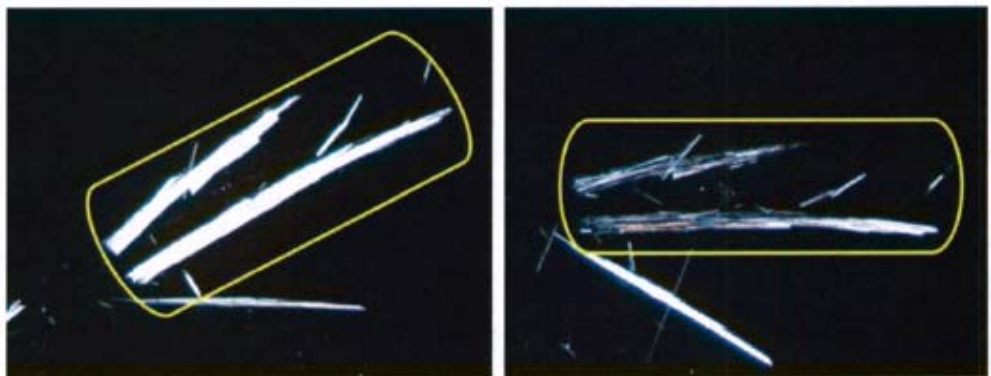


Figure 56. Field of View: 2.5mm; Parallel extinction.

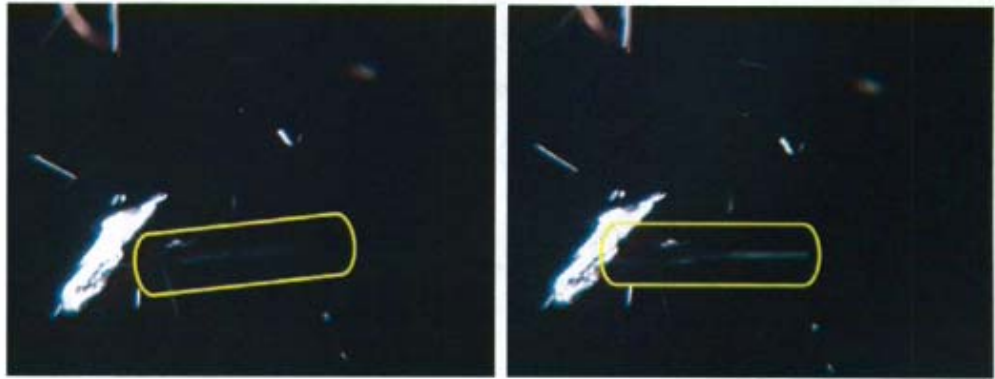


Figure 57. Field of View: 2.5mm; 5 degree extinction angle.

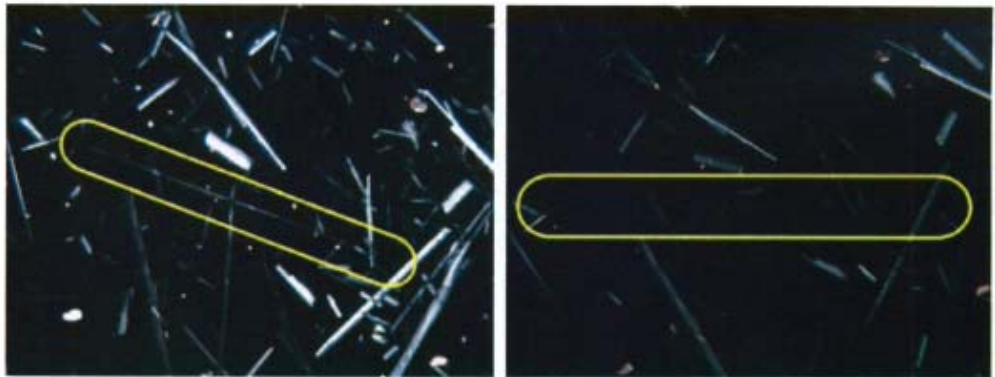


Figure 58. Field of View: 1.0mm; Parallel extinction.

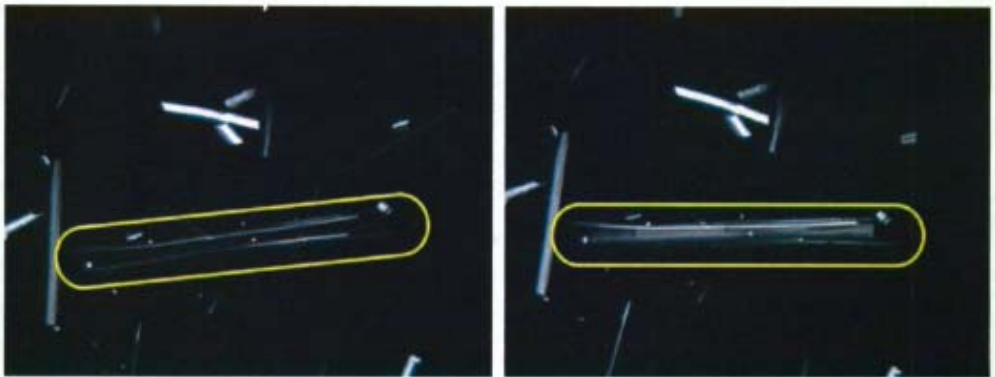


Figure 59. Field of View: 0.5mm; Parallel extinction.

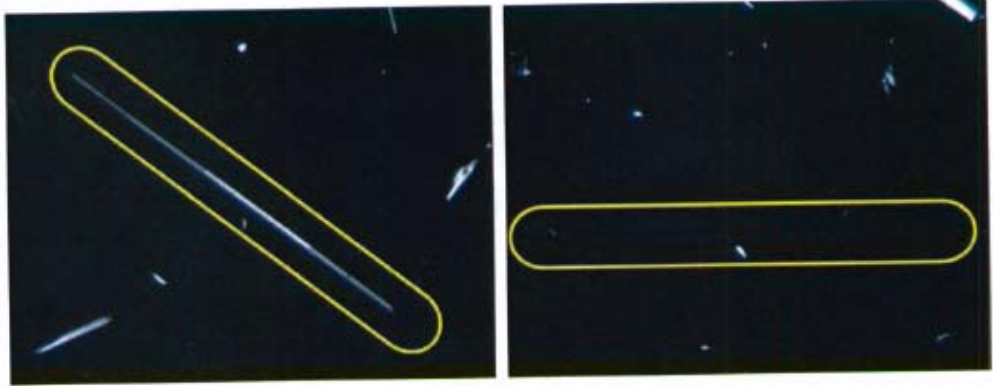


Figure 60. Field of View: 0.5mm; Parallel extinction.

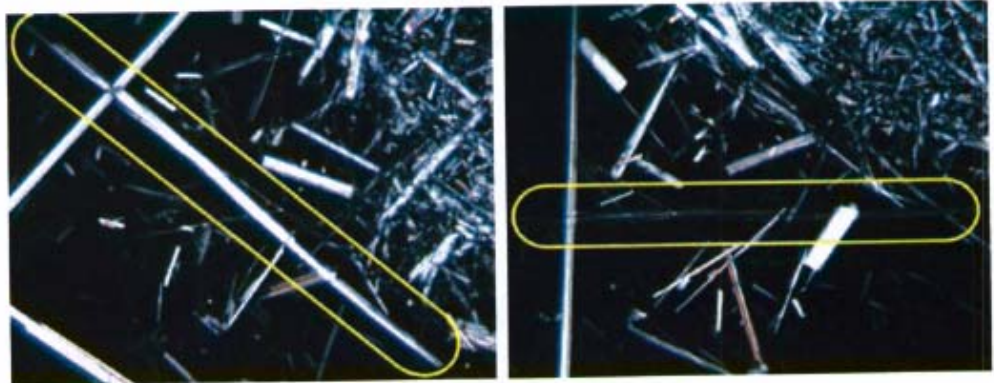


Figure 61. Field of View: 1.0mm; Parallel extinction.

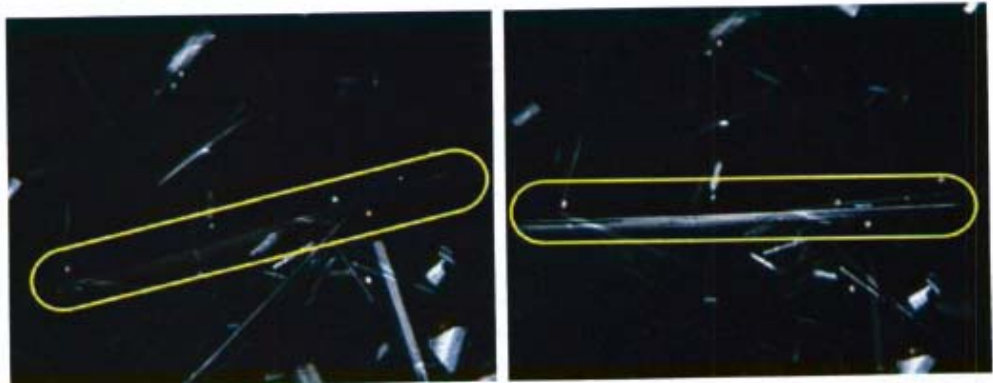


Figure 62. Field of View: 0.5mm; 13 degree extinction angle.



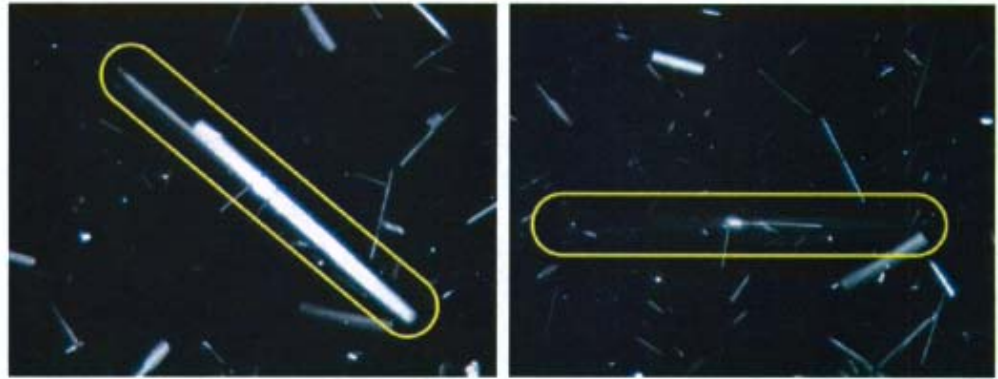


Figure 63. Field of View: 0.5mm; Parallel extinction.

### 2.2.2 Fibers with 2 Criteria of Asbestos

Fibers containing 2 criteria of asbestos are presented in Figure 64 through Figure 89. Two images for each fiber were taken to show the extinct and non-extinct appearance of the fiber. The fiber is circled, and the field of view and measured extinction angle are displayed in each image for clarification.

2.2.2.1 Harvard Way

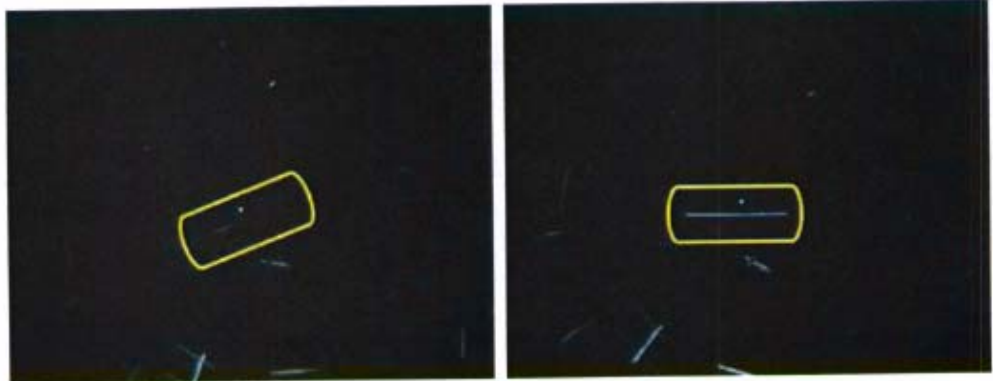


Figure 64. Field of View: 0.5mm; 18 degree extinction angle.

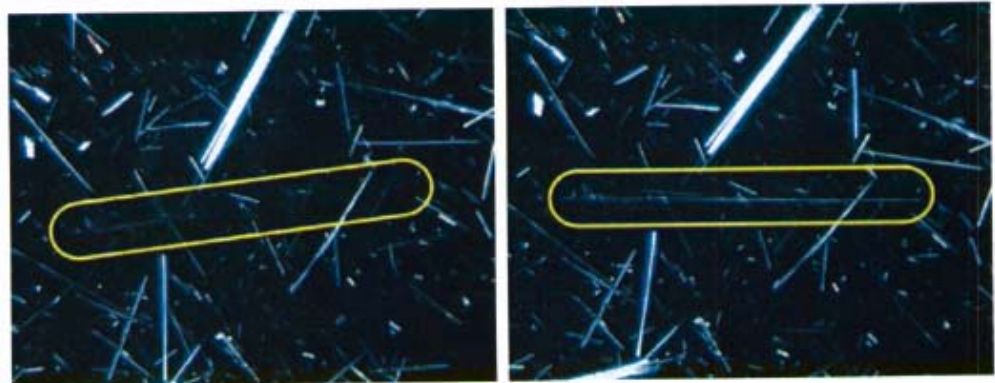


Figure 65. Field of View: 1.0mm; 7 degree extinction angle.

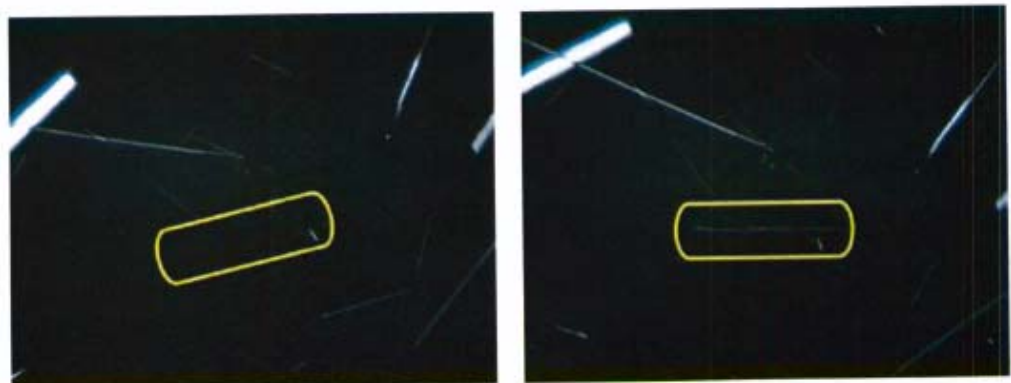


Figure 66. Field of View: 0.5mm; 15 degree extinction angle.

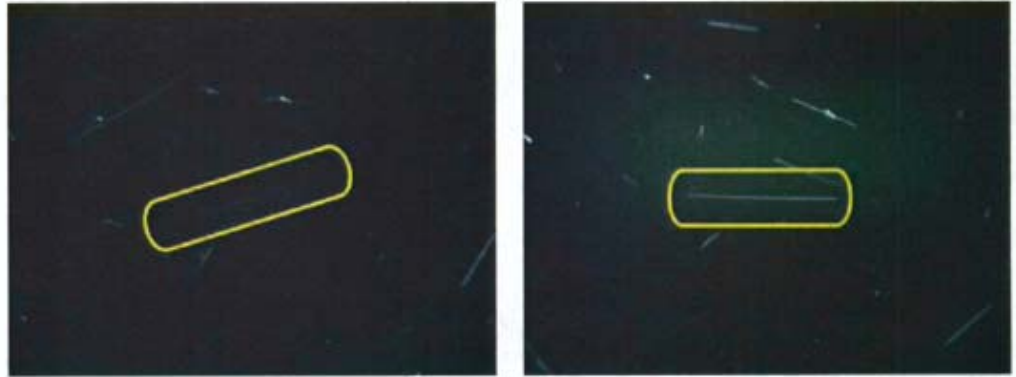


Figure 67. Field of View: 0.5mm; 17 degree extinction angle.

