

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



WPR22FA354

MATERIALS LABORATORY

Factual Report 23-050

June 30, 2023

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A. ACCIDENT INFORMATION

Location: Sisters, Oregon
Date: September 22, 2022
Time: 14:39 mountain daylight time
21:39 coordinated universal time
Vehicle: Piper PA-28-140, N7063R
Investigator: Stephen Stein, AS-WPR

B. COMPONENTS EXAMINED

Sections of fractured aileron cables

C. EXAMINATION PARTICIPANTS

Specialist Erik Mueller, Ph.D., P.E.
Office of Research and Engineering - Materials Laboratory Division
NTSB, Washington, DC

D. DETAILS OF THE EXAMINATION

On September 22, 2022, a Piper PA-28-140 was destroyed when it was involved in an accident near Sisters, OR. The pilot was fatally injured. A witness near the accident site reported hearing a "thud" sound from a small airplane. The witness stated that the engine sounded smooth and continuous before impact. The airplane came to rest on a slope of South Cinder Peak, with both wings, the fuselage, the empennage, and the engine being collocated with the first point of impact and wreckage. The wreckage was retained for further examination, and sections of the aileron cables were sent to the NTSB Materials Laboratory for additional review.

Two sections of aileron control cable were sent to the NTSB Materials Laboratory. Figure 1 illustrates the section from the left aileron control cable. The cable measured 2.87 inches long and comprised six strands with a central core. The average outer diameter of the wire measured 0.141 inches.

The section of the right aileron control cable is shown in Figure 2. This cable measured 8.00 inches in length, with an average outer diameter of 0.132 inches. Like the left aileron cable, the right cable comprised six strands with a central core. Unlike the right aileron cable, there was a region of frayed and deformed strands located approximately 2.75 inches from the fracture surface or 5.25 inches from the sectioned end (see Figure 3). Several wires had fractured in this area, although the wire was still intact and able to bear loads when pulled in the laboratory without continued fraying or deformation. As such, the average outer diameter of the cable between the fracture and frayed area was 0.153 inches.

The fractured end of the left aileron cable, showing the fracture surfaces of the wires, is shown in Figure 4. The strands were labeled 1 through 5 counterclockwise for this report. Figure 5 shows the fractured ends of strands 1 and 2. These fractured wires were located consistently near each other, with no indications of longer or shorter wires in these strands.

Figure 6 shows a closer view of the strand 1 wires, which exhibited a white substance on the exterior surfaces, consistent with salt deposits from marine environments. Later examination using energy-dispersive x-ray spectroscopy (EDS) found these substances to be primarily sodium, potassium, and chlorine, consistent with salt deposits. These salt deposits were removed by cleaning the wire section in an ultrasonic bath of acetone.

The wire fracture surfaces were generally slanted in orientation, with indications of necking and protruding shear lips (see the upper wire fractures in Figure 6). After cleaning, the wire fracture surfaces were more pronounced, exhibiting a dull brownish-metallic luster, in contrast to the more reflective surfaces, consistent with post-fracture smearing and impact damage (Figure 7).

Strand 3 from the left aileron cable is shown in Figure 8. These wires had all fractured at the same location, and the strand exhibited a V-shaped downward buckle with the wire bent upward along the fracture. Some of the fractured wires showed slanted orientations, and others exhibited local thinning or necking near the fracture. A similar morphology was observed in strands 4 and 5 of the left cable, shown in Figure 9. These features on the wire fractures and strand overall were also observed in strand 6, shown in Figure 10. These fractured wires were inconsistent with the opposite, cut side of the left aileron cable, illustrated in Figure 11. This end exhibited a reflective luster, with flat, streaky features consistent across almost all wires.

The fractured wire ends from the left aileron cable were examined using a field emission scanning electron microscope (SEM). The fracture surfaces of the wires from strand 3 are illustrated in Figure 12. As shown in the figure, the location of the wires' fracture surfaces was consistent with each other.

Figure 13 shows a closer view of one of the center wire fractures. The surface exhibited two slanted surfaces, with protrusions along the periphery of the fracture edges. The adjacent fractured wire in the lower left mirrored the lower left diagonal areas of the fracture surface. A closer view of this fracture surface, shown in Figure 14, revealed dimpled rupture, consistent with overstress fracture of the wire.

Likewise, Figure 15 illustrates another fractured wire with a distinct slant-oriented surface. The upper right of the figure exhibited a protrusion consistent with a shear lip, which folded back towards the fracture surface. The surface exhibited river

patterns consistent with fracture from the bottom of the figure towards the upper right. The area of initiation, shown in Figure 16, displays flow marks upward and a flatter edge. A closer view of this area revealed a slanted dimpled rupture, consistent with shear overstress of the wire (Figure 17). These features were consistent along the wire fracture surface.

Figure 18 shows an angled wire from strand 5. This surface exhibited an upward apex along the center of the fracture surface, with a smaller perpendicular ridge along the edge on the bottom of the figure. Examination of the ridge and the rest of the fracture surface revealed dimpled rupture, as shown in Figure 19. Similar wire fracture features and orientations were prevalent on those wires in strands 4 and 5, shown in Figure 20. Figure 21 shows a fractured wire with two opposite-facing outer slanted surfaces and outward deformation at 90° to the surfaces on the top and bottom of the figure. Examination of the fracture surface, illustrated in Figure 22, showed slanted dimpled rupture or indications of post-fracture damage (smearing). No other features were observed on the fracture wires of the left aileron control cable.

Figure 23 illustrates the fractured wires of the right aileron cable as received. Like the left aileron control cable, the wire fractures were generally located in the same area, with no wires significantly longer or shorter than the others. This end did exhibit some strands that had bent outward, as demonstrated in the figure. The strands were also labeled 1 through 6 counterclockwise in Figure 23 for this report.

Figure 24 shows a closer view of strand 1 and some of strand 2 from the right aileron cable. The wires did exhibit a blocky, brownish material on the surface, later determined to be consistent with the salt deposits discussed earlier. The other strands of fractured wires from the right aileron cable are illustrated in Figures 25 and 26. These wires exhibited consistent fracture features, as detailed below.

The right aileron control cable fracture was cleaned in an ultrasonic bath with acetone and examined using a field-emission SEM. Figure 27 shows some of the wires from strand 5, which exhibited fracture surfaces slanted in orientation. Figure 28 shows a closer view of one of the fractured wires, displaying protruding shear lips along the right and bottom edges, with an area of post-fracture smearing in the upper left. The overall undamaged fracture surface exhibited parallel linear features towards the lower right. A closer view found these features to be dimpled rupture, oriented along the grain direction consistent with the wire drawing direction.

Figure 30 shows the fractured wires of strand 6. Most of the broken wires exhibited a slanted fracture orientation, with an area of another surface (facing upward in the figure) consistent with post-fracture rubbing or smearing damage. Several wires from the top of the figure exhibited perpendicular secondary tears. One of these wires is highlighted in Figure 31, showing the fracture features between two tears. All the

areas revealed dimpled rupture—along the tear surfaces, the dimples were more equiaxed in shape, whereas on the primary fracture, they were elongated, consistent with the grain direction of the wire.

Figure 32 shows some of the fractured wires from strand 3. These wires exhibited localized thinning or necking deformation adjacent to their fractured surfaces. These wires revealed dimpled rupture, as illustrated in Figure 33. The wire in Figure 33 also exhibited post-fracture smearing damage on half of the fracture. The orientation of this smearing damage was consistent on most of the wires in this strand.

Further, the smearing and deformation on the wire fractures were oriented both horizontally and vertically, as shown in Figure 34. These features were consistent with rubbing or wear of the fractured wires repeatedly after fracturing. The fracture features were consistent with overstress fracture in tension.

Examination of the wires using EDS found their chemical composition to be consistent with carbon steel. Zinc was also found on the wire fractures and the outer surface, consistent with a galvanizing treatment.

Both cables exhibited fracture features consistent with overstress fracture in tension and shear directions, consistent with bending. The left aileron cable strands exhibited bending and buckling, consistent with having been pinched and bent. Several wires also showed opposite slanted fracture surfaces, consistent with pinching or cutting during overstress fracture. After fracture, many of the surfaces of the wires of both control cables continued contact with adjacent components or structures, as evidenced by post-fracture damage.

Submitted by:

Erik M. Mueller
Materials Research Engineer



Figure 1. Section of the left aileron control cable.



Figure 2. The section of the right aileron control cable.

