

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



September 5, 2018

MATERIALS LABORATORY ADDENDUM REPORT

Report No. 18-057B

1. ACCIDENT INFORMATION

Place : Alexandria, Louisiana
Date : April 20, 2018
Vehicle : Boeing MD-83, N807WA
NTSB No. : DCA18FA144
Investigator : Lorenda Ward, AS-10

2. COMPONENTS EXAMINED

Fractured remnants of a main landing gear assembly

3. DETAILS OF THE EXAMINATION

This NTSB Materials Laboratory Addendum Report details the fatigue analysis performed on the thumbnail crack on the upper fracture surface of the landing gear cylinder (see Figure 1). Using a scanning electron microscope (SEM) the thumbnail crack was measured as being 0.035 inches (0.89 mm) in depth and 0.072 inches (1.84 mm) in length.

The fatigue striation counts were taken at over 14 random, unique, and non-duplicated places on the fracture surface, with the distances from the initiation site recorded as well. The distances were measured using a field emission scanning electron microscope (FESEM). These locations and the measurements are shown in Figure 3 through Figure 16. No measurements were taken in the noted overstress bands, located at approximate depths of 0.022 inch (0.56 mm), 0.030 inch (0.76 mm), and 0.033 inch (0.83 mm).

Using a FESEM, a number of striations were counted, and the distance of the counted striations was measured. This analysis assumed that each counted striation (a feature consistent with crack growth) correlated directly to a landing cycle with no other comparable stresses (such as from braking or vibrations). The analysis also assumed that sampled regions were representative regions of fatigue crack growth at each particular crack depth, the fracture surface was flat, and that the fatigue striation spacing increased with crack depth. The summary of the results is recorded in Table I and converted to inches in Table II.

The data in the tables show the measured distance for the origin, the number of striations counted, the distance measured in the striation count, and then the calculated change in crack length over number of cycles (da/dN), from which the cumulative number of cycles was determined. For this fatigue crack, the total number of cycles was estimated to be 1774 cycles for the depth of the crack 0.035 inches (0.89 mm). The length of the crack for the depth of the end of the crack was measured as 0.072 inches (1.82 mm). This ratio of final crack length to final crack width (2.042) was used to calculate an estimated crack length for each sample depth, tabulated in both tables.

Of interest to the study was the estimated crack length at the time of the last inspection. The number of cumulative cycles versus crack depth was plotted in Figure 17. A linear regression of the data was performed, with the data in over 99% agreement. Using the regression formula, the crack depth at 218 cycles prior to the end of the crack (1556 cycles) was 0.029 inches (0.738 mm). The estimated crack length at this time would have been 0.059 inches (1.507 mm).

Erik M Mueller
Materials Research Engineer

Table 1 – Compiled data of the fatigue analysis on the fatigue crack, showing the individual striations counted and distance measured for each micrograph site (2 through 15), in metric units. The crack length at each increment was determined to be 2.042 the measured depth, based on the shape ratio of the thumbnail crack.

[illegible]

Table 2 – Compiled data of the fatigue analysis on the fatigue crack, showing the individual striations counted and distance measured for each micrograph site (2 through 15), in inches. The crack length at each increment was determined to be 2.042 the measured depth, based on the shape ratio of the thumbnail crack.

[illegible]

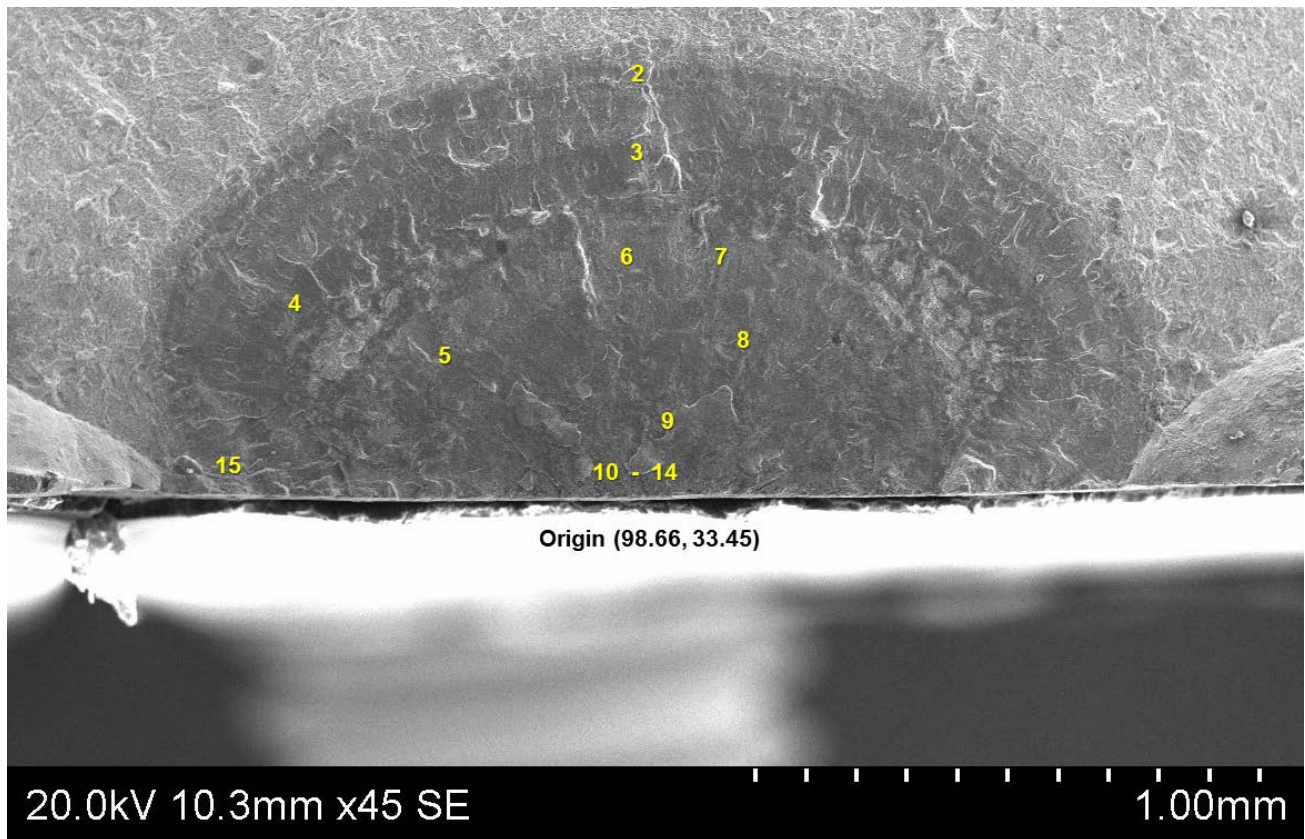


Figure 1 – Secondary electron (SE) micrograph of the thumbnail-shaped fatigue crack on the lower fracture surface, with relative locations of the 15 micrographs in Figure 3 through Figure 16 labeled.

