# Engineering Analysis/Report

**On-Site Testing of Earthbuster – Deep Soil Decompactor**

**Date Tested: 7/10/23, 1:30 pm MDT**

**Objective:** Determine direction of Earthbuster fracture seams in soils

**Test Property Location:** 917 Washington Ave, Laurel, MT 59044

## 1) Scope

Earthbuster owner Ken Miller had contacted Stahllion LLC to help analyze and conduct a test for determination of the fracture seams created by the Earthbuster product. The Earthbuster Deep Soil Decompactor has been around for years without any technical testing completed to analyze where and how the fracture seams occur when in use. The purpose of this testing was to try and determine where the fracture seams occur within an undisturbed sample of soil or undisturbed for a significant period similar to a representative sample of a typical subsurface wastewater treatment system or drain field. Determining where and how the fractures occur was thought to be visually observable via injecting a colored tracer powder into the system as the fractures occur.

## 2) Background

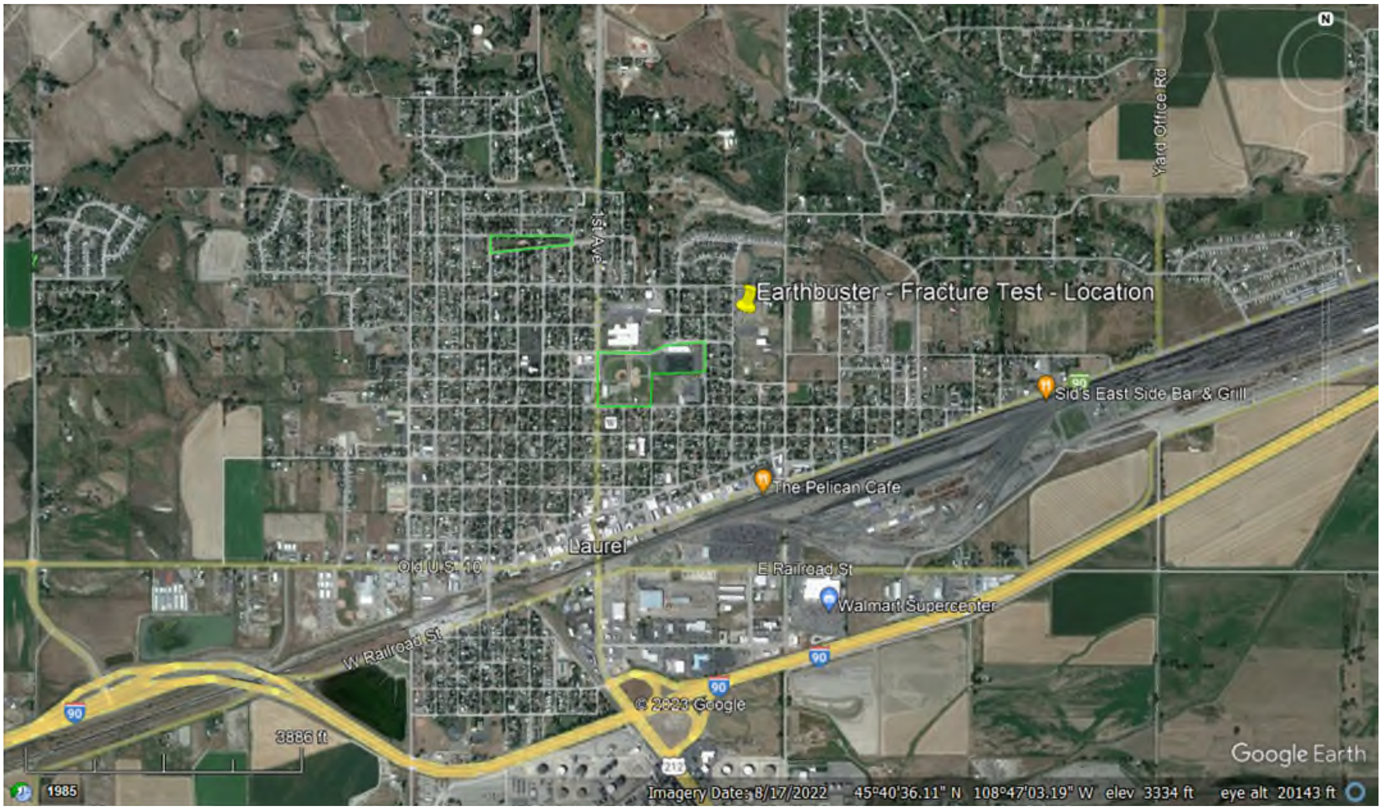
The Earthbuster has been designed to create fractures or loosen soils thereby allowing further water, air, and effluent infiltration. In one of the most common practices, the Earthbuster product is used to help rejuvenate drain fields for septic systems. The Earthbuster uses compressed air at 130 psi attached to the product to rapidly inject into the soils via a probe positioned into the soils at different depths thereby fracturing the soils anywhere from the surface to approximately 6 feet below the surface. Methods of positioning and driving the probe range from different types of equipment such as skid steers, excavators, telehandlers, etc. that have the ability to maneuver and create downward pressure to press the probe into the soils. The product also has a hammering mechanism similar to a pneumatic post driver built into it to help aid in the driving of the probe downward into the soils.

