The Misty Method: A new technique to improve and increase the efficiency of airscribes in matrix removal

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Abstract: Fossils in matrix frequently require extensive preparation prior to storage, study or display, often remaining stored for decades. Originally, collectors used picks, shovels, hammers, chisels, brushes, and dental tools to remove matrix. Hand-held airscribes (mini jackhammers) that are slightly larger than an indelible marker, are now used where air compressors are available. A person holds a single airscribe that vibrates the substrate as air is forced around the stylus tip.

During the 2018 field season, while using ME 9100 Airscribes that operate at 15,000 cycles per minute (cpm) and 100-120 per square inch (psi) at the Hanksville-Burpee Dinosaur Quarry, we pioneered a method that simultaneously uses two tools, and dramatically increases the efficiency of matrix removal. This new method can speed getting the fossils from field to exhibit. Traditionally, a single airscribe removes only a shallow furrow in dense, fine-grained rocky matrix or spalls off fingernail-size pieces which removes the matrix slowly. The user should wear eye and ear protection, gloves and take reasonable care using the tool with any airscribe method. In contrast, two stylus points held a short distance apart generated a fracture threshold that surpassed the matrix strength to a greater degree, thus allowing faster removal. Our experiments in the field and in the laboratory varied the angles of the two tips as they are aimed at each other, with angles ranging from 90° to nearly parallel. One tip was also held steady while the other tip moved. This enabled us to determine of the range of maximum effect of this removal technique. We named the technique the Misty Method after the paleontologist who originated it. The Misty Method does not alter a preparator's ability to control the positions of the stylus tips or to decide which method to use; therefore this method can be used safely near a delicate or fragile fossil as can the traditional single airscribe method. A single airscribe must be used for far longer than two airscribes used together. Using a single airscribe subjects the user's hand and the specimen to the vibrations over a longer span of time. The Misty Method uses one airscribe in each hand; therefore, it needs a shorter amount of time to reveal the specimen. No damage to any of the specimens recovered could be detected. The Misty Method is useful from about 300 mm (12 inches) of matrix down to near the fossil, and is useful in both field and laboratory.

INTRODUCTION

The Hanksville-Burpee Dinosaur Quarry, managed by the Bureau of Land Management (BLM), is located in Wayne County, west of Hanksville, Utah. This quarry is a part of the Brushy

Basin Member of the Late Jurassic Morrison Formation (156.3 +/- 2 Ma -146.8 +/- 1 Ma ; Trujillo et al. 2006).

> Kirkland (2009) reported, "The Hanksville-Burpee Dinosaur Quarry is a gigantic site. It represents a large eastward flowing, braided-river channel with isolated dinosaur bones and many relatively intact skeletons shallowly buried in an area about one third of a mile long and three hundred feet wide (roughly 10 acres). This site compares well with the largest known Morrison dinosaur sites, such as the Carnegie Quarry at Dinosaur National Monument, and is the southernmost such megasite known in the Morrison Formation outcrop belt. Five species of dinosaurs have been identified in the field".