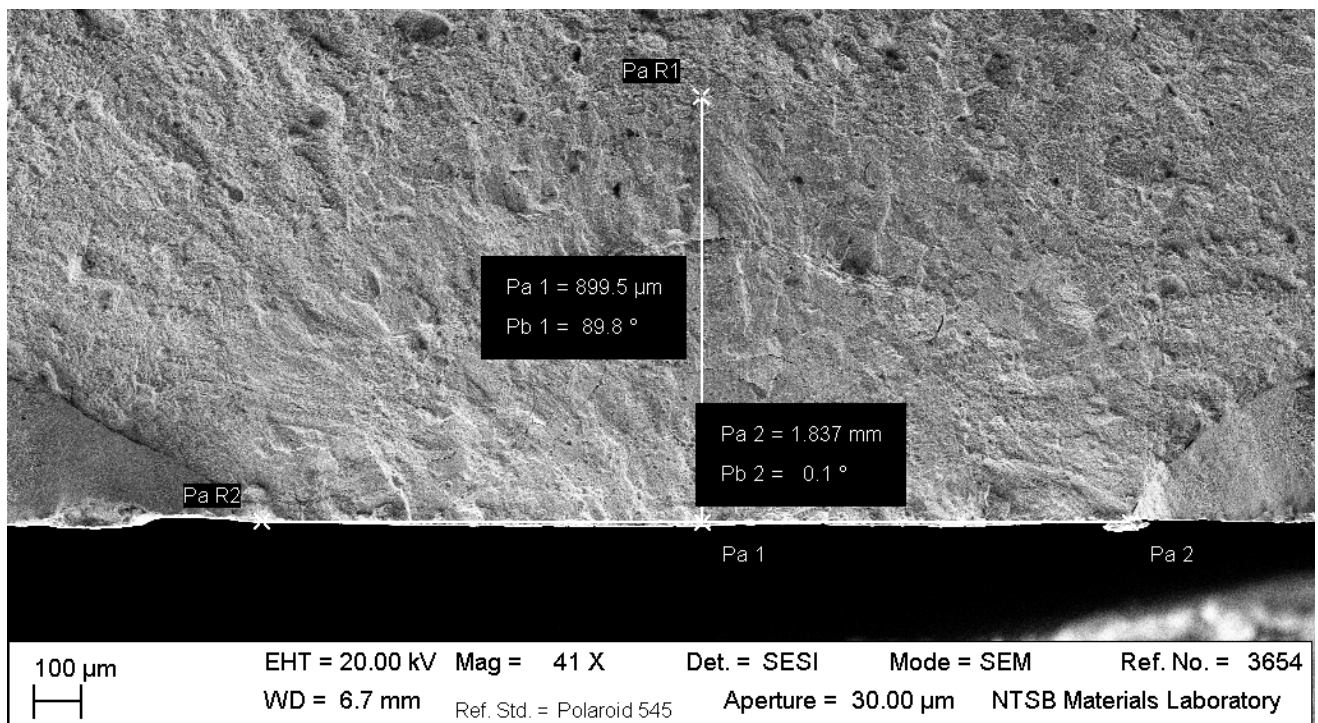


Figure 2 – SE micrograph showing the measured depth and length of the thumbnail crack.

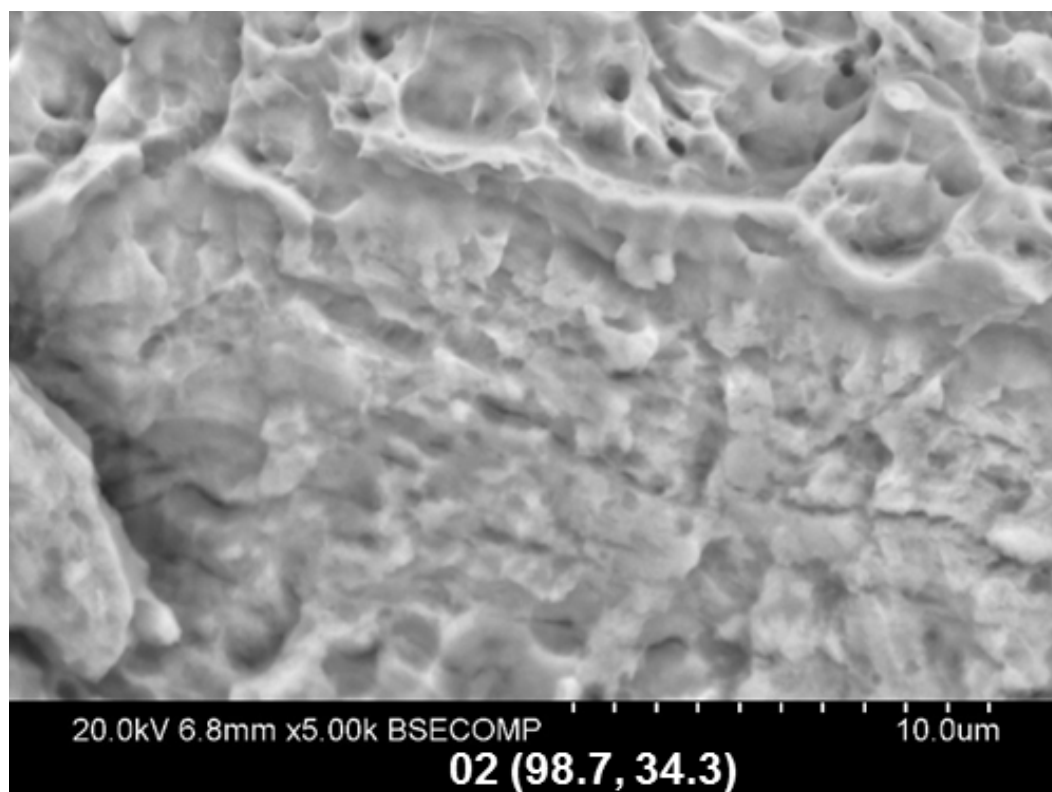


Figure 3 – SE micrograph with striation measurements at site 2 on the fracture surface.