Website: https://www.earthbuster.com/

Soils typically seen as having hydraulic issues include clays, clay loams, and silty clay loams. However, typically more infiltrative soils have seen hydraulic infiltration issues also, but other factors can be present such as biomat which can essentially line the absorptive area of the drain field. Poor absorption by nature of the soil conditions or biomat buildup can both have an effect on the ability for soils to absorb water or allow the oxygenation needed for a properly functioning drain field.

## 3) Location

The location of the testing conducted was an area known to have silty clay to silty clay loam type soils. The soils had angular blocky to somewhat columnar shaped peds. The location of testing was completed near coordinates 45°40'40.09"N, 108°45'49.24"W in Laurel, MT. See *Appendix A* for the test location layout.




**Location Map**

## 4) <u>Test Parameters</u>

Testing parameters included 3 main test locations and differing depths for each location. Additional tests were conducted in a trial-and-error platform without knowledge of how the soils and materials used would react during testing alongside an excavation. To try and trace the fractures created, two different tracer injection powders were planned to inject along with the compressed air that would hopefully create a visual representation of path taken by the compressed air during the fracturing. Mica and Green Tea were used for tracer injection powders. Both products are environmentally safe and chosen for their environmentally safe nature as well as intended visual tracing qualities. Powders were injected at different depths and then soils excavated in successive distances from the injection site to find the nearest traces of powder. A device was created to introduce the powders into the compressed air system of the Earthbuster. The device essentially included a hopper that could be filled with the tracer powders and injected in line with the compressed air.

<u>Additional test parameters were as follows:</u>

1. Pressures – 130 psi
2. Pressure Relief Valve – Set at 150 psi
3. Powder Sample Chamber (Hopper) – 12 inch long x 2 inch diameter threaded steel pipe
4. Tracer Powders –
    a. Matcha Green Tea (QTY 2 @ 2 lb bag, 907 g)
    b. Mica Powder – Blackish Green (QTY 4 @ 200 g each)
5. Air Injection Probe – marked every one foot to have an approximation on depth of air pulse fractures.

Elevations of surface and fractures were initially taken from a randomly chosen base elevation with a laser level and checked on the initial few tests with the green tea powder, but as more testing was completed, elevations from surface via tape measure seemed to be an appropriate method as it was representative of the immediate area in relation to the air injection surface.

**5) Test Procedure**

Three tests were conducted along with some experimental pulses following the main tests. The first test utilized Matcha Green Tea as a tracer powder, the remaining two tests used Mica powder. The tests consisted of injecting a tracer powder at depths ranging from a minimum of 18” and maximum of 66” at the specified locations, then excavating on two sides of the injection point starting at 3’ away and moving closer to the injection point by 6” until tracer powder was identified. Experimental pulses were conducted afterward to see if fractures could be viewed while an open excavation was near the injection point.

**6) Results**

See the attached tabulated results in *Appendix B*. Images depicting the results are shown in *Appendix C*.