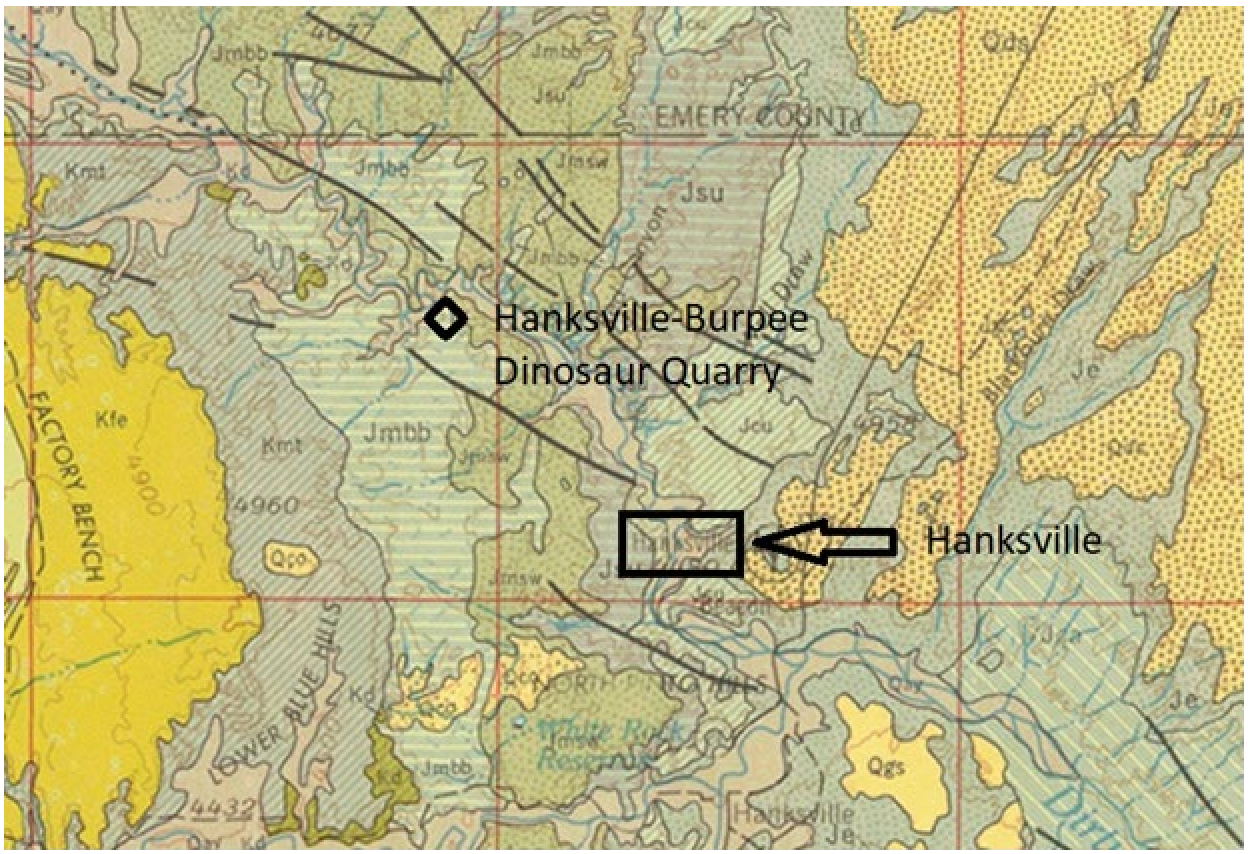

Figure 1. Geologic map showing the location of the town of Hanksville in relation to the Hanksville-Burpee Dinosaur Quarry. Doeling et al. (2015). Note: The Source map was enlarged to show detail and the boxes and the arrow were added for clarification.

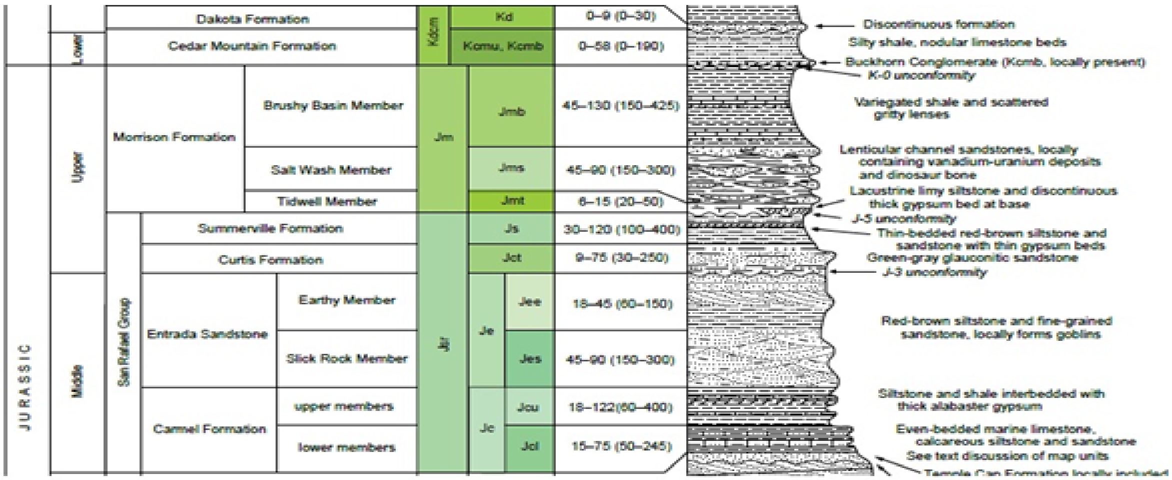

Figure 2. The Hanksville-Burpee Dinosaur Quarry is in the Brushy Basin Member of the Upper Jurassic of the Morrison Formation. Doeling et al. (2015).