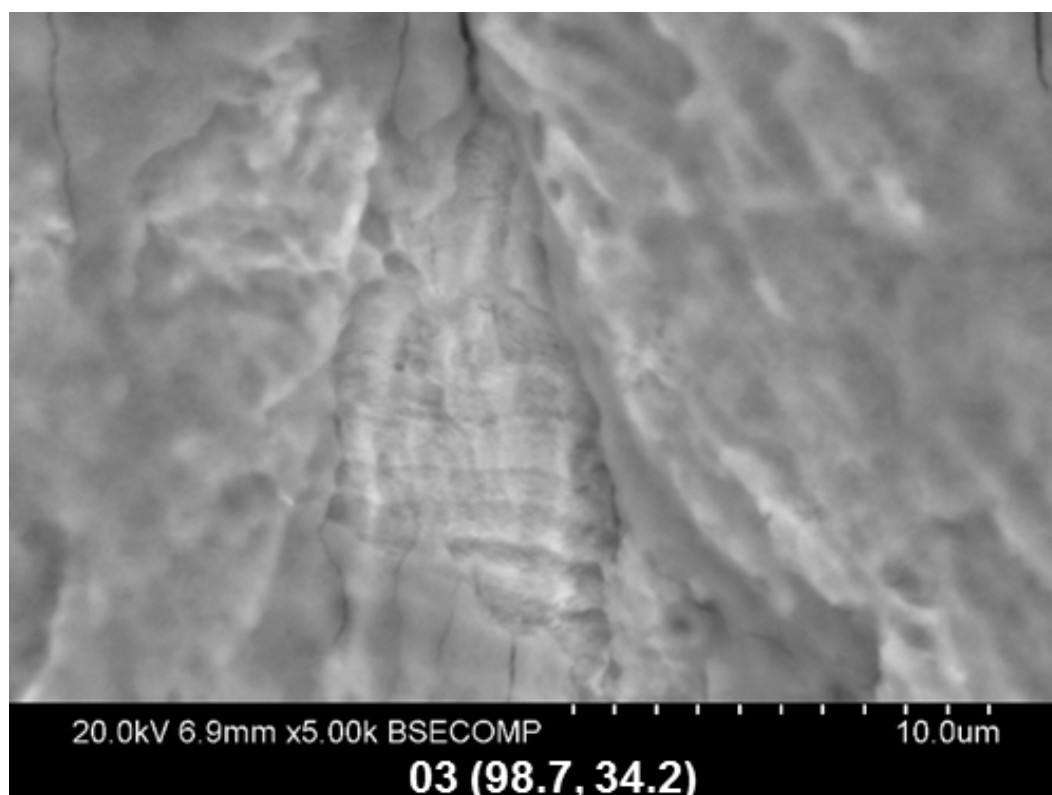


Figure 4 – SE micrograph with striation measurements at site 3 on the fracture surface.

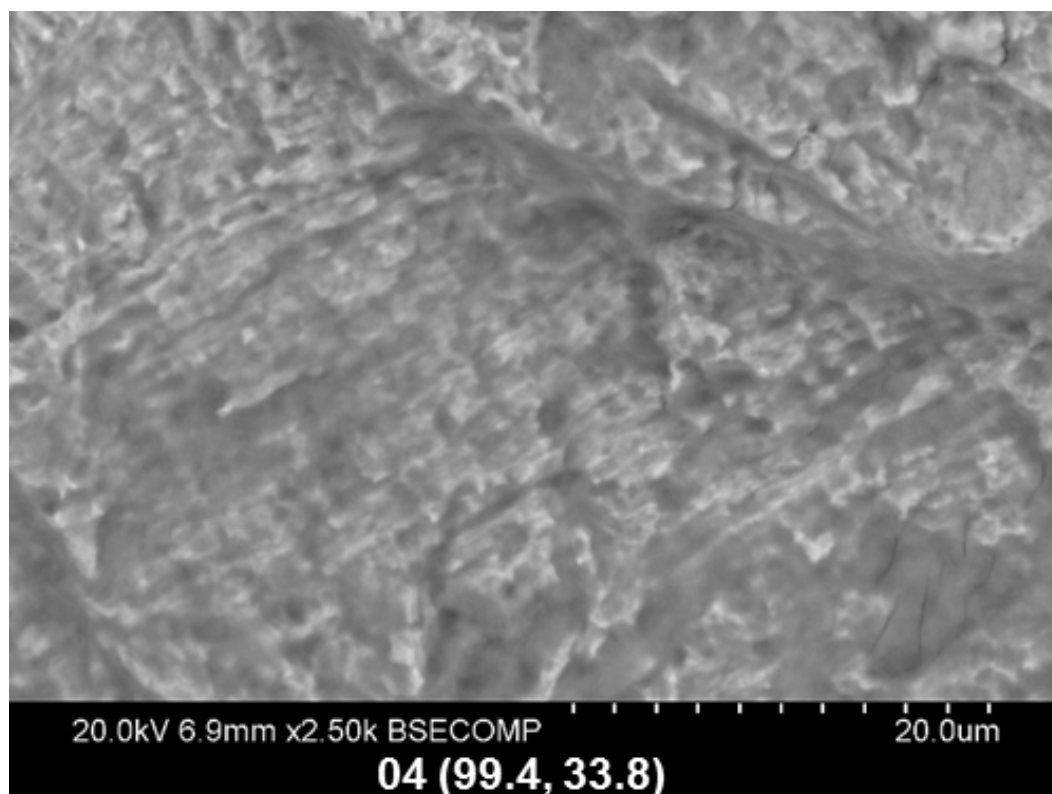


Figure 5 – SE micrograph with striation measurements at site 4 on the fracture surface.