The matcha green tea tracer powder was found not to be an effective tracer material as it was difficult to identify unless directly next to the injection point. Also, higher soil moisture content did appear to be present near the test location of green tea powder. It was evident after the first test was conducted that the green tea powder was not a good candidate for the tracer powder.

The Mica powder was identifiable and used for the last two tests as it was easily seen as compared to the tea powder. When able to identify the fracture line, removing the soil above the fracture line was in some instances possible which made it easy to see the surface of the soil that the compressed air and powder traveled. The fracture lines observed were generally directed upward towards the surface on all observed fractures during this testing to some degree. See *Appendix C Images 5 & 6*. Some of the paths of travel were slightly more abrupt and yet some were less angled towards the surface. Differing angles were thought to be due to soil conditions such as compaction/hardness, moisture content, type, structure, etc.

Fractures occurred randomly through the soil. Noticeable fractures that were identifiable were seen in a generally horizontal style fracture easily when close enough to the injection point. However, it seemed that some fractures would occur in a vertical manner as well from the injection point and the results of inspection showed vertical fissures that had Mica powder escape to the surface.

Bearing pressure from the equipment being used may influence the direction and nature of fractures in the soil. In this case a skid steer was used to handle the Earthbuster equipment. The front tires from the skid steer did seem to affect the direction of the fracture as one visual observance showed the soils lift toward the skid steer until reaching its zone of bearing pressure influence surrounding the front tires. Most other pulses of compressed air seemed to travel out away either in front or to the sides of the equipment handling the product. The probe has injection holes oriented perpendicularly from the probe axis at every 90 degrees from each other allowing the compressed air to travel in four quadrants once exiting the probe. A change in the amount of ejection holes or the angle at which they oriented to the probe axis may be considered to the equipment if a certain angle or direction of fractures is desired.

Some of the air injections did escape next to the probe. This was likely due to the probe loosening the soil as it was pushed into the ground. The vertical lift of the skid steer used theoretically should allow the probe to be inserted completely vertical without repositioning of the equipment, however if the probe was not plumb before inserting, the probe would tend to "push" against the soils slightly compressing one side of the soils against the probe and in effect creating a lesser pressure on the other side of the probe. Any movement the machinery may experience could cause loosening of the soils around the probe also. This could have been the cause for some of these results and is a condition to consider when using the Earthbuster product for maximum benefit to soil aeration.

When excavating the soils next to the injection points, the excavator bucket tended to smear the soils immediately next to the bucket creating an area that was hard to identify as a fracture. Using a shovel or equipment to clear away the smeared surface or pushing the probe over while inserted into the soil to break off the immediate sides of the excavation wall made visually viewing the fractures more evident.

The additional experimental tests were performed with and without tracer powder to determine how the compressed air would escape next to an excavated area. Visually viewing the areas where the soil separated due to the air injection was still difficult unless soft powdery soil was present that indicated the air movement. Additional experimental tests with powder tracers were not quite as conclusive due to the powders escaping along the probe in the instances tested vs horizontally and out towards the excavation. One instance showed the powder escaping horizontally but only 8" of horizontal travel before exiting into the excavated trench did not show a definitive direction within the short amount of travel. See images *7, 8,* and *9* in *Appendix C*.

## 7) <u>Lessons Learned</u>

- Green tea powder injected approximately 6" of powder per air pulse
- Mica about 3" of powder per air pulse
- Green tea tracer powder not visible until excavated within approximately 6" of probe installation
- Soil moisture absorbed green tea tracer, only used for 1$^{st}$ test as Mica was found to be a better tracer material
- Mica powder still difficult to see without careful observation but certainly better as tracer and could be found easier
- Soil type and conditions play significant role in the ability to trace fractures
- Excavation/smearing of soils increased difficulty of viewing fractures
- Equipment bearing pressure seems to affect the direction of fracture travel to a degree