METHODOLOGY

EQUIPMENT

A Cannon 5D Mark II Digital Single Lens Reflex with 21.1 megapixel resolution, and a 24-105 mm zoom lens with image stabilization was used for documentation in both the field and laboratory. This camera takes both still and video images. Additional still and video images were generated using a Samsung Galaxy S8 Active cell phone with a 20-megapixel resolution camera. All fossils were extracted from the matrix using Paleotools ME 9100 airscribes that operate at 15,000 cycles per minute (cpm) and 100-120 pressure per square inch (psi). (6.9 to 8.2) barometric pressure (BAR). 696.9-828.2 kilopascal (KPA).

Figure 3. An ME9100 airscribe is shown with a scale to illustrate size of the tool. The exposed stylus length as depicted here is 50 mm, and the diameter of the stylus tip is 1 mm

These tools each consume about 2.5 cubic feet of air per minute (CFM). The airscribes used in our excavation require, at minimum, a two-horsepower air compressor that can produce 6-7 CFM at 110 psi, with at least a 30-gallon reservoir. An in-line splitter can be used to accommodate two airscribes without a reduction in efficiency (Fig. 4).

Figure 4. One of the coauthors (MH) is using an airscribe on the experimental matrix in the laboratory at Burpee Museum of Natural History. This photo shows both the single airscribe method in the laboratory and the splitter, so two tools can be used without loss of power.

Under typical field conditions, wind, sand, and debris removed by the airscribe(s) that accumulate around the fossil being excavated confound the ability to measure accurately the amount of matrix removed. Additionally, as you work around a fossil, debris from the overburden matrix may fall onto the work area, making it resemble an ant lion's den. Therefore, we also conducted experiments in the laboratory to ensure accurate measurements of the amount of matrix removed using a single airscribe versus two airscribes simultaneously. In the laboratory, we had access to three samples of poorly lithified, nonfossil-bearing matrix samples so that the accuracy and speed of the Misty Method could be measured.

SINGLE AIRSCRIBE METHOD

A major improvement in fieldwork has been the ability to use power tools. These tools require power at the excavation site, which is not always possible. When air compressors are available, pneumatic tools, such as airscribes, speed the process of removing surrounding matrix accurately from fossils. Traditionally, one airscribe is used in the dominant hand with the tip placed against the dry matrix (http://preparation.paleo.AMNH.org/41/mechanical). The airscribe tip is drawn across the matrix. As the airscribe is used, the force generated by the tool surpasses the fracture strength of the matrix. The amount of material removed is limited by the hardness and consistency of the matrix, the size of the fossil, the fossil's location, and the size of the tool itself. There are different sized tools, and these vary in shaft length, tip diameter and force generation capabilities. Only ME9100s were available for our use in the field, and for consistency we also used only ME9100s to conduct our laboratory experiments. Our ME9100s have styluses 500 mm in length with a 3 mm shaft width and a 1 mm width tip.

Airscribes are similar to miniature jackhammers; compressed air is used to push a piston back and forth at thousands of cycles per minute (cpm). The tool is held firmly, much like a pencil, sometimes using the finger as a guide for the point of the tool. Small strokes should be used, in a regular pattern (http://preparation.paleo.amnh.org/41/mechanical). This occurs with almost every type of matrix from poorly lithified sediments to concretions to cement-like matrices (J. Mathews, pers. comm.).

The single airscribe method is under the control of the preparator. The preparator judges the appropriate placement and length of duration for using the airscribe for each type of matrix and fossil. Because the preparator chooses the tool and positions the tip of the stylus, these tools can be used in close proximity to even the most delicate of fossils. A skilled preparator maximizes the efficiency of matrix removal, but is still limited by using only a single airscribe. To date, this has been the standard method used in both the field and in the laboratory. This method is very time consuming, and a fossil may take hundreds of hours to go from original site of discovery to display. As an example, "Jane" a juvenile Tyrannosaurus rex (85% complete and 8.5 m long) at the Burpee Museum of Natural History, took 10,500 hours of preparation.