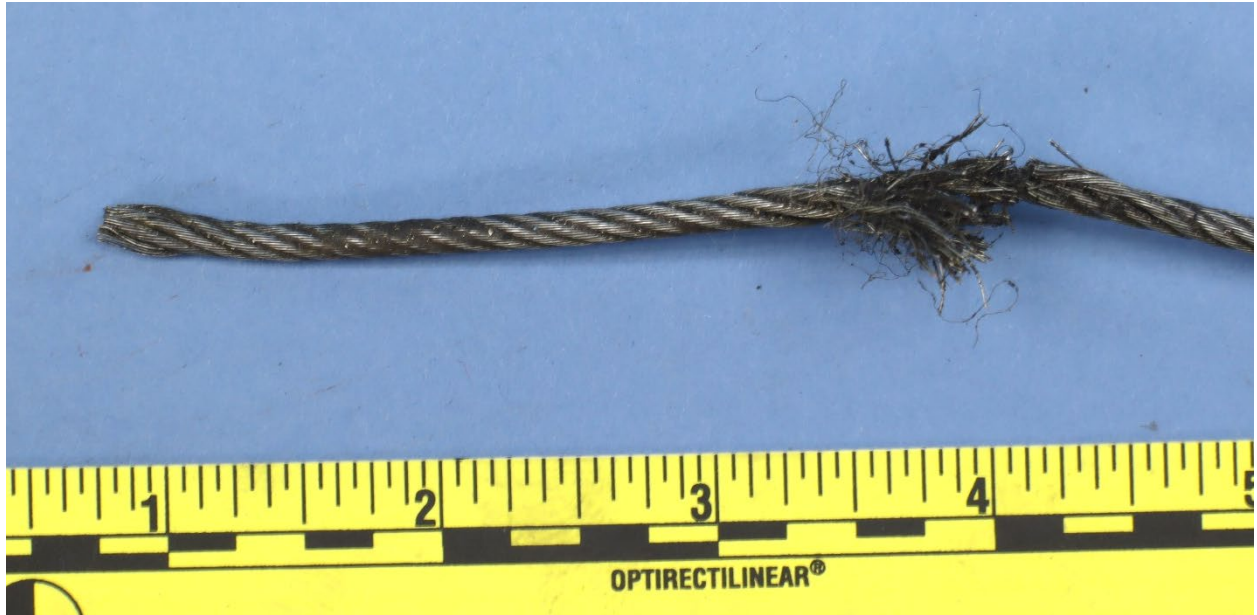


Figure 3. Closer view of the fractured end of the right aileron control cable from Figure 2.



Figure 4. The fractured wire ends of the strands of the left aileron cable.

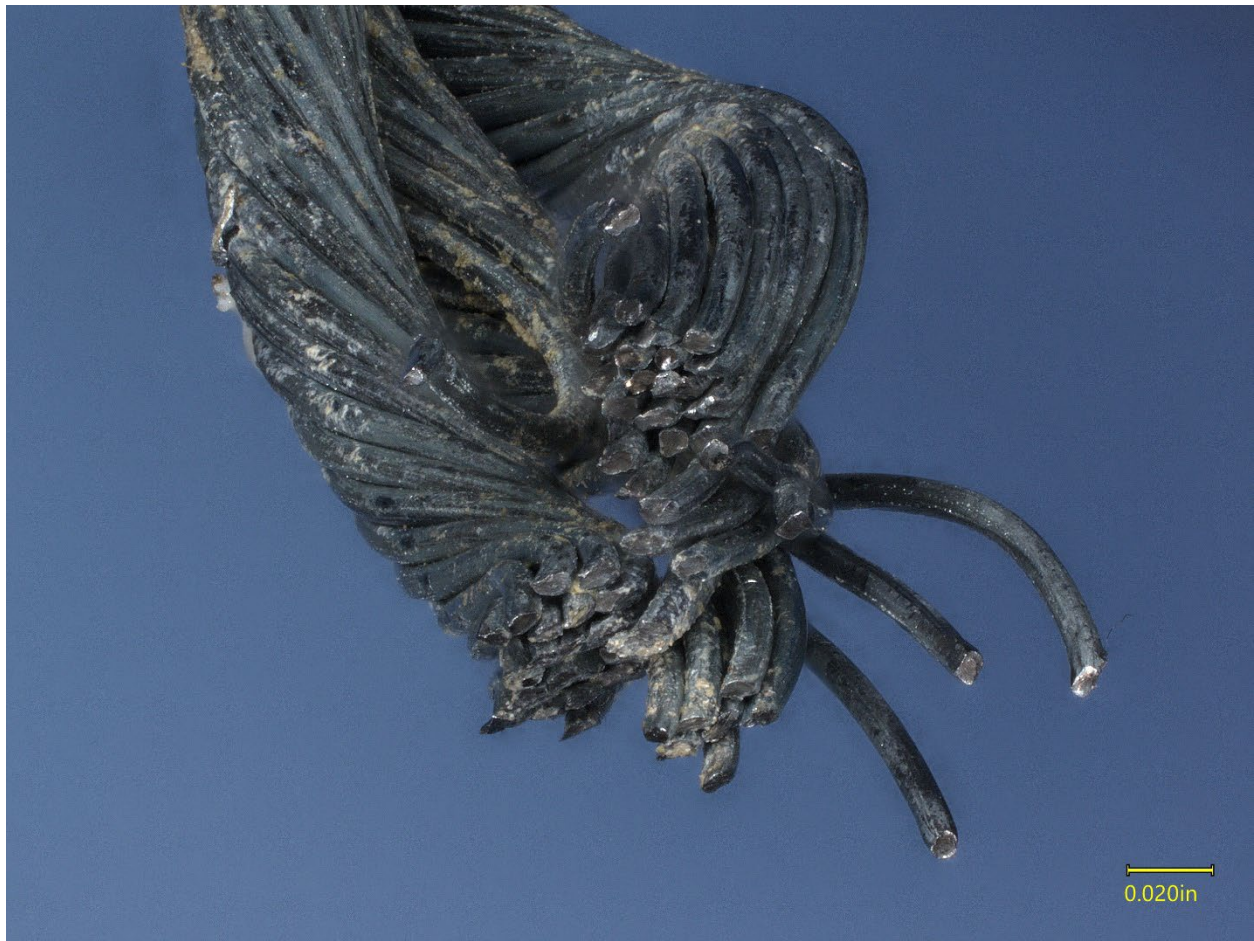


Figure 5. Fractured wires of strands 1 and 2 of the left aileron cable.



Figure 6. Closer view of the left aileron strand 1 wire fracture surfaces.

