

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA22LA167

MATERIALS LABORATORY

Specialist's Factual Report 22-073

October 13, 2022

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A. ACCIDENT INFORMATION

Location: Winder, Georgia
Date: March 25, 2022
Time: 10:48 eastern daylight time
14:48 coordinated universal time
Vehicle: Cessna 172P, N62283
Investigator: Heidi Kemner, AS-ERA

B. COMPONENTS EXAMINED

Remnants of aileron cables

C. EXAMINATION PARTICIPANTS

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

D. DETAILS OF THE EXAMINATION

On March 25, 2022, about 1048 eastern daylight time, a Cessna 172 was destroyed when it was involved in an accident near Winder, GA. The flight instructor and student pilot were seriously injured. According to the student pilot, they believed that the aileron cable may have become detached while attempting a landing approach. The flight instructor took control and noted a lack of response to the flight control inputs. The airplane then descended into trees, and a post-impact fire consumed the fuselage and wings. The wreckage was retained for further examination, with sections of a fractured aileron cable sent to the NTSB Materials Laboratory for additional examination.

Figure 1 shows the two remnants of the aileron cable, as received. For the purposes of this report, the cable remnants were labeled as 'left' and 'right' side remnants. The left side remnant was measured as 25.5 inches in length, and the right side one was 24.75 inches in length. Each cable remnant exhibited an approximately 90° kink, as labeled in Figure 1. The kink was located approximately 17.5 inches from the fracture on the left side, and 13.5 from the fractures on the right side.

The mating sides of the cable fracture surfaces are shown in Figure 2 and Figure 3. As shown in these figures, the general orientation of the strand fractures was flat, with some of the wires in the strands having tapered to a flat point. There was little macroscopic difference in the locations of the individual wire fractures. Also, as shown in the figures, the surfaces of the cable wires exhibited a reddish-brown or

maroon hue, with indications of flaky compounds. This surface material was consistent with rust or surface iron oxides, exemplified on the right side of Figure 4.

To examine the cables and the underlying fracture surfaces, the cable remnants were sectioned approximately 2 inches from their fracture surfaces. The sections with the fracture surfaces were then sequentially and repeatedly cleaned in an ultrasonic bath with an Evapo-Rust solution.¹ This cleaning procedure slowly removed the surface oxidation, as exemplified in Figure 4.

During the repeated cleaning process, the morphology of the cable fracture surfaces was revealed, as shown in Figures 4 and 5. Each fracture exhibited a slanted morphology on one side, with frayed and fractured wires on the other. The cable arrangement was consistent with a six-strand cable with a core strand. Two of the strands exhibited wire pullout and local elongation, whereas the rest exhibited a slanted or angled orientation. The fracture surfaces mated as illustrated in Figures 4 and 5, with the elongated and frayed wire strands mating, and the angled strands forming a V-shaped gap.

The fracture surfaces themselves were examined using optical microscopy and a field-emission scanning electron microscope (SEM). Figure 6 shows the as-received fracture surface of the right-side cable remnant. This surface exhibited enough surface oxidation to completely obscure most of the underlying features of the wires.

Figure 7 shows the right-side cable remnant fracture surface, after cleaning most of the surface oxidation compounds off the wires. This surface exhibited about 10 wires elongated past the fracture surface, exhibiting erratic deformation directions. These wires exhibited angled fracture surfaces, or localized necking near the fractures. Many of the other broken wires, particularly in the core and upper right of Figure 7, exhibited flat surfaces, with smearing or wear lines. The direction of these smearing lines was consistent across multiple wires, generally oriented in the vertical direction of Figure 7.

Figure 8 shows the mating left-side cable remnant fracture surface, after cleaning enough to remove some, but not all, of the surface oxidation. A flatter wire strand area in the lower left of the figure still contained some rust-colored compounds. The strands on the left exhibited consistent flat surfaces, though they were located about the still-corroded strand in the lower left. The wires in the strands on the upper right exhibited elongation and deformation, consistent with the mating wires on the right-side fracture surface illustrated in Figure 7.

¹ Evapo-Rust - a commercially-available chelating rust stripper currently manufactured CRC Industries, headquartered in Horsham Township, PA.

Figure 9 shows a closer view of the strand from the left-side cable fracture surface in Figure 8 when still covered in corrosion compounds, demonstrating the extent of the layering and compound intrusion between the individual wires. Figure 10 shows two of the strands with pulled out or elongated wires. Many of these fracture wires exhibited slanted fracture surfaces, with parallel streaks consistent with smearing and witness marks of wear.

The left side fracture surface was cleaned repeatedly until almost all the surface oxidation was removed. Figure 11 shows a typical view of the flatter wires, after this process. Many of the wires exhibited pock-marked features and missing material, consistent with the remainder of the underlying metal material after removal of the surface corrosion compounds.

A closer view in Figure 12 shows a closer view of some of the flatter wires that had exhibited relatively less surface corrosion damage. These wires exhibited an angled and flat surface orientation, with parallel streaks, consistent across the adjacent wires. In Figure 12, these streaks were oriented vertically. In addition, there were areas of deformed and thinned material (on the right side of the wires in Figure 12).