MISTY METHOD

The Misty Method, named for the inventor, does not alter a preparator's ability to control the positions of the stylus tips or to decide which method to use; therefore this method can be used safely near a delicate or fragile fossil as can the traditional Single Airscribe method. The Misty Method differs from the usual Single Airscribe method because it uses two airscribes at the same time. This method is not dependent on using only the dominant hand. [Note: many people play the piano or guitar who are not ambidextrous. Fortunately, all preparators that have tried this method have been able to master it in a short amount of time.] Because the Misty Method uses two airscribes, one in each hand, the preparator needs a shorter amount of time to reveal the specimen. The Misty Method generates a fracture threshold that surpasses the matrix strength to a greater degree, thus allowing faster removal. Our experiments in the field and in the laboratory varied the angles of the two tips as they were aimed at each other with angles ranging from 90° to nearly parallel. One tip was also held steady while the other tip moved. This enabled us to determine the range of maximum effect of this removal technique. The tools must be oriented toward one another at an angle that allows the unique field. This process requires overlap of the energy field generated by each tool. Used in conjunction, the two tools work to amplify the vibrations, and thereby surpass the fracture threshold to a greater degree. This method is most effective in facilitating the removal of matrices surrounding fossils, where the thickness of the matrix ranges from approximately 300 mm (approximately 12 inches) of matrix above the fossilized bone, to 100 mm or (approximately ½ inch) above the bone. For amounts of matrix of less than 10 mm or (approximately ½ inch) in thickness, or near a small, delicate or poorly consolidated fossil specimen, a preparator needs to use the usual degree of caution to avoid damaging the specimen. As is the case with using a single airscribe, the Misty Method can be employed near fossil specimens because the stylus tips are always under the control of the preparator. The Misty Method is effective in increasing the amount of material removed per unit of time under all cases tested so far. This testing was done on dry materials, ranging from fine to coarsely grained, poorly lithified, concretion-embedded, and concrete-like matrices.

Figure 5. One of the authors (MH) using two airscribes near a fossil specimen at the Hanksville-Burpee Quarry in 2018.

HANKSVILLE-BURPEE EXPERIMENT

We discovered this method in the field, under field conditions. The Morrison Formation has many types of matrices in close proximity to each other, often surrounding the same fossil. We conducted our field experiments on poorly lithified matrix, hard matrix, and very hard matrix. We classified poorly lithified matrix as pebbly with compacted sand and small stones or small amounts of concretion (Mohs hardness scale 4-5). Hard matrix we classified as stone-like (Mohs hardness scale of 7). Very hard matrix we classified as an 8 or more on the Mohs hardness scale. Our experiments tested a single airscribe versus the Misty Method for ease of removal of matrices.

We found that we were able to improve the effect of the single airscribe method slightly by making groves in a grid pattern. We were then able to get chips off of the interior of the grid square. While this technique is an improvement, it did not compare with the efficacy of the Misty Method.

ANALYSIS

We were impressed by the amount of matrix that we could remove in the field using the Misty Method, but we were unable to capture and weigh the amount of matrix that was removed in situ due to the conditions. At this site, which is in a desert-like area, there was loose sand and blowing wind, which blew sand and debris from the airscribe(s) onto the area of testing. Additionally, when you remove material, the hole you are creating fills with loose sand. This made determining how much of the material was removed by the single airscribe and Misty Method impossible. Therefore, we went to the Burpee Museum of Natural History, in Rockford, Illinois, and used their preparation laboratory which had controlled conditions. In this lab we used three different matrix samples. The Burpee Museum allowed us to use three samples that were poorly lithified, nonfossil-bearing matrix (Figures 6-10). These samples, being soft matrix in nature, were used for this destructive sampling. This insured that the accuracy and speed of the Misty Method could be experimentally measured.

We placed each sample, one at a time, in a large plastic box (Figure 6).