## 8) <u>Conclusion</u>

The testing conducted on July 10$^{th}$, 2023, provided a general idea of the path taken during the fracture testing with compressed air. In the observed cases, the tracer powder and compressed air appeared to escape to atmosphere or until pressure dissipated from injection point either via a generally horizontal path or somewhat vertical path. Soil type and condition play a significant role in the travel of the injected air. The direction and path taken by the compressed air can only be predicted in a general sense.  In most cases, the pressure created by the Earthbuster Deep Soil Decompactor will be lessened as the air escapes to a lower pressure zone or along localized faults created by the introduction of the compressed air.  The air pressure disperses as it creates these faults until it finds a path towards a lower pressure or disperses enough through the localized faults to lessen the pressure caused by the injection.  It is reasonable to conclude that the injected air would find a way to lower pressure zones within the soil.  In a typical scenario, the deeper the soil, the more static pressure within the soil, therefore lower pressure areas would be near the surface of the soil.  Assuming most soil and geological formations are fairly uniform (devoid of any voids), injected air pressure should travel to a lower pressure area which in the test cases conducted, traveled nearer the surface.  However, there exists a chance that a lower pressure zone could be found below the injection point in certain situations.

In the testing conducted, tracer powder was not found to have traveled deeper than the injection points during the testing in these soils.