Figure 13 shows a closer view of one of these wires. While some of the surface material had been consumed by corrosion (and some corrosion products were still present, colored darker grey in backscattered electron mode), the parallel streaks were still present.² In addition, the deformed areas on the right exhibited rough features, consistent with the remainders of dimpled rupture—a feature consistent with overstress fracture of this localized area.

Some of the elongated wires, absent flat angled surfaces, are shown in Figure 14. Several of the wires had thinned erratically and exhibited pockmarks on all the surfaces—these features were consistent with corrosive attack of the wire metal. The damage was extensive enough on these wires that no discernible fracture features could be observed. Several of the other wires, like in Figure 15, did exhibit localized deformation in the form of necking near the fracture surface. In Figure 15, the wire exhibited tapering to a point, along with splitting of the wire material away from the fracture. The wire illustrated in Figure 16 exhibited a fracture surface with a classical cup shape. This fracture surface morphology, and the underlying dimple-like features, were consistent with tensile overstress fracture.

The corrosive attack to the wires was also present along the length of the cable and individual strands. Figure 17 shows an area of widespread attack on several strands of the left-side cable remnant. These wires exhibited material loss, spalling, and

² Backscattered electrons - SEM micrographs produced using backscattered electrons display contrast that is associated with the atomic numbers of the elements in the micrograph. Materials containing elements with higher atomic numbers visually appear lighter relative to other materials containing elements with lower atomic numbers.

deposits of corrosion compounds. The wire surfaces were often pock-marked, consistent with corrosive attack of the wire material, made bare after cleaning and removal of much of the surface oxide (Figure 18).

The wires also exhibited a cylindrical surface layer, exhibiting a columnar grain structure where fractured. Figure 18 shows a closer view of some of this surface material, which had surrounded the center wire where it was not spalled. Examination of this layer using energy-dispersive x-ray spectroscopy (EDS) found it to be consistent with an iron oxide. These compounds appeared visually black in color, as shown on the sides in Figure 8.

The composition of the wires was also examined using EDS, in an area absent corrosion. The core of the wires was consistent with carbon steel, and the surface exhibited high levels of zinc. These data were consistent with galvanized steel. The columnar-grained surface oxidation shown in Figure 18 was absent detectable levels of zinc.

Submitted by:

A handwritten signature in black ink, appearing to read 'Erik M. Mueller', with a long horizontal stroke extending to the right.

Erik M. Mueller
Materials Research Engineer

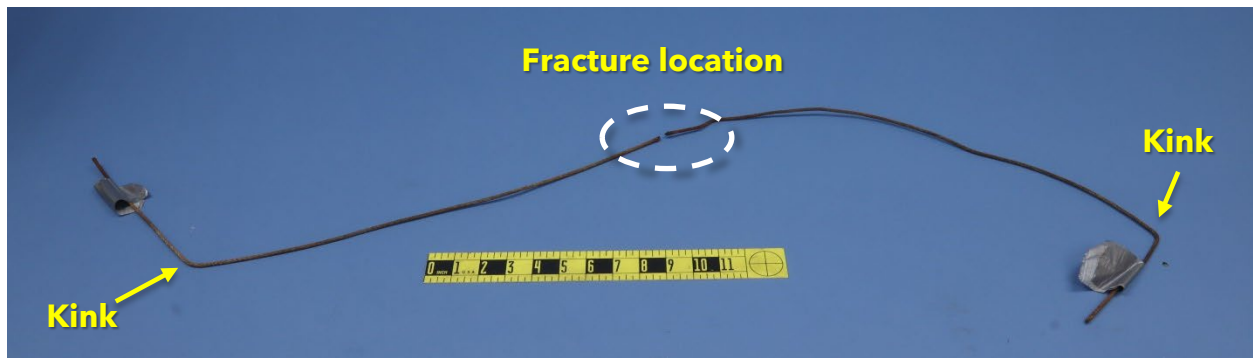


Figure 1. The two remnants of the fractured aileron cable, positioned with the fracture surfaces facing each other.



Figure 2. Closer view of the fractured region of the aileron cable.



Figure 3. View of the fractured aileron cable ends, positioned to face each other, as received.



Figure 4. The fractured ends of the left cable remnant (left side, post-cleaning) and the right cable remnant (right side, as-received).



Figure 5. View of the fractured ends of the aileron cable, positioned in the location consistent at fracture, post-cleaning of both sides.



Figure 6. View of the right side cable remnant fracture surface, as received.



Figure 7. View of the right side cable remnant fracture surface, after cleaning.



Figure 8. View of the left side cable remnant fracture surface, after first cleaning.