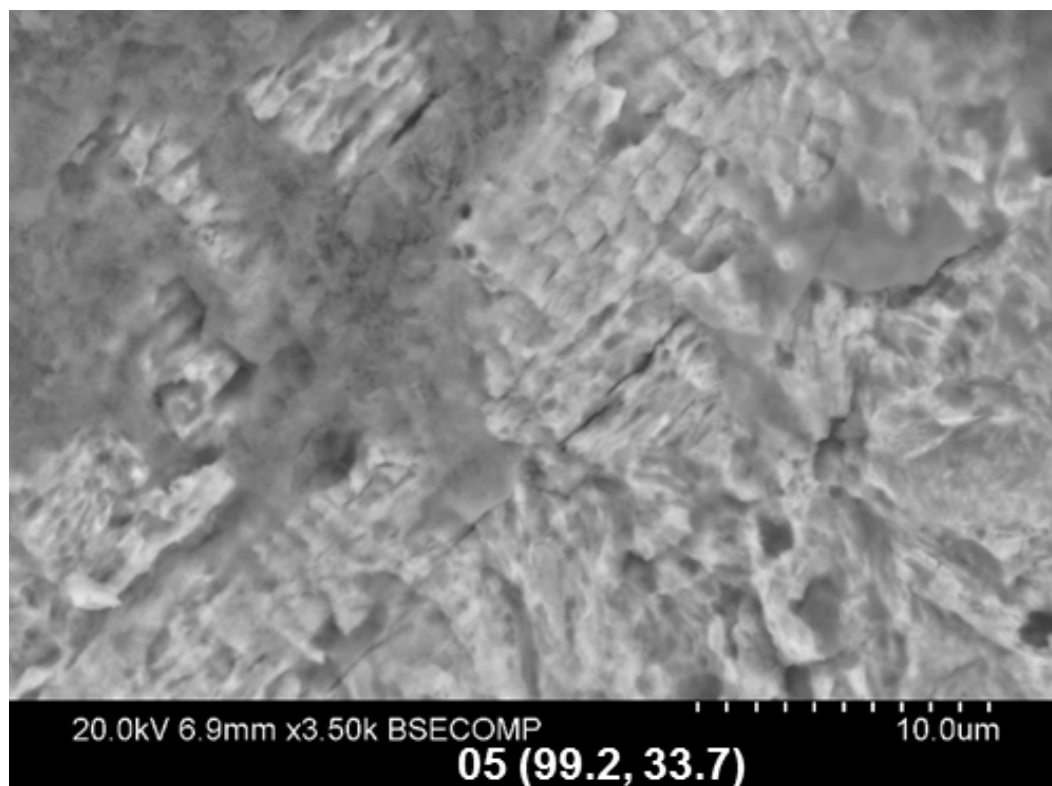


Figure 6 – SE micrograph with striation measurements at site 5 on the fracture surface.

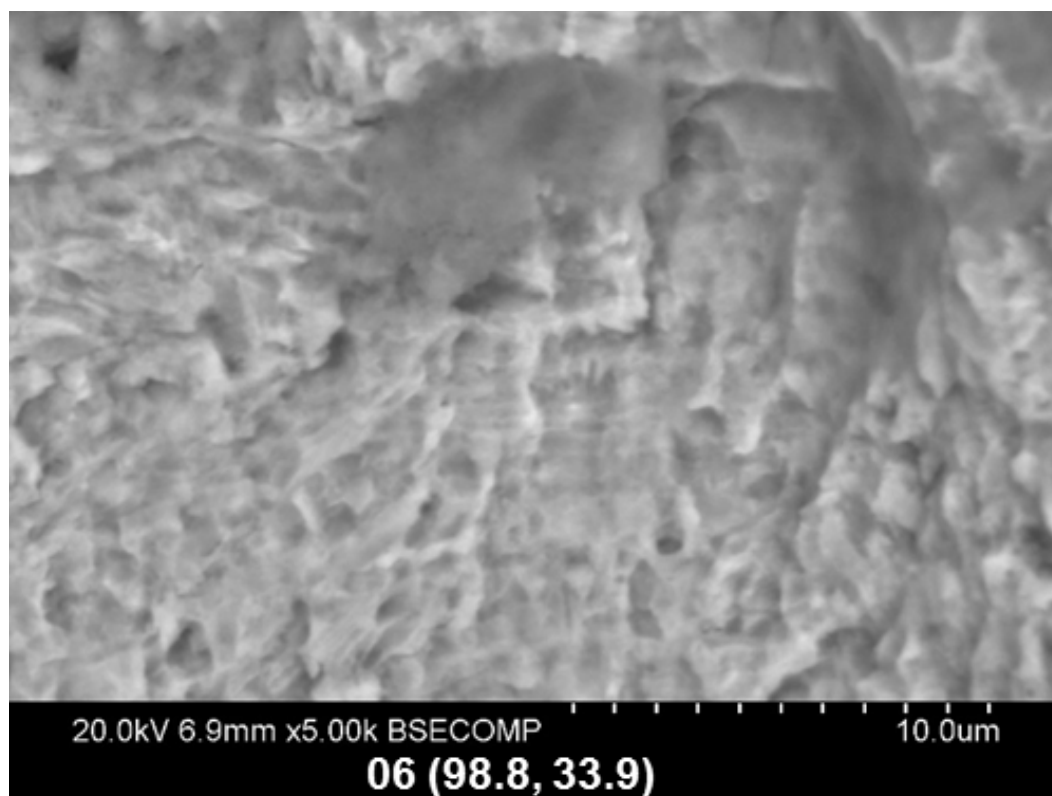


Figure 7 – SE micrograph with striation measurements at site 6 on the fracture surface.

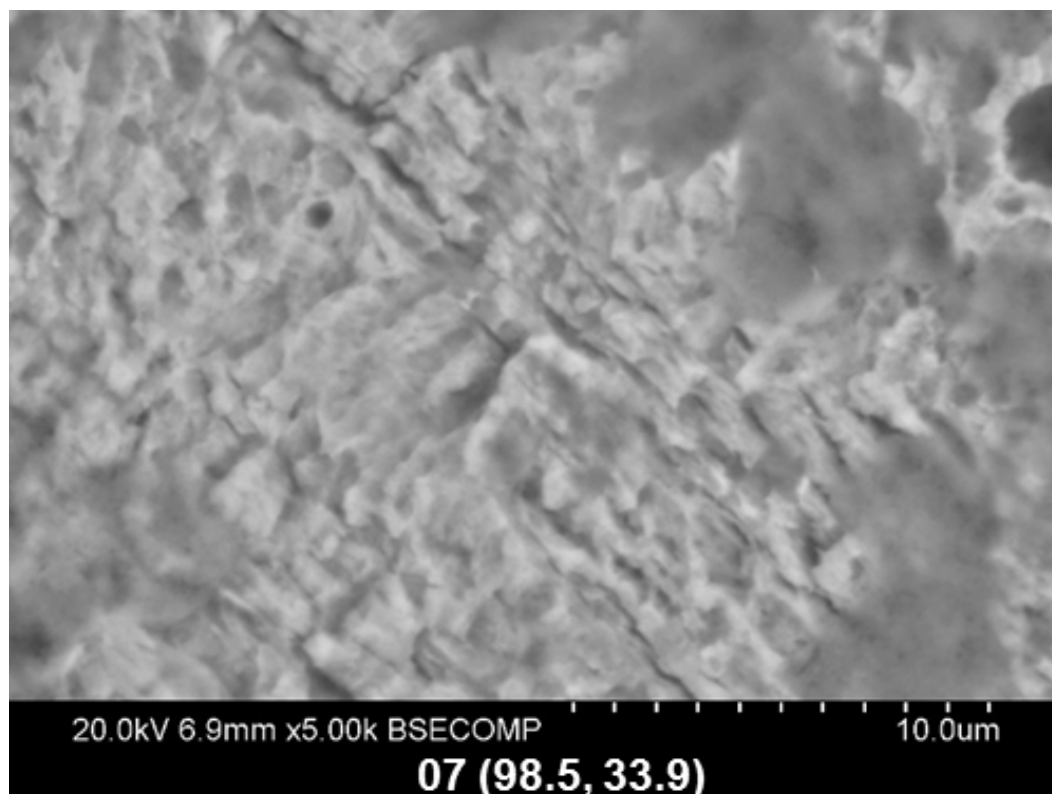


Figure 8 – SE micrograph with striation measurements at site 7 on the fracture surface.