# Appendix A – Site Layout

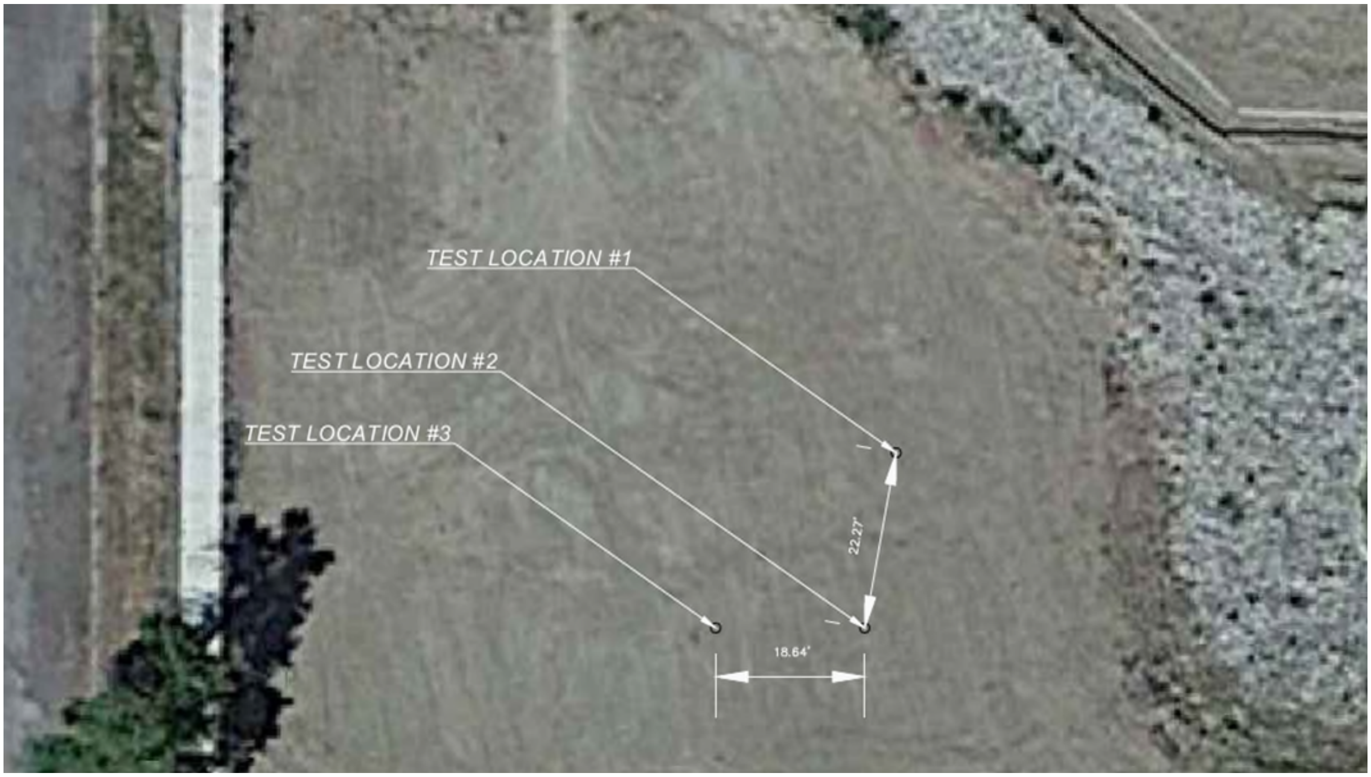



**Image A-1: Test Location Layout Map (North Up)**

# Appendix B – Tabulated Results

Earthbuster Soil Fracture Testing

Date and Time of Test - 7/10/2023, 1:30 pm MDT

Soils: Silty Clay to Silty Clay Loam

**Test 1:**

| Test Material: Matcha Green Tea - 2 lb bag (907g) | | |
|---|---|---|
| **Depth (inches)** | **Air Pulse Count** | **Observations** |
| 18 | 2 | |
| 30 | 2 | Hopper may have been out of powder - refilled after these pulses |
| 42 | 1 | |
| 54 | 1 | Refilled hopper after with 6" |
| 66 | 1 | |
| | | *approximately 6" of powder per pulse |

| Excavation Results | | |
|---|---|---|
| **Distance away** | **Depth Noticed (inches)** | **Column1** |
| 3' | | No discernable fracture lines or powder traces |
| 2.5' | | No discernable fracture lines or powder traces |
| 2' | | No discernable fracture lines or powder traces |
| 1.5' | | No discernable fracture lines or powder traces |
| 1' | | No discernable fracture lines or powder traces |
| .5' | 18 to 24 | Green tea powder traces - appeared to be absorbed into soil moisture |

**Test 2:**

| Test Material: MICA Powder - Blackish Green | | |
|---|---|---|
| **Depth (inches)** | **Air Pulse Count** | **Observations** |
| 18 | 1 | Fracture/pressure exited near skid steer tire |
| 30 | 1 | 1/3 of powder in hopper left |
| 42 | 1 | |
| 54 | 1 | Refilled after pulse to 6" |
| 66 | 1 | |
| | | *approximately 3" of powder per pulse |

| Excavation Results | | |
|---|---|---|
| **Distance away** | **Depth Noticed (inches)** | **Column1** |
| 3' | | No discernable fracture lines or powder traces |
| 2.5' | | No discernable fracture lines or powder traces |
| 2' | | No discernable fracture lines or powder traces |
| 1.5' | 20, 24, 31 | Clear fissures w/ Mica traces - fissure @20" approx. 4' 6.5" long (end to end) |
| 1' | | Fracture lines and powder traced back to injection point |
| .5' | | Fracture lines and powder traced back to injection point |

**Test 3:**

| Test Material: MICA Powder - Blackish Green | | |
|---|---|---|
| **Depth (inches)** | **Air Pulse Count** | **Observations** |
| 18 | 0 | |
| 30 | 0 | |
| 38 | 3 | Pulsed 3 times to make thicker Mica trace, filled hopper as needed |
| | | |
| | | |
| | | |

| Excavation Results | | |
|---|---|---|
| **Distance away** | **Depth Noticed (inches)** | **Column1** |
| 3' | | No discernable fracture lines or powder traces |
| 2.5' | | No discernable fracture lines or powder traces |
| 2' | | No discernable fracture lines or powder traces |
| 1.5' | | No discernable fracture lines or powder traces |
| 1' | 30.5 | Mica powder present - fracture appeared vertical & escaped to surface, soil pulled away from injection point for ease of viewing |
| .5' | | Mica powder present - fracture appeared vertical & escaped to surface, soil pulled away from injection point for ease of viewing |