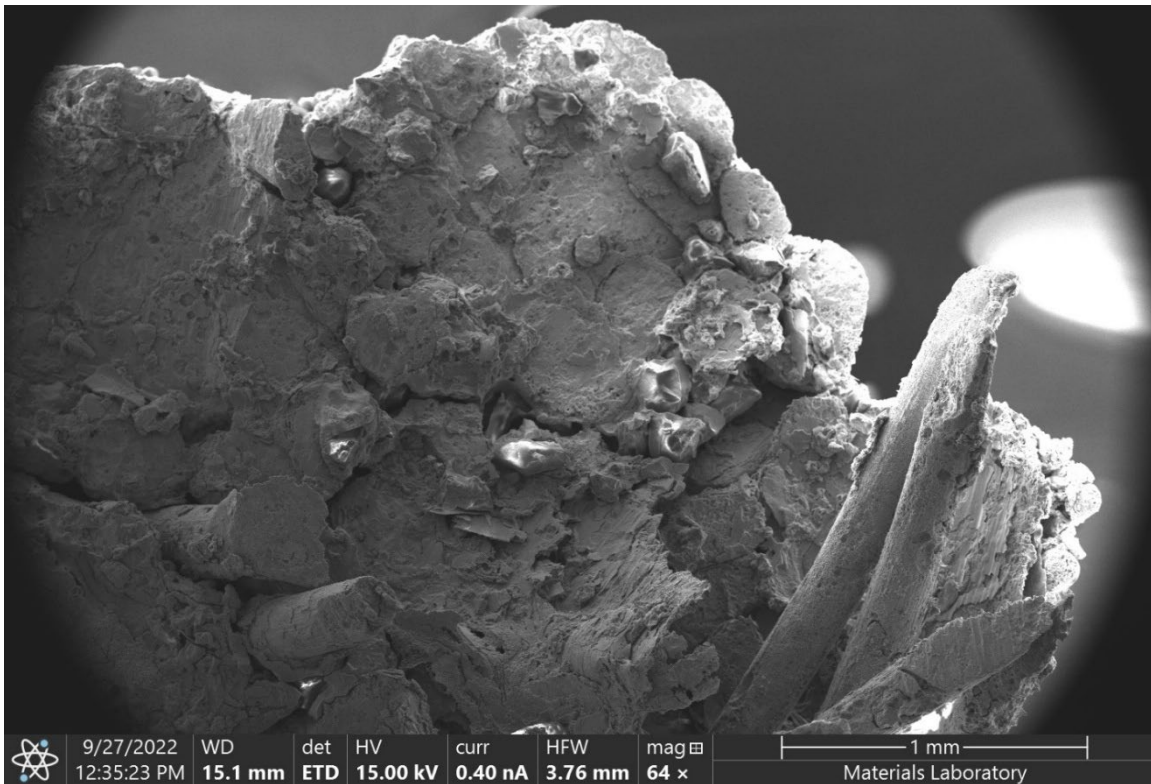


Figure 9. Secondary electron (SE) micrograph of the flatter area of the cable fracture.

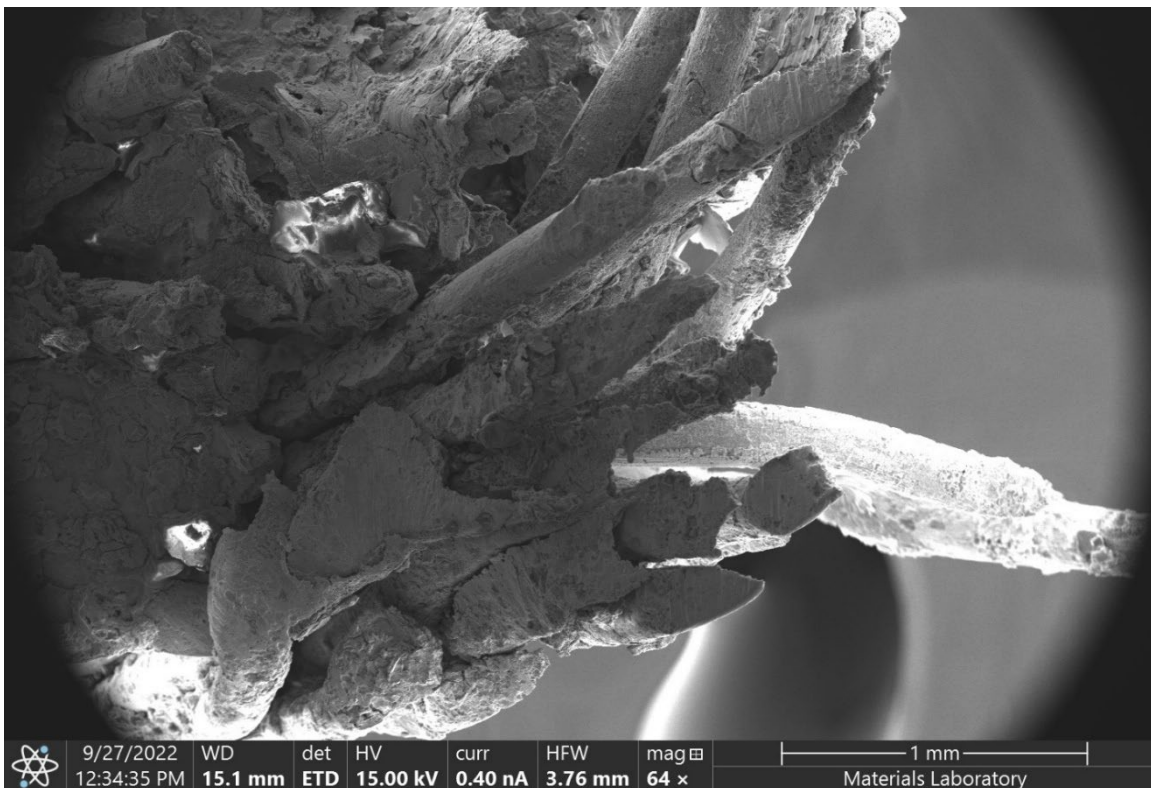


Figure 10. SE micrograph of the wire pullout area of the cable fracture.