2.2.2.2 Jamestown

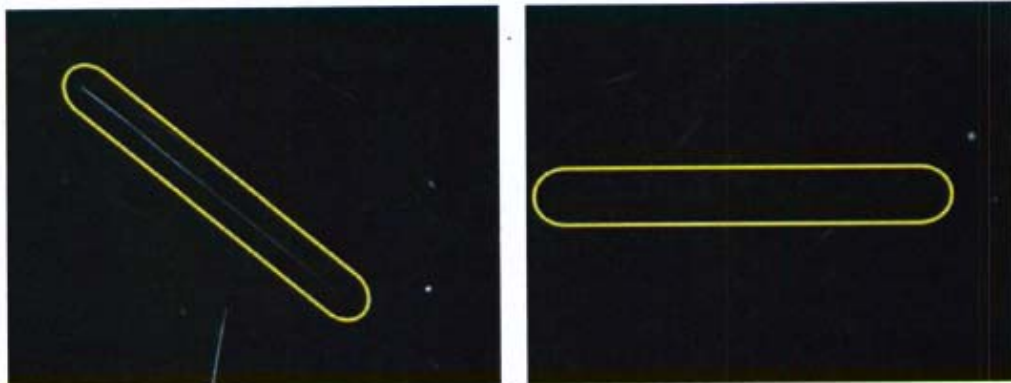


Figure 68. Field of View: 1.0mm; Parallel extinction.

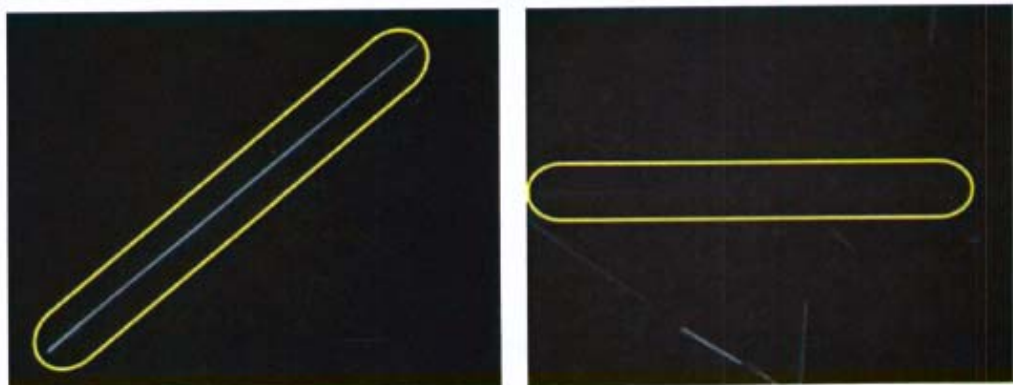


Figure 69. Field of View: 0.5mm; Parallel extinction.

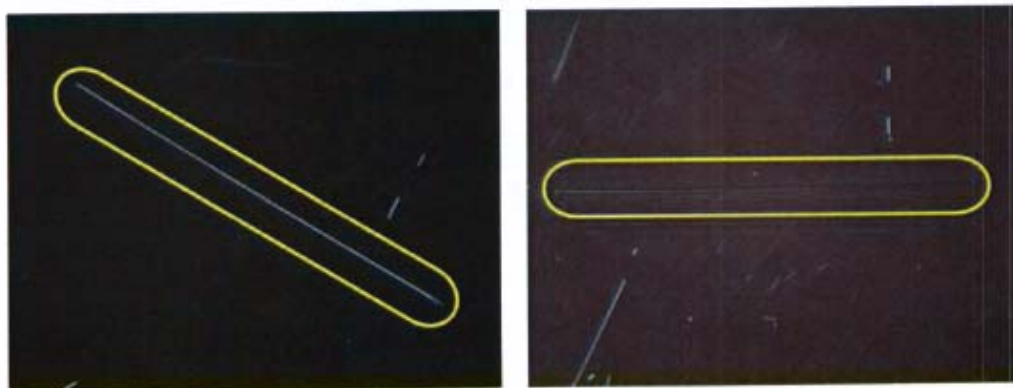


Figure 70. Field of View: 0.5mm; Parallel extinction.

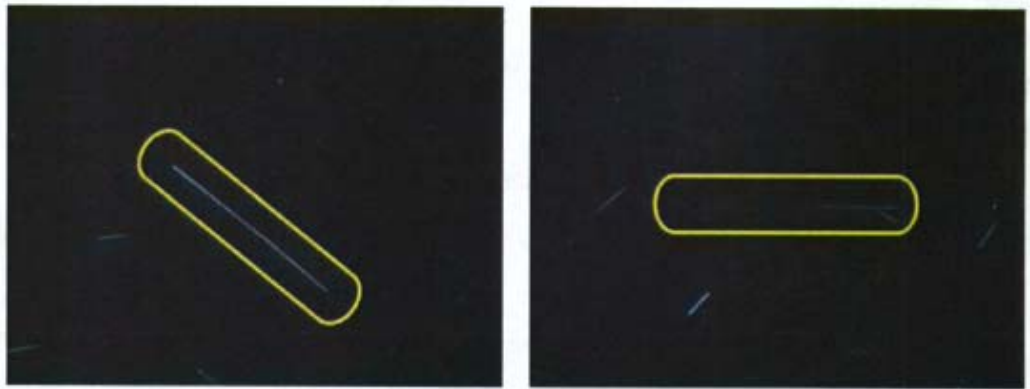


Figure 71. Field of View: 1.0mm; Parallel extinction.



Figure 72. Field of View: 1.0mm; Parallel extinction.

### 2.2.2.3El Dorado Hills Soil

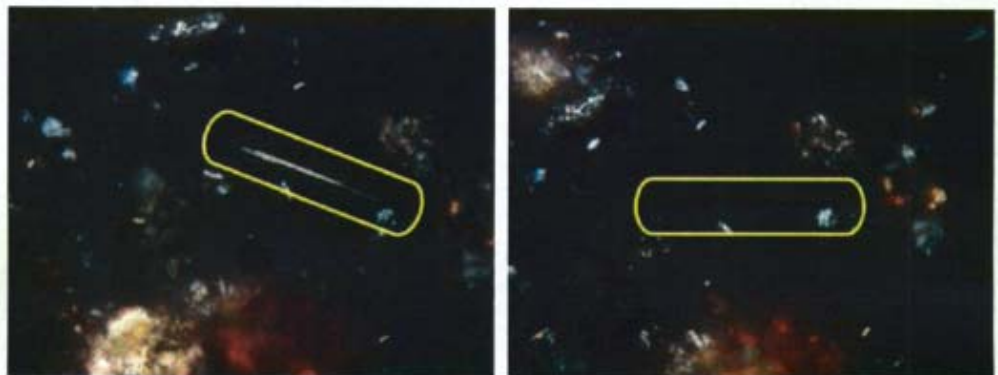


Figure 73. Field of View: 0.5mm; Parallel extinction.

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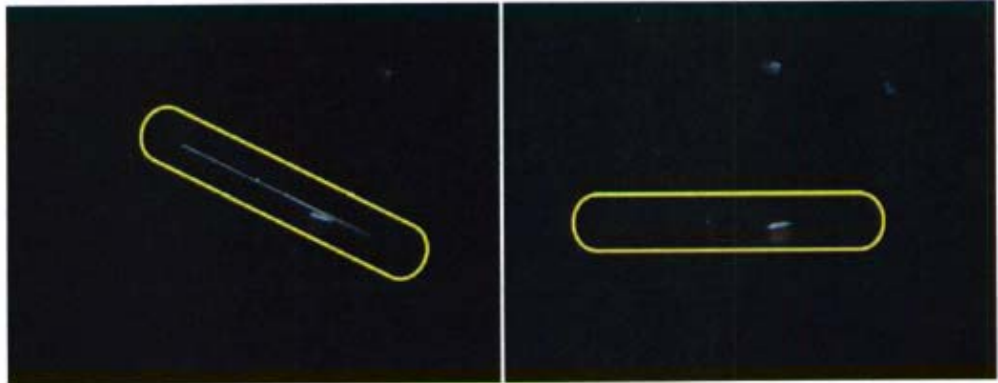


Figure 74. Field of View: 0.5mm; Parallel extinction.

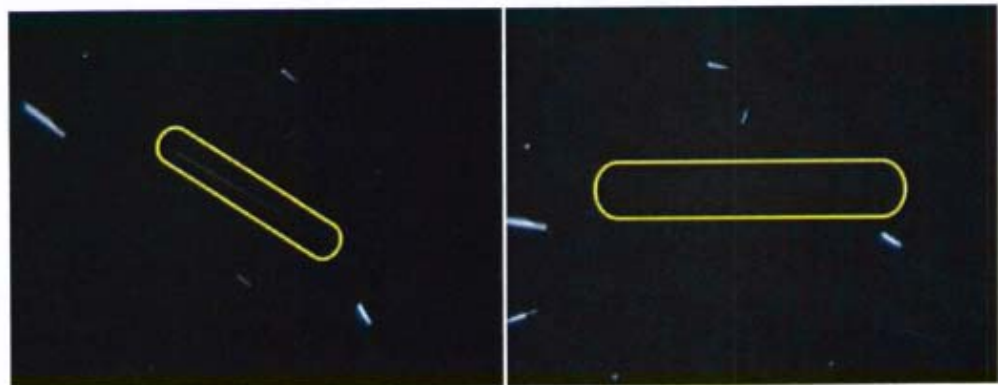


Figure 75. Field of View: 0.5mm; Parallel extinction.

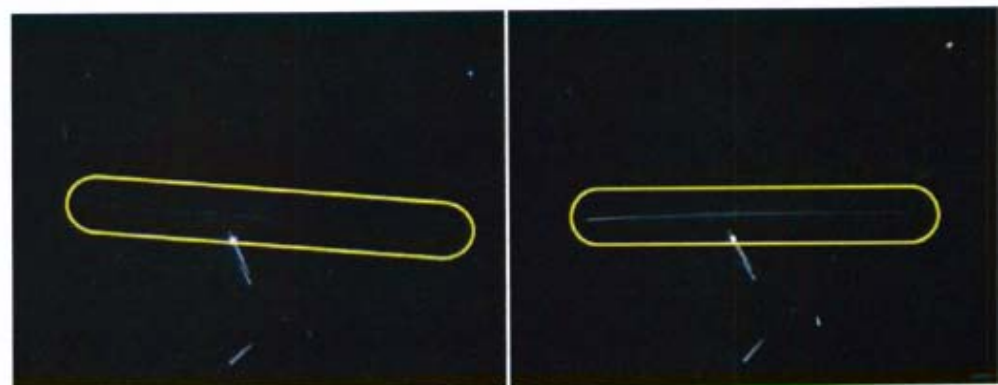


Figure 76. Field of View: 0.5mm; 6 degree extinction angle.

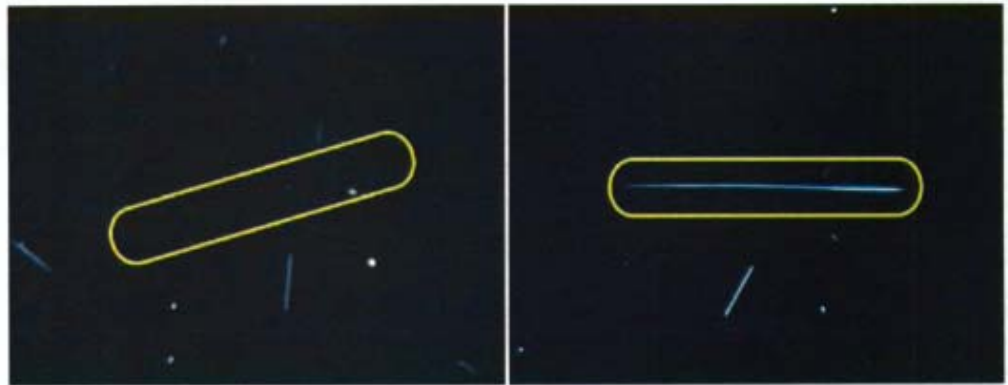


Figure 77. Field of View: 1.0mm; 23 degree extinction angle.

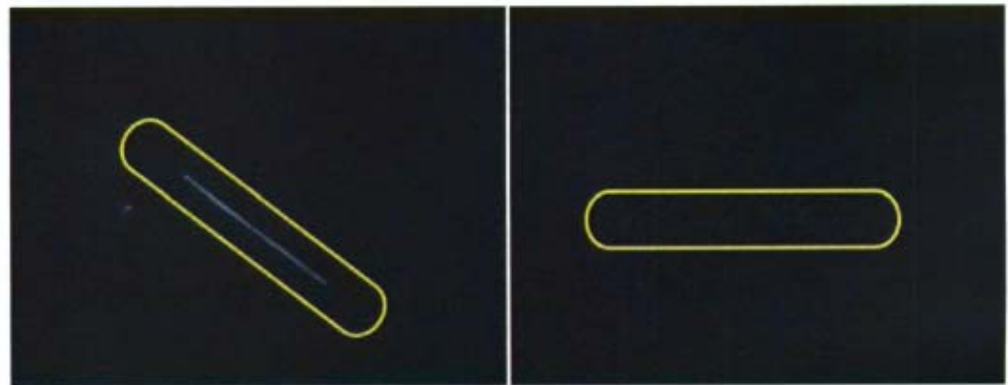


Figure 78. Field of View: 0.5mm; Parallel extinction.

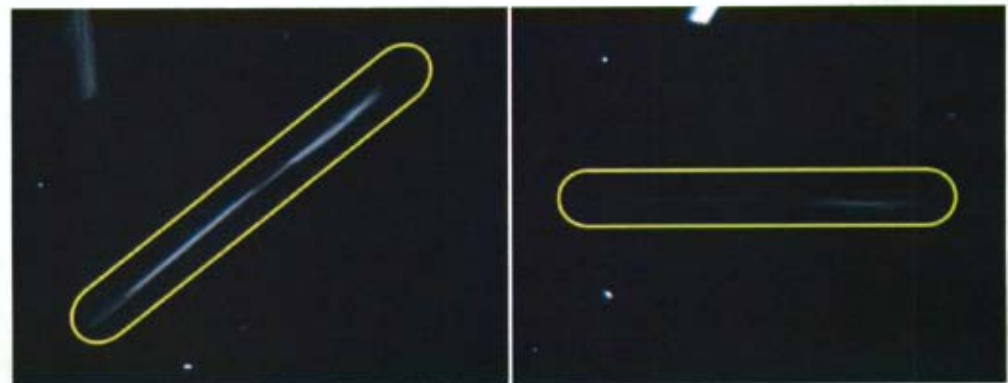


Figure 79. Field of View: 0.5mm; Parallel extinction.

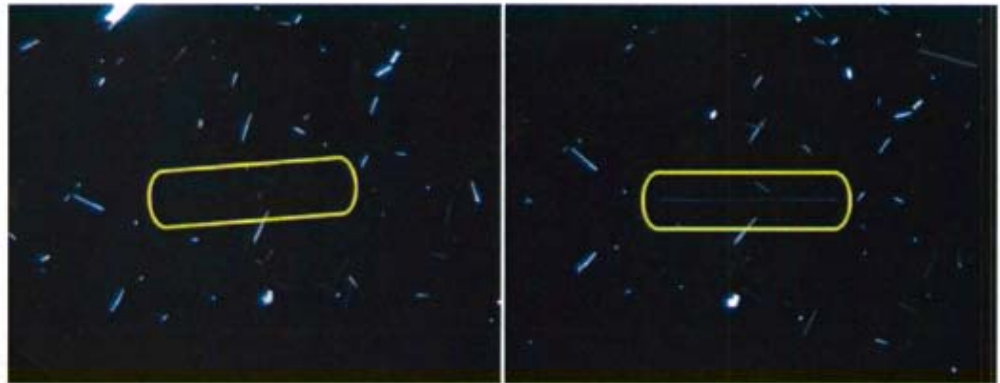


Figure 80. Field of View: 1.0mm; 15 degree extinction angle.

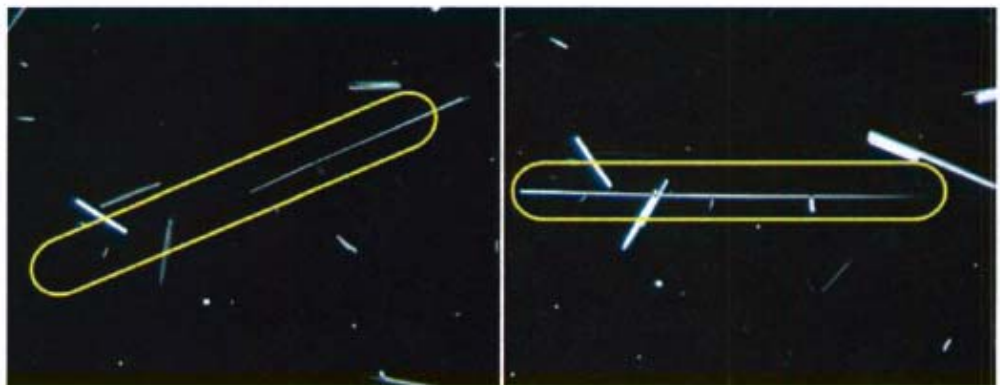


Figure 81. Field of View: 1.0 mm; Parallel extinction.