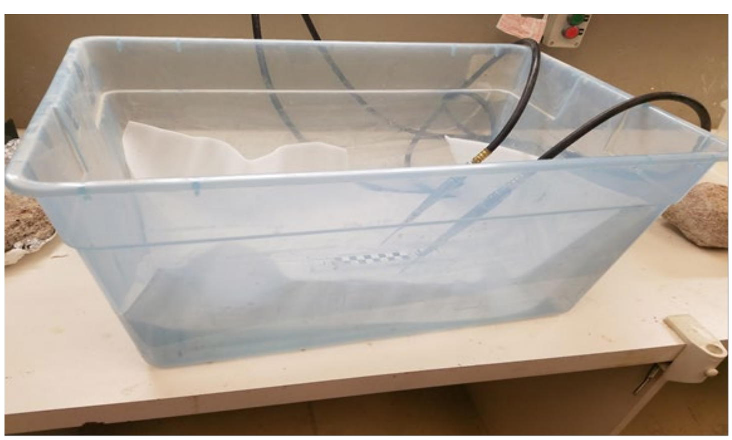

Figure 6. This image depicts the large box in which the single airscribe and Misty Method were tested. Use of a deep box ensured that we were able to capture all of the debris removed by the airscribes for weighing.

Figure 7. This image shows the first specimen of matrix tested in the laboratory experiments.

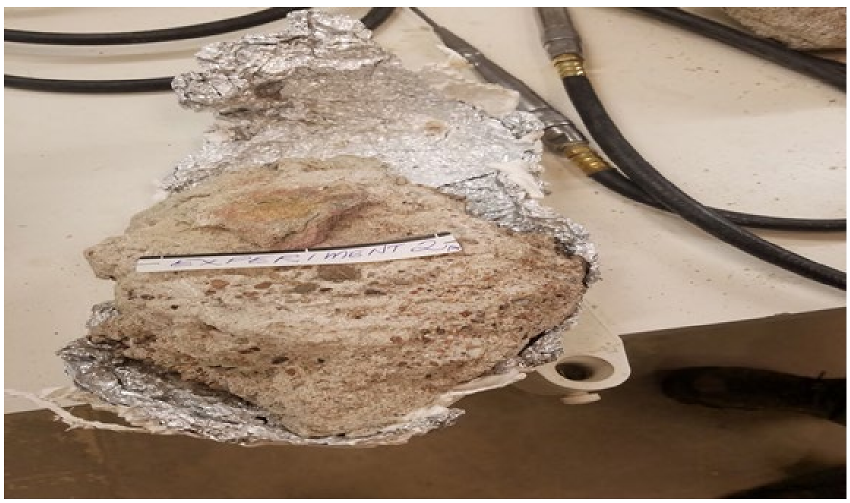

Figure 8. This image shows the specimen of matrix used in the second set of experiments

Figure 9. This image shows the specimen of matrix used in experiment 3 (Fig.10).

Each matrix sample was placed on a sandbag for stability (Figure 7). Photos and measurements were taken before and after as well as video. We used the single airscribe method for sixty seconds for each sample and then weighed the results. Then we reset and began the Misty Method using two airscribes for sixty seconds for each sample, and then weighed the results. In Figure 10 there are three different samples of soft matrix obtained by permission of the Burpee Museum of Natural History using one airscribe versus two airscribes (the Misty Method), and the percentage of increase in the amount of matrix removed when a second airscribe is employed simultaneously.

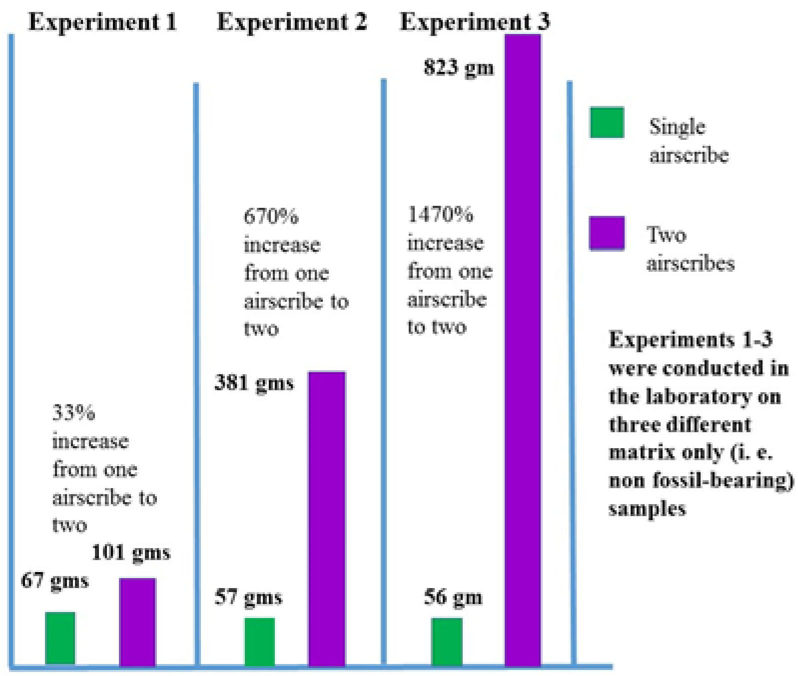

Figure 10. This figure shows three different samples of soft matrix obtained by permission of the Burpee Museum of Natural History using one airscribe versus two airscribes (the Misty Method), and the percentage of increase in the amount of matrix removed when a second airscribe is employed simultaneously.