# Appendix C - Images



**Image C-1:**
**Tracer Powders**

**Image C-2: Test 1 - Matcha Green Tea Tracer Powder – Powder absorbed into moist soil**

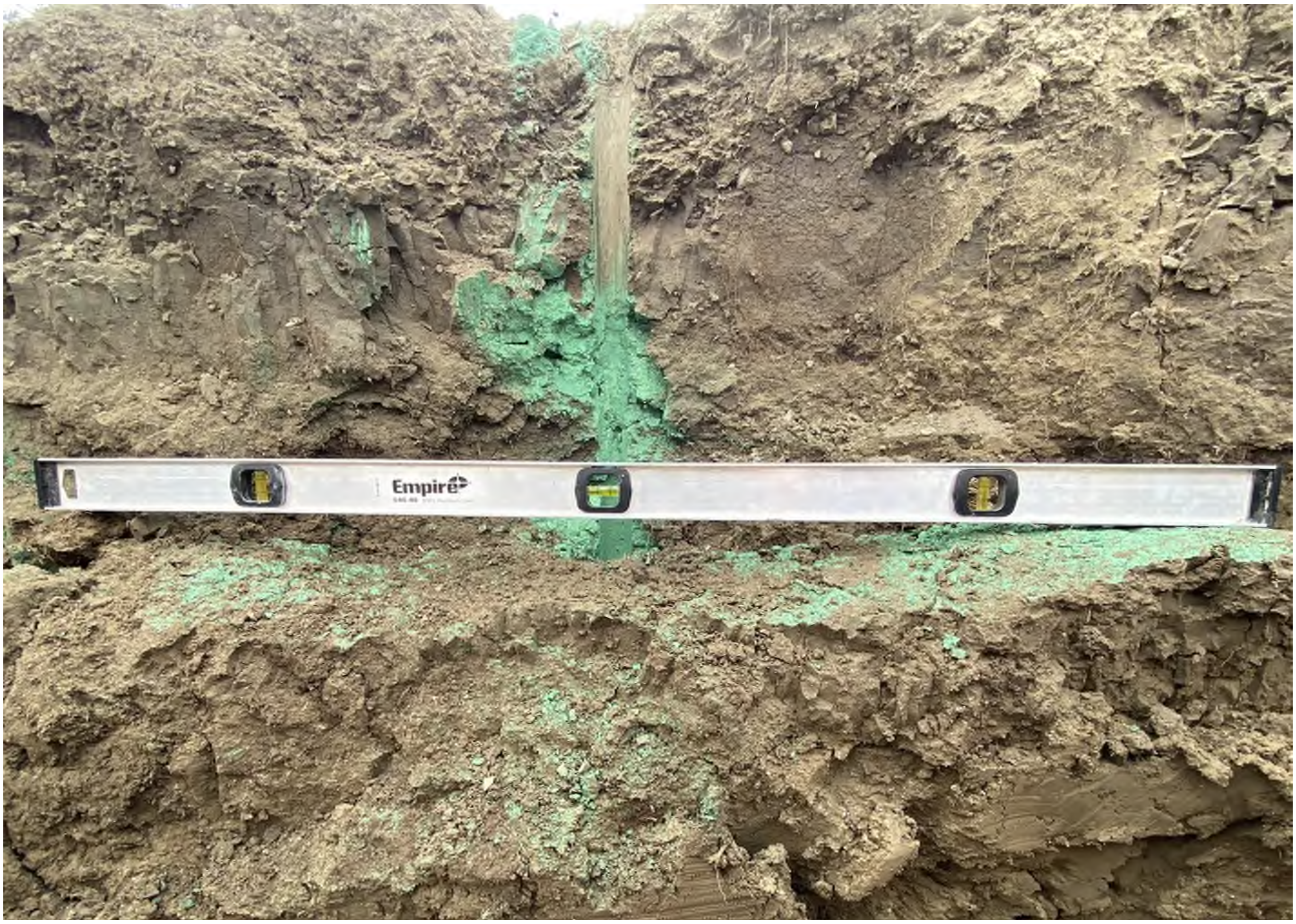



**Image C-3: Test #2 - Upward Horizontal Fracture @ 20" Deep with Mica Trace Along Surface of Fracture**

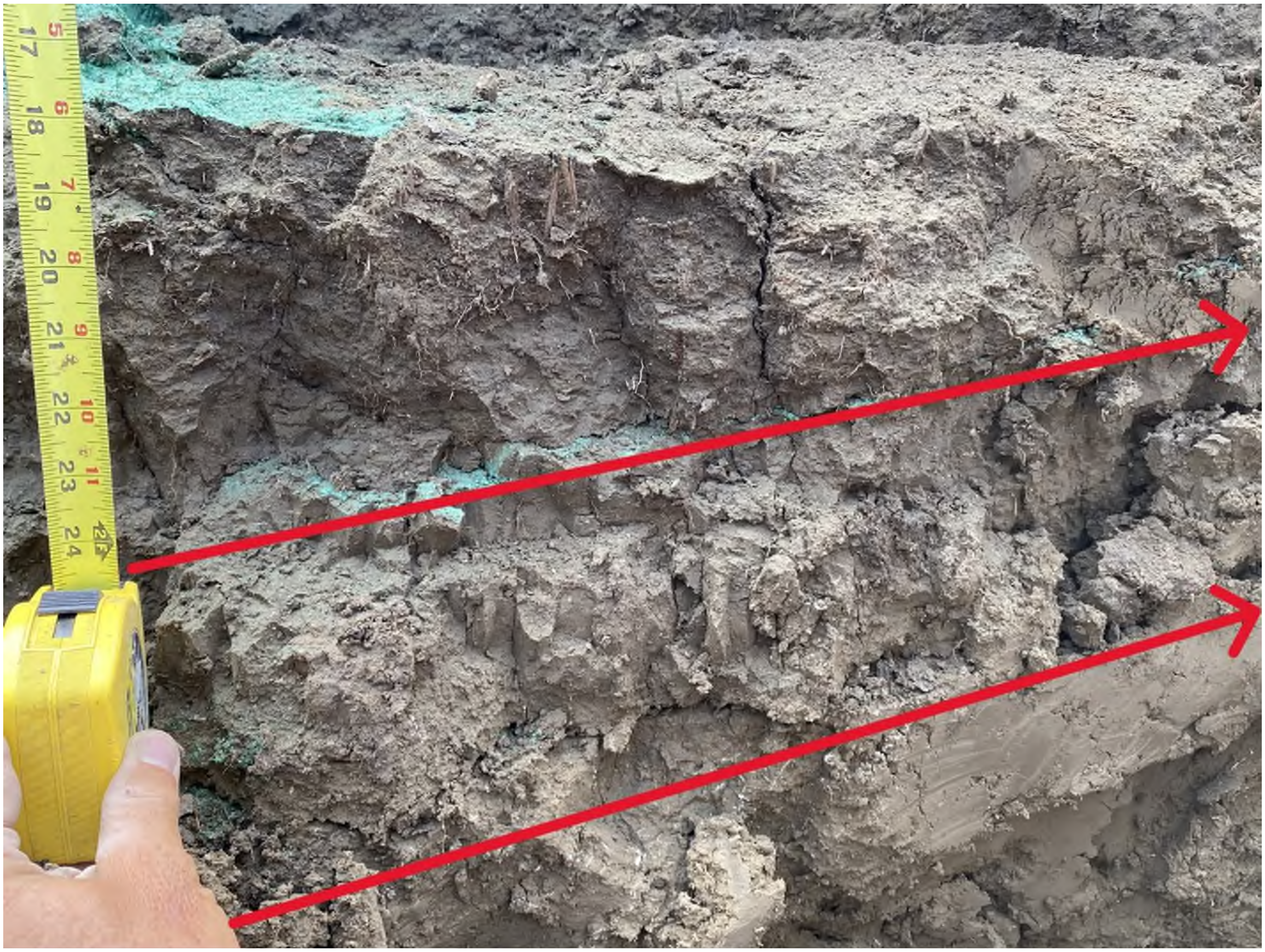