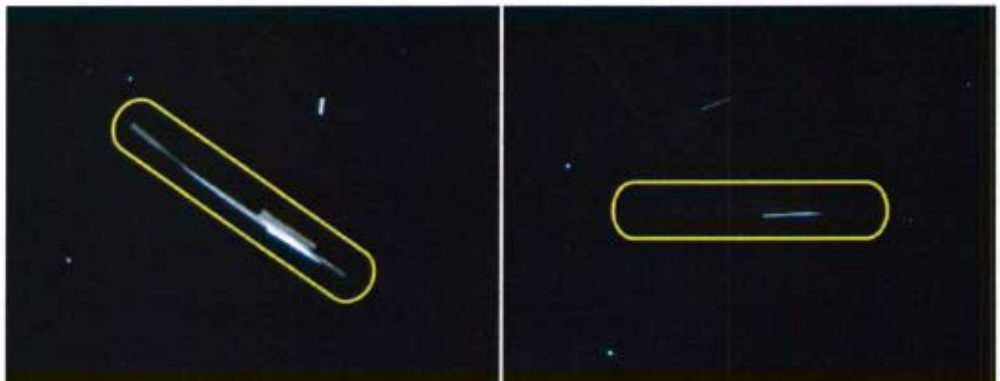


Figure 82. Field of View: 0.5mm; Parallel extinction.



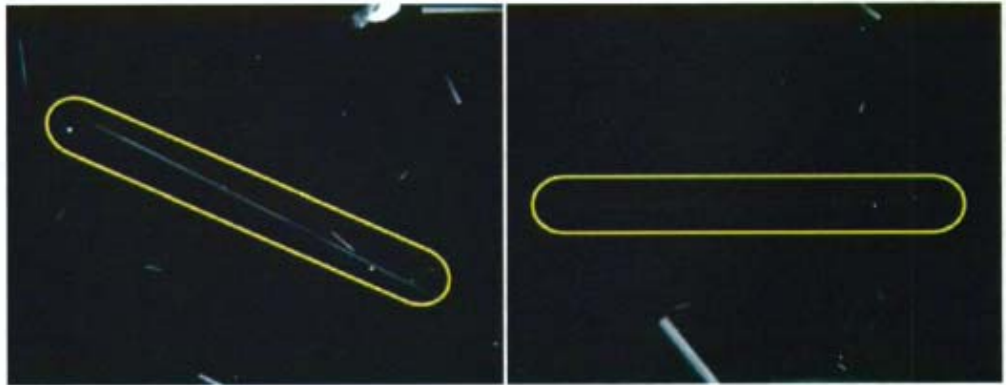


Figure 83. Field of View: 0.5mm; Parallel extinction.

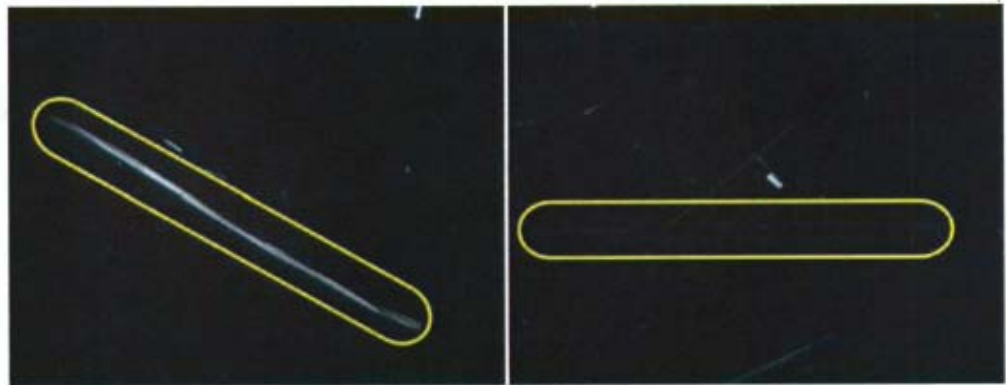


Figure 84. Field of View: 0.5 mm; Parallel extinction.

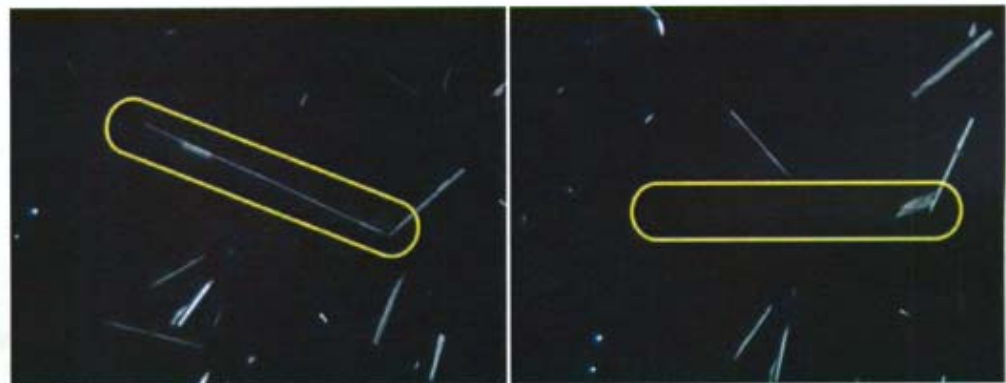


Figure 85. Field of View: 0.5mm; Parallel extinction.

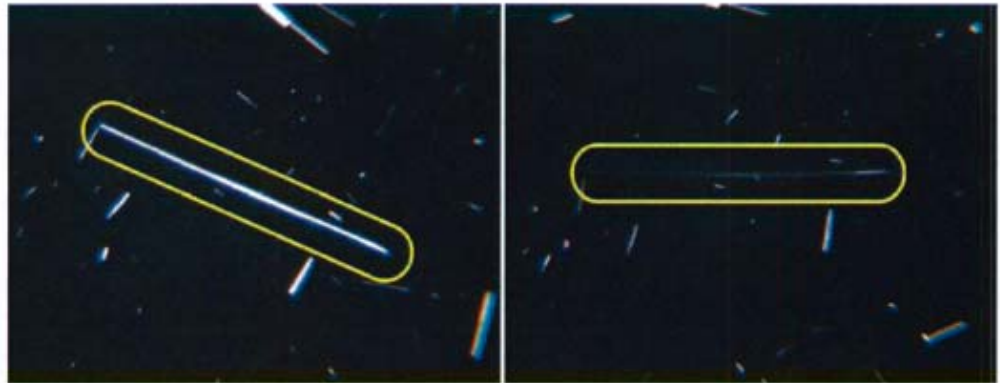


Figure 86. Field of View: 2.5mm; Parallel extinction.

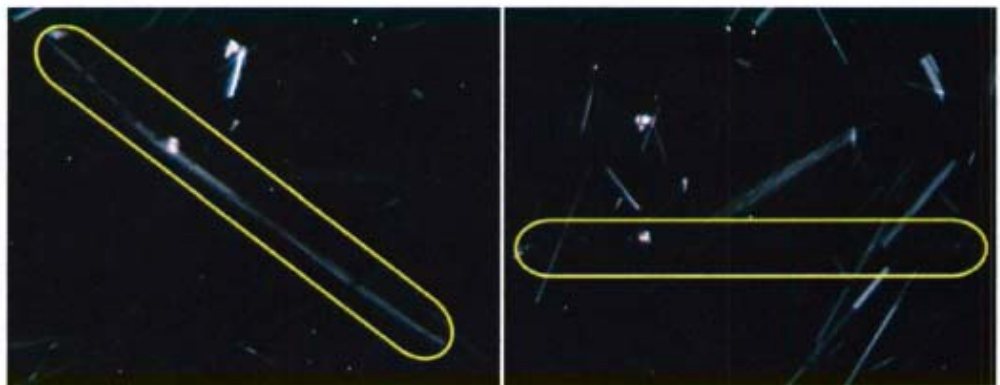


Figure 87. Field of View: 0.25mm; Parallel extinction.

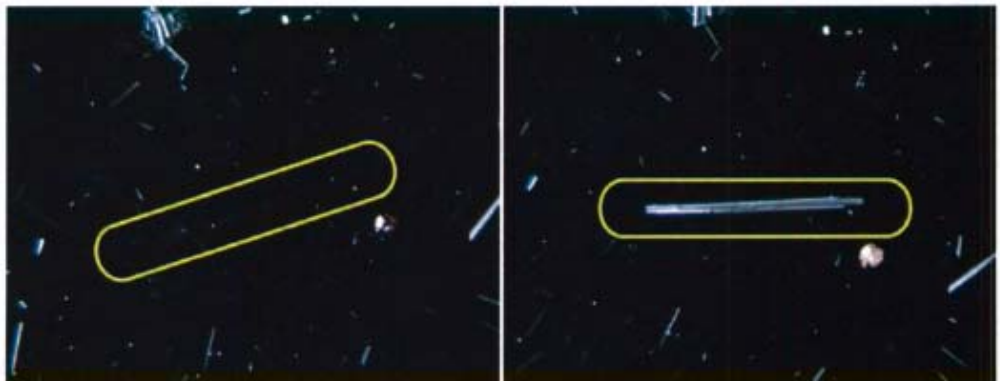


Figure 88. Field of View: 1.0mm; 17 degree extinction angle.

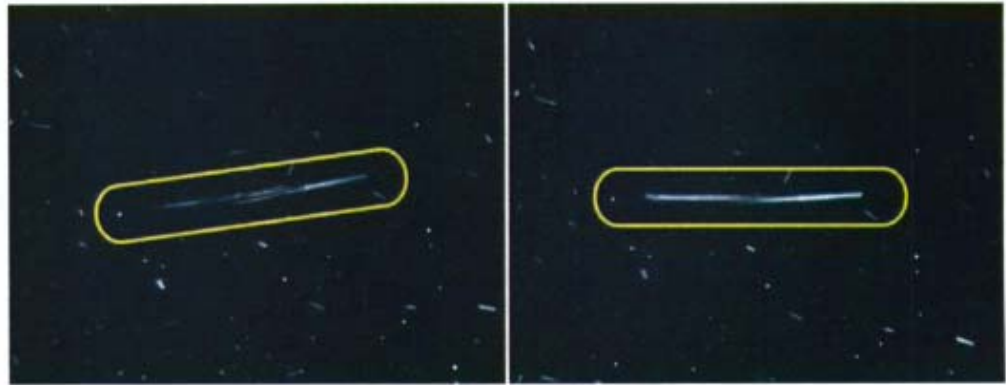


Figure 89. Field of View: 2.5mm; 8 degree extinction angle.

### 2.2.3 Fibers with No Criteria of Asbestos

Fibers containing none of the criteria of asbestos are presented in Figure 90 through Figure 163. Two images for each fiber were taken to show the extinct and non-extinct appearance of the fiber. The fiber is circled, and the field of view and measured extinction angle are displayed in each image for clarification.

2.2.3.1 Harvard Way

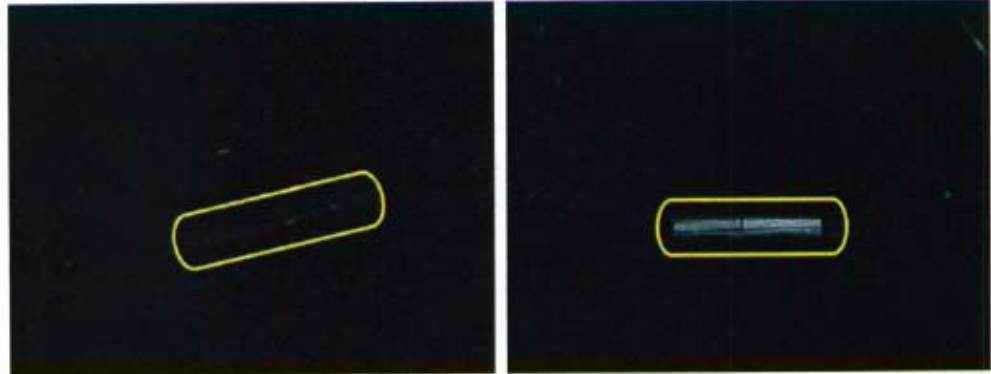


Figure 90. Field of View: 0.5mm; 16 degree extinction angle.

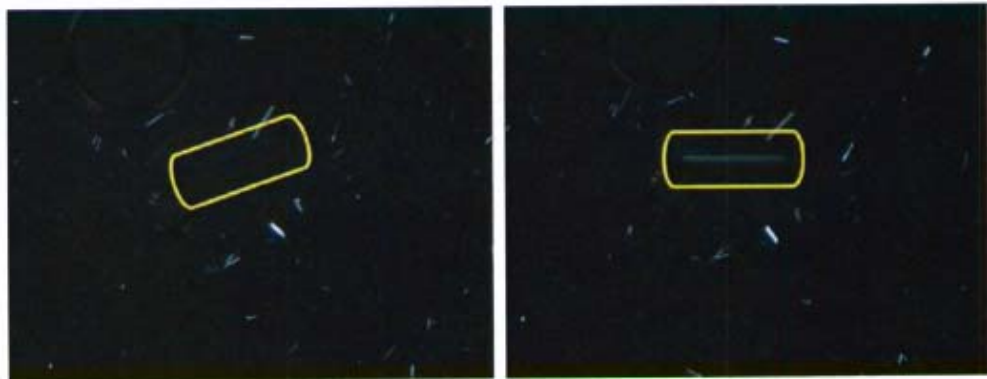


Figure 91. Field of View: 0.5mm; 10 degree extinction angle.

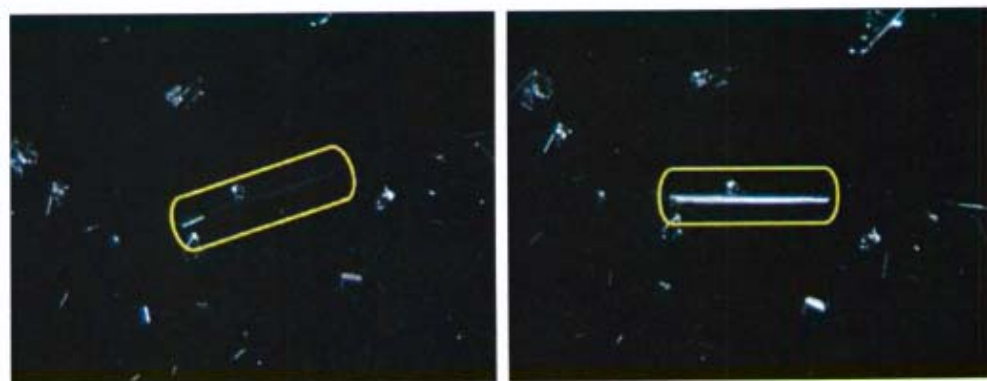


Figure 92. Field of View: 1.0, 16 degree extinction angle.

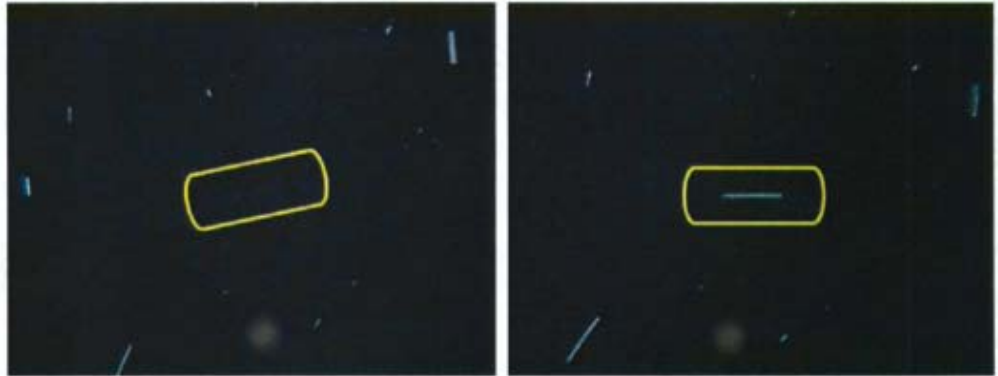


Figure 93. Field of View: 1.0mm; 13 degree extinction angle.