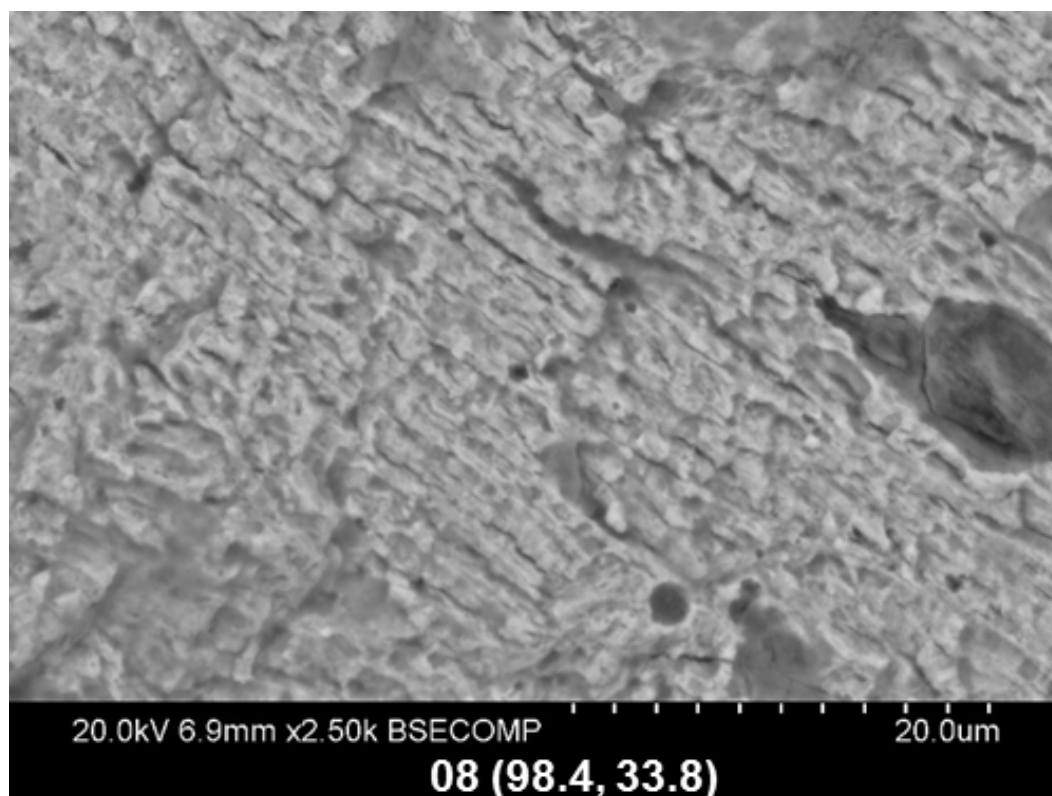


Figure 9 – SE micrograph with striation measurements at site 8 on the fracture surface.

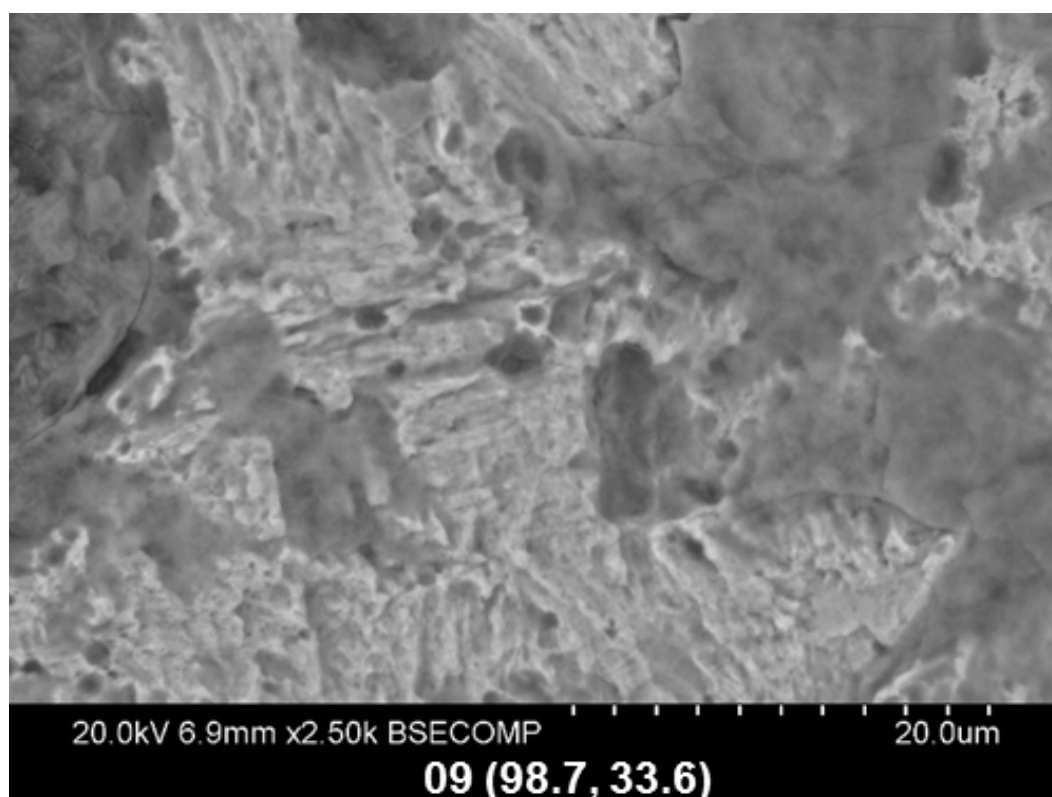


Figure 10 – SE micrograph with striation measurements at site 9 on the fracture surface.