The first experiment was to determine the amount of matrix removed by one airscribe used alone for 60 seconds and two airscribes for 60 seconds. The result of one airscribe for 60 seconds was 67 gm of matrix removed, and the result of two airscribes was 101 gm, a 33% increase.

One would expect that if one airscribe removed 50 gm of matrix, then using a single airscribe for 120 seconds, one would expect the result to be 100 gm.

The second experiment repeated the process on a different non fossil-bearing matrix sample. The result of one airscribe for 60 seconds was 57 gm of matrix removed, and the result of two airscribes was 381 gm, a 670% increase.

The third experiment also repeated the process on yet a third and different non fossil-bearing matrix sample. The amount removed using one airscribe alone for 60 seconds was 56 grams and the result of two airscribes was 823 gm, a 1470% increase.

All three non fossil-bearing matrices were of a poorly lithified consistency. These results show that the amount of matrix removed by a single airscribe is not significantly different statistically. The result of the Misty Method shows that the result of two airscribes greatly improves the amount of matrix removed, well above the amount predicted by using a single airscribe for twice as long.

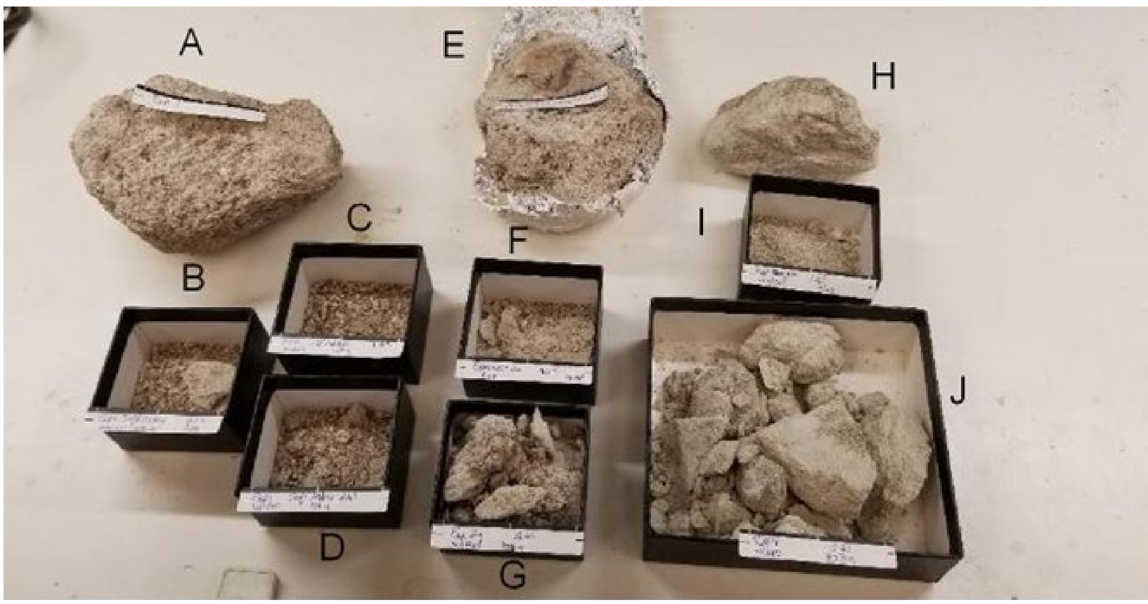

Figure 11. This is the photograph of the samples from Figure 10. This shows three different matrix samples (A, E, H) using one airscribe versus two airscribes. A was the first sample used, without being secured. As a result, it was unsteady; therefore, the material removed, shown in B, was discarded. Sample A was remeasured, then secured by being placed on a sandbag and the experiment resumed. Using the stabilized specimen A, C shows the amount of matrix removed using one airscribe for one minute, and D is the result of using two airscribes for one minute. E is the second sample, with F being the material removed using one airscribe for one minute and G is material removed using two airscribes for one minute. H is the third sample, with I the result of using one airscribe for one minute and J using two airscribes for one minute.