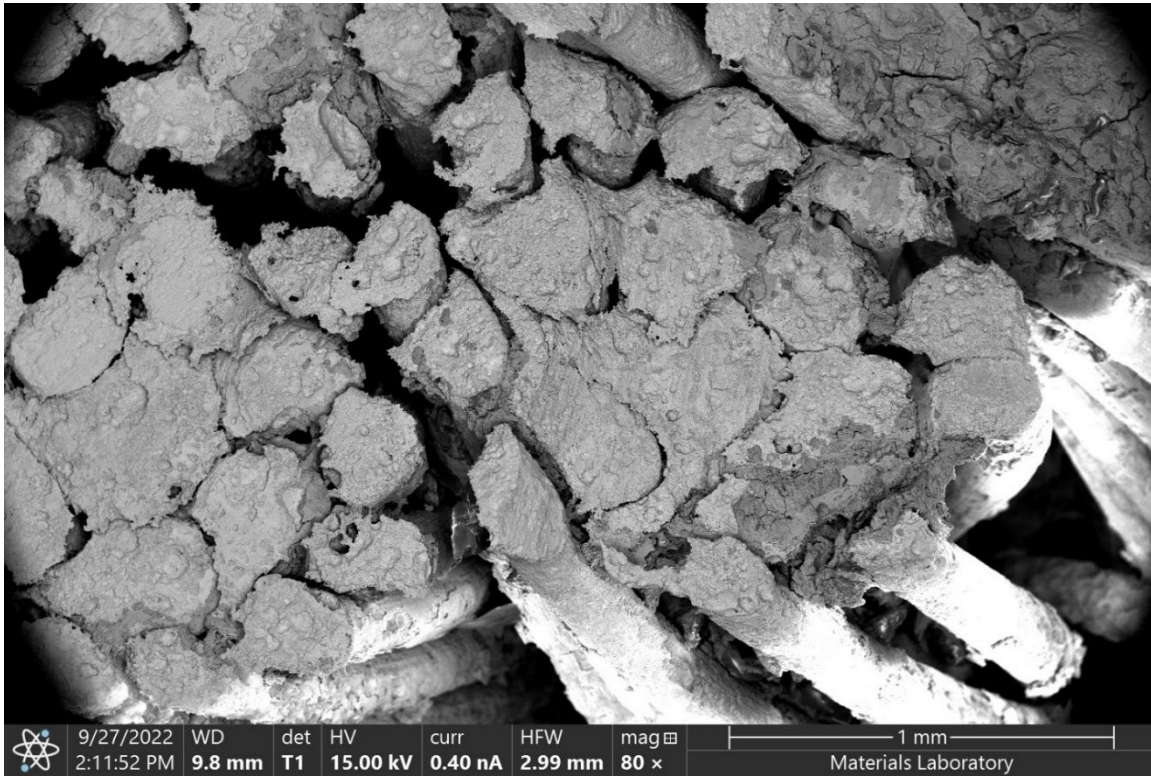


Figure 11. Backscattered electron (BE) micrograph of Figure 9, after successive cleaning.