Figure 94. Field of View: 1.0mm; Parallel extinction.

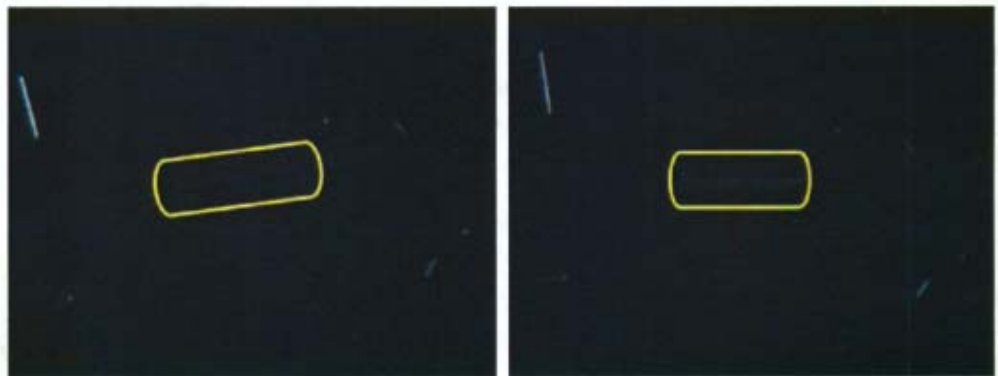


Figure 95. Field of View: 0.5mm; 7 degree extinction angle.

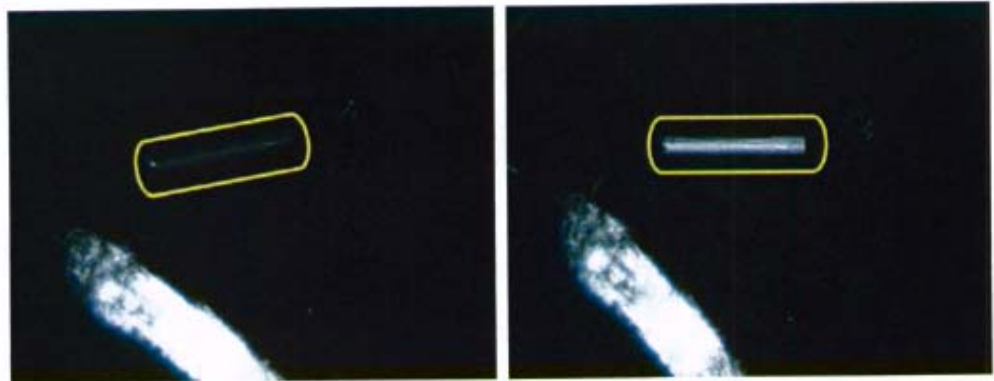


Figure 96. Field of View: 0.5mm; 10 degree extinction angle.



Figure 97. Field of View: 0.5mm; 11 degree extinction angle.

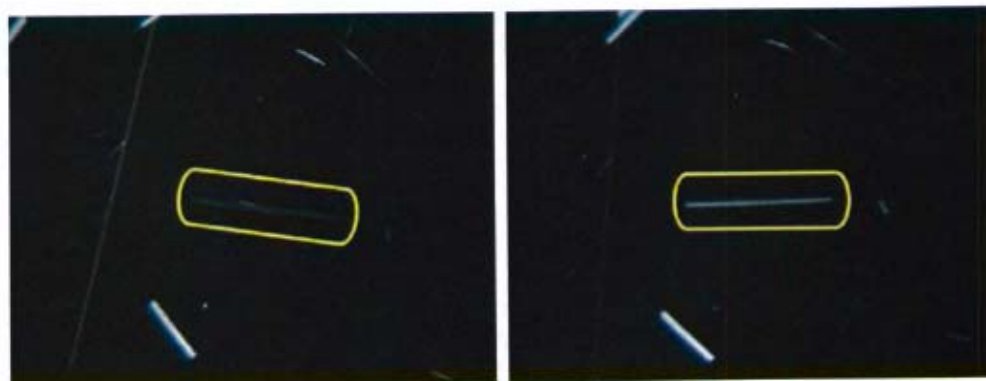


Figure 98. Field of View: 0.5mm; 8 degree extinction angle.



Figure 99. Field of View: 0.5mm; 11 degree extinction angle.

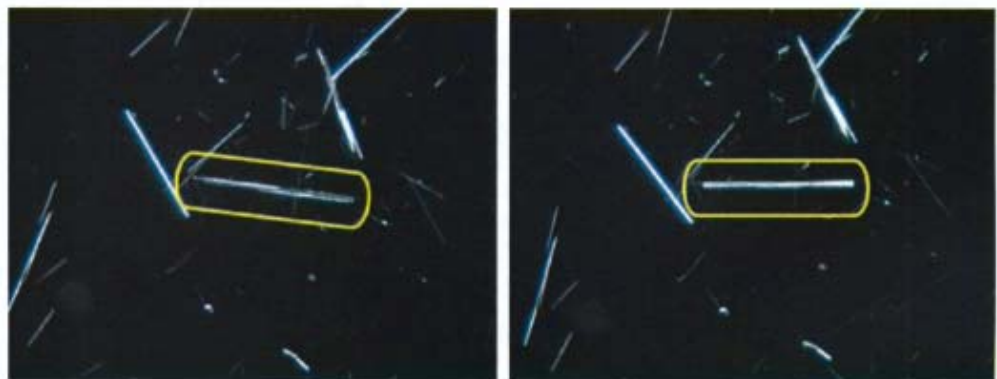


Figure 100. Field of View: 1.0mm; 6 degree extinction angle.



Figure 101. Field of View: 1.0mm; 6 degree extinction angle.

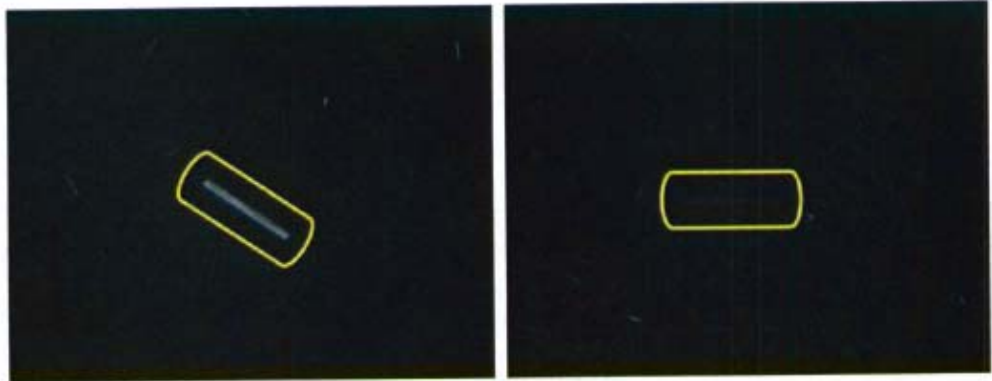


Figure 102. Field of View: 0.5mm; Parallel extinction.

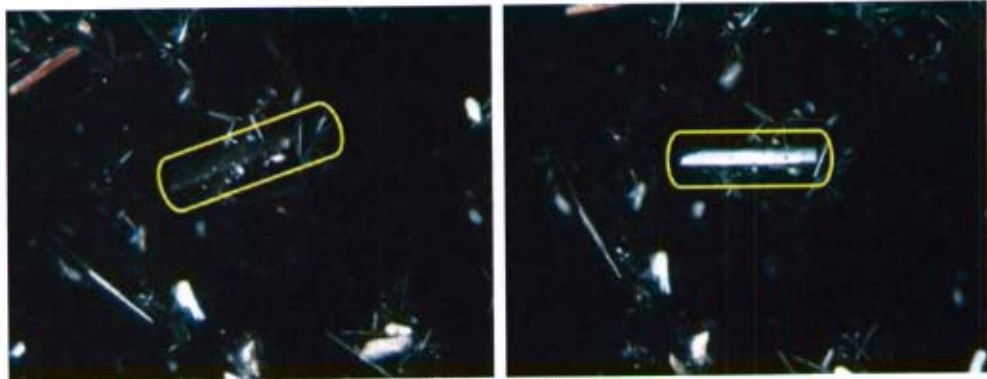


Figure 103. Field of View: 0.5mm; 20 degree extinction angle.

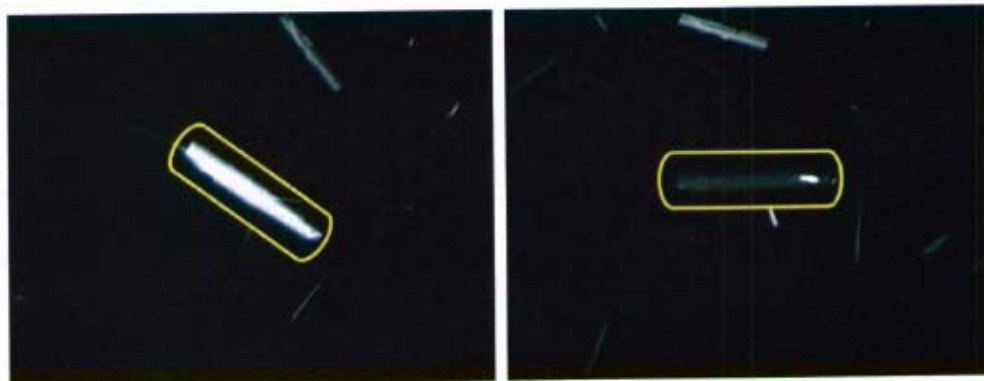


Figure 104. Field of View: 0.5mm; Parallel extinction.



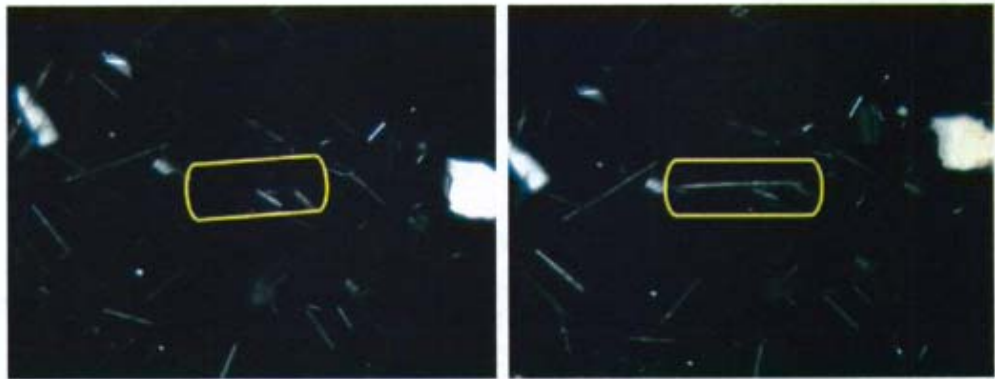


Figure 105. Field of View: 0.5mm; 10 degree extinction angle.

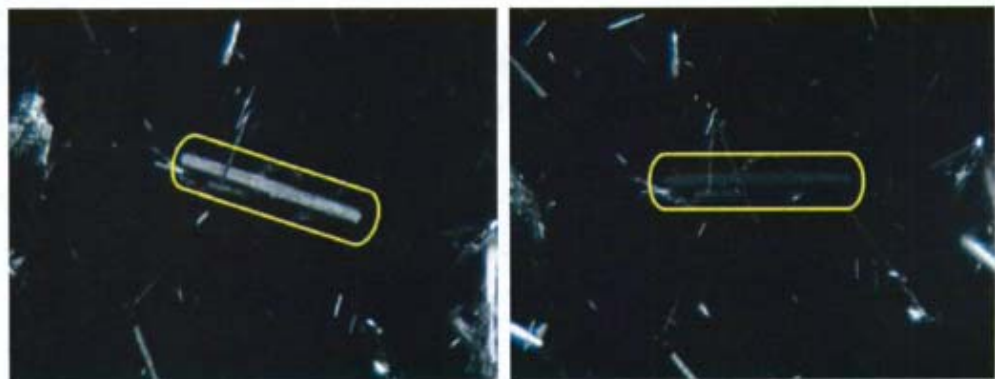


Figure 106. Field of View: 0.5mm; Parallel extinction.

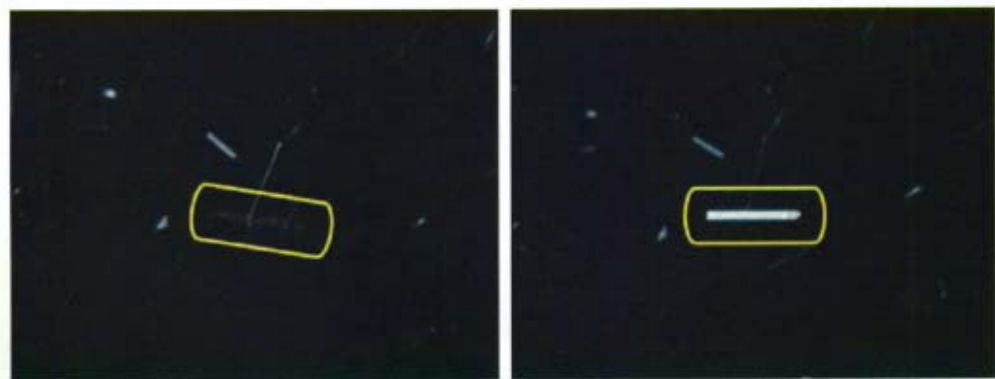


Figure 107. Field of View: 0.5mm; 8 degree extinction angle.

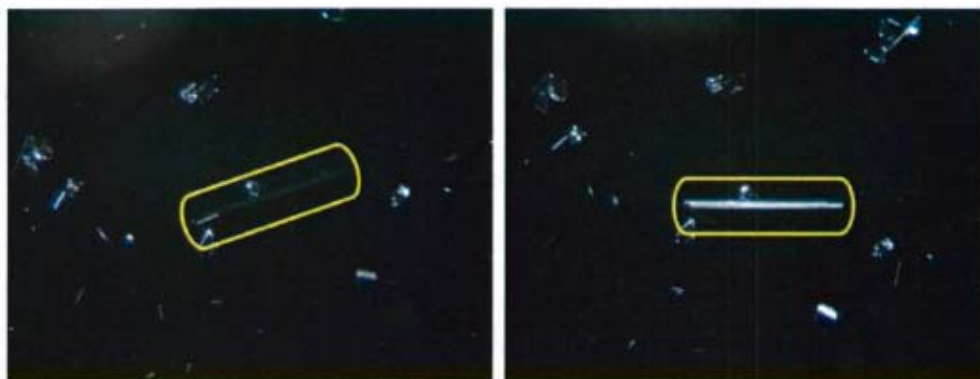


Figure 108. Field of View: 1.0mm; 18 degree extinction angle.

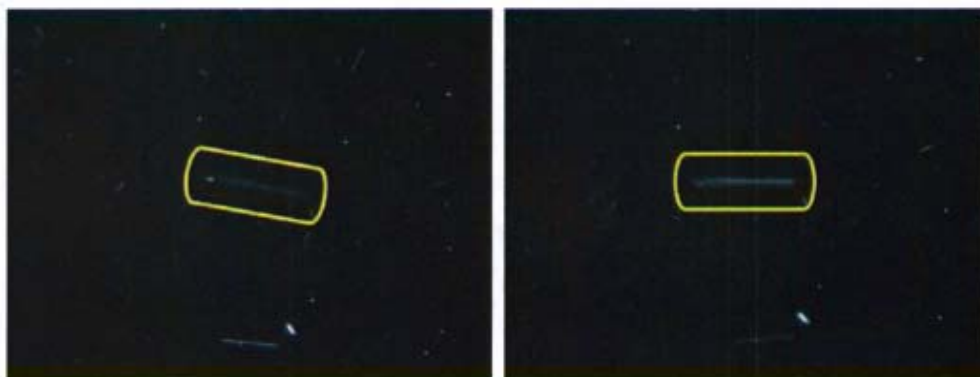


Figure 109. Field of View:0.5mm; 11 degree extinction angle.