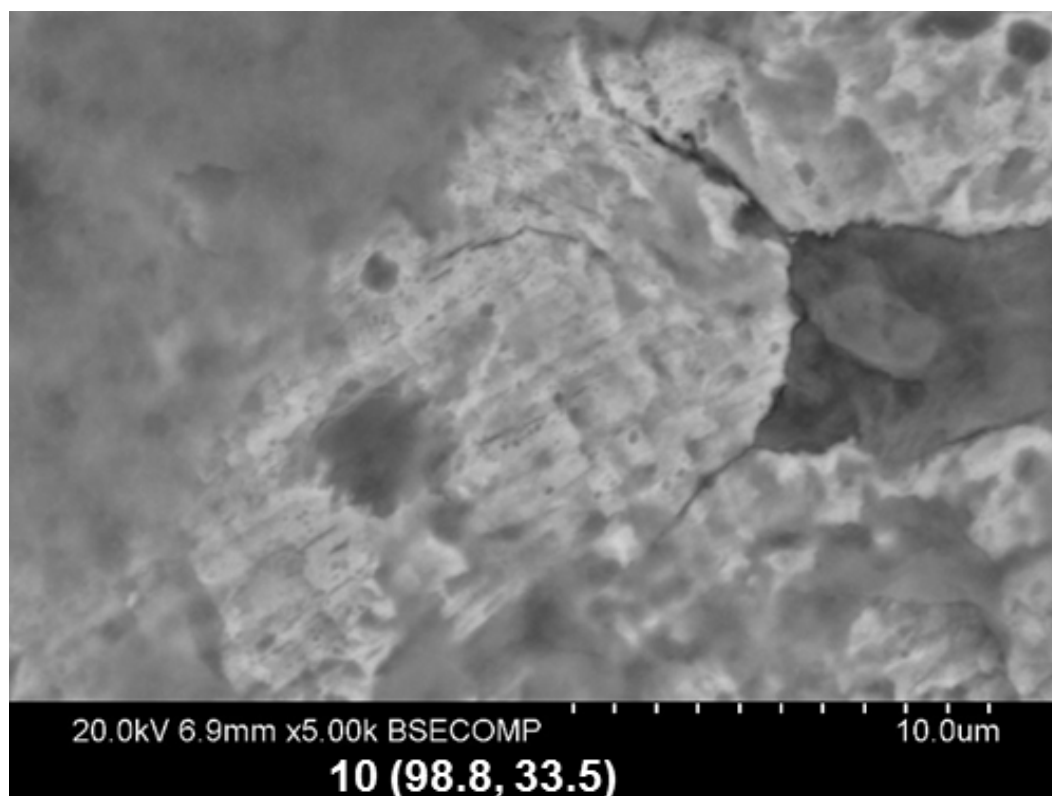


Figure 11 – SE micrograph with striation measurements at site 10 on the fracture surface.

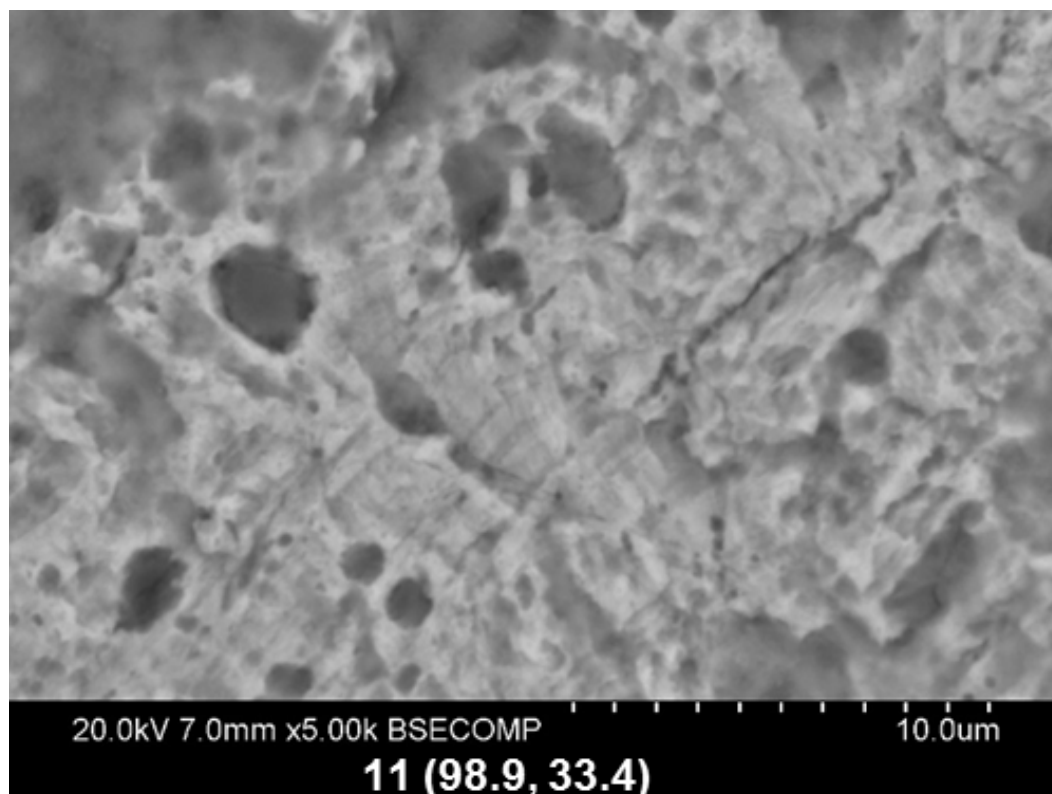


Figure 12 – SE micrograph with striation measurements at site 11 on the fracture surface.