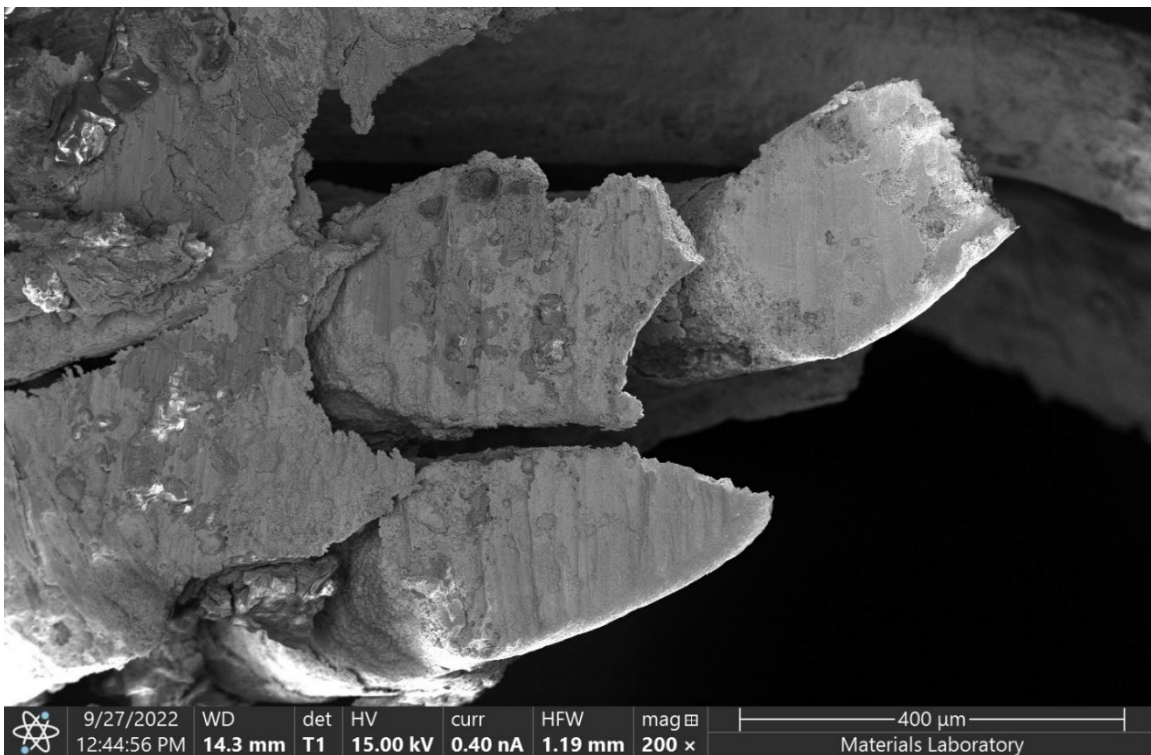


Figure 12. BE micrograph of the wire surfaces of the flat cable strand region.

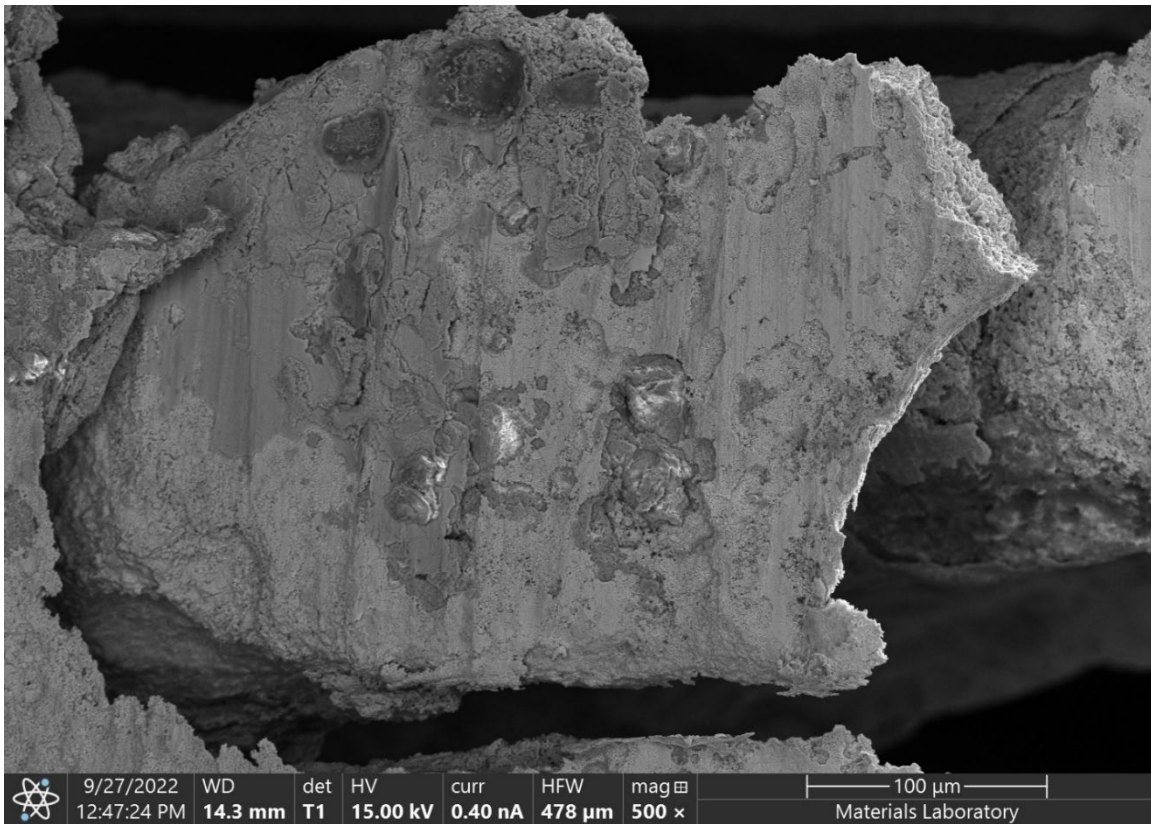


Figure 13. BE micrograph highlighting the surface of one wire in Figure 12.