2.2.3.2 Jamestown

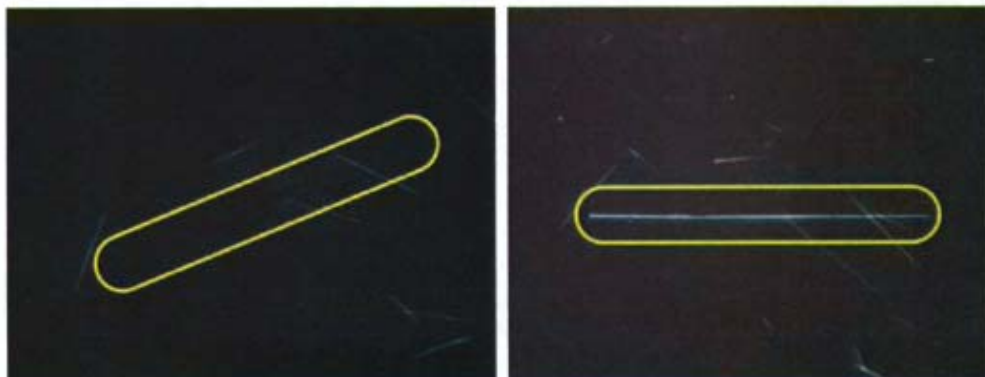


Figure 110. Field of View: 0.5mm; 20 degree extinction angle.

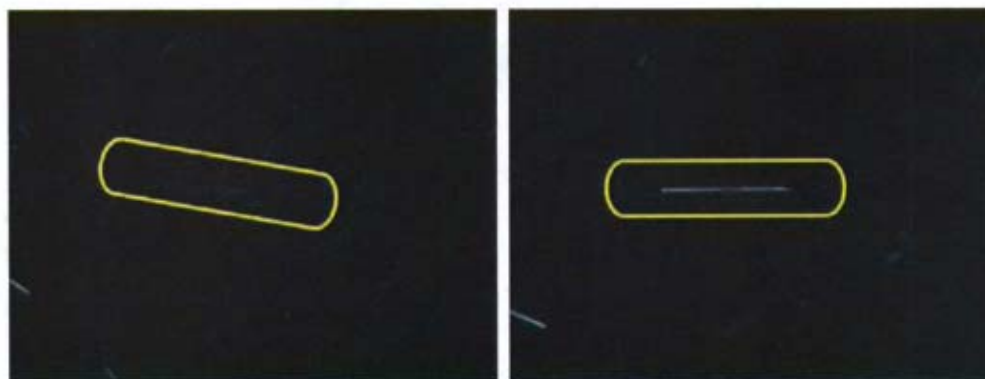


Figure 111. Field of View: 0.5mm; 10 degree extinction angle.

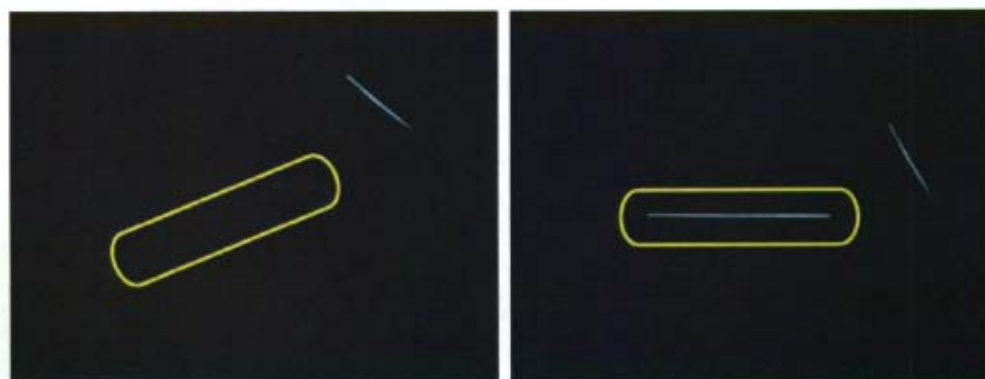


Figure 112. Field of View: 0.5mm; 19 degree extinction angle.

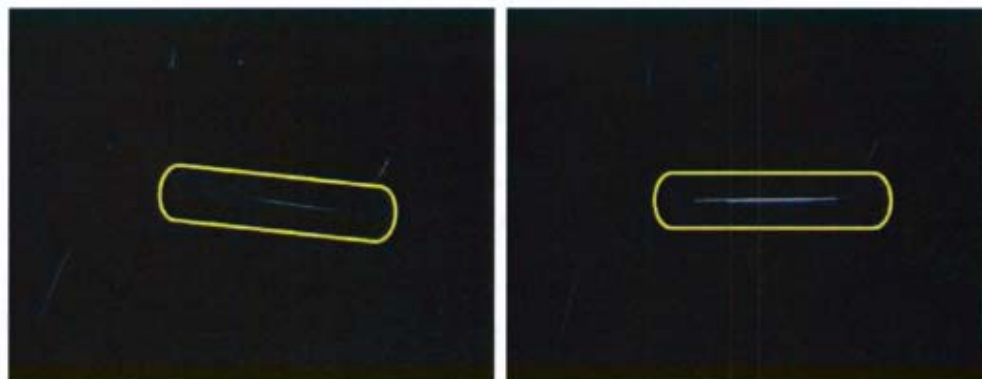


Figure 113. Field of View: 0.5mm; 10 degree extinction angle.

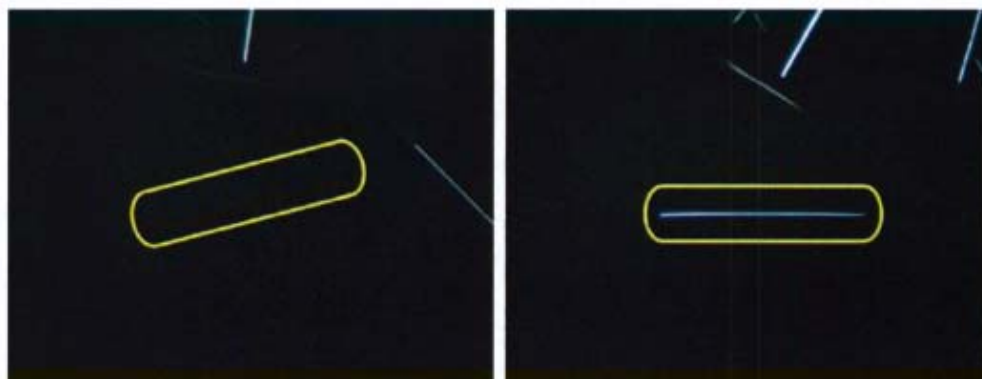


Figure 114. Field of View: 1.0mm; 22 degree extinction angle.

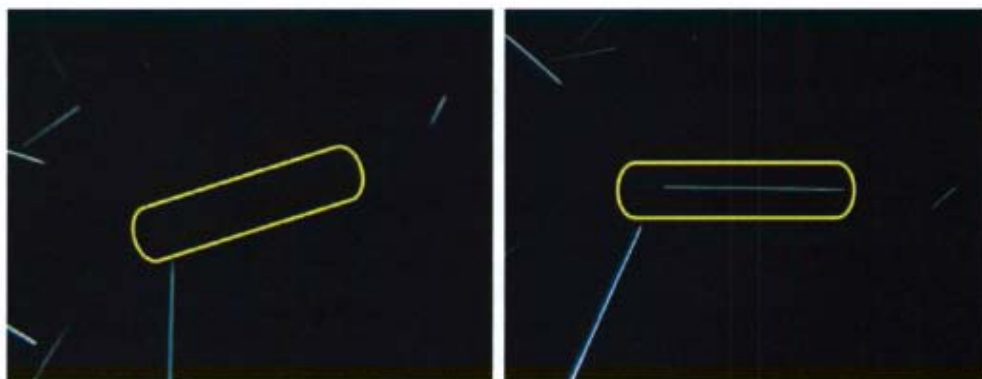


Figure 115. Field of View: 1.0mm; 24 degree extinction angle.

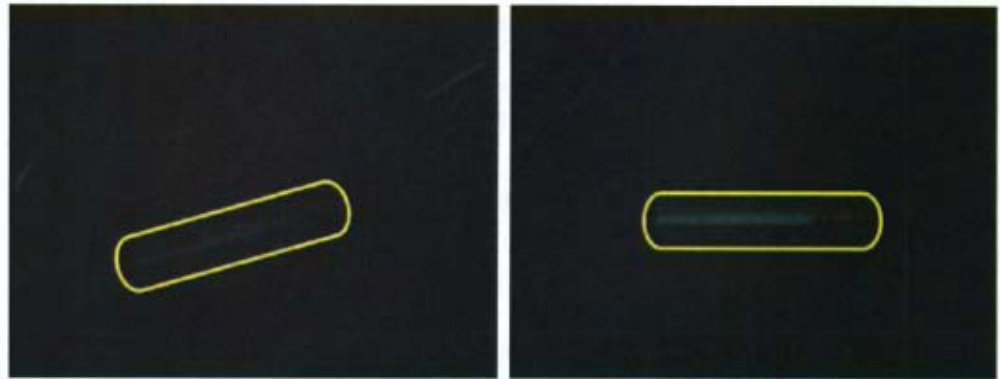


Figure 116. Field of View: 0.25mm; 17 degree extinction angle.

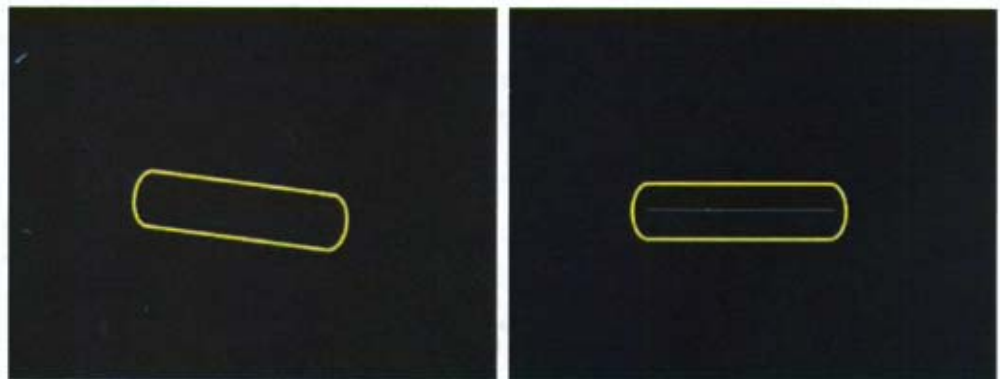


Figure 117. Field of View: 1.0mm; 7 degree extinction angle.

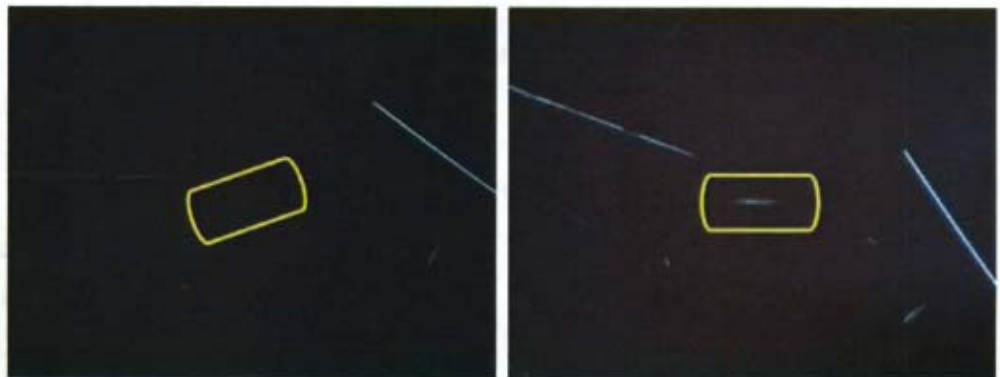


Figure 118. Field of View: 0.5mm; 20 degree extinction angle.

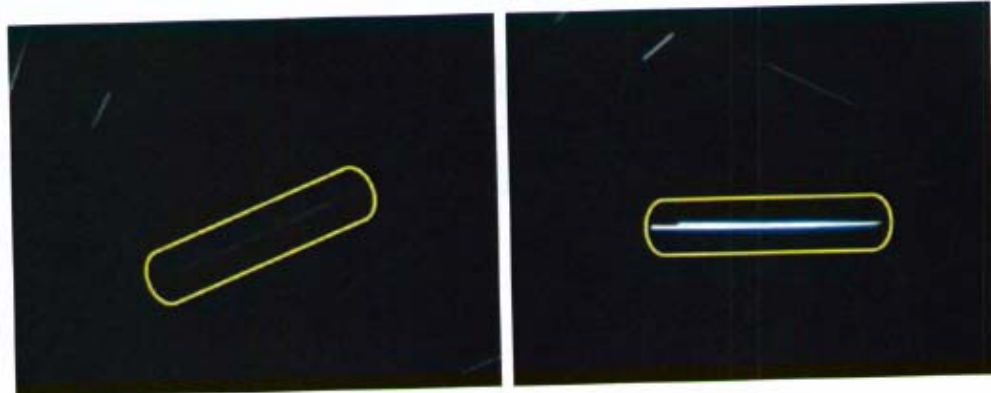


Figure 119. Field of View: 0.5mm; 23 degree extinction angle.

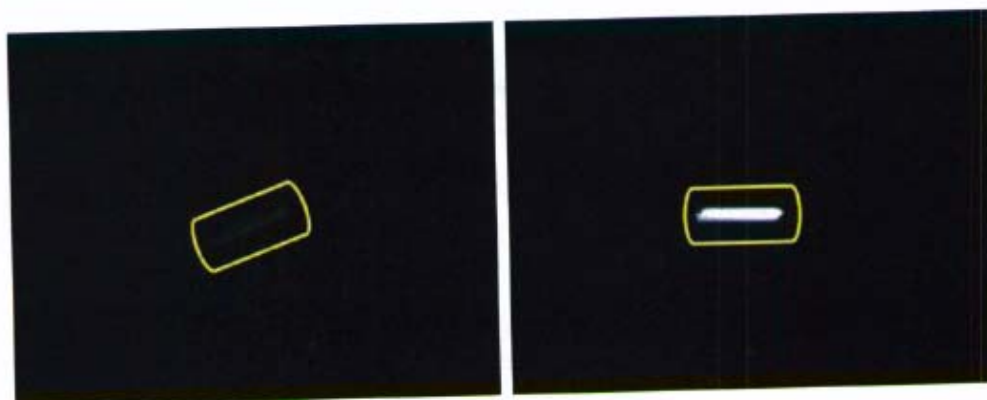


Figure 120. Field of View: 1.0mm; 22 degree extinction angle.

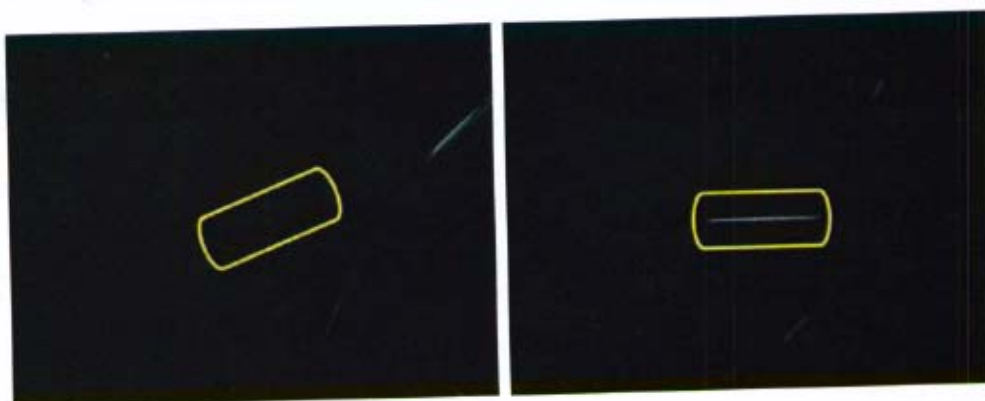


Figure 121. Field of View: 0.5mm; 22 degree extinction angle.

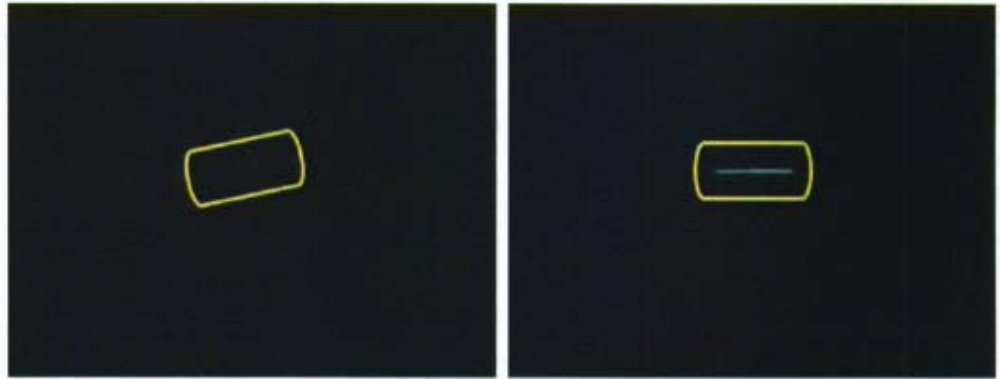


Figure 122. Field of View: 0.5mm; 10 degree extinction angle.