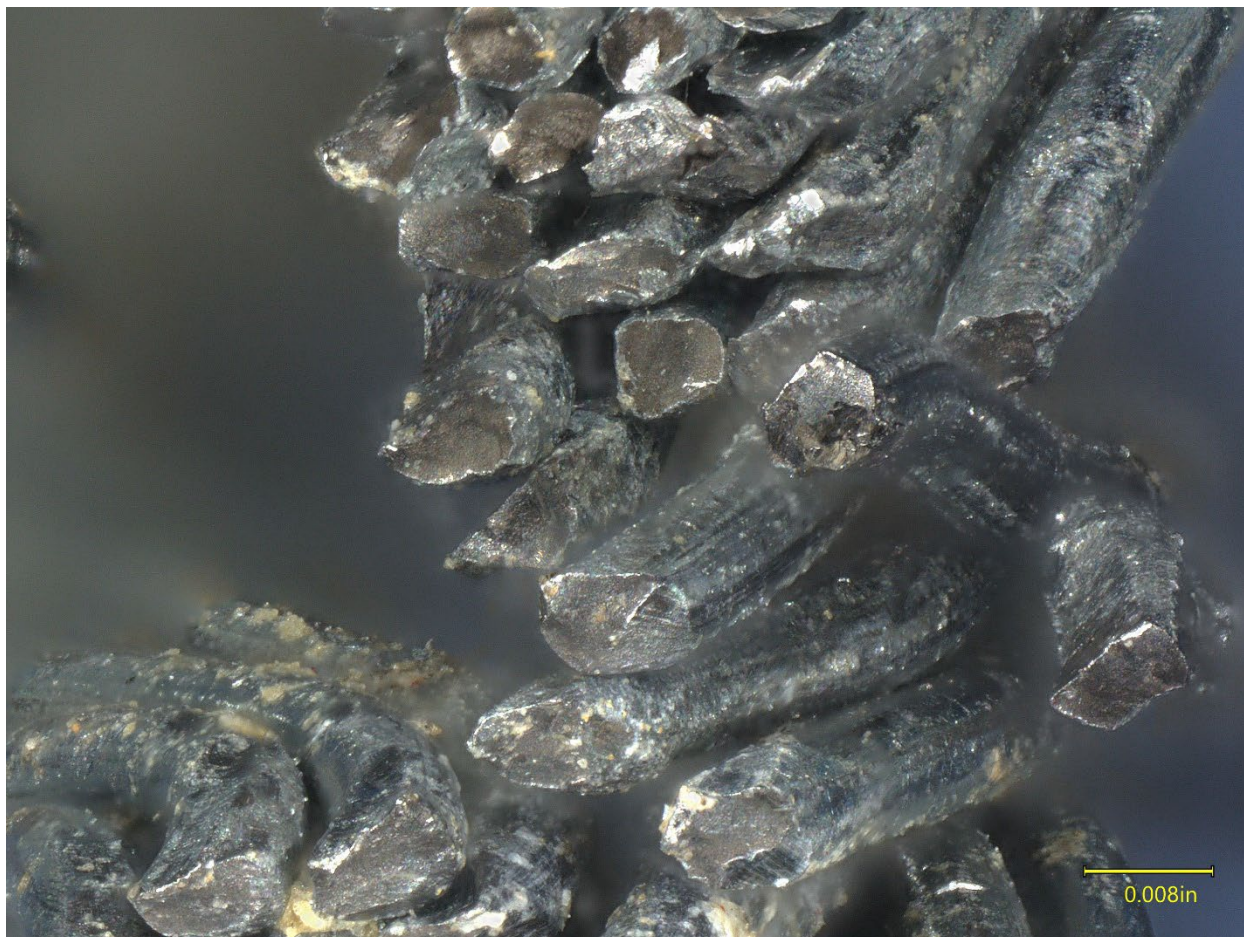


Figure 7. Fractured wires from strands 1 and 2 in the left aileron control cable.



Figure 8. View of the fractured wire ends of strand 3 from the left cable.



Figure 9. Slanted fracture surfaces of the wires from strands 4 and 5 from the left aileron control cable.



Figure 10. View of the fracture surfaces of the strand 6 wires from the left cable.



Figure 11. Comparative view of the opposite cut and sectioned wires from the left aileron cable, shown for comparison to the fractured end.



Figure 12. Backscattered electron (BE) micrograph of strand 3 fractured wire surfaces from the left cable.

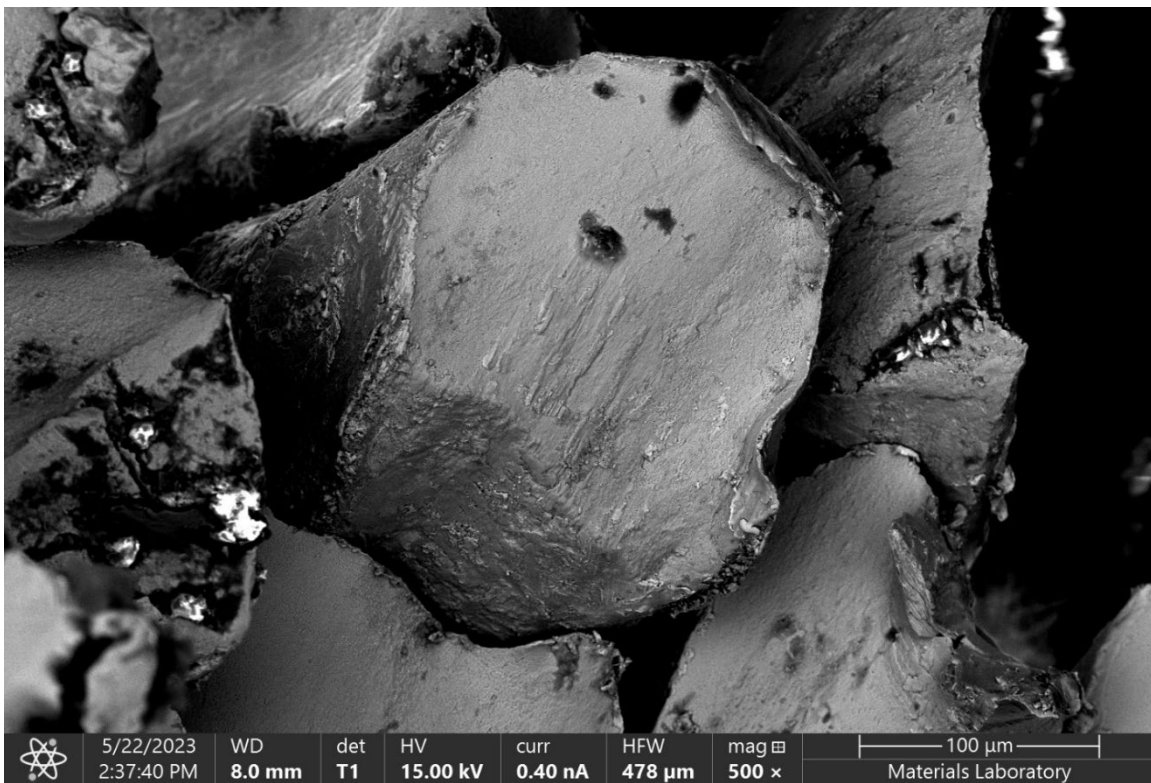


Figure 13. BE micrograph of a typical fractured wire in strand 3 from the left cable.

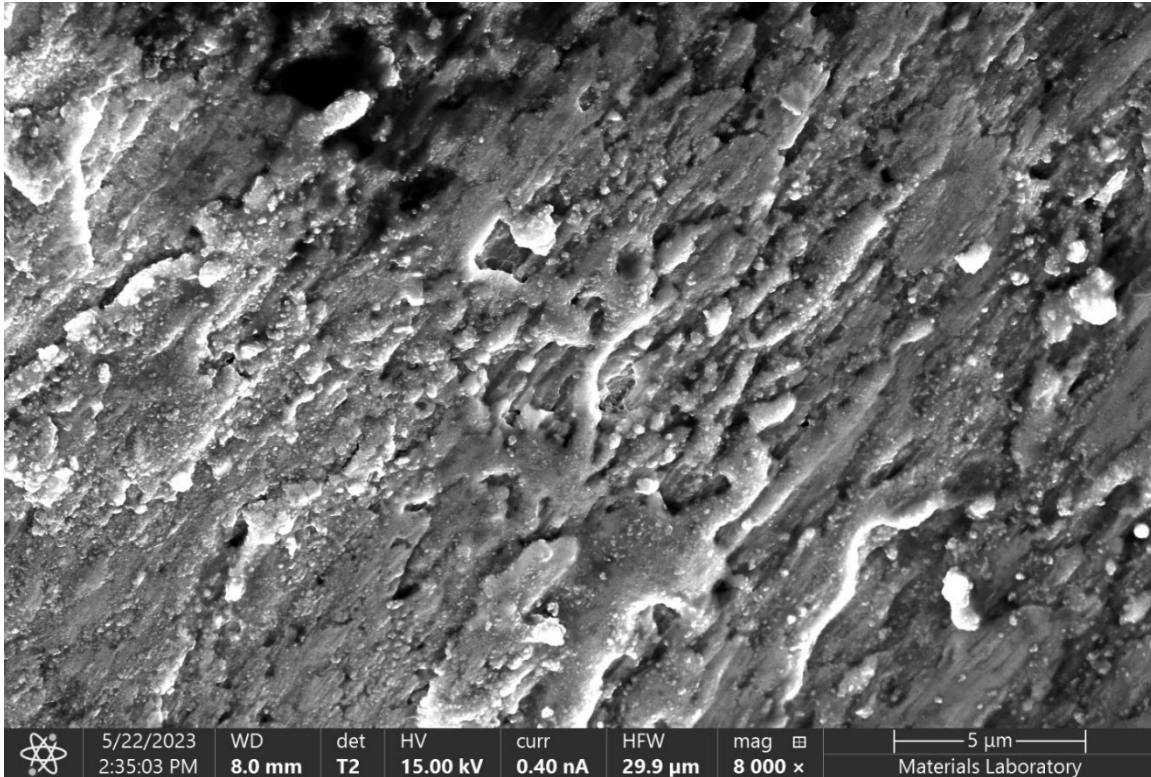


Figure 14. Secondary electron (SE) micrograph of a closer view of the fracture surface in **Figure 13**.