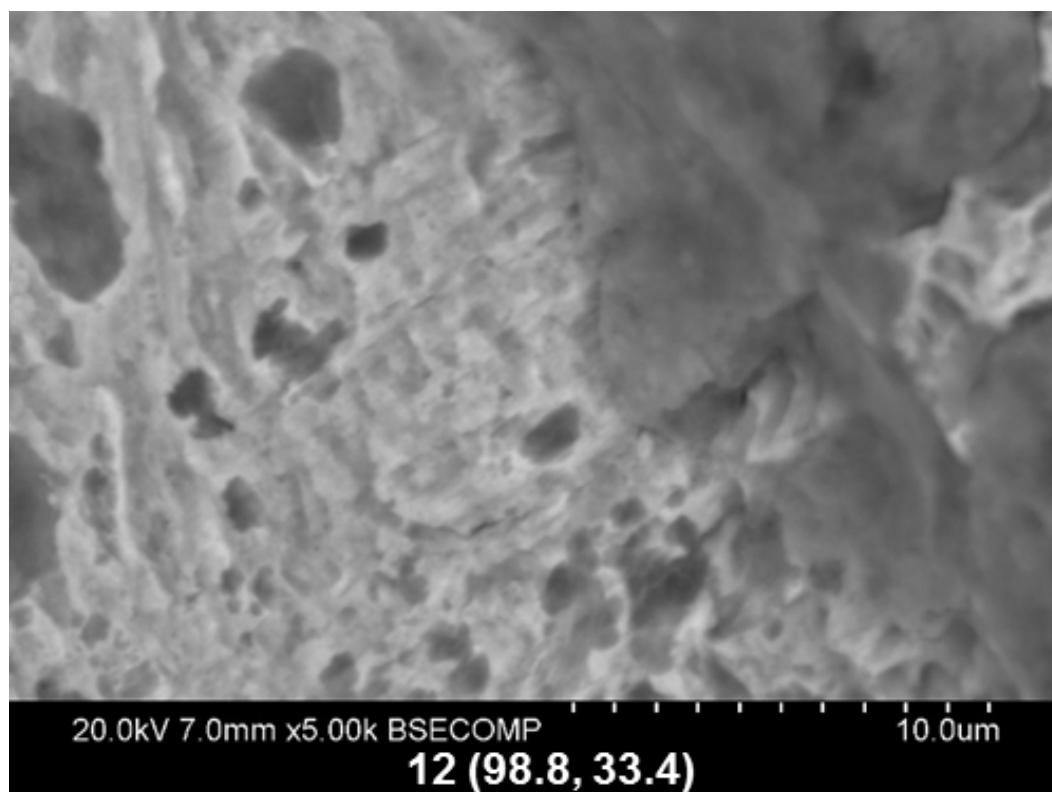


Figure 13 – SE micrograph with striation measurements at site 12 on the fracture surface.

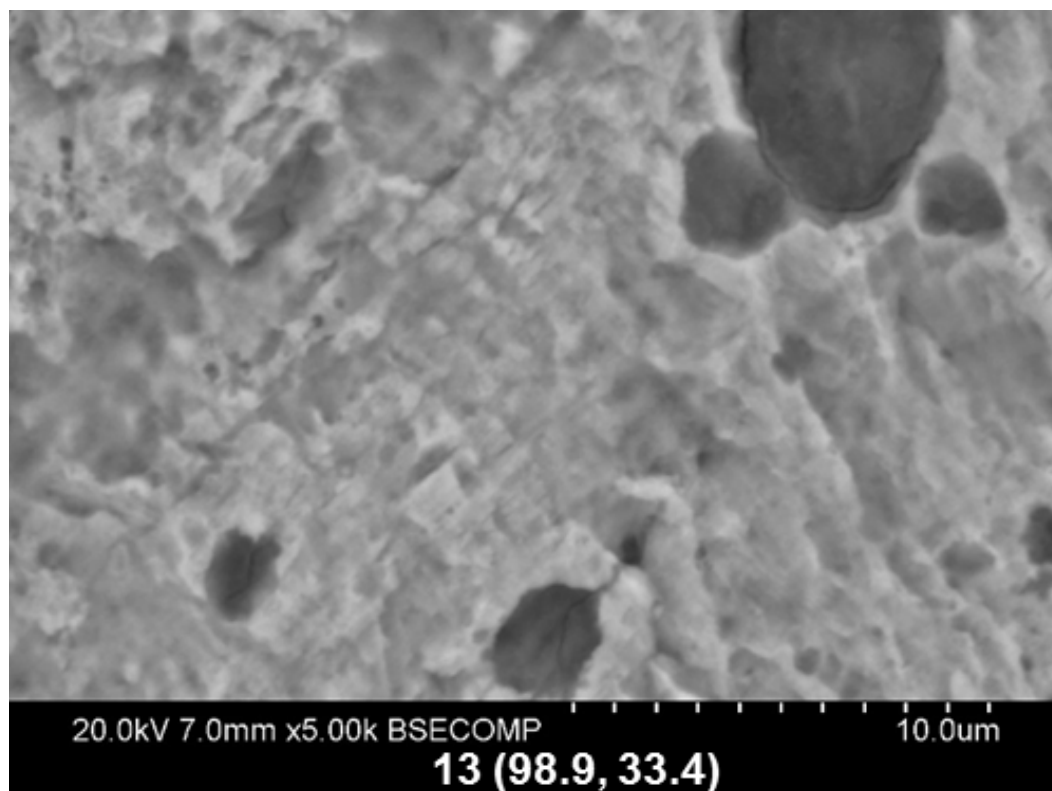


Figure 14 – SE micrograph with striation measurements at site 13 on the fracture surface.

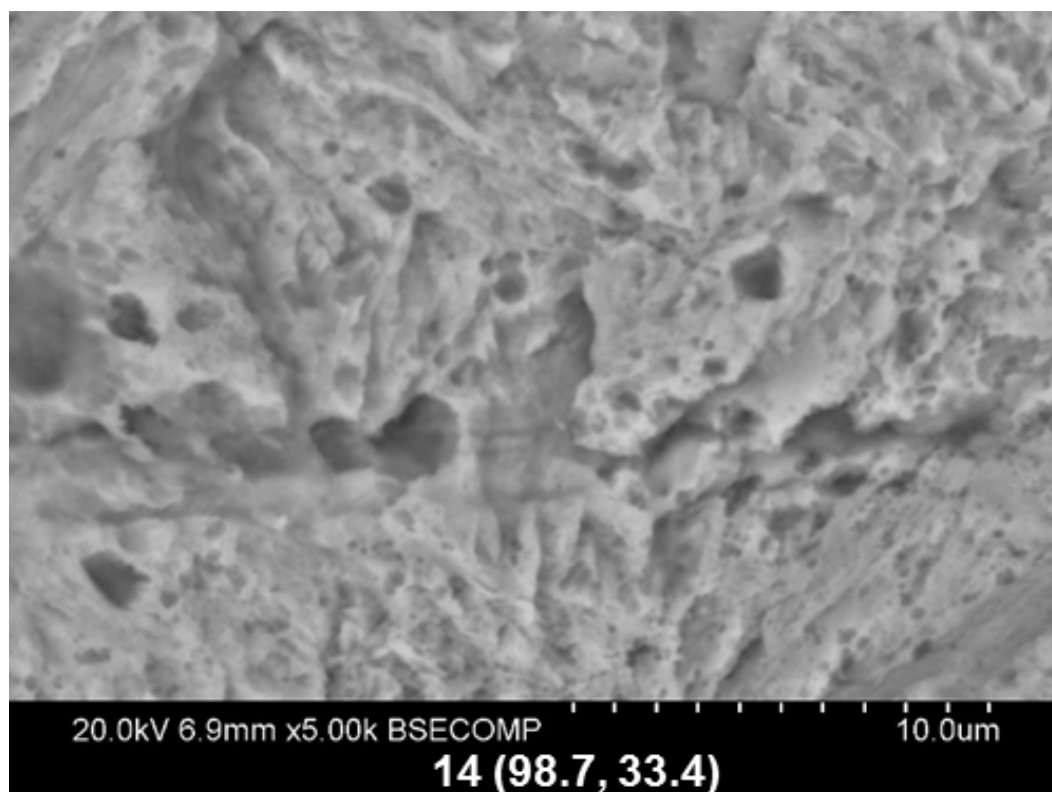


Figure 15 – SE micrograph with striation measurements at site 14 on the fracture surface.