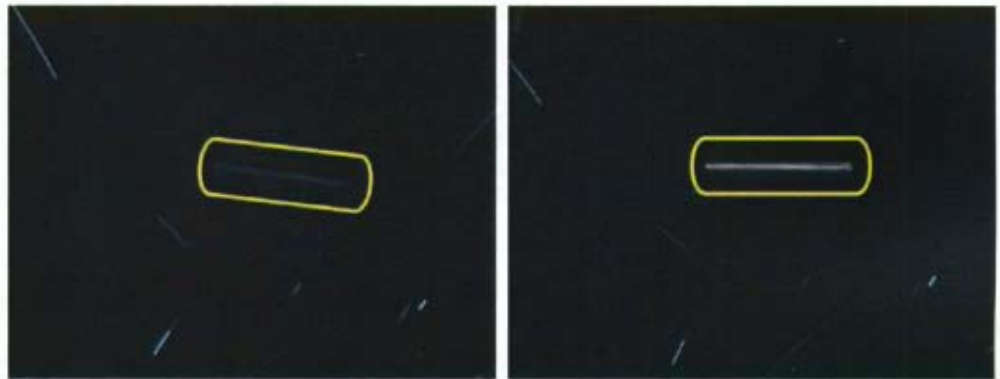


Figure 123. Field of View: 0.5mm; 7 degree extinction angle.

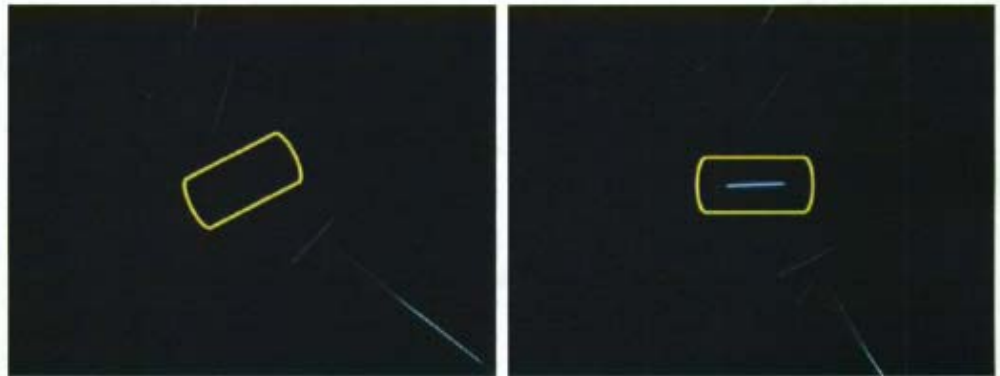


Figure 124. Field of View: 0.5mm; 23 degree extinction angle.

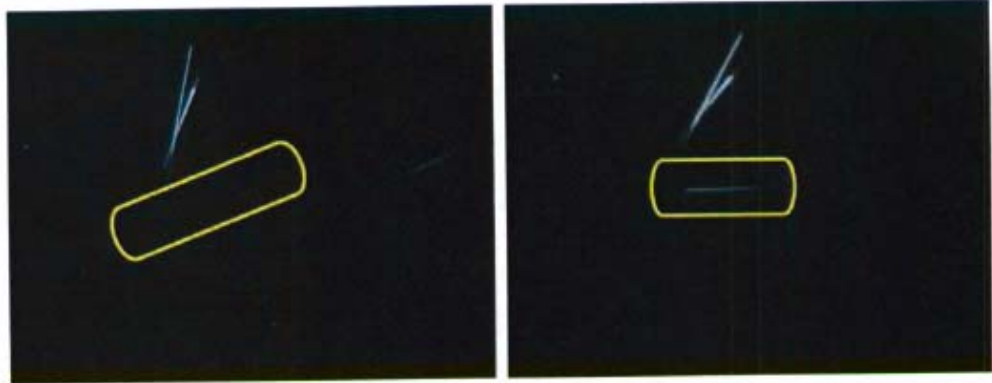


Figure 125. Field of View: 0.5mm; 14 degree extinction angle.

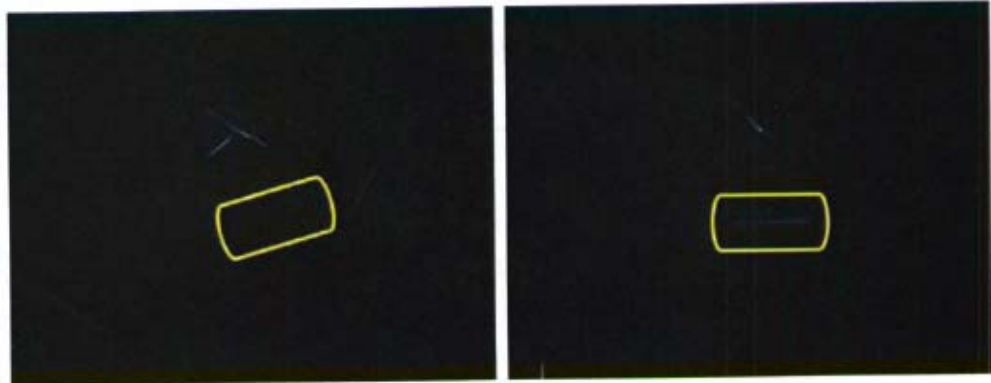


Figure 126. Field of View: 0.5mm; 16 degree extinction angle.

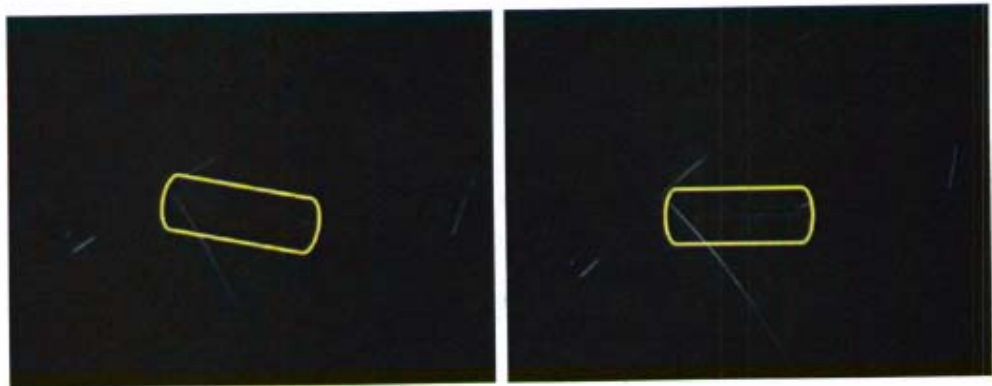


Figure 127. Field of View: 0.5mm; 15 degree extinction angle.



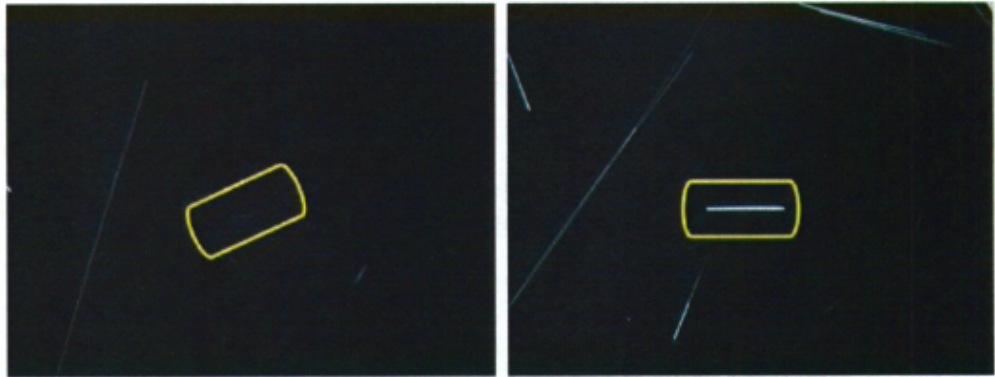


Figure 128. Field of View: 0.5mm; 19 degree extinction angle.

2.2.3.3 El Dorado Hills Soil

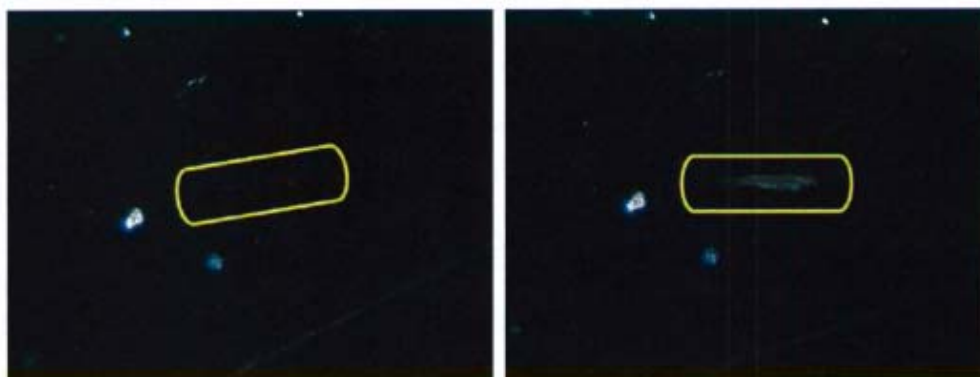


Figure 129. Field of View: 0.5mm; 4 degree extinction angle.



Figure 130. Field of View: 0.5mm; 22 degree extinction angle.

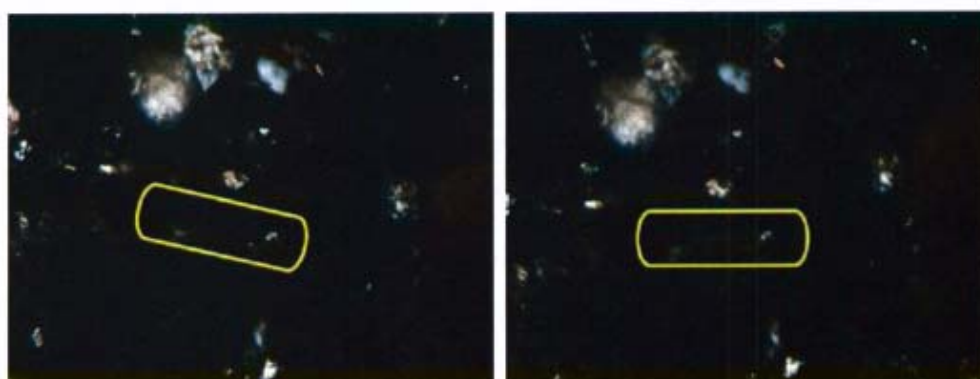


Figure 131. Field of View: 0.5mm; 14 degree extinction angle.

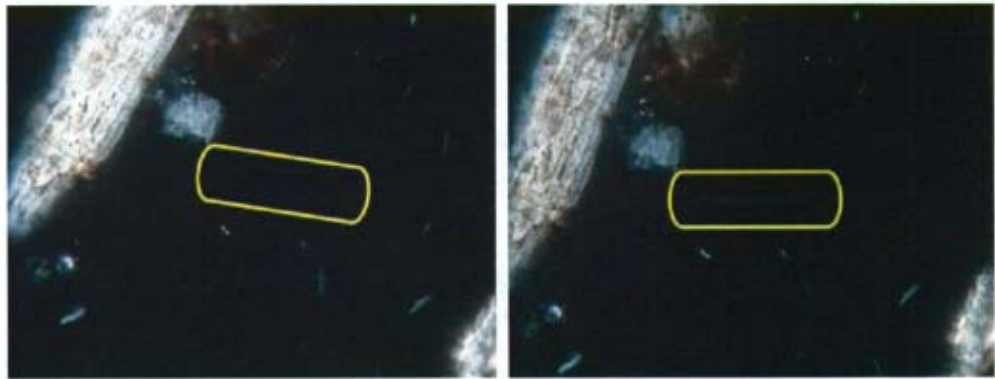


Figure 132. Field of View: 0.25mm; 10 degree extinction angle.

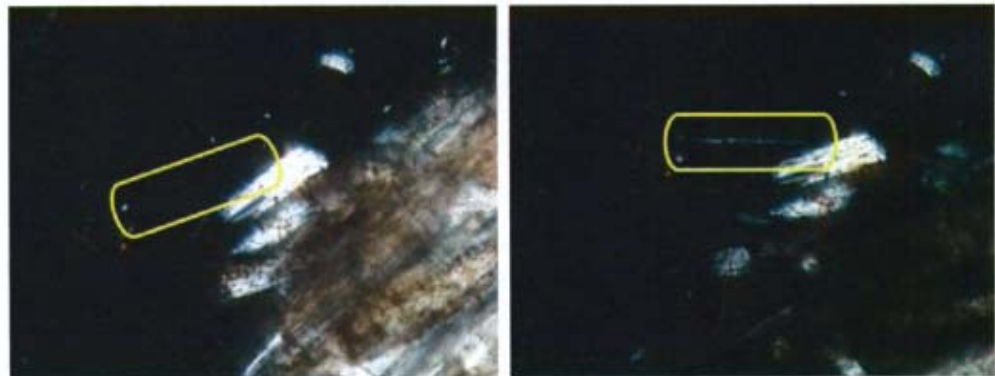


Figure 133. Field of View: 0.25mm; 16 degree extinction angle.

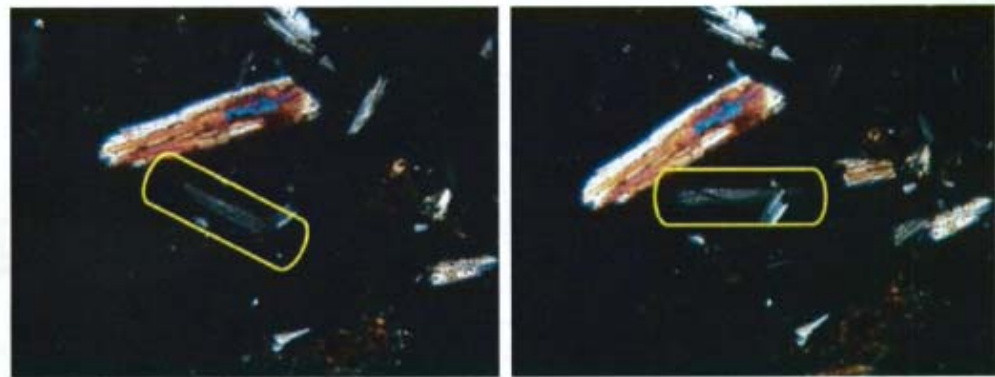


Figure 134. Field of View: 0.25mm; 13 degree extinction angle.



Figure 135. Field of View: 0.25mm; 28 degree extinction angle.

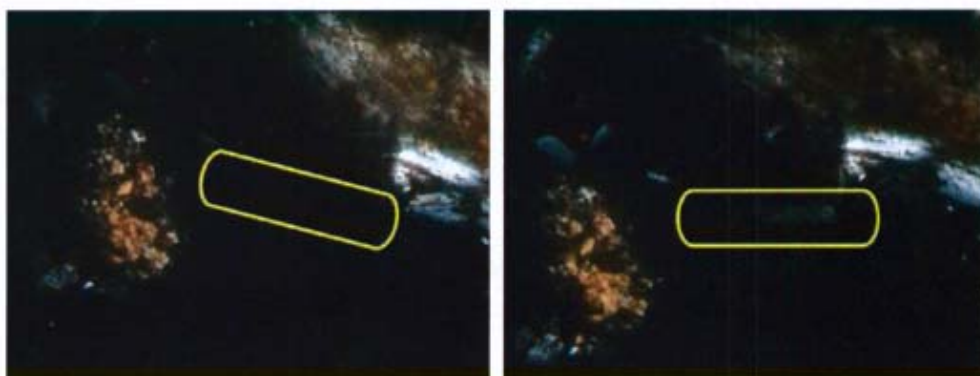


Figure 136. Field of View: 0.25mm; 9 degree extinction angle.



Figure 137 Field of View: 0.25mm; 12 degree extinction angle.