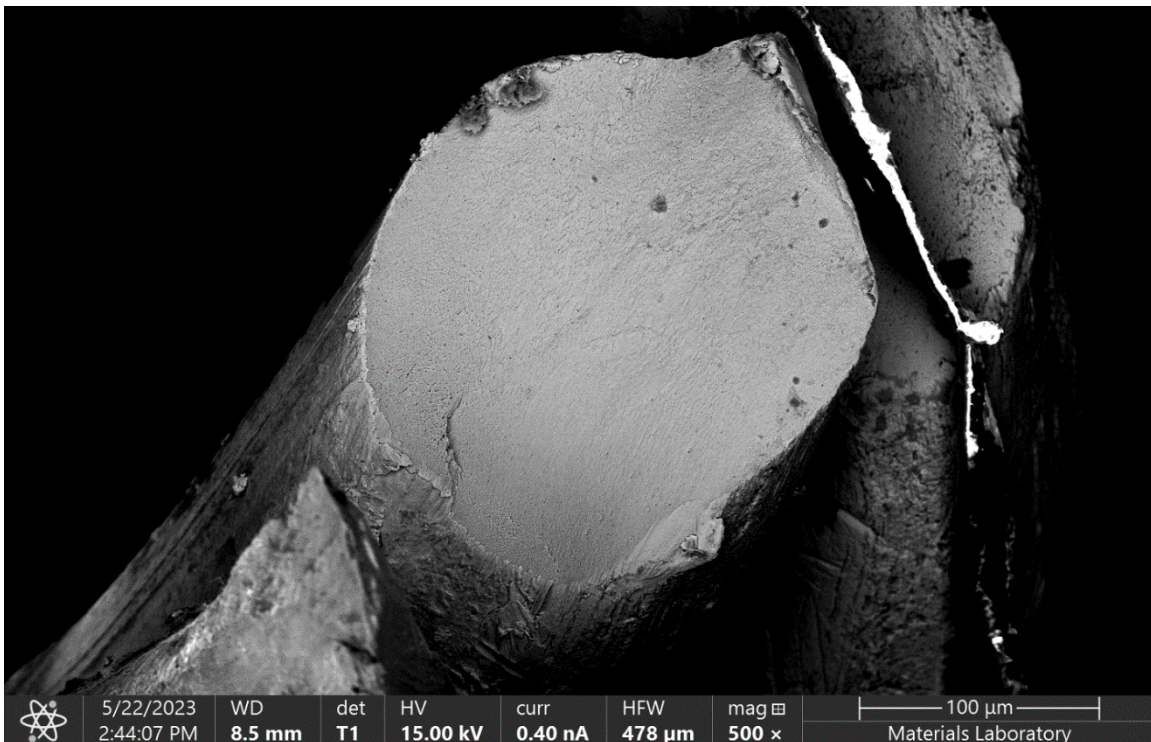


Figure 15. BE micrograph of a second wire from the strand 3 in **Figure 12**.

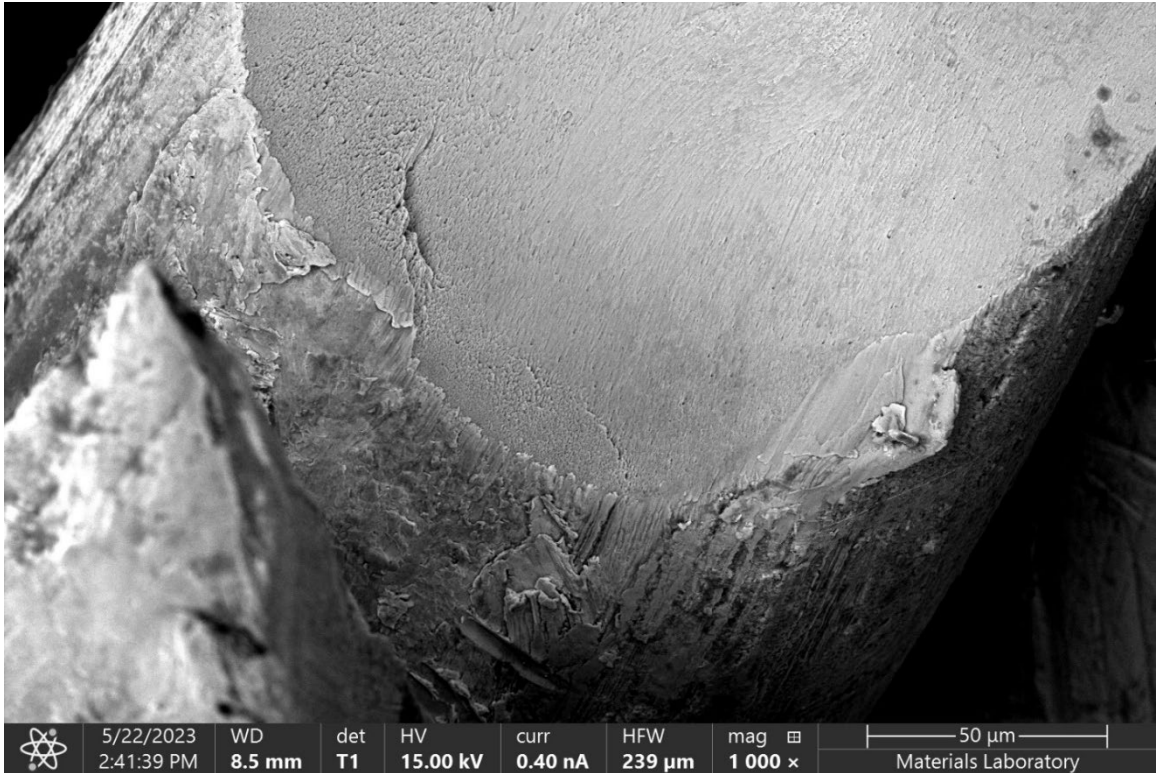


Figure 16. BE micrograph of the fracture edge of the wire in **Figure 15**.

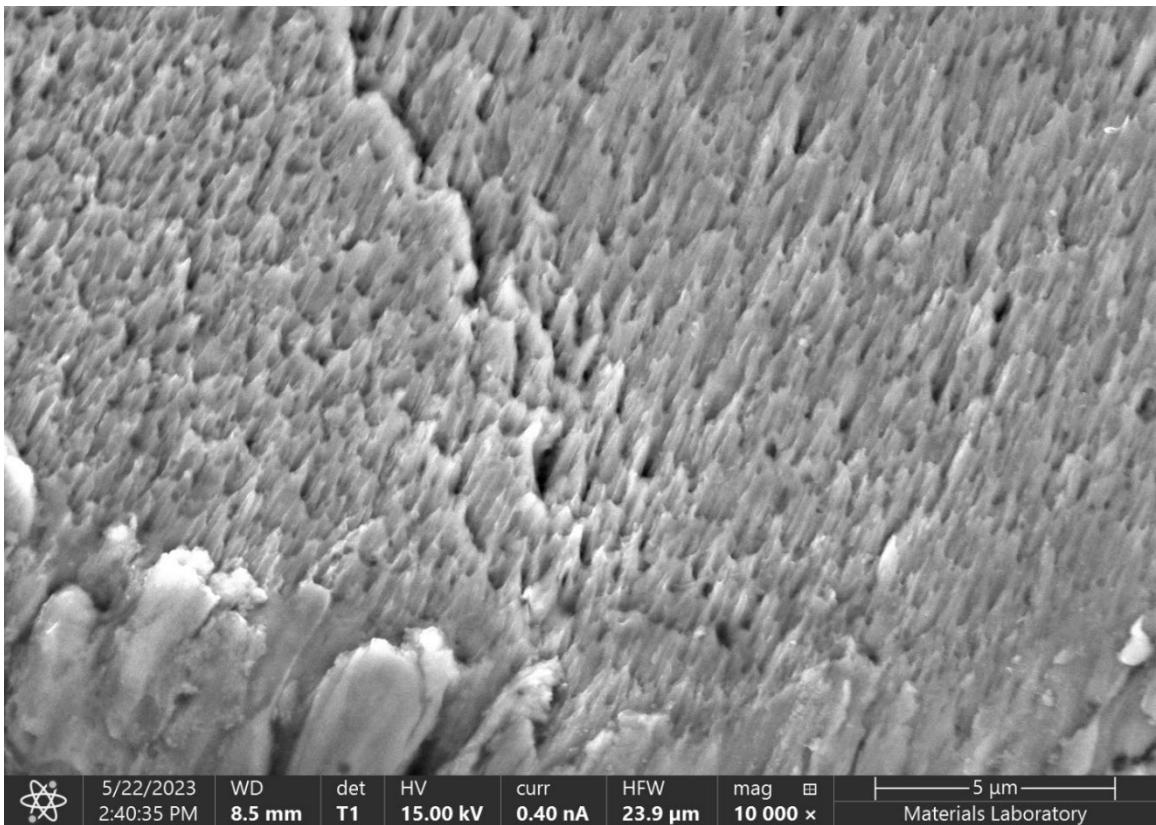


Figure 17. BE micrograph of slanted dimple rupture on the area in **Figure 16**.