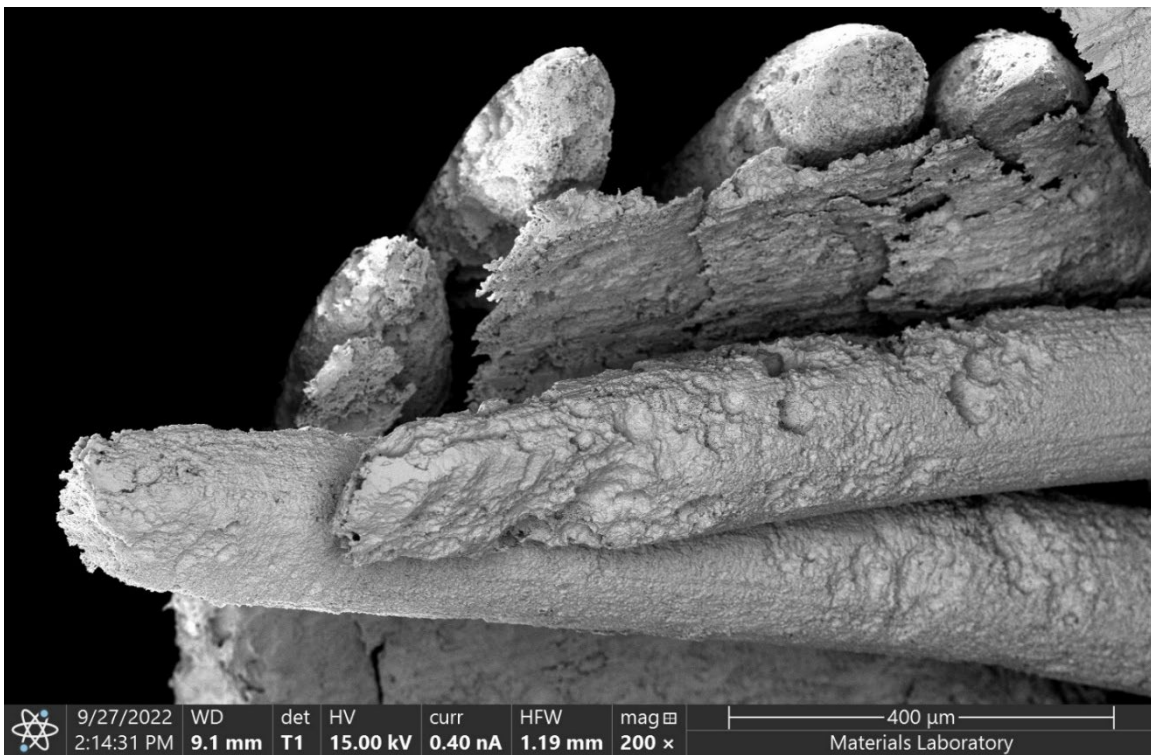


Figure 14. BE micrograph of elongated wires on the cable fracture.

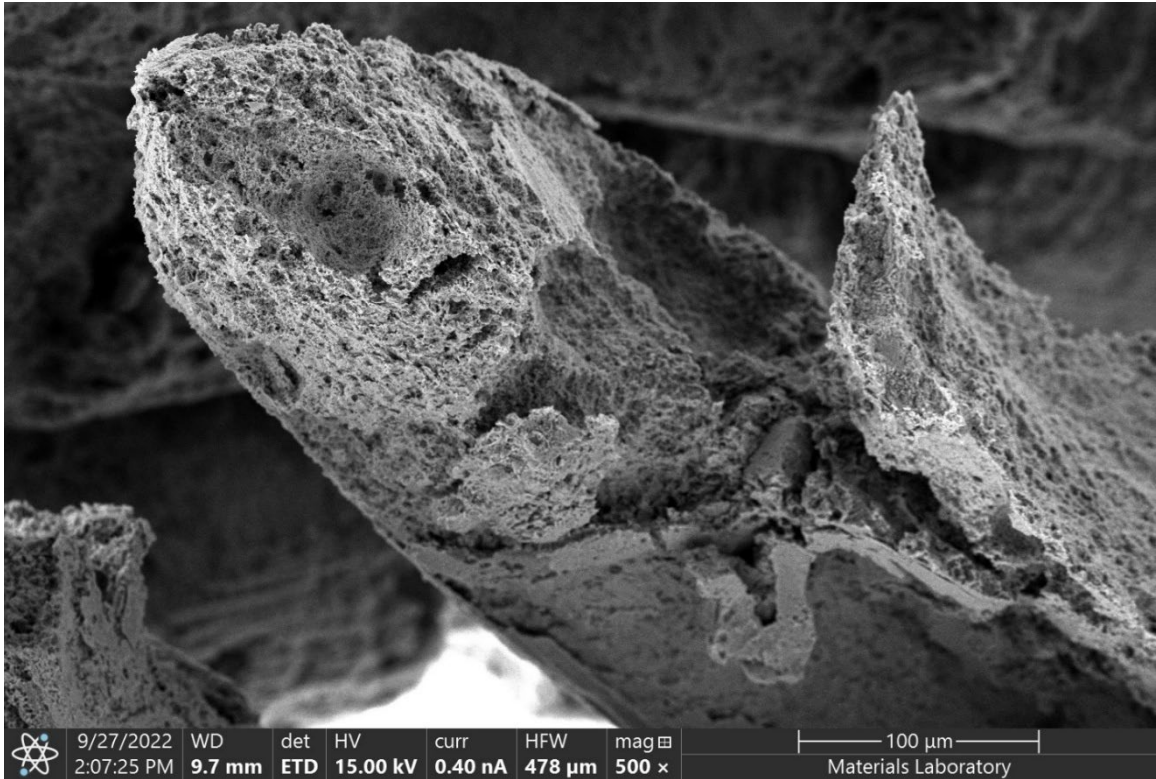


Figure 15. SE micrograph of a split wire that had necked near its fracture surface.