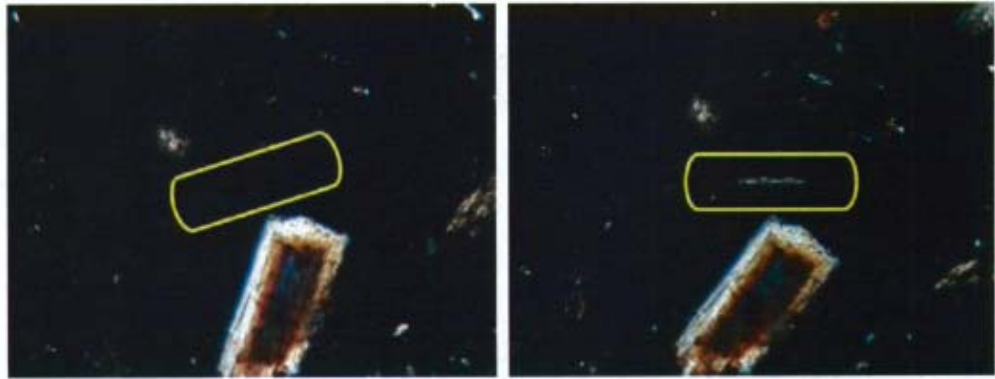


Figure 138. Field of View: 0.5mm; 17 degree extinction angle.



Figure 139. Field of View: 0.25mm; 22 degree extinction angle.

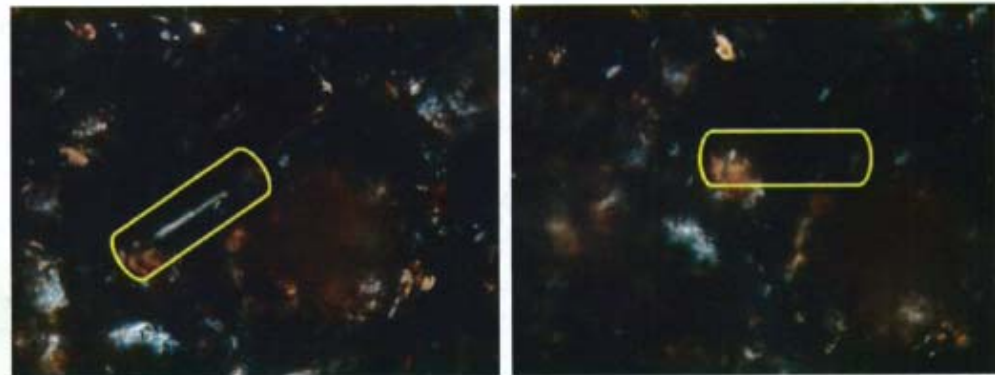


Figure 140. Field of View: 0.25mm; Parallel extinction.

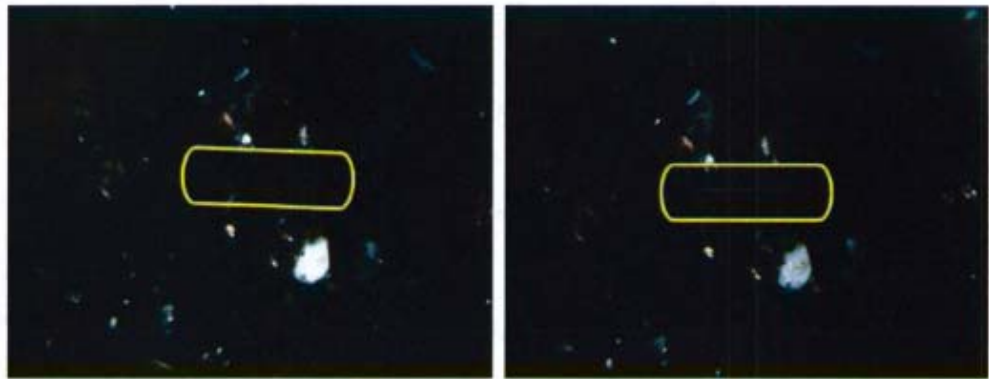


Figure 141. Field of View: 0.25mm; 6 degree extinction angle.

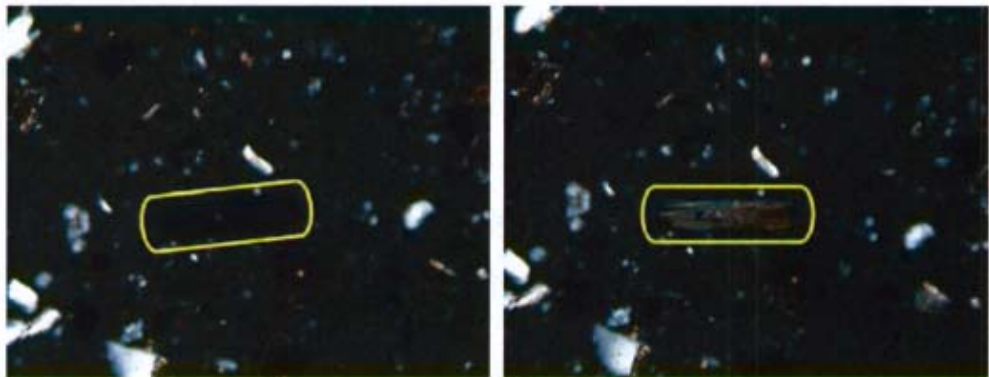


Figure 142 Field of View: 0.5mm; 7 degree extinction angle.

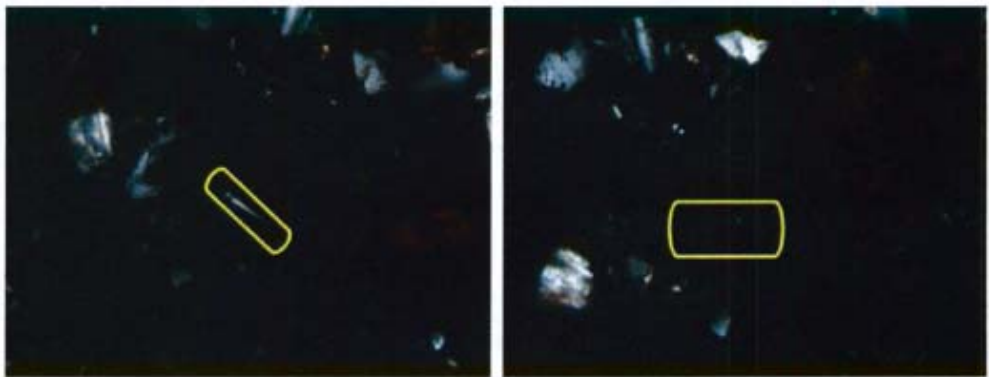


Figure 143 Field of View: 0.5mm; Parallel extinction.

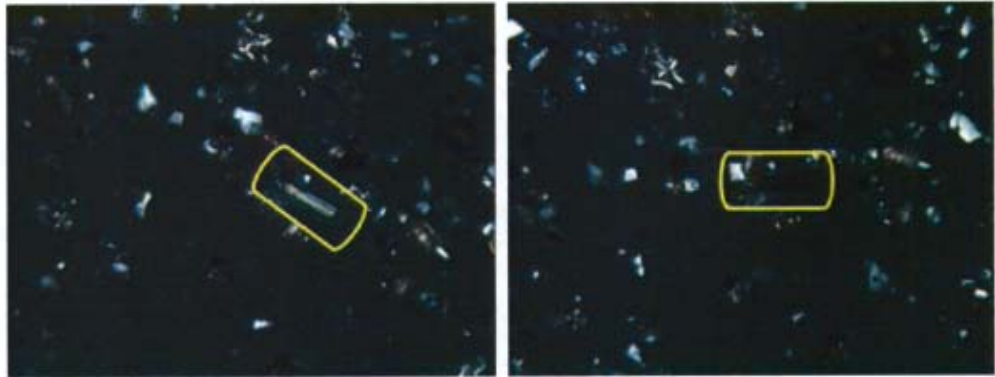


Figure 144 Field of View: 0.5mm; Parallel extinction.

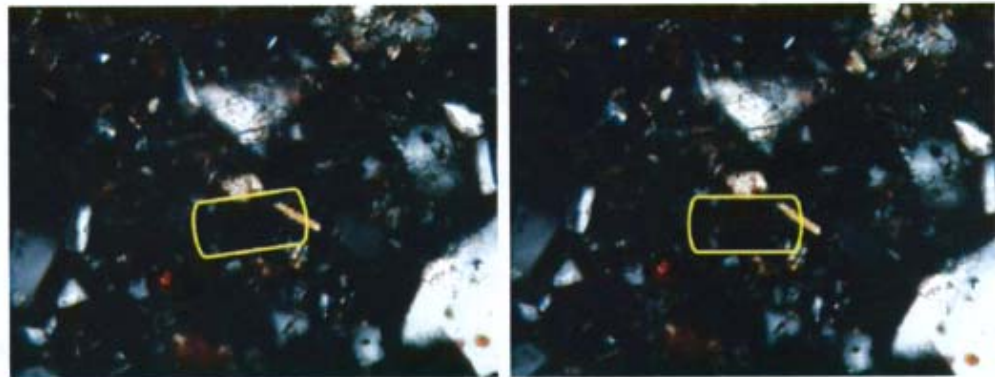


Figure 145. Field of View: 0.5mm; 7 degree extinction angle.

2.2.3.4SRM 1867a

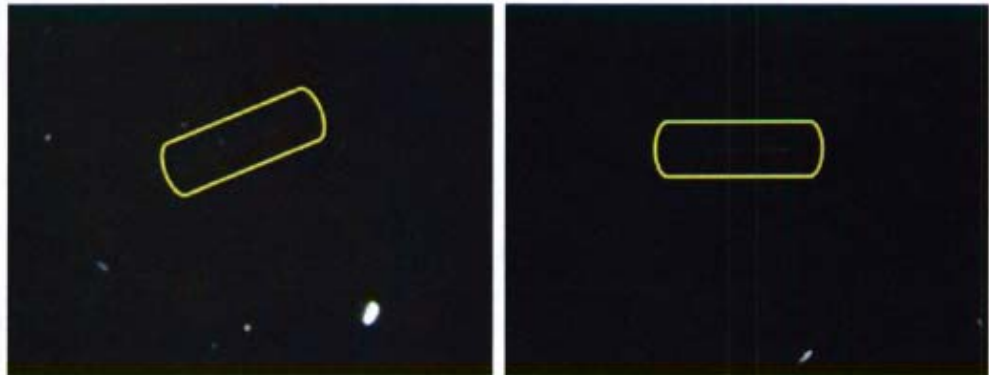


Figure 146. Field of View: 1.0mm; 20 degree extinction angle.

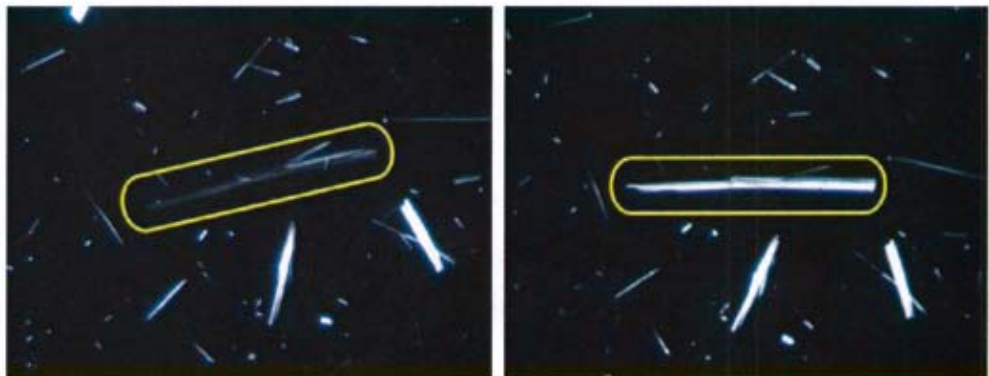


Figure 147. Field of View: 1.0mm; 11 degree extinction angle.

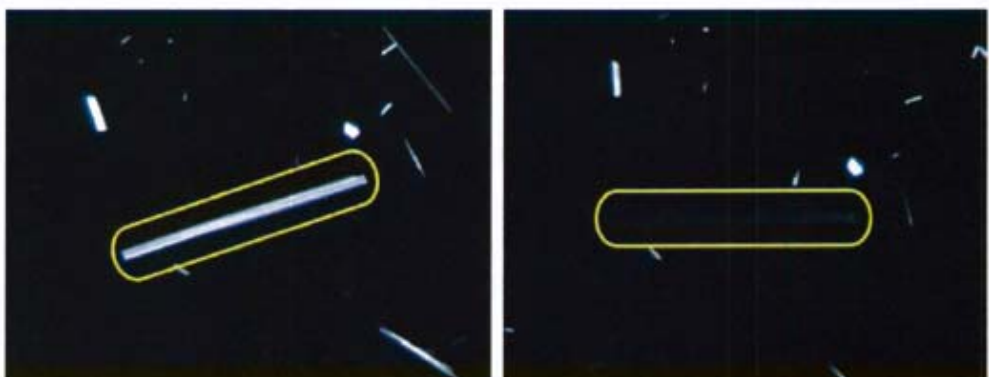


Figure 148. Field of View: 1.0mm; Parallel extinction.



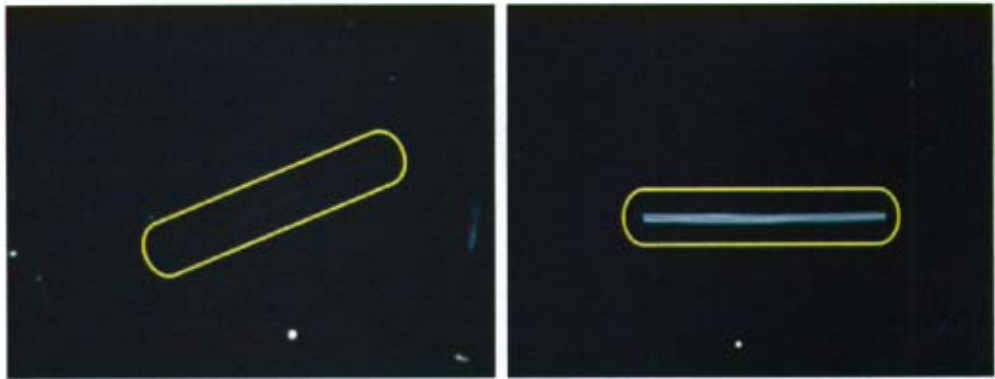


Figure 149. Field of View: 0.5mm; 24 degree extinction angle.

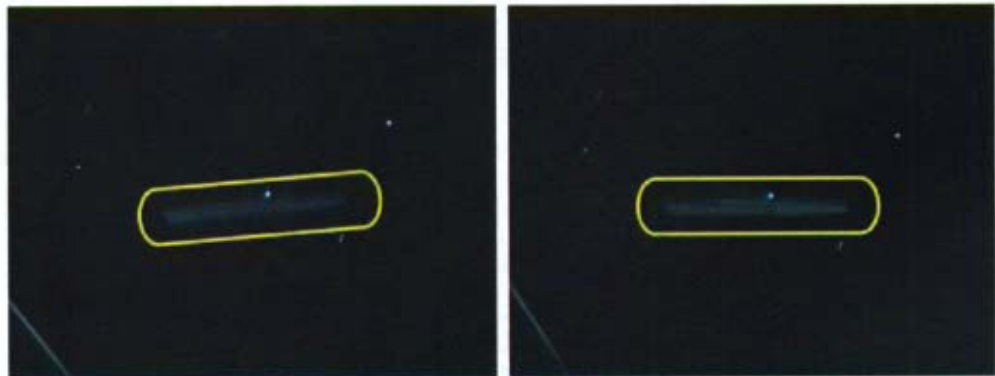


Figure 150. Field of View: 0.5mm; 6 degree extinction angle.