DISCUSSION

Up to now, matrix has been removed by a single airscribe. The Misty Method, using two airscribes, presents a unique means of allowing more matrix to be removed in the same amount of time. The fracture threshold of the matrix is exceeded by one airscribe, but is exceeded to a much greater degree when two are used simultaneously. Each airscribe operates in an identical manner. The increased effect of the juxtaposed airscribes occurs by summation of the forces generated by each that results in a greater total fracture force. The effect of two airscribes is greater that one airscribe for twice as long - the effect is greater than merely the summation of the forces. Using one airscribe for twice as long would subject the fossil to the same amount of force but for twice the time duration.

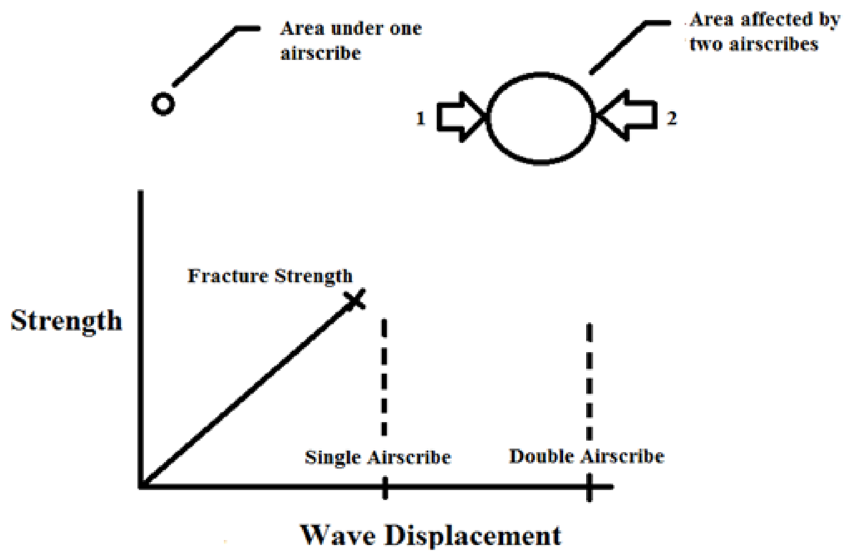

Figure 12. This simple representation shows the area under a single airscribe versus the area affected by two airscribes. It also shows the result of the fracture strength. Using two airscribes surpasses the initial fracture threshold to a much greater extent.

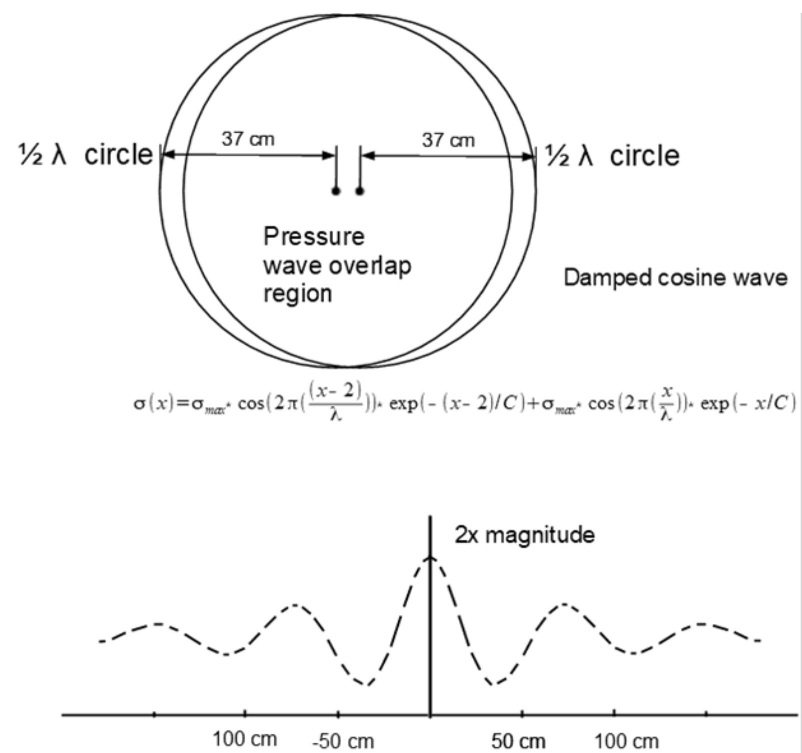

Figure 13. This shows the pressure wave overlap region, the damped cosine wave, and the single damped cosine wave phenomena in mathematical terms. We developed this basic theoretical model to explain the events occurring in the Misty Method.