Figure 16. SE micrograph of cup-shaped wire fracture surface.

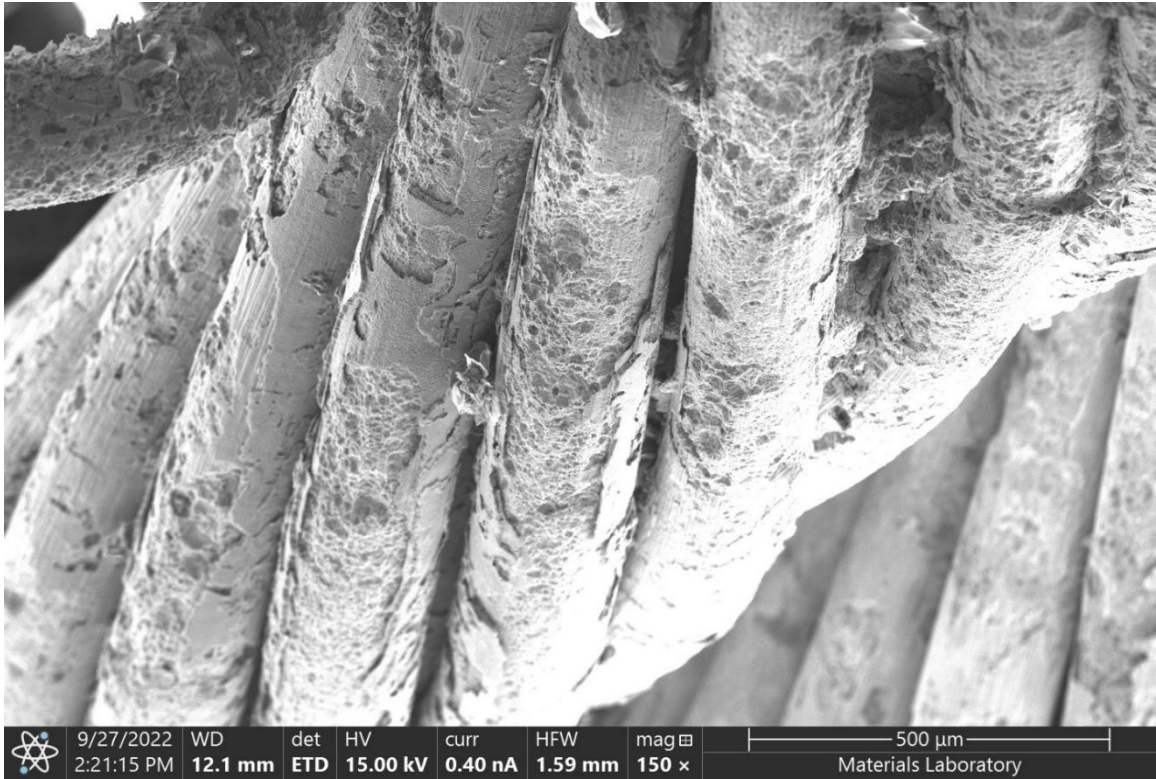


Figure 17. SE micrograph of the sides of several wires in a strand near the fracture surface.