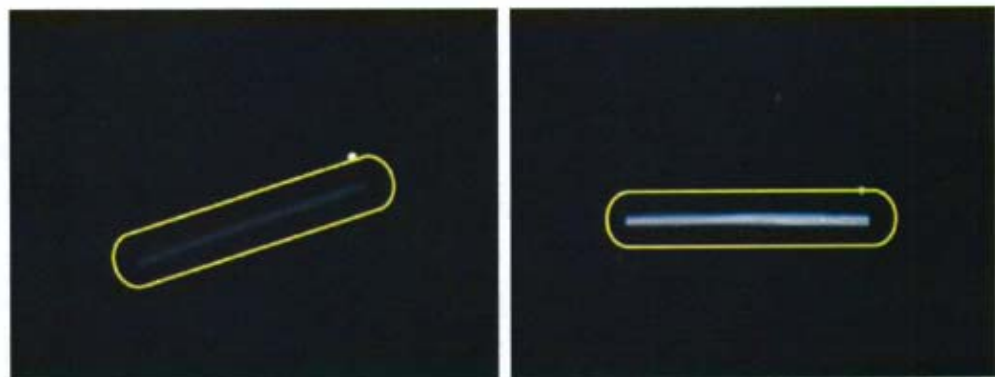


Figure 151. Field of View: 0.5mm; 19 degree extinction angle.

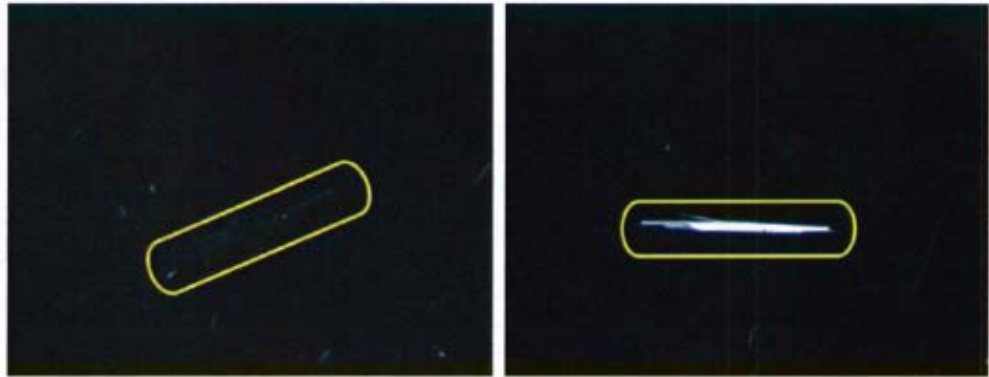


Figure 152. Field of View: 0.5mm; 20 degree extinction angle.

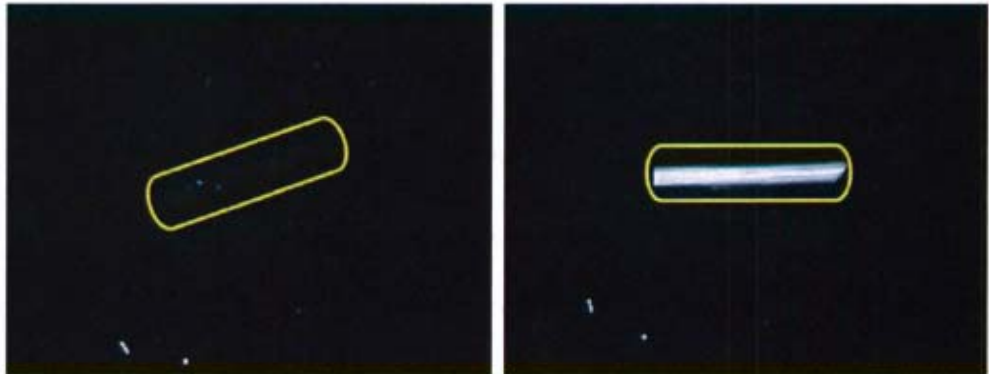


Figure 153. Field of View: 0.5mm; 17 degree extinction angle.

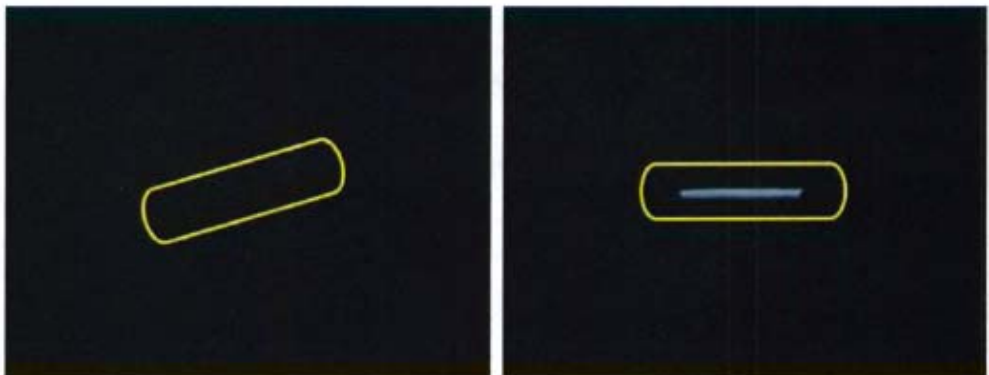


Figure 154. Field of View: 0.5mm; 15 degree extinction angle.

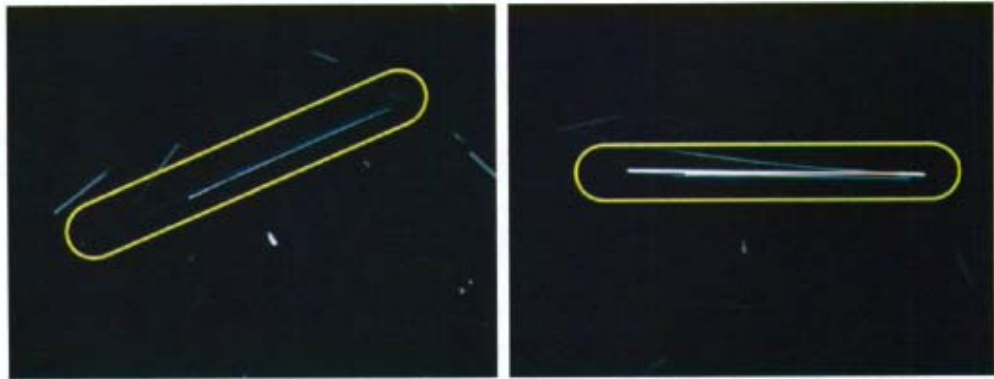


Figure 155. Field of View: 1.0mm; 24 degree extinction angle.

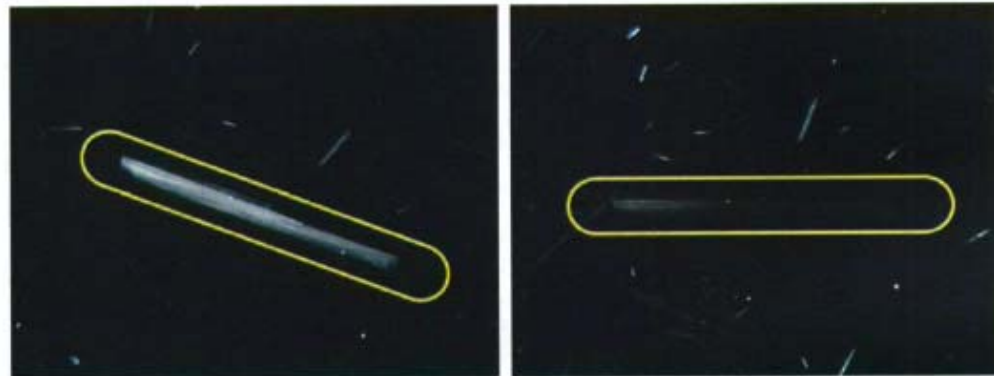


Figure 156. Field of View: 0.5mm; Parallel extinction.

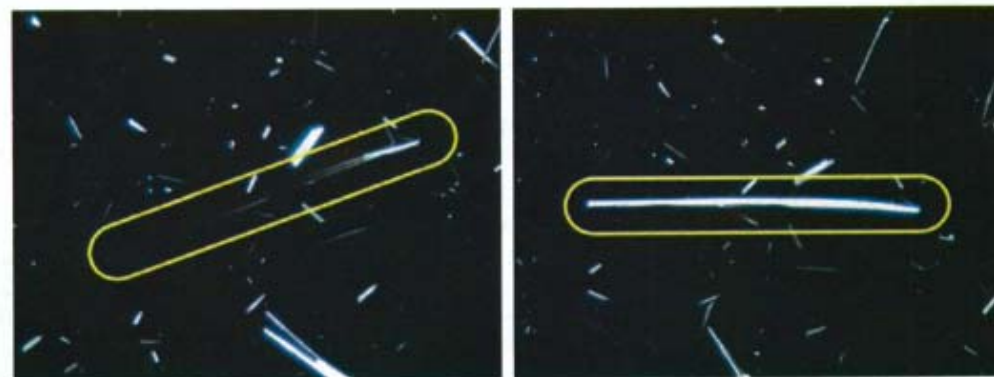


Figure 157. Field of View: 1.0mm; 22 degree extinction angle.

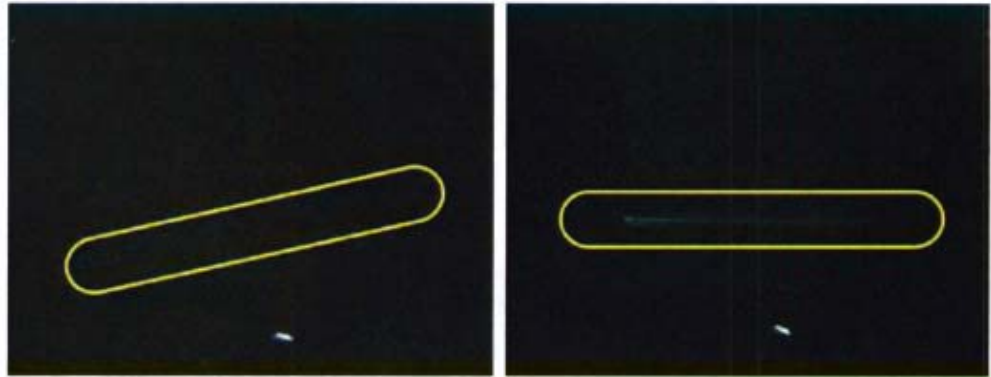


Figure 158. Field of View: 0.25mm; 13 degree extinction angle.

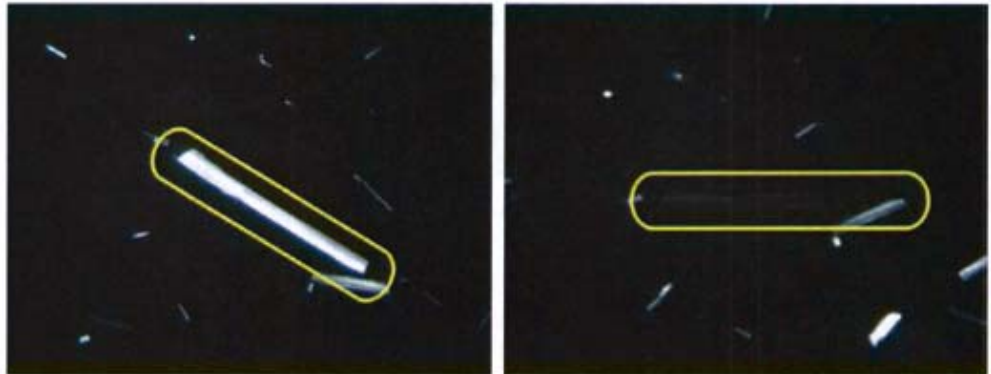


Figure 159. Field of View: 0.5mm; Parallel extinction.

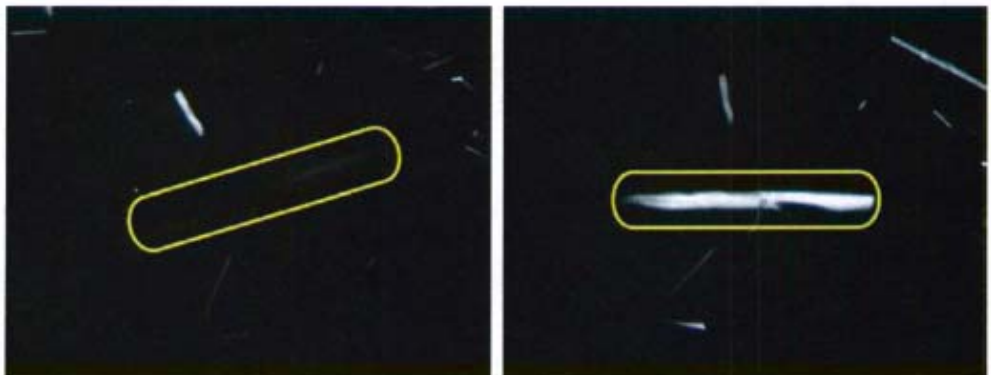


Figure 160. Field of View: 0.5mm; 22 degree extinction angle.

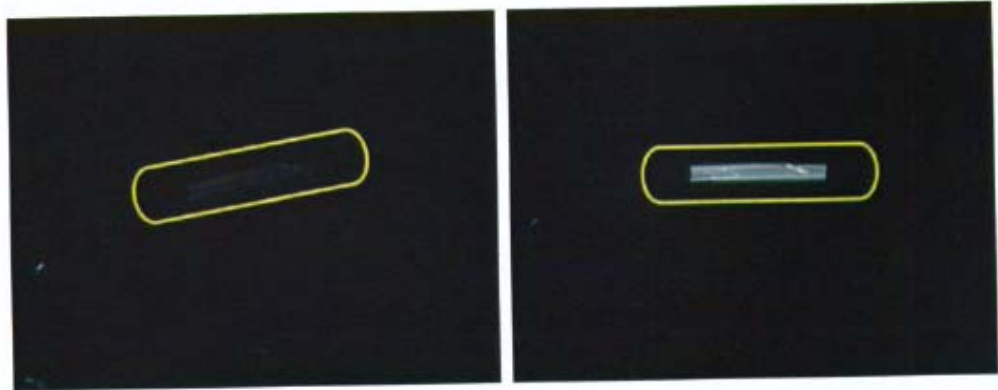


Figure 161. Field of View: 0.5mm; 11 degree extinction angle.

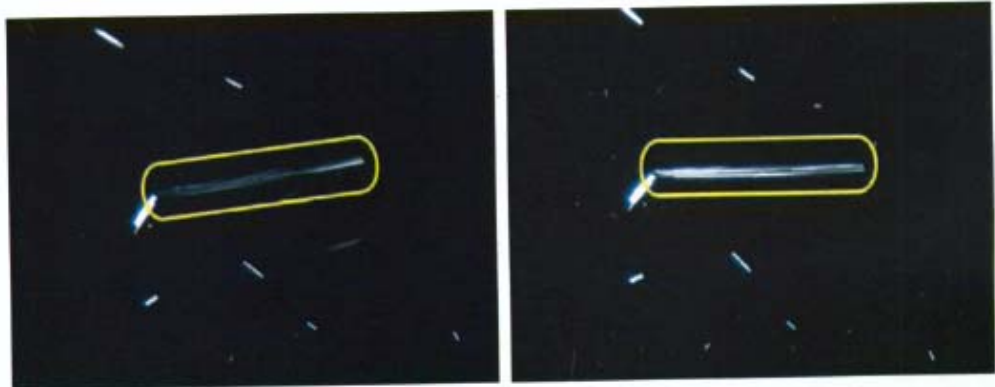


Figure 162. Field of View: 1.0mm; 7 degree extinction angle.

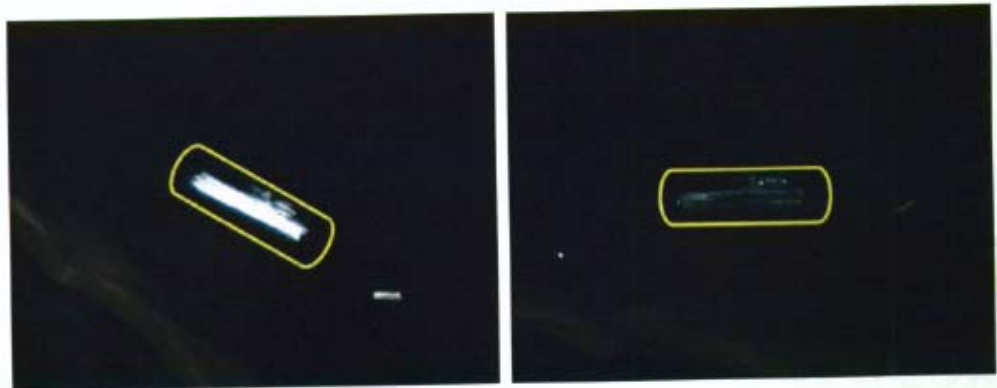


Figure 163. Field of View: 0.5mm; Parallel extinction.