The pressure wave overlap region in Fig. 13 shows the effect when two airscribes are placed 10 mm apart. Each time a stylus tip contacts the substrate it generates a pressure wave in a 370 mm diameter circle. With a distance of 10 mm between the two stylus tips, the pressure waves overlap to a large degree.

One of the most difficult types of matrix is of approximately the same harness as concrete. In fact, many of the matrices in the field (and some specimens in the laboratory as well) were very similar in hardness to concrete. Because concrete-like matrix is very difficult to remove from a fossil, we chose this as our first experimental example. We used the force calculations for concrete because they have been determined experimentally. In the pressure wave overlap region, the Misty Method, using two airscribes, is depicted in this model by two dots showing the tips approximately 10 mm apart. The circles represent the pressure wave area. The circles are calculated from the known speed of sound passing through concrete. The speed of sound in concrete is 1850 m per second (mps). The frequency of vibration of the airscribe tip is 15,000 cpm, or 250 cycles per second (cps). (www://Paleotools.com).

The wavelength is the velocity (1850 mps) divided by the cycles per second (250 cps). This gives a wavelength of 740 mm (equals λ), the wave decays, as shown by our single damped cosine wave illustration. As it travels, the wave decreases in amplitude over time. Multiplying speed (mps) by cycles/second frequency times is 370 mm. This represents the λ/2 circle. Furthermore, the damped cosine wave has been shown mathematically, and is graphed in Fig. 13.

CONCLUSIONS

The Misty Method that uses two airscribes is more effective in removal of matrix because it allows a greater amount of matrix, in a wide variety of hardnesses, to be removed. The use of two airscribes simultaneously removes more matrix more efficiently than merely using a single airscribe tool for twice the length of time. The method does not require any novel technologies, but rather creates a new way of using existing equipment in a more efficacious manner. Misty is not a paleontologist by training, and therefore had no preconceived notion that limited her understanding of airscribe usage. While not shown in this paper, the Misty Method also works on different hardnesses and types of matrices, with similar results. We have done additional work in other laboratories as well. The Misty Method was debuted as a poster at the Society of Vertebrate Paleontology meetings in 2018, and demonstrated during the meeting to preparators and other paleontologists at the Albuquerque Museum of Natural History. At the museum we were privileged to work on a specimen of a rare juvenile Pentaceratops embedded in a very hard, i.e., concrete-like matrix, one of the hardest that he has ever seen (Peter Larson, pers. comm.). The preparators said that there was approximately 50 mm of matrix to remove that would have taken them two weeks using the single airscribe method. After a short period of instruction, each of the participants mastered the technique. The Misty Method removed at least a 12 mm depth of this material in about five minutes. This method has a dramatic potential to increase the efficiency of fossil extraction in both the field and laboratory.

In conclusion, The Misty Method is the first significant innovation to increase the efficiency of fossil preparation since the availability of power tool use in both the field and laboratory. This method also allows maximization of the consistency of the matrix removal process regardless of the nature of the substrate that must be ablated.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY

DOELING, H. H., KUENE, P. A., WILLIS, J. B. and EHLER, J.B. 2015. Geologic Map of the San Rafael Desert 30’ x 60’ Quadrangle, Emery and Grand Counties, Utah. 29 p.

KIRKLAND, J. 2009. Scientific Investigations at Giant Hanksville-Burpee Dinosaur Quarry. Utah Geological Survey. Survey Notes 41(1): 5-6.

TRUJILLO, K.C., CHAMBERLAIN, K.R., STRICKLAND, A. 2006 Oxfordian U/PB Ages From SHRIMP Analysis for the Upper Jurassic Morrison Formation of Southeastern Wyoming with Implications for Biostratigraphic Correlations Geological Society of America Abstracts Programs 38(6):7.