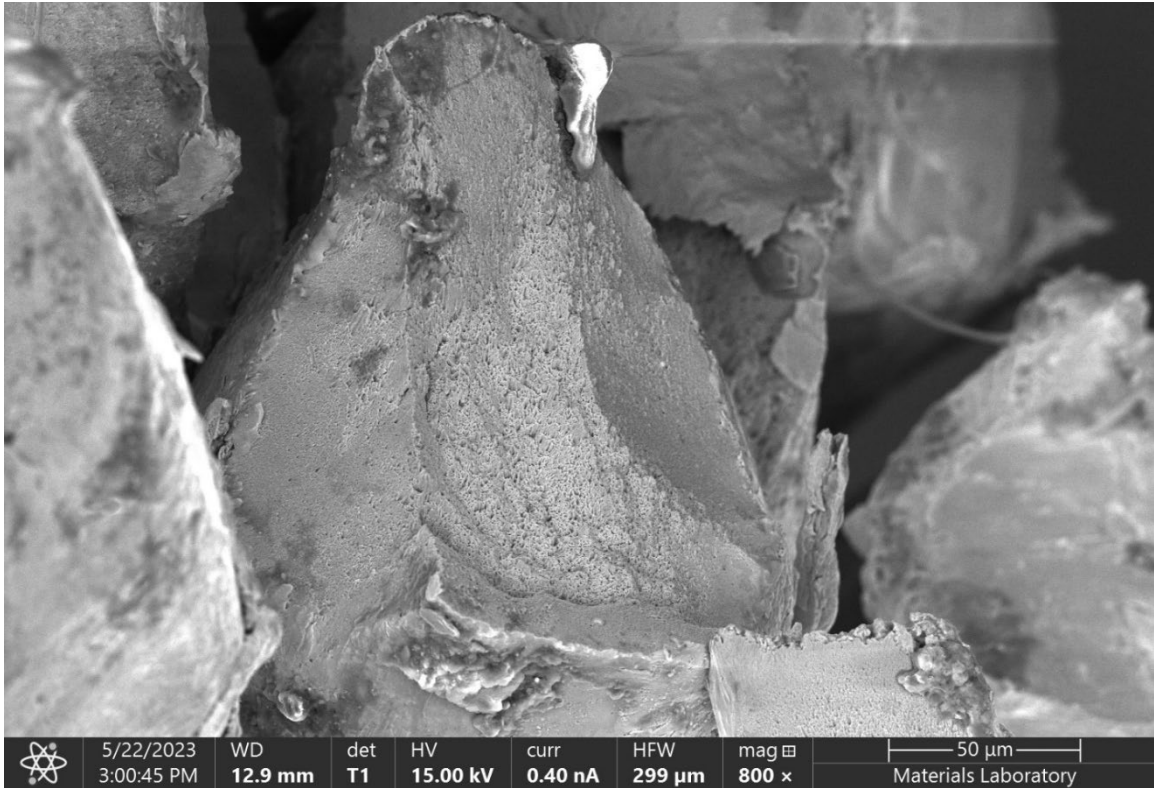


Figure 18. BE micrograph of angled fractured wires from strand 5 of the left cable.

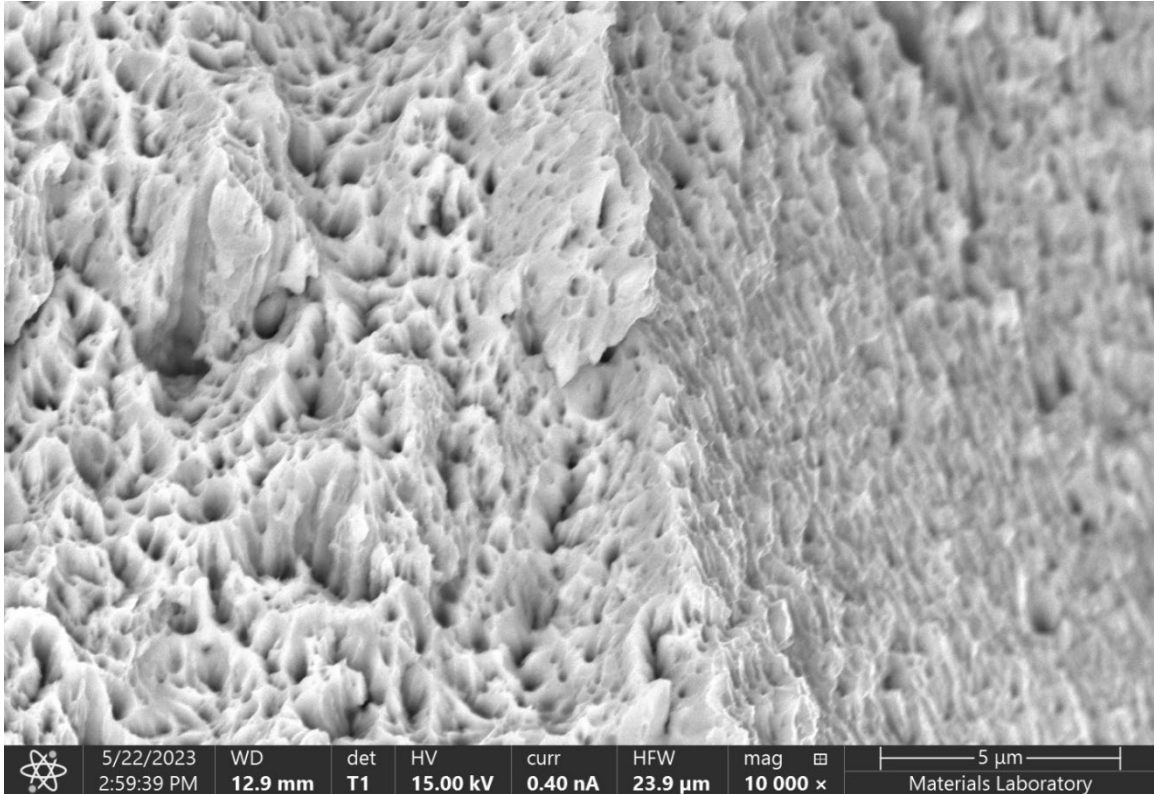


Figure 19. BE micrograph of the wire ridge in **Figure 18**, showing dimpled rupture.



Figure 20. BE micrograph of the fourth and fifth wire strands from the left cable.



Figure 21. BE micrograph of a deformed wire from Strand 4 in **Figure 20**.

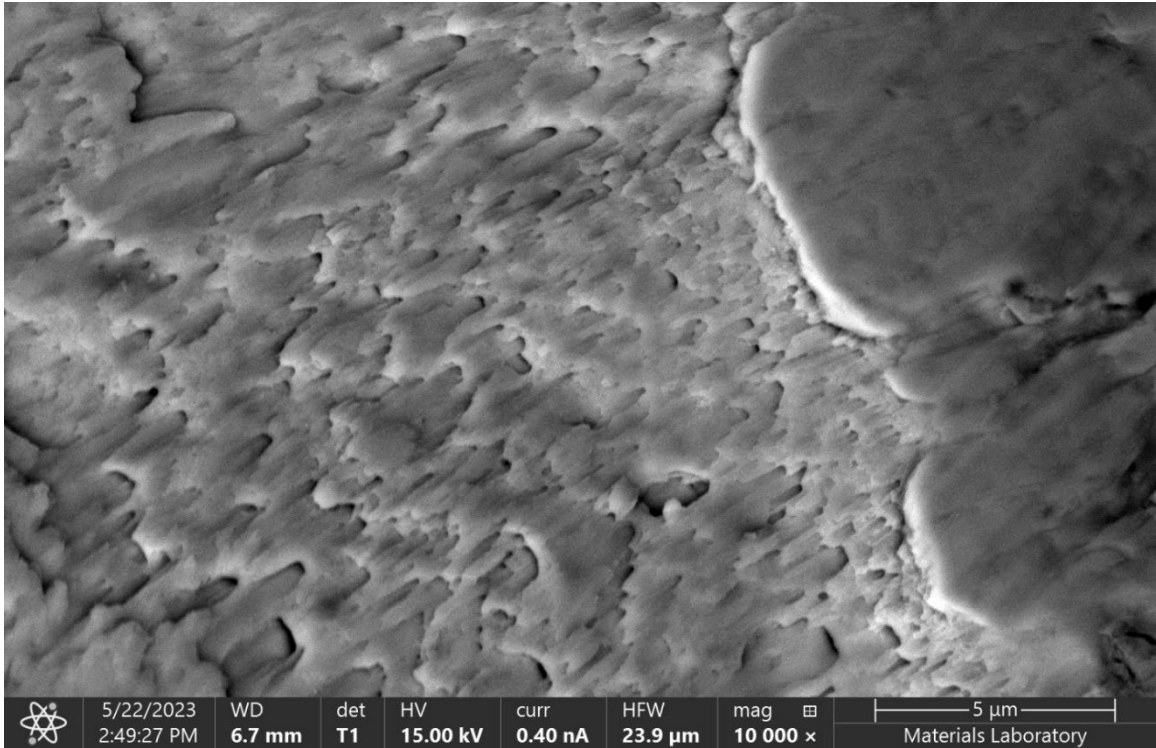


Figure 22. BE micrograph of slanted dimpled rupture from the left half of the wire in Figure 21.

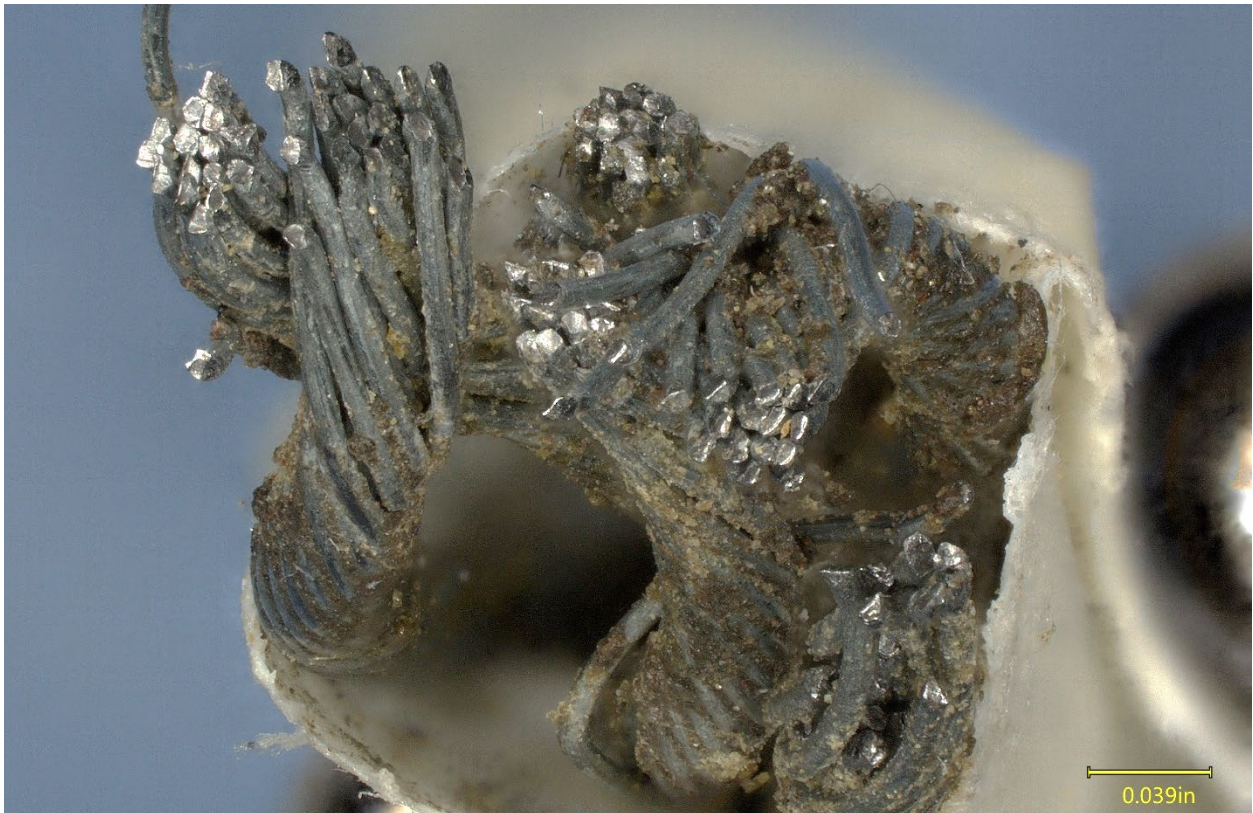


Figure 23. The fractured end of the right aileron cable, showing the fractured wires.



Figure 24. Closer view of fractured wires of strand 1 from the right aileron cable.



Figure 25. The fractured ends of strands 2 and 3 from the right aileron cable.



Figure 26. The fractured ends of strands 5 and 6 from the right aileron cable.

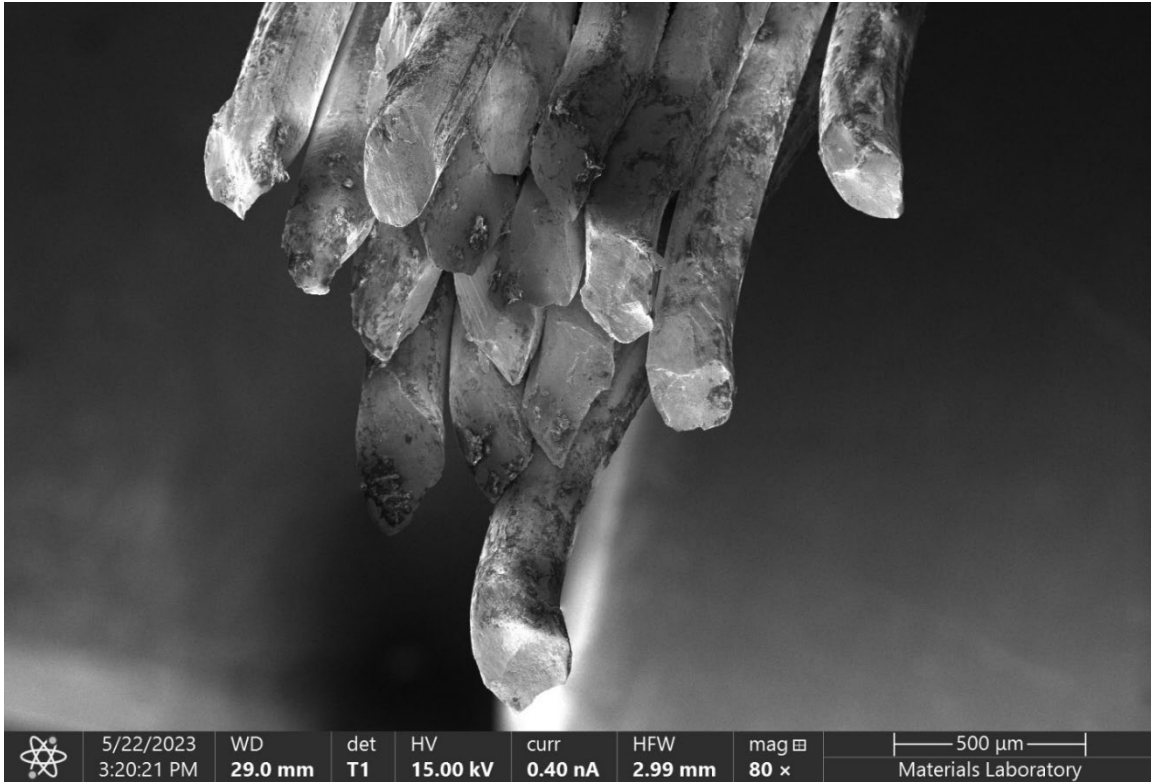


Figure 27. BE micrograph of the fractured wire ends of strand 5 from the right cable.

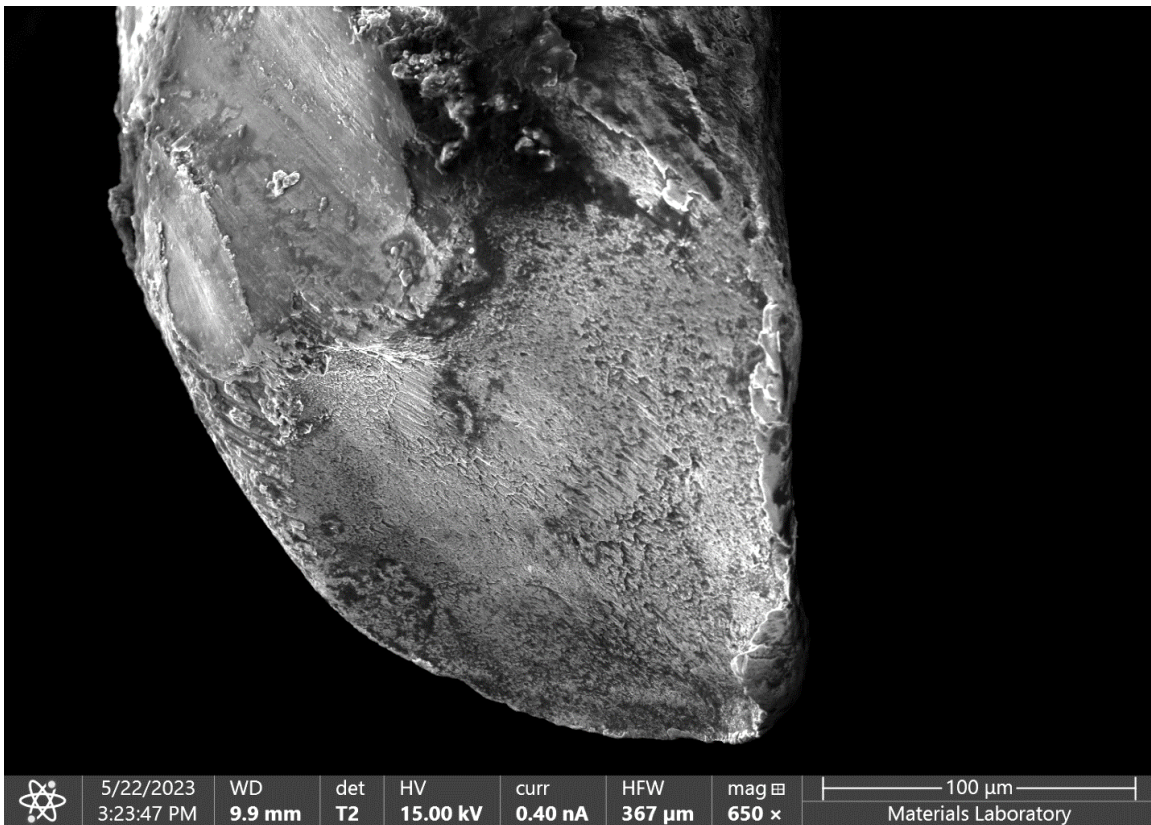


Figure 28. SE micrograph of the center left wire from strand 5 in **Figure 27**.

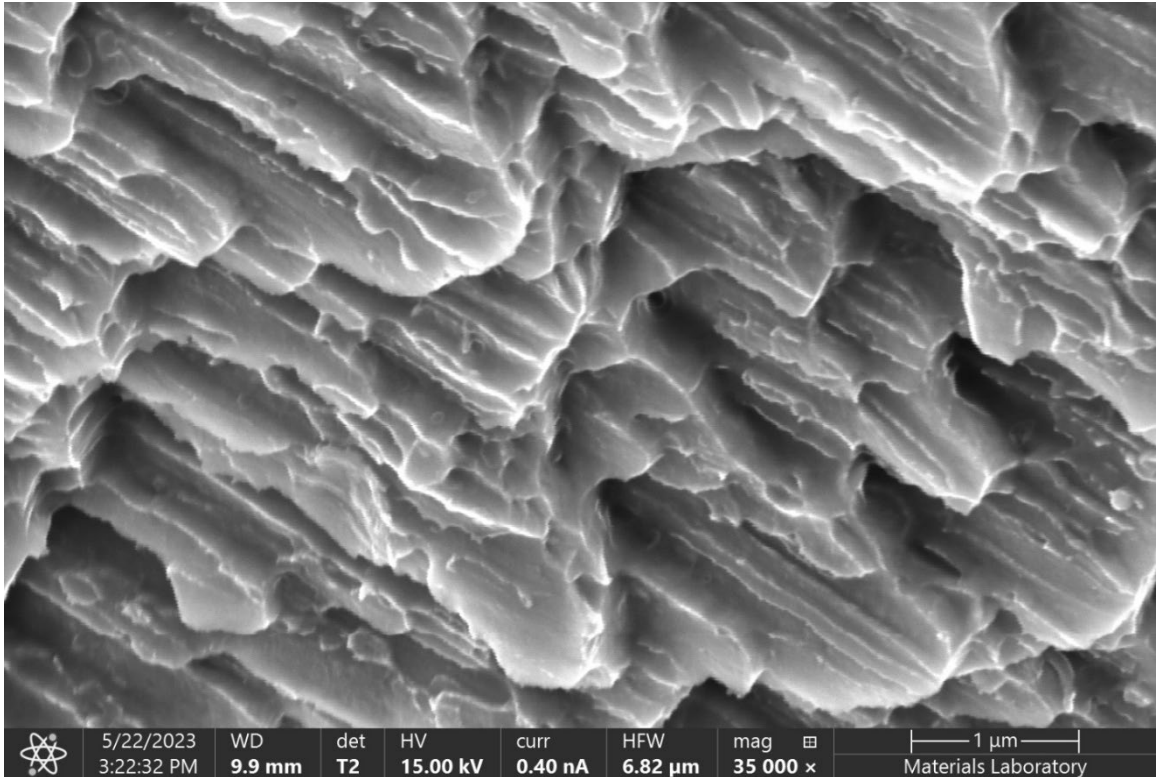


Figure 29. BE micrograph of dimpled rupture features from the wire surface in Figure 28.

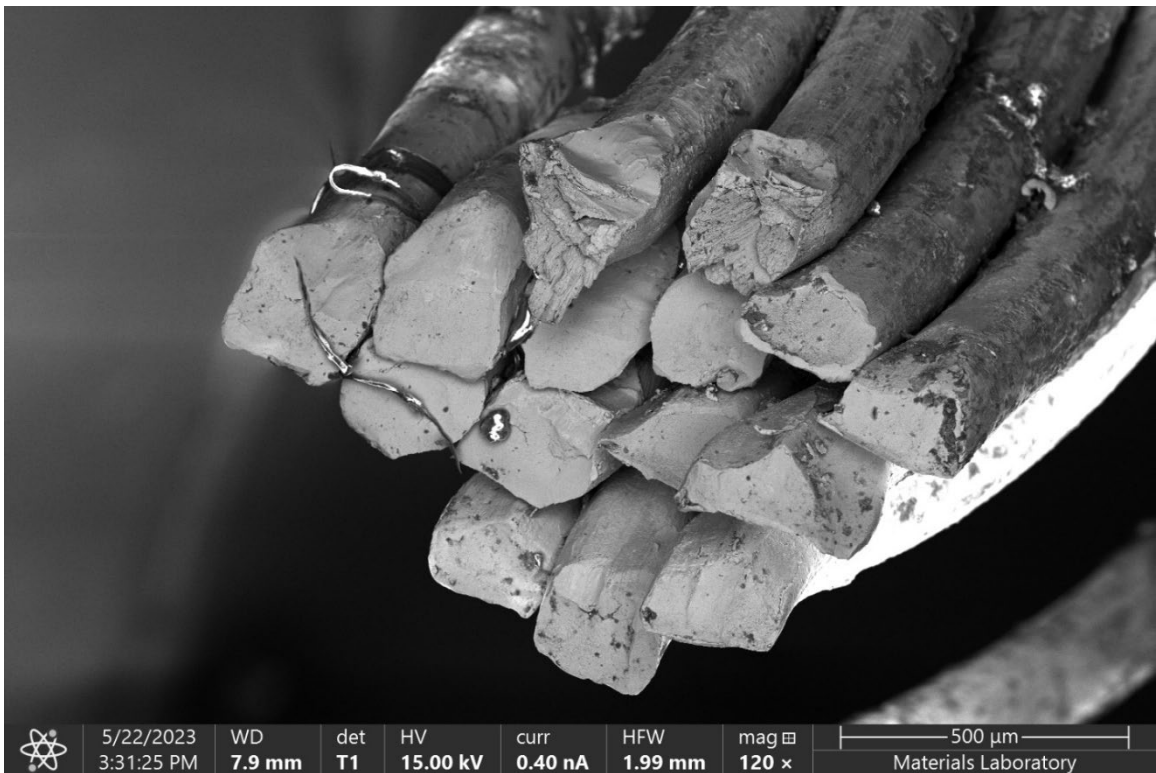


Figure 30. BE micrograph of the fractured wires of strand 6 from the right cable.



Figure 31. BE micrograph of the upper right wire fracture surface in **Figure 30**, showing ductile tearing and dimpled rupture along the elongated grain direction.

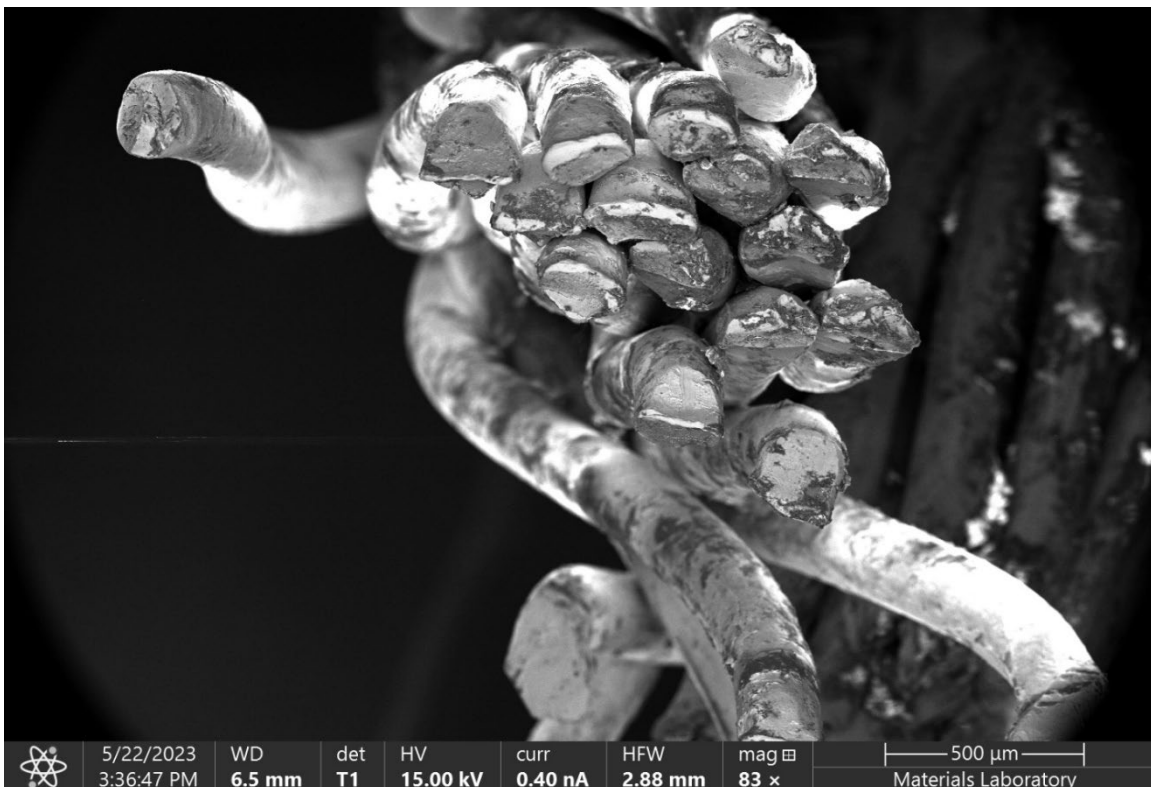


Figure 32. BE micrograph of the fracture wires from Strand 3 of the right aileron cable.

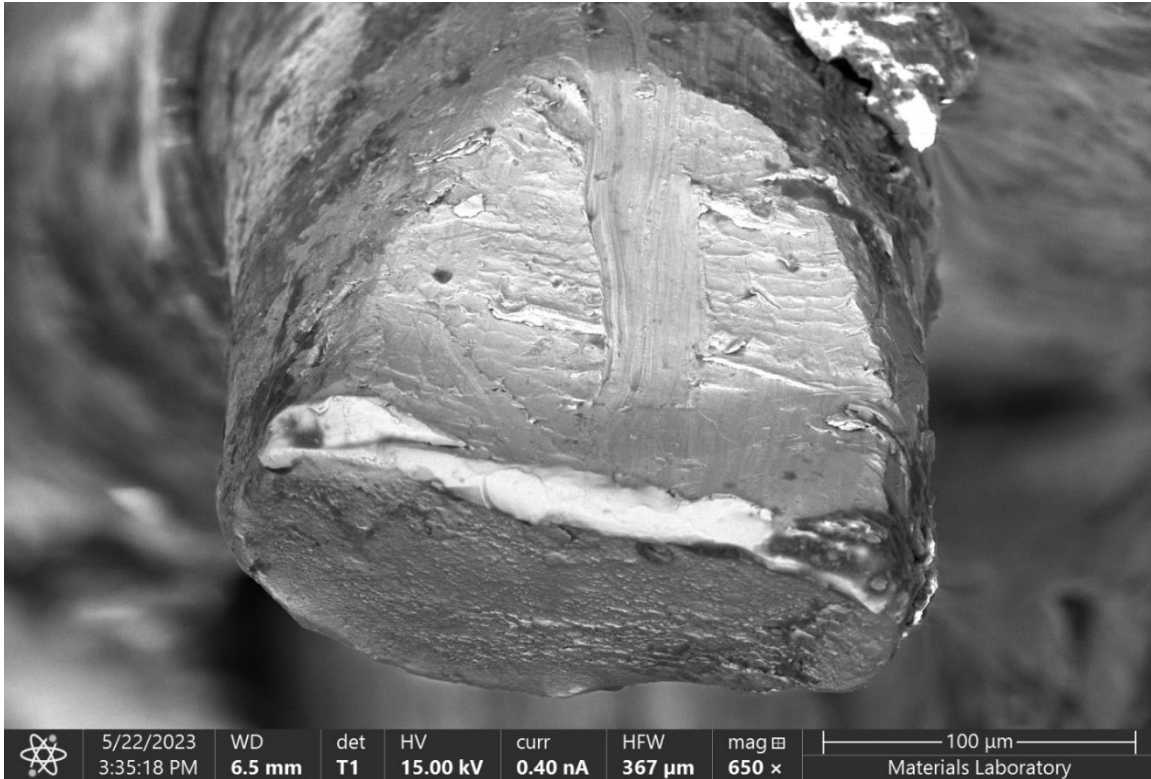


Figure 33. BE micrograph of a fractured wire from **Figure 32**, showing smearing (top) and dimpled rupture (bottom),

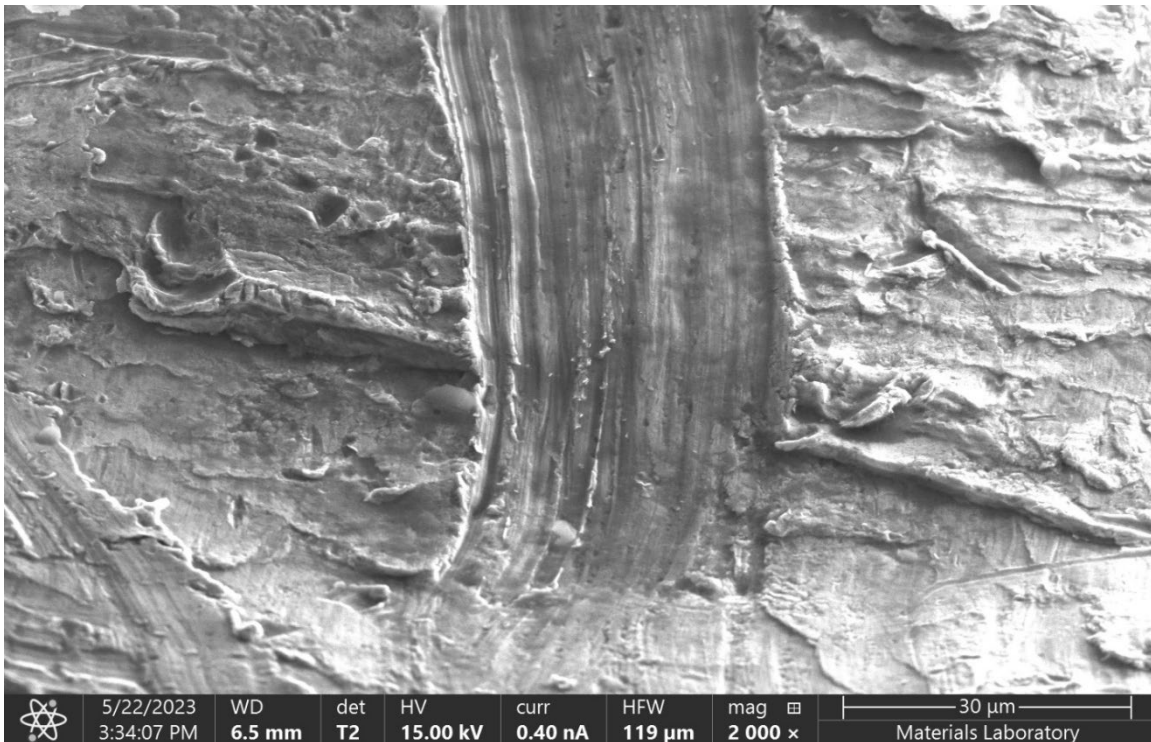


Figure 34. BE micrograph of the post fracture damage and smearing to part of the wire fracture surface in **Figure 33**.