**Image C-4: Test #2 - Upward Horizontal Fracture @ 24” & 31” Deep with Mica Trace Along Surface of Fracture**

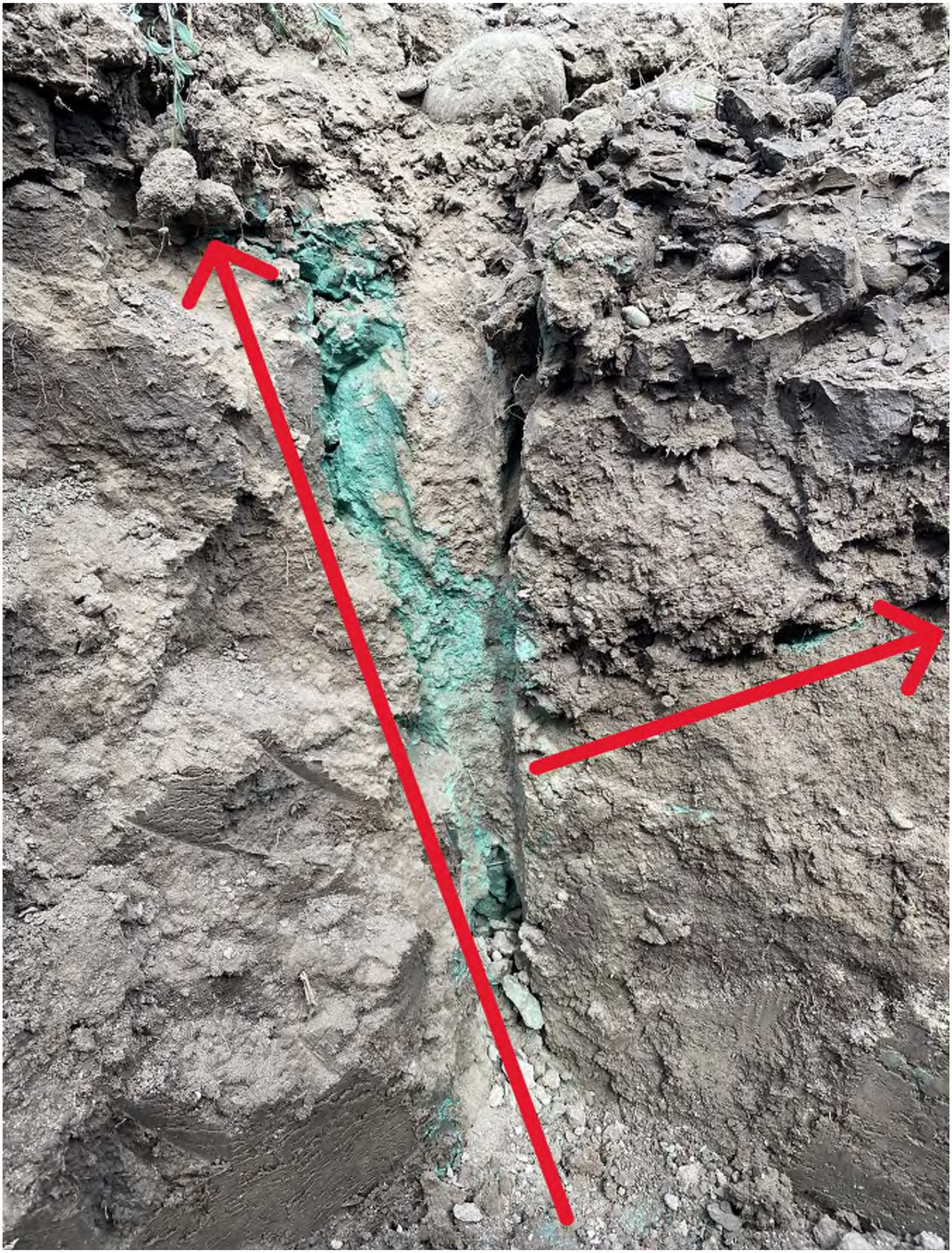


**Image C-5: Test #3 - Mica Powder Escaped Between Towards Surface**

**<u>Image C-6: Test #3 - Mica Powder Escaped Between Columnar Peds Towards Surface</u>**

Image C-7: Time Lapse Experimental Test Near Trench (Powder Exiting Near Probe)

Image C-8: Time Lapse Images - Experimental Test - Mica Powder Exiting into Trench

**Image C-9: Experimental Test (No Tracer) Air Exiting Vertical Fracture and into Trench**