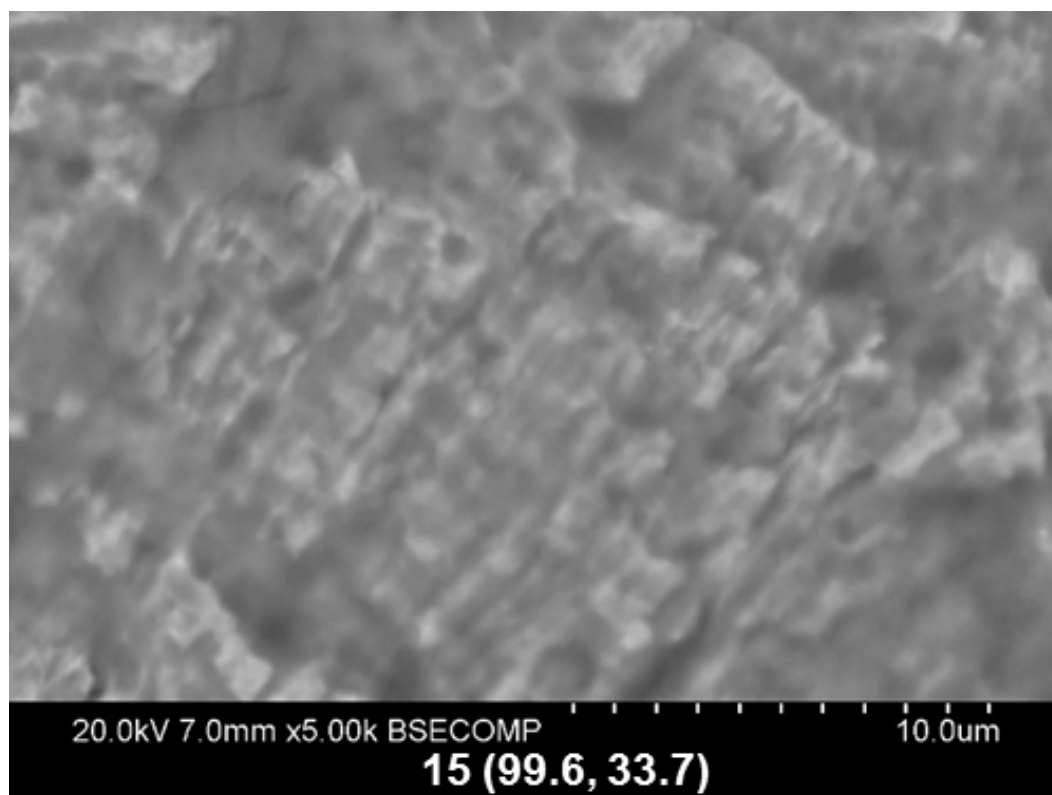


Figure 16 – SE micrograph with striation measurements at site 15 on the fracture surface.

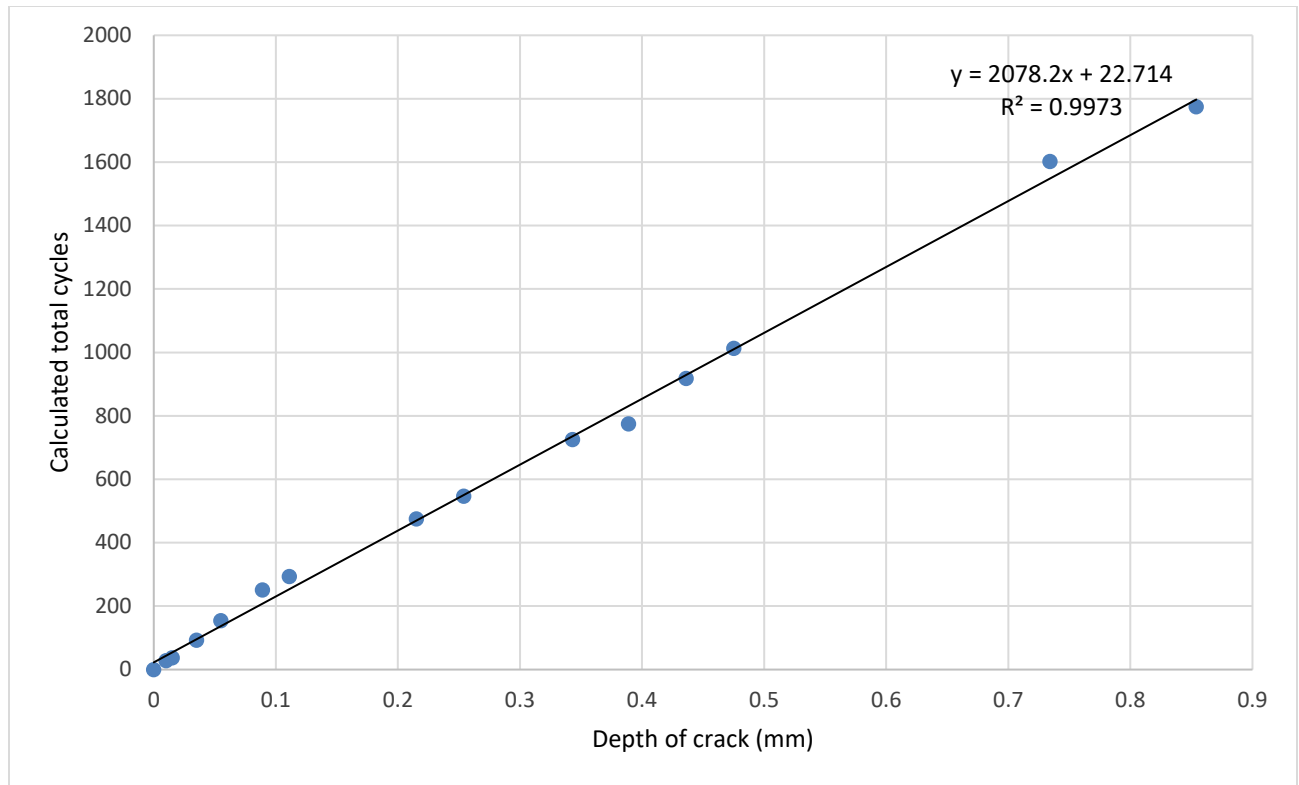


Figure 17 – Plot of the cumulative calculated number of cycles (based on striation count) per depth counted. The data was fitted to a linear regression, with the formula and R^2 information on the chart.