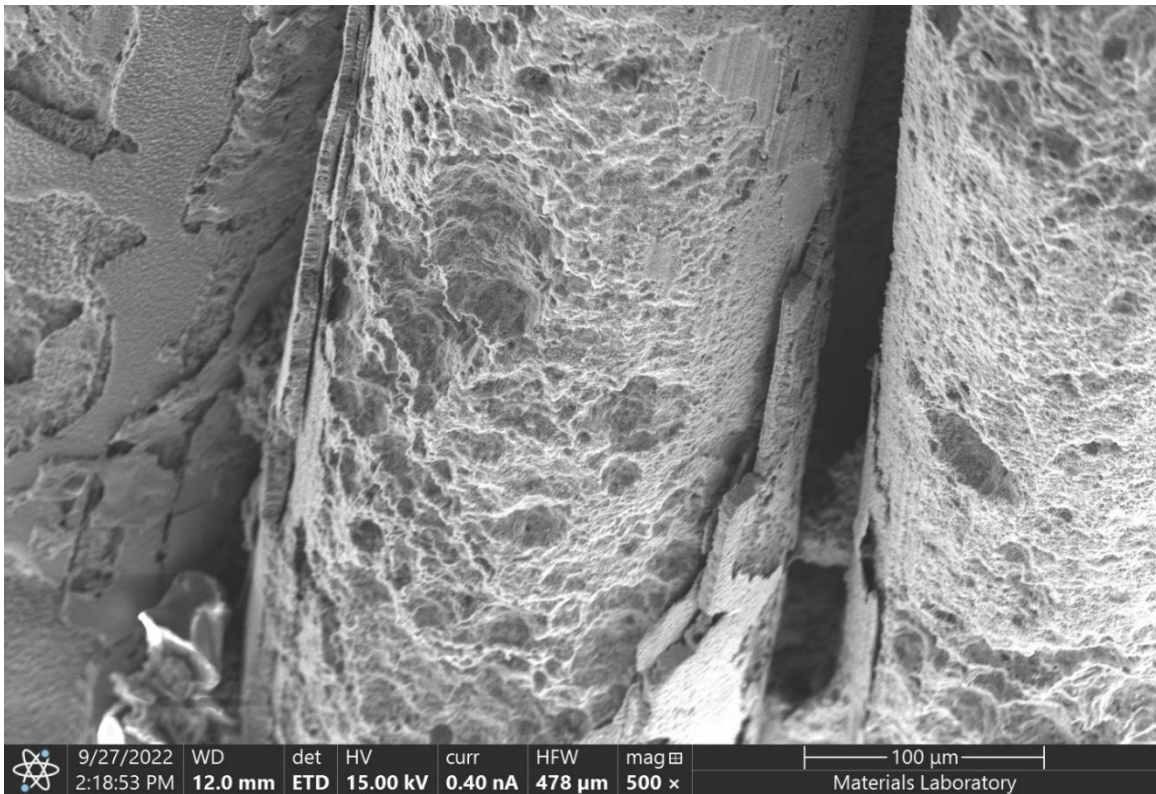


Figure 18. SE micrograph of corrosion and surface scale of a wire in Figure 17.

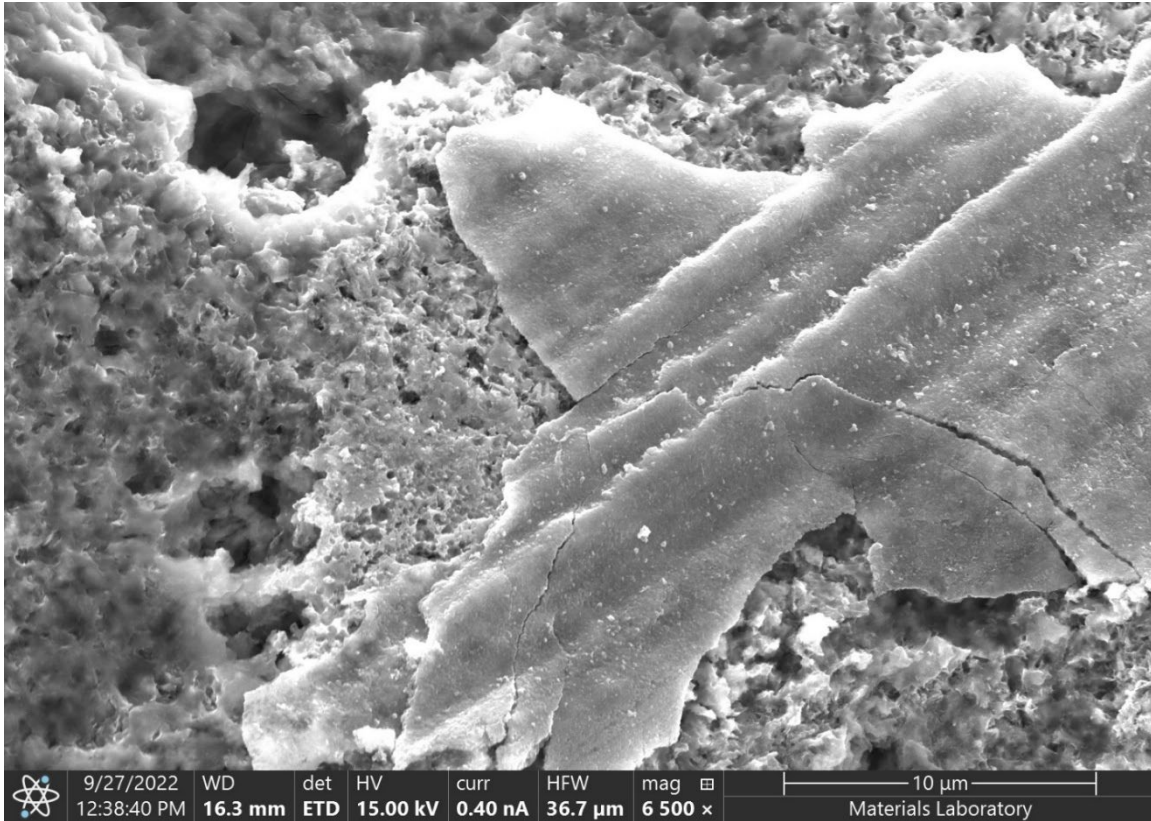


Figure 19. SE micrograph of a wire side surface, showing surface scale and an underlying surface